UNIVERSITY OF CHICAGO

Waters of Unification:

The Yuan Grand Canal as an Engine of Imperial Administration

Master of Arts

in

Anthropology

by

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Abstract

When the Mongols established the Yuan Dynasty in 1271, they inherited not only the vast territory of a fragmented China but also the structural challenge of ruling it. Their decision to build a northern capital at Dadu, far from the agrarian and economic heartlands of the south, raised an urgent logistical question: how could a steppe-based empire sustain power across such a spatial and cultural divide? This study explores how the Grand Canal, redesigned and extended under Yuan rule, became a crucial infrastructure that supported imperial governance. It focuses the canal's role in facilitating long-distance movement of both essential goods and high-value commodities and uses porcelain as a proxy to investigate how the canal supported imperial logistics, cultural exchange, and regional integration. Through GIS modeling and archaeological evidence, the project evaluates how the redesigned canal improved transport efficiency and reshaped economic connections across the Yuan Empire.

Introduction

The Yuan Dynasty (1271–1368), established by the Mongols, ruled from a northern capital in Dadu (modern Beijing) while relying heavily on the economic productivity of southern China. This geographic and demographic imbalance created urgent logistical demands, particularly in provisioning the capital and maintaining imperial control over a diverse and fragmented empire. To address these challenges, the Yuan court reconstructed the Grand Canal, reorienting its flow from the older Luoyang-centered network to a direct north–south axis. This transformation was not only infrastructural but also political, enabling the extraction of resources, consolidation of power, and integration of distant regions.

China under the Yuan Dynasty

The Yuan Dynasty (1271–1368) was the first unified dynasty in Chinese history established by an ethnic minority. In 1206, Temüjin unified the Mongol tribes and founded the Great Mongol Empire. In 1271, his grandson Kublai Khan formally declared the establishment of the Yuan Dynasty. By 1279, the Yuan had conquered the Southern Song, bringing an end to the centuries of political fragmentation and division that had persisted since the late Tang period. From the fall of the Southern Song onward, the Yuan maintained a unified power over China for a total of 89 years. As a northern, pastoral people, the Mongols faced significant challenges in governing an expansive territory beyond their original homeland, with large Han Chinese population. They selected Dadu (modern Beijing) as their capital because of its proximity to

Territories of Tang, Southern Song, and Yuan

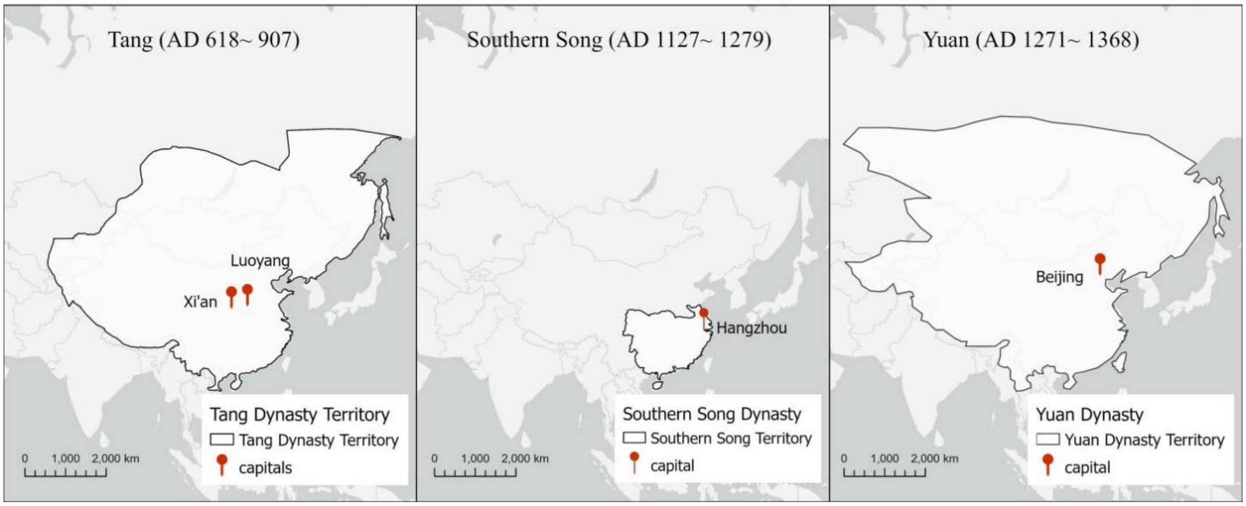

Figure 1. Territories of Tang, Southern Song, and Yuan dynasties. Map created by the author.

traditional pasturelands and its strategic value as a military base, which helped tap into their nomadic socioecological resources and maintain their military strength.

The legacy of the Southern Song period (*AD 1127–1279*), however, left a profound demographic and economic imprint on the Chinese landscape. As a result of prolonged conflict and political instability in the north, a large portion of the population had migrated southward, leading to an enduring concentration of people and economic activity in the lower Yangtze River (Figure 2). It is possibly to argue that this geographic imbalance created major provisioning challenges, as it became critical to supply the northern capital with food, materials, and resources from the southern heartlands. To address this, the Yuan government undertook a major redesign and expansion of the Grand Canal, aiming to streamline the extraction and transportation of resources from the south to the capital in the north.

By reconstructing and expanding the Grand Canal, the Yuan dynasty not only resolved pressing supply issues but also strategically integrated southern economic resources into northern political control, reinforcing imperial authority over a diverse population and securing the

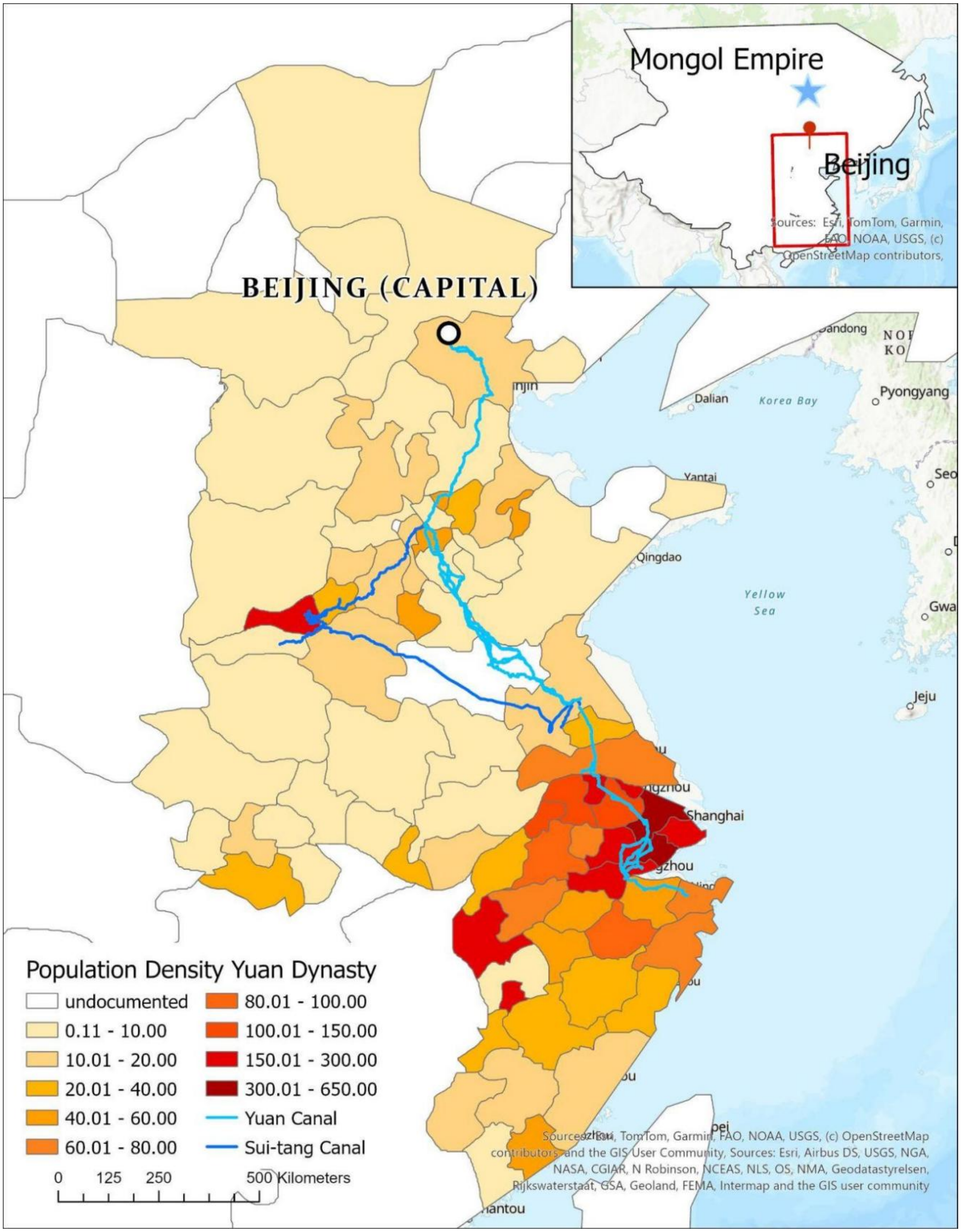

Figure 2. Population density of the grand canal area. Data gathered from *Population History of China* by Jianxiong Ge. Population density is calculated at the sub-provincial level, adjusting for sparse or undocumented areas by applying the lowest density or estimating data based on household records, and is aligned to the canal's completion in 1290 using estimated growth rates, ensuring consistency and comparability. Map created by the author.

stability of their rule. This research explores this idea by investigating two questions: (1) To what extent did the Yuan Dynasty's reconstruction of the canal improve transportation efficiency compared to earlier routes or the absence of a canal? (2) How did the canal's operation contribute to cultural interaction and exchange across regions, both between southern and northern Yuan China, and in connecting its regime to transnational area like Central Asia?

Since the Yuan dynasty brought together completely different ethnic groups, it became essential to establish control over them and create stronger connections across the empire. The political system of the Yuan Dynasty was characterized by a dual structure combining Mongol and Han institutions, a hybrid model known as "multiple systems coexisting" (诸制并举), designed to accommodate the needs of a vast, multiethnic empire encompassing diverse economic and cultural regions. However, instead of promoting ethnic integration, the Yuan administration institutionalized ethnic divisions through a formal legal hierarchy known as the "Four-Class System" (四等人制), which exacerbated social tensions (Chen et al., 2011, p. 2).

Although the Yuan rulers implemented the ethnic hierarchy by dividing people into four classes, their unification of a fragmented China under a single regime facilitated economic and cultural exchange among different ethnic groups. The establishment of an extensive and efficient courier station system across the empire connected distant regions and previously isolated communities. (Ren, 2009, p. 28). Within the territory of the Yuan Empire, waves of ethnic migration occurred continuously and never ceased throughout the dynasty. These movements included not only various ethnic groups relocating from peripheries to the central plain such as Henan, Shandong, etc., but also Han Chinese migrating to borderlands like the north of the Gobi dessert, leading to widespread patterns of mixed and interwoven settlement across the empire.

These migrations were driven by a variety of factors, including military garrison duties, official appointments, state-organized resettlement policies, the capture and relocation of slaves, exile as punishment for crimes, and commercial activities (Ren, 2009, p. 28-31). In these mixed settings, the Han Chinese were the most populous group, with the most advanced economy and highest level of cultural development largely due to their long history and deeply rooted cultural traditions in these lands. As a result, the various ethnic groups that had migrated into the interior central plain region gradually came under the influence of Han civilization, increasing their cultural commonalities with the Han over time (Ren, 2009, p. 31).

The Yuan dynasty also marked one of the most vibrant periods of cultural exchange in Chinese history. With the empire's vast territory and the expansion of both land and maritime transportation networks, the barriers between regions largely disappeared. The Yuan government actively encouraged merchants to conduct trade across the world, resulting in a large influx of foreign traders into China. Additionally, the Yuan dynasty's policy of tolerance toward various religions and cultures created favorable conditions for cultural interactions between East and West. Cultural exchange with neighboring regions across East and Central Eurasia mainly focused on poetry, Confucianism, and Buddhism; exchanges with Africa emphasized the trade of goods, while communications with Europe largely involved the arrival of missionaries in China such as Marco Polo, Rubruquis, Odorico da Pordenone, etc, . During this period, Chinese innovations such as printing technology, gunpowder, and weapons manufacturing spread to the West, while astronomical and medical achievements from the Arab and Persian worlds were introduced to China (Ren, 2009, p. 42). These exchanges not only enriched Chinese society but also helped integrate the Yuan Empire into a broader global network of cultural and economic connections.

Grain-Transportation via Waterways (*caoyun* 漕运)

The *caoyun* system—the state-organized transport of grain and essential goods via waterways—formed the material foundation of centralized imperial authority in premodern China. As the late Qing statesman Kang Youwei succinctly observed, "*The system of caoyun is the great political matter of China*," a remark that captures both its strategic importance and its deep entanglement with the stability of autocratic rule (Kang and Tang, 1981, p. 354). The *caoyun* system was critical in supplying the political core, most often the capital city, with the grain, provisions, and resources necessary to sustain the royal court, officials, soldiers, institutions, and urban populations. Grain transported via this system, commonly known as *caoliang* (漕粮), played a direct role in ensuring the survival and normal functioning of the state. It supported everything from the imperial household's consumption to the rations of capital garrisons, stipends for bureaucrats, and food for displaced populations (Wu, 2000, p. 12). In this sense, *caoyun* was a lifeline for imperial governance.

Moreover, the central government's control over *caoyun* reinforced national unification and actively cultivated the rise of regional separatism. By managing the collection, movement, and allocation of grain and taxes across provinces, the imperial court effectively monopolized the most critical flows of fiscal revenue, undermining the economic base of local powerholders. With reliable material supply, the state could suppress rebellion, maintain garrisons across strategic frontiers, and respond rapidly to both internal crises and external threats (Wu, 2000, p.

13). The *caoyun* network was also a vital tool of social regulation and crisis management. Throughout Chinese history, natural disasters, famines, refugee crises, and market instability, whether triggered by environmental or human causes, threatened social order. In such moments, the imperial state relied on the *caoyun* system to redistribute grain, provide emergency relief, and stabilize food prices through public granary sales. When facing price speculation, merchant hoarding, or war-induced shortages, the dynasties always turned repeatedly to the water-based transport system to ensure continuity and calm (Wu, 2000, p. 13). Therefore, beyond being an instrument of administrative routine, the *caoyun* system was a mechanism of imperial survival, one that played a decisive role in sustaining centralized power, military strategies, and socio-economic stability across the vast, often volatile, landscapes of dynastic China.

The Grand Canal

The functioning of *caoyun* system depended greatly on canals. The existing north–south canal, originally constructed during the Sui Dynasty and extensively utilized throughout the Tang and Song periods, centered around Luoyang in the Central Plains (Figure 3). Therefore, it has become incompatible with the transportation needs of the Yuan Dynasty (Ji, 2008, 1024). The Mongols, with their capital in Dadu, needed a reliable system to ensure the steady flow of grain, goods, and personnel from the agriculturally rich southern regions to the northern capital. To address this, the Yuan court initiated one of the most ambitious infrastructure projects in Chinese history—the expansion and reconfiguration of the Grand Canal. Under the supervision of key Yuan officials, particularly figures like Guo Shoujing, the canal was rerouted to create a more direct and efficient connection between Hangzhou in the south and Dadu in the north (Figure 3).

Figure 3. The Grand Canal area waterways. Map created by the author.

The canal was fed mainly by Qiantang River and underground water. The southernmost section links to the Qiantang River on China's east coast while the northernmost section of the canal connects to the Hai River in Tianjin. Unlike earlier canal systems, which had a more east-west orientation, the Yuan Grand Canal was designed primarily to facilitate north-south transportation, reflecting the shifting political and economic priorities of the empire.

One of the core functions of the Grand Canal throughout Chinese imperial history was to support the *caoyun* system. More importantly, the Grand Canal also played a crucial role in resolving the challenges of long-distance transport of fragile and high-value goods such as porcelain. Originally a product of Han agrarian society, porcelain held deep cultural significance that the Mongol rulers of the Yuan dynasty actively adopted, modified according to their own aesthetic preferences, and used as a symbol of status and political power. Its production, circulation, and consumption were closely tied to both economic policy and political symbolism. For the Mongols, who came from a steppe tradition, the appropriation and large-scale deployment of porcelain in royal and diplomatic contexts served to legitimize their rule. By adopting and commissioning fine porcelain for court rituals, diplomatic gifts, and elite consumption, the Mongol rulers presented themselves as rightful heirs to Chinese imperial traditions, embedding their foreign rule within a recognizable cultural framework. Overland transportation of fragile porcelains was risky. By allowing major kiln sites to connect with different segments of the canal according to their proximity, the system greatly enhanced the safety, efficiency, and scale of porcelain transportation to the capital. Not only porcelain, but also commercial goods produced in both northern and southern, were thus able to flow continuously into Dadu (Beijing), the Yuan capital, via the canal system and alongside ports.

Data & Methods

This study adopts an interdisciplinary approach, combining spatial analysis with archaeological interpretation to assess the impact of the Grand Canal during the Yuan Dynasty. To assess transportation efficiency, this study employs a Geographic Information Systems (*GIS*) framework to model and compare the hypothetical cost of transportation across three chronological phases: Pre-canal phase, representing movement overland and along natural rivers before the construction of any major canal infrastructure; Sui–Tang canal phase, representing routes centered on Luoyang that dominated during the early imperial canal system; Yuan canal phase, reflecting the reengineered canal system with new sections such as the Huitong and Tonghui rivers that directly linked the Jiangnan region to Dadu.

Spatial analysis was conducted using ArcGIS Pro, with base terrain data derived from Digital Elevation Models (*DEM*) acquired via the USGS Earth Explorer at a 30-meter resolution. First, slope values were calculated from the DEM to represent the degree of physical resistance across the terrain. Subsequently, the slope raster was reclassified into cost categories to translate raw gradient values into generalized levels of movement difficulty, where steeper slopes were assigned higher cost values. Next, canal routes were manually digitized based on historical maps and scholarly reconstructions. Each set of canal segments was then converted into separate raster layers to align with the cost surface format and allow further manipulation within the analysis. To simulate the broader accessibility of waterways and reduce cost around canal paths, the rasterized canal segments were expanded using the Focal Statistics tool. Following this, the canal rasters were reclassified to assign lower cost values to canal pathways, distinguishing them from natural terrains. The reclassified slope and canal rasters were then combined for each phase to generate three distinct cost surfaces, each representing the relative movement difficulty for a given historical period.

Jingdezhen (Jiangxi) and Longquan (Zhejiang), two major kiln sites with long histories and peak production during the Yuan dynasty, were selected as origin points for the Least Cost Path analysis. Although both predate the Yuan, Longquan from the Three Kingdoms period (*AD 220- 280*) and Jingdezhen from the Tang (AD 618-907), their use in the pre-canal model is primarily analytical which allows a consistent comparison across all three historical phases by establishing a baseline transport cost in the absence of canal infrastructure. Similarly, the central palace complex of the Yuan Dynasty in Dadu served as the destination point in the analysis. While the capital during the construction of the Sui–Tang Grand Canal was located in Luoyang, and temporarily in Chang'an (*present-day Xi'an*), Beijing was retained as the fixed destination across all phases. By keeping the origin and destination points constant, the analysis focuses on how different canal infrastructures shaped transport efficiency under the same conditions. Using the Distance Accumulation tool, the cumulative cost of moving across each surface from the origin point to the destination was calculated. Finally, the Optimal Path tool was used to determine the least cost path (LCP) for each cost surface.

Complementing the GIS analysis, the study examines archaeological materials found along the Yuan Grand Canal corridor. Excavation reports, museum archives, and published datasets are used to analyze the presence and distribution of culturally significant artifacts, particularly porcelains. Emphasis is placed on southern-produced porcelains(*e.g., blue-and-white porcelain from Jingdezhen kiln and Longquan celadon from Longquan kiln*) found in canal-side sites. These data points are used to trace cultural exchange and interaction facilitated by the canal. As a result, this study uses porcelain as a lens to highlight how luxury goods, alongside essential resources like grain, benefited from the expanded canal network. Although porcelain transport alone did not drive the Yuan's investment in the canal, its circulation reflects the broader logistical priorities and imperial strategies that the canal supported.

Several limitations in the spatial data and modeling approach must be acknowledged. First, the study region, southeastern China, is largely composed of flat terrain (Figure 4), meaning that, in the absence of waterways, the cost of movement across natural terrain would already be relatively low. Meanwhile, the relationship between slope and movement cost is not linear but tends to increase exponentially. In other words, slight increases in gradient at low slopes already represent meaningful differences in ease of movement. To address this, additional reclassification groups were assigned to the lower slope values in an effort to create more nuances and highlight subtle variations in movement difficulty. However, this remains an approximation. Second, while slope and canal presence were the primary factors considered in constructing the cost surfaces, other variables—such as soil type, vegetation, seasonal flooding, and sociopolitical constraints—also likely influenced historical mobility but are not included in the present model. Thirdly, the assignment of cost values to both slope and rasterized canal layers is inherently subjective. Although care was taken to follow logical assumptions grounded in terrain analysis and historical context, the final values reflect solely interpretive choices. As many scholars have noted, LCP analysis is best understood as producing a baseline model, a theoretical representation of possible optimal movement under selected criteria, rather than an exact reconstruction of historical routes (Howey, 2007, p. 1837)

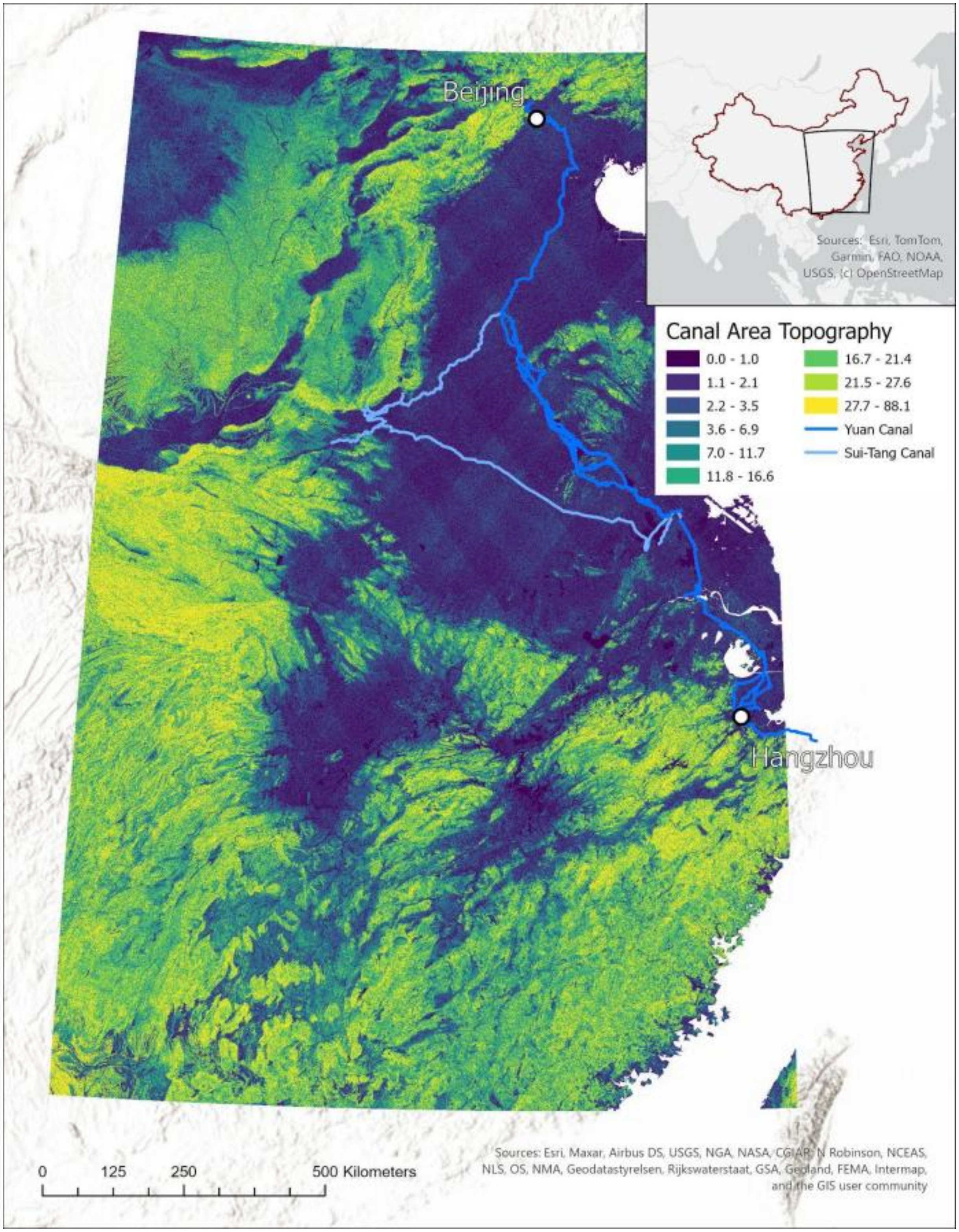

Figure 4. The Grand Canal area topography. Terrain data acquired from USGS World Explorer. Map created by the author.

Finally, the kiln sites selected for this study do not encompass the full diversity of Yuan-period ceramic production. Notably, Cizhou ware, which was one of the most frequently recovered porcelains in the Yuan capital, was excluded from this model due to its northern location and the project's focus on southern kilns (Hu, 2019, p.4). As such, the results should be interpreted as representative of a specific subset of the Yuan dynasty's broader porcelain

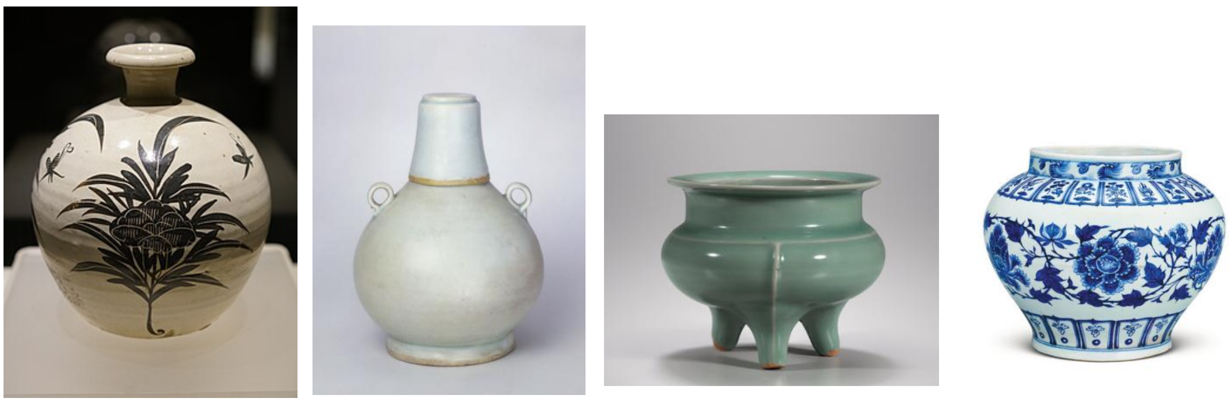

Figure 5. Representative examples of porcelain types discussed in this thesis. From left to right: Cizhou ware (Wikipedia, 2013), Jingdezhen ware (The Palace Museum, n.d.), Longquan ware (Johan's, n.d.), and blue-and-white porcelain (wenweipo, 2021). These images are intended for visual reference and do not necessarily correspond to actual excavated artifacts, as the original site reports often lack colored photographs.

economy.

While porcelain was a valuable good that moved along the Grand Canal, it was not the primary motivation for the canal's construction or reconstruction. The Grand Canal primarily served larger strategic needs, such as transporting grain to feed the northern capital, facilitating the movement of troops and officials, and maintaining the empire's economic integration. Porcelain was chosen as the focus of this study not because it was the primary cargo of the Grand Canal, but because it provides a tangible, traceable form of archaeological evidence that survives to the present day. Unlike grain or other perishable goods, which leave little material remains, porcelain allows us to better reconstruct patterns of production, movement, and consumption across the Yuan empire. As such, porcelain serves as a practical proxy to understand the broader logistical networks the canal supported, even though it was only one part of the empire's larger transport economy.

GIS Results

This section presents the results of the GIS-based least cost path analysis across three

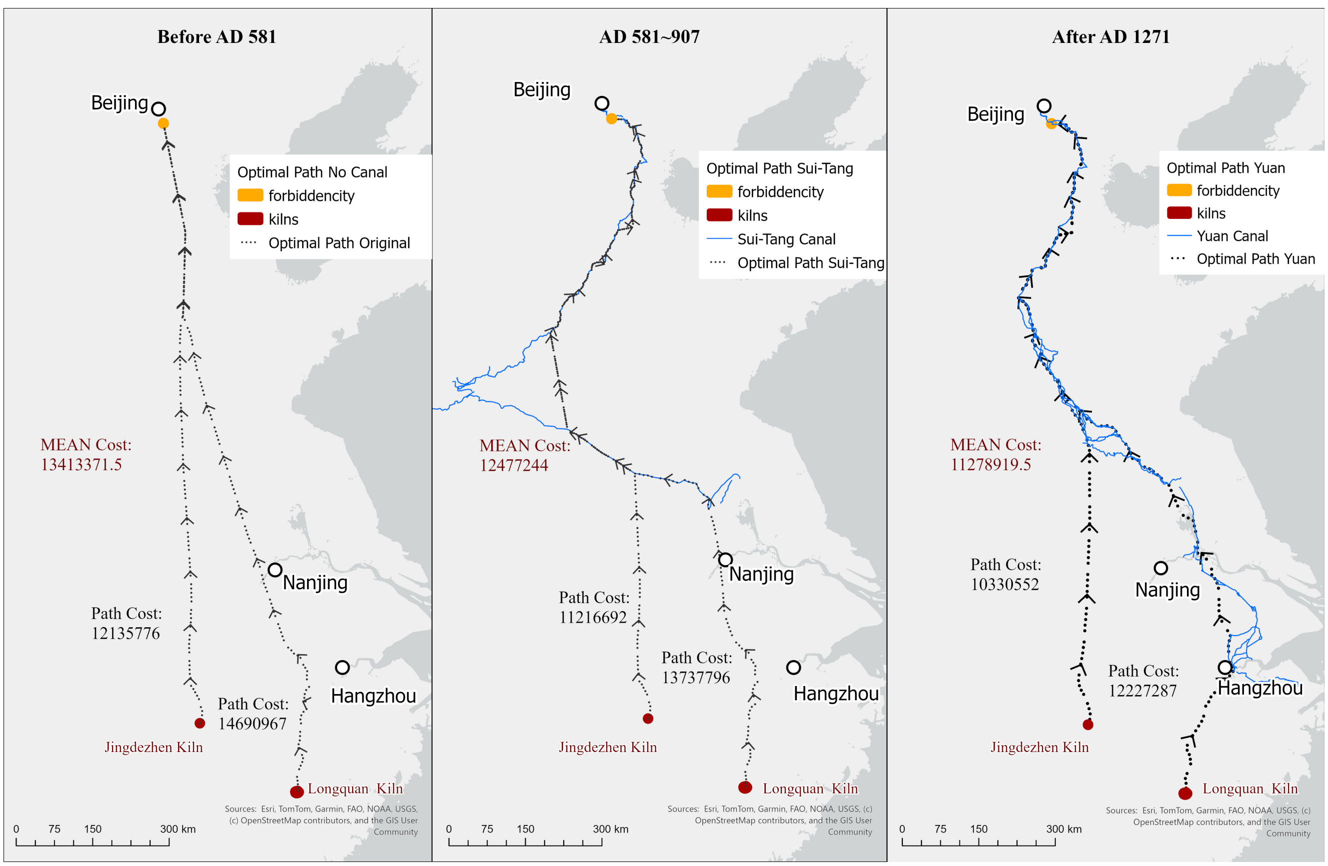

Figure 6. Least Cost Paths of the three selected phases. Map created by the author.

historical phases—pre-canal, Sui–Tang canal, and Yuan canal.

Period/Path	Jingdezhen Path	Longquan Path	Path Mean Cost	Cost Reduction Compare to Previous Stage
Pre-Canal	12,135,776	14,690,967	13413371.5	
Sui-Tang Canal	11,216,692	13,737,796	12477244	-6.98%
Yuan Canal	10,330,552	12,227,287	11278919.5	-9.60%

Table 1. LCP results including cost reduction percentage. Table compiled by the author.

In the absence of state-built canal infrastructure, the optimal paths of the pre-canal phase from southern kiln sites to Beijing would have followed a direct, linear trajectory along a south-to-north axis (Figure 6). The calculated mean path cost across both routes was 13,413,371.5, with the Longquan kiln-originating path reaching 14,690,967, and the Jingdezhen kiln path reaching 12,135,776. These values indicate substantial travel difficulty, likely due to topographic constraints, lack of navigable waterways, and minimal state-sponsored transport infrastructure.

The introduction of the Sui-Tang Grand Canal marked a considerable transformation in imperial transport strategy. The mean path cost decreased to 12,477,244, representing an approximate 7% reduction in travel cost from the pre-canal period (Table 1). Specifically, the path from the Jingdezhen kiln site dropped to 11,216,692, while the Longquan kiln path cost decreased to 13,737,796. In this model, optimal paths began to align more closely with the canal's course, especially in the northern and central plains. However, the route did not fully follow the canal, instead, it cut across the central plain midway through its journey north (Figure 6). This can be explained by the relatively flat terrain of southeastern China, where following the detoured canal route incurred a higher cost than moving directly across the plains.

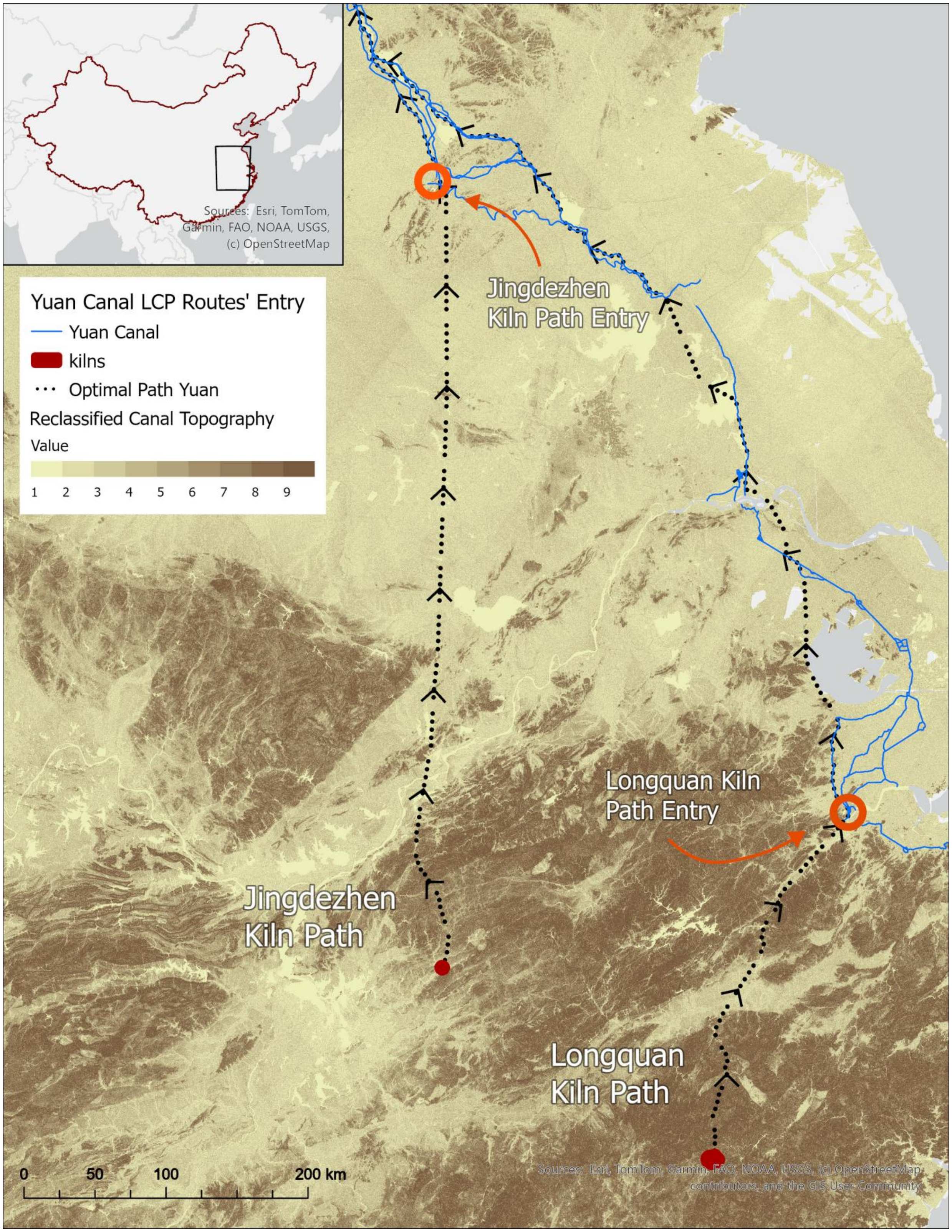

Figure 7. A close-up examination of the different entry points of the Canal LCP routes during Yuan dynasty. Symbology altered for clearer visualization. Map created by the author.

Following the construction and extension of the Grand Canal under the Yuan dynasty, the LCP results exhibit the lowest transport costs of all three periods. The mean path cost further decreased to 11,278,919.5, with the Jingdezhen-originating path at 10,330,552 and the Longquan kiln path at 12,227,287. These figures reflect a further 9.6% cost reduction compared to the Sui-Tang period and a 16% reduction compared to the pre-canal era (Table 1). The optimal paths now align closely with the canal system throughout its length (Figure 6), illustrating its central role in facilitating movement. However, the two paths show some differences in how they enter the canal system. The Longquan kiln path joins the canal early at Hangzhou and follows it almost entirely northward, closely aligning with the canal's full length. In contrast, the Jingdezhen kiln path does not merge with the canal until it reaches Suzhou, entering at a much later stage in its route. This divergence is partly due to geography: if the Jingdezhen route were to join the canal at either Ningbo—the southernmost starting point—or Hangzhou, it would have to traverse a mountainous region (Figure 7). By contrast, the Longquan route, situated to the south and west, is able to bypass these mountains by partially utilizing the Yangtze River, allowing easier access to the Hangzhou entrance in the early phase of the canal.

Shipwreck Remains along the Canal Routes

In 1976, remains of six Yuan dynasty shipwrecks were uncovered in Nankaihe Village, Cixian County, Hebei Province (Figure 8). A total of 383 ceramic artifacts were recovered, with ship No.1 carrying 339 objects (Table 2). The majority originated from the Cizhou kilns, a prominent northern ceramic production center. The assemblage also included a small number of Jingdezhen and Longquan wares, indicating that ceramics from both southern and northern kilns were being transported together along this route, likely destined for northern consumption centers such as Dadu. Among the upright vessels, Ship No. 4 is particularly significant. An inscribed wooden plank recovered from the wreck identifies it explicitly as a grain transport vessel (Zhu, 1978, p. 388~393).

Shipwreck/Info	Length (cm)	Width (cm)	Porcelains	Iron*	Bronze*	Wood*	Ceramics	Stone*	Glass*
No. 1	824	290	339	22	5	0	4	2	0
No. 2	1008	302	37	30	1	0	3	1	0
No. 3	538	268	2	11	0	3	0	0	1
No. 4	964	/	5	17	1	0	0	0	0
No. 5	1660	/	0	2	0	0	0	0	0
No. 6	300	/	0	0	0	0	0	0	0

Table 2. Summary of the Cixian shipwrecks: dimensions and recovered artifacts. Starred entries (*) indicate that the word "artifacts" was omitted for simplicity (Zhu, 1978, pp. 392 & 399). Table compiled by the author.

These shipwrecks were found capsized or overturned, and some still contained human skeletal remains. On the first ship, a male skeleton estimated to be in his fifties was found near the bow. On the second ship, lower limb bones were recovered from the stern, and a male skull—estimated to belong to a man around twenty-five years old—was located near the bow. Between the first and third ships, archaeologists uncovered the remains of a man in his thirties. Notably, none of the skeletal remains exhibited signs of trauma or injuries from weapons, suggesting that these individuals were not victims of violence or attack. Instead, the evidence points to a scenario in which the vessels likely sank while anchored, possibly due to sudden environmental events such as high winds or storms (Zhu, 1978, p. 388~393).

In April 2002, a Yuan dynasty grain-transport vessel (漕船), measures 16.2 meter, was excavated from the Liaocheng section of the Beijing-Hangzhou Grand Canal (Figure 8). A large number of porcelain sherds were recovered from the shipwreck, with 43 identifiable vessel forms including cups, bowls, lidded containers, and Han-style vases. Although this wreck yielded only four relatively intact ceramic pieces, they are of considerable interpretive value (Chen et al., 2020, p. 202). The vessels were of low grade, bearing clear signs of wear, and were likely used for eating, storing wine, or holding water. Their condition and utilitarian nature suggest they belonged to laborers or boatmen, not elites, offering a valuable angle into the daily life and material culture of those who worked along the canal (Chen et al., 2020, p. 199-204).

In 2010, a Yuan-period shipwreck, measures 21 meter, was excavated in Heze, Shandong, situated along a vital segment of the Grand Canal between Hangzhou and Dadu (Figure 8). This site lies on what would have been a necessary transit corridor for vessels moving goods between southern production zones and the Yuan capital. Over 200 artifacts were recovered from the wreck, including several high-quality and symbolically significant items. Key finds include a blue-and-white meiping vase with dragon motifs, a blue-and-white dish with phoenix motifs, a qingbai-glazed carved dish with dragon design, and a jade washer shaped like a lotus leaf. Porcelains include wares from Jingdezhen, Longquan, Jun, and Cizhou kilns, indicating a wide distribution network spanning major production centers in southern and central China. (Wang et al., 2016; Liu et al., 2022, p.133).

The shipwreck assemblages underscore two important patterns in Yuan canal transport: the absence of a strict division of labor and function among vessels and the likelihood of bidirectional movement. For instance, grain transport vessels were also used to carry ceramics, as seen in Ship No. 4 from the Nankaihe site, explicitly identified as a grain ship but containing a substantial ceramic assemblage. Similarly, the Liaocheng wreck yielded utilitarian ceramics likely used by laborers. These cases suggest that vessels were not specialized solely for either

Figure 8. Site distribution of shipwreck remains. Site locations acquired from site reports respectively as illustrated below. Map created by the author.

state provisioning or commodity transport, but instead fulfilled multiple functions along their routes. Furthermore, it could be argued that these vessels did not exclusively travel south-to-north, instead, they likely carried goods in multiple directions, depending on cargo needs and administrative demands. Therefore, this evidence supports a more fluid, integrated view of canal logistics, where cargo types, travel direction, and vessel function were flexibly configured to serve the broader goal of south–north integration.

Rethinking the Route: LCP Modeling and the Logic of Yuan Canal Planning

While paleo-environmental data is limited and qualitative motives cannot be objectively measured, the LCP model serves as a heuristic tool to explore the spatial logic behind canal construction rather than to assert definitive inaccuracies. The observed reduction rate is relatively lower than expected, which may be due to the fact that the initial pre-canal Least Cost Path (LCP) model only considered slope as a variable, leading to an unrealistic baseline. In reality, different surfaces would dramatically affect travel speed and difficulty. Marshes or wetlands, for example, would have been nearly impassable without boats or specially prepared roads. Even if a slope is gentle, rivers and streams without bridges would create major obstacles. People and carts might need to detour long distances to find a fordable crossing or ferry.

Meanwhile, unlike the Yuan dynasty and Sui-Tang period, which needed to manage an extensively vast and unified territory, earlier dynasties majorily utilized localized, small-scale canals and administrative post stations primarily served regional wagon traffic and caravan routes. When considering long-distance transportation from the south to the north, though might not serve pressing necessity for these earlier periods, the overall travel cost would still have been comparatively high. Therefore, if these factors could be quantified and incorporated into the model, the initial path cost would likely be much higher, resulting in a more significant reduction rate when comparing pre-canal and canal-enabled transportation routes.

The Canal Segments and its Configuration

To understand how transport costs decreased during the Yuan period, it is necessary to examine not only the existence of the Grand Canal, but also the specific structural modifications made to it under Yuan rule. The earlier Sui–Tang canal, which centered on Luoyang, followed a west-east orientation that was less efficient for direct movement between the economic south and the political north. For transporting to the new capital at Dadu from the south, these routes often required detours that increased travel time and cost (Figure 3). The Yuan Grand Canal, in contrast, reflects a reorientation of imperial priorities and logistics. Rather than relying on inherited infrastructure, the Yuan court constructed entirely new canal segments and modified existing ones to establish a direct waterborne corridor between Hangzhou and Dadu. In this section, we will examine a few major segments that were added or rerouted during the Yuan dynasty and how these specific interventions were motivated initially and contributed to the marked improvement in transport efficiency.

One of the most critical Yuan interventions was the construction of the Tonghui River (通惠河)—the final stretch connecting Tongzhou to Dadu at the northernmost point of the Grand Canal (Figure 9) Although previous dynasties had managed to bring grain ships as far north as Tongzhou through waterways, there was no water route connecting Tongzhou to the capital itself. As a result, shipments had to be transferred onto land routes for the final segment—a laborintensive and inefficient process. Recognizing this obstacle, the Yuan court initiated the excavation of the Tonghui River to achieve full hydraulic integration of the north-south transport network (Zhang, 2019, p. 96-97).

Designed by the eminent astronomer and hydraulic engineer Guo Shoujing (郭守敬*)*, the project overcame two major challenges: a sharp elevation gradient between Tongzhou and Dadu, and a lack of natural water sources to sustain the canal flow. Guo Shoujing developed a technically sophisticated plan that involved connecting and regulating several natural waterways, including the Wenyu River (温榆河), White River (白河*, a tributary of the Chaobai River* 潮白河), and Kunming Lake (昆明湖). Through dredging, rerouting, and gradient control, the Tonghui River was successfully opened and became the final segment needed to achieve full connectivity between southern China and the Yuan capital via water (Zhang, 2019, p. 96-97). Only after this link was completed could the Grand Canal be considered truly continuous.

As the essential transit region for moving grain and goods from the south to the northern capital, Shandong played a vital role in the Yuan dynasty's broader *caoyun* strategy. Recognizing its geographical significance, the Yuan government undertook a range of infrastructural initiatives in Shandong to strengthen the connection between southern production zones and Dadu. Among the most ambitious efforts were the excavations of the Jiaolai Canal, Jizhou River , and Huitong River (Figure 9). These projects aimed to integrate Shandong into a seamless network that linked natural river bodies in the north with the canal system in the south, thus completing the full stretch of what would later be known as the Beijing-Hangzhou Grand Canal (Zheng & Du, 2024, p.67).

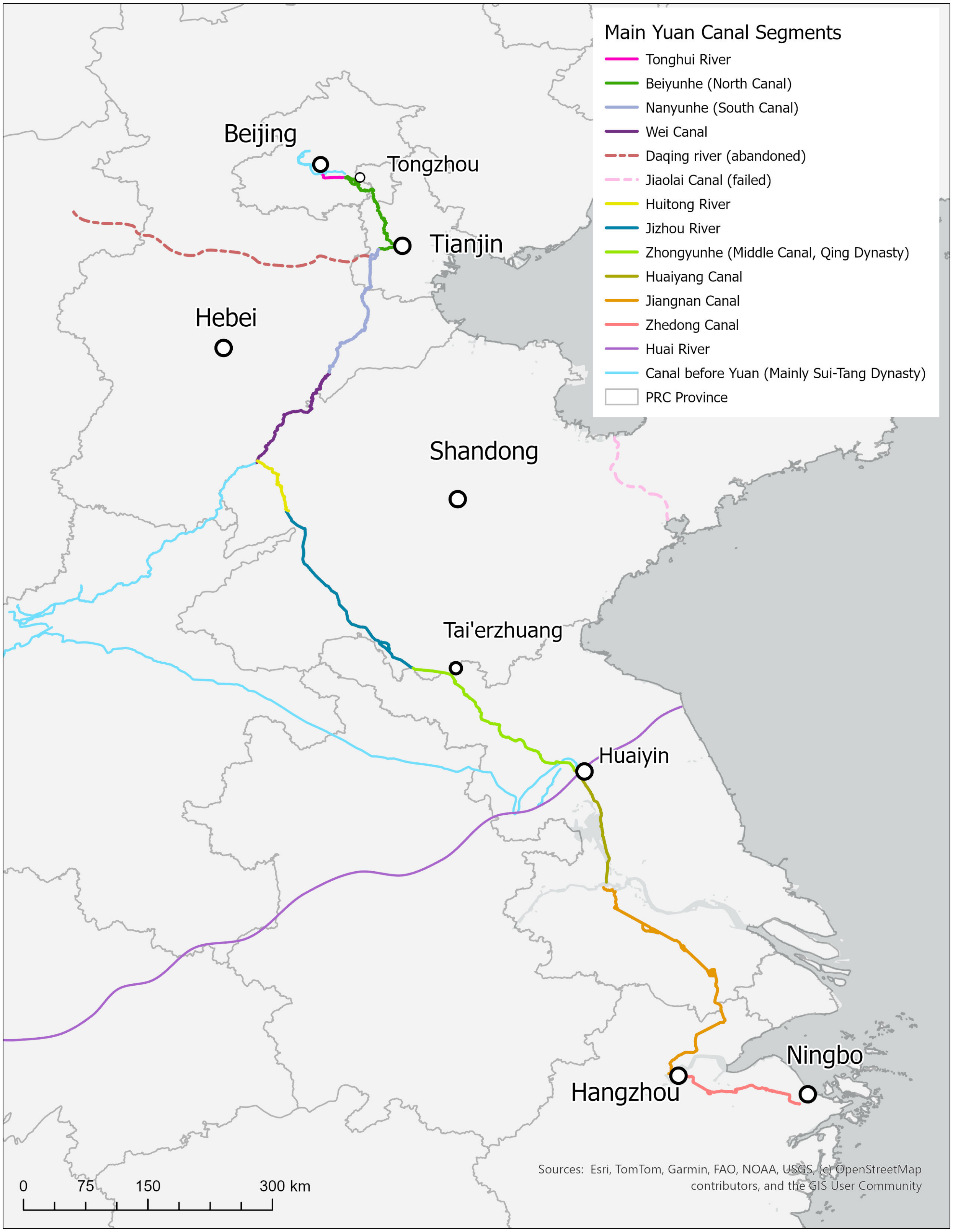

Figure 9. Main Segments of Yuan Canal (Approximated based on historical maps (Groverlynn, 2016; Fang, 2006; "Yuan Grand Canal", n.d.). Canal segments' name and scale might slightly differ regarding the variability of sources. Map created by the author.)

Of particular note was the Jiaolai Canal (*known in the Yuan period as the Xinhe, or "New River"*), envisioned as an inland waterway cutting across the Shandong Peninsula to shorten the distance of maritime transport. While sea transport was seen as faster and more efficient than overland routes, it was also more dangerous when transferring between coastal and inland river systems. The Jiaolai Canal was designed to address this by offering a controlled, secure path for grain shipments through the peninsula (Zheng & Du, 2024, p.67).

However, the project faced severe limitations: inadequate surveying of river and bay topography, insufficient freshwater sources, and poor understanding of the local terrain made sustained use difficult. The canal's elevation above sea level also created extreme gradients, making it difficult for seagoing grain vessels to enter and exit the canal system. Although the canal ultimately failed to achieve long-term navigability, it nonetheless functioned for a period as a major grain and commercial transport route. Its excavation marked the first historical attempt in China to cut an artificial canal across a peninsula, connecting Laizhou Bay to Jiaozhou Bay. Moreover, the failure of the Jiaolai Canal highlights internal political tensions within the Yuan government. The imperial court was divided into factions advocating sea transport, inland river transport, or a combination of both. These competing interests hindered coordinated planning and execution, while the enormous financial costs of canal construction, combined with widespread public exhaustion and imperial fiscal strain, ultimately doomed the project to limited success (Zheng & Du, 2024, p. 68-69). Still, even as an incomplete effort within the whole canal project, the Jiaolai Canal demonstrates the Yuan dynasty's willingness to experiment with large-scale infrastructural integration in response to strategic challenges.

The Yuan government also initiated major canal-building efforts in western Shandong, leading to more enduring successes. Among these were the construction of the Jizhou River and the Huitong River, both located within the province and later collectively referred to as the Huitong River (会通河) in historical records due to their eventual connection. Although these two rivers were ultimately linked, their original purposes were distinct. The inland Jizhou River was initially conceived as part of a river-sea combined transport strategy. Southern grain ships traveling northward would enter the Jizhou River and proceed into the Daqing River, which then flowed into the sea. From there, cargo would continue by sea to Zhigu (*modern Tianjin*) and travel inland via the White River to reach Beijing. However, this plan was eventually compromised by heavy siltation at the Daqing River's mouth, which made it increasingly difficult for grain ships to access the sea (Zheng & Du, 2024, p. 69). In response, the Yuan court, led by Guo Shoujing, redirected its canal-building strategy, choosing to continue excavation northward from the Jizhou River until it connected directly with the Wei Canal, thereby creating the Huitong River (Figure 9). This reorientation ensured a fully inland water route connecting the southern production centers to the capital without relying on unpredictable maritime segments (Zheng & Du, 2024, p. 69).

The excavation of the Jizhou and Huitong Rivers during the Yuan dynasty laid the foundation for the entire Shandong canal system as it existed in the Ming and Qing periods. Moreover, the Yuan court's implementation of hydraulic engineering structures such as sluices and dams along these routes had a long-lasting influence, with many of these water-control strategies being adopted and adapted by subsequent dynasties (Zheng & Du, 2024, p. 71). These interventions not only reshaped the geography of Shandong but also exerted long-term socio-economic effects on the region's development.

To ensure the efficient northward movement of grain, porcelain, and imported goods, the Yuan government also invested in expanding and modifying canal segments in southern China, where many major production and trade centers were located. This infrastructural shift was driven by a pressing political and economic question that emerged after the pacification of Jiangnan: how could the wealth of the south, its agricultural surplus, artisanal goods, and foreign imports, be effectively transferred to the northern capital, Dadu. As imperial unification progressed, the demand for grain and goods in Dadu surged, quickly surpassing what the existing transport infrastructure could support. In the aftermath of the fall of Hangzhou, Boyan (伯颜), the renowned military commander who had helped bring down the Southern Song, recognized this challenge and advocated for the construction of a fully integrated canal system to channel Jiangnan's resources northward. His proposal marked the beginning of a series of major engineering efforts across the southern canal segments (Pan, 2020, p. 7).

As previously discussed, the Huitong River served as the critical northern segment that connected the Grand Canal to Dadu, enabling the flow of goods from the south to reach the Yuan capital. Yet this northbound movement was only made possible through a series of regional canals in Jiangnan, which formed the southern counterpart to the imperial network (Pan, 2020, p. 9). The Jiangnan region served as a crucial intermodal hub where canal and maritime transport intersected, making it central to the success of the broader system. The condition and navigability of canals in this area directly affected not only the efficiency of sea-bound grain shipments and the northward redistribution of Jiangnan goods, but also the movement of people and overseas trade commodities traveling between southern ports and the northern capital. In this sense, the functionality of Jiangnan's canal network was inseparably linked to the performance of the national transportation system as a whole, influencing the smooth operation of both domestic and international flows (Pan, 2020, p. 15-16). Therefore, based on the existing canal, the Yuan government regularly undertook dredging operations, constructed and reinforced sluices and weirs, and invested in water-control infrastructure with the explicit aim of regulating water levels to ensure the consistent movement of grain boats and commercial vessels (Pan, 2020, p. 11).

However, despite the significant improvements introduced during the Yuan period, the canal system was not without its limitations. One major issue stemmed from the fact that part of the Yuan canal network was constructed by linking existing natural water bodies. For example from Tai'erzhuang, Shandong, to Huaiyin, Jiangsu, where vessels had to navigate through the Huai River basin in order to reach the Huaiyin sluice and connect to the Li canal (also known as Huaiyang canal). Before the 27th year of Emperor Kangxi's reign (*AD 1688*), this section of the rivrecourse was intertwined with the main current of the Yellow River, whose turbulent flow made navigation dangerous and unstable. Not only did this compromise the safety of vessels and cargo, but it also imposed great difficulties in hydraulic management. It was not until 1686, during the Qing dynasty, that a lasting solution was implemented: under the direction of River Conservancy Governor Jin Fu, the Zhongyunhe (Middle Canal 中运河*,* Figure 9) was excavated to permanently separate the Grand Canal from the Yellow River (*"*避黄行运*"*). Once completed, the Zhongyunhe eliminated the need to rely on roughly 100 kilometers of the treacherous Yellow River, resolving a logistical vulnerability that had persisted since the Yuan dynasty (Zhang, 2019, p. 105).

Nevertheless, it was precisely the excavation of the Huitong River and related canal works during the Yuan dynasty that transformed the previously fragmented and fan-shaped layout of the Sui-Tang canal system into a continuous, straightened north–south waterway, which became known as the Grand Canal, marking a structural shift in China's canal system. The Yuan dynasty's reengineering efforts laid the foundation for the canal's enduring form, the Ming and Qing dynasties would go on to maintain and dredge the Yuan canal, preserving the basic north–south orientation that defined China's inland transport system for centuries to follow.

An alternative interpretation might suggest that goods—especially porcelains—could have reached the north via maritime routes or overland relay systems independent of the canal. Indeed, the northward transport of Longquan celadon during the Yuan dynasty is generally understood to have relied on a combination of maritime shipping and inland waterways, with overland movement used when necessary (Sun, 2019, p. 1). Meanwhile, from major ports and the capital Dadu, overseas distribution occurred primarily via maritime routes, reaching Japan to the east; Iran, the Arabian Peninsula, the Red Sea region, Syria, East Africa, and North Africa to the west; and Southeast and South Asia to the south. In parallel, overland routes extended westward through Gansu, Mongolia, and Xinjiang, facilitating trade with Central Asia and parts of the Middle East, including Iran (Sun, 2019, p. 10). It is therefore important to recognize that the Yuan state emphasized both canal and maritime transport as complementary components of its logistical network. Along the Grand Canal, the state established local financial and administrative institutions to oversee logistics, taxation, and trade, embedding the canal deeply into the economic infrastructure of Yuan governance. Simultaneously, it developed three major maritime shipping routes linking the north and south, highlighting the strategic and economic importance of sea transport (Liu et al., 2022, p. 119).

Yet despite the presence of alternative paths, overland and coastal maritime routes were far less suited to the high-volume, fragile, or perishable goods critical to imperial redistribution. As the following cases will demonstrate, it was the Grand Canal that enabled the efficient circulation of both foreign imports and domestically produced commodities linking far-flung regions of the empire to its political and economic center.

To start with, the dominant role of the canal route can be illustrated through the spatial distribution of southern porcelains discovered in Shandong province which due to its geographic position, was a critical node in both inland and maritime networks, serving as a mandatory stop along all three maritime routes (Liu et al., 2022, p. 119). Of the eleven sites where southern porcelain has been unearthed in Yuan contexts, only Penglai site is located along the coast; the remaining ten sites are all situated along the Grand Canal or within the Qing River basin, which connects directly to the canal system. This pattern strongly suggests that southern ceramics, including Longquan and Jingdezhen wares, were primarily transported to northern markets via the Grand Canal and its tributaries, rather than by maritime routes alone (Liu et al., 2022, p. 120).

How foreign goods entered and moved through Yuan territory is also worth-exploring. The city of Guangzhou served as the empire's primary hub for foreign commerce, attracting merchants from across Asia, the Middle East, and beyond. According to the renowned Lingnan scholar Chen Dazhen, Guangzhou maintained trade relations with as many as 147 foreign countries (Qiu, 2001, p. 41- 49). A vast quantity of imported goods—including spices, precious

Figure 10. A visual reconstruction of inland transportation route starting from Guangzhou imported goods. Map created by the author based on the text (Pan, 2020, p. 14).

materials, and luxury items—converged in Guangzhou before being transported inland. These goods typically traveled through Guangdong, crossed Jiangxi via Poyang Lake, and entered Jiangnan, where they were transferred onto the Grand Canal for northbound shipment (Figure 10). The canal thus served as the final and most crucial corridor in a broader global supply chain, enabling the imperial court and elite households in Dadu to access and consume goods sourced from across the Eurasian world (Pan, 2020, p. 14).

Meanwhile, under the combined influence of state support and commercial incentives, Yuan overseas trade expanded to unprecedented levels. Therefore, in addition to moving foreign goods inland, the Grand Canal also enabled the export of Chinese products, transporting items like porcelain, silk, and tea from inland production centers to ports for overseas trade. Historical records and travel accounts from the period mention over 200 foreign countries and regions engaged in maritime exchange with China. These trading partners spanned a vast area, including mainland and maritime Southeast Asia, the Indian subcontinent and its surrounding seas, the Persian Gulf, the Arabian Peninsula, and as far as East and North Africa (Huang, 2014, p. 79). By the late 13th and early 14th centuries, Chinese porcelain, specifically, achieved significant penetration into the western Indian Ocean trade networks, particularly replacing earlier Iranian glazed ceramics. The survey data from southern Iran and the northern Persian Gulf indicates that after centuries of Iranian dominance in ceramic production and regional trade, products from Far Eastern workshops—most notably Chinese porcelain—began to abruptly displace locally produced ceramics by the end of the 13th century (Soroush, 2025, p. 165-168).

Among all exported porcelain, Yuan blue-and-white porcelain stood out as one of the most distinctive and highly prized commodities in foreign trade. Its vivid cobalt decoration,

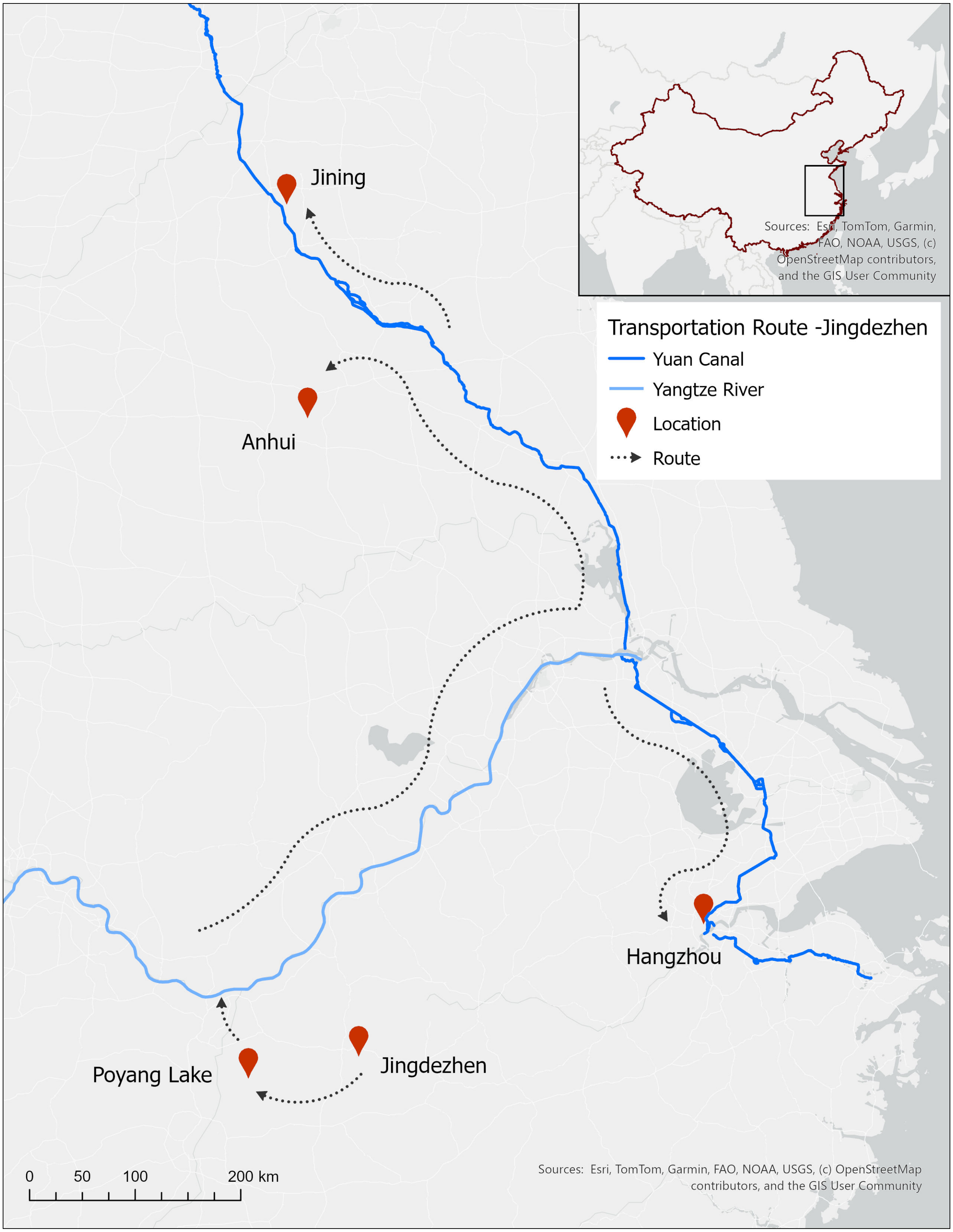

Figure 11. A visual reconstruction of inland transportation route starting from Guangzhou imported goods. Map created by the author based on the text (Pan, 2020, p. 14).

elegant forms, and refined glaze appealed strongly to Arab regions of West Asia and various European markets, where such pieces were collected and treasured. Yuan blue-and-white ware can be considered the “most dazzling jewel in the crown” of Yuan foreign trade, representing both the technical sophistication of Chinese ceramics and their far-reaching cultural impact. (Wang, 2024, p. 127).

The trade route of Yuan blue-and-white porcelain typically began at major kiln sites, from which goods were transported via the Grand Canal to Dadu, where they were collected, redistributed, or prepared for export. (Zhao, 2024, p. 61) For example, Jingdezhen, as the largest production kiln of Yuan blue-and-white porcelain, relied on the canal route as the primary transportation corridor. Once fired, the porcelain was first shipped along the Yangtze River, which runs through Jingdezhen, into Poyang Lake, and from there entered the Yangtze River system to travel along the canal (Figure 11). This is similar to how Guangzhou imported goods enter the canal system (Figure 10). Archaeological finds of Yuan blue-and-white porcelain in southern Anhui and Jiangsu, particularly along both banks of the Yangtze, such as at Gudangwan in Hangzhou and the tomb at Suixi in Anhui, as well as tomb sites near Jining, collectively outline the route that connected Jingdezhen to the Yuan Grand Canal (Huang, 2014, p. 77).

Therefore it is possible to state that the Grand Canal during Yuan dynasty functioned as an interconnection between maritime and inland transport systems, enabling a expansive river–sea network, within the empire. Through this system, overseas trade goods (舶货) imported via maritime routes were transferred inland through southern ports such as Guangzhou and transported northward via the canal, ultimately reaching the political and economic centers of the Yuan empire— Dadu (Pan, 2020, p. 3).

Broader Social and Economic Implications

The Yuan chose to establish their capital in Dadu not only to solidify control over the north but also because it offered a direct link to the Mongol steppe homelands, maintaining cultural and political continuity with their origins. However, this northern location also meant that the capital depended heavily on grain shipments from the agriculturally rich south. As *History of Yuan* noted, "the Yuan capital was in Yanjing [Beijing], far from Jiangnan, and the numerous civil and military institutions, as well as the resident population, all depended on the south for provisions. (Song, 1998)" In this context, the south-to-north transport of grain via the Grand Canal became a critical pillar of imperial policy, supporting the capital, stabilizing the depopulated north, and ensuring the administrative functioning of the Yuan state.

The strategic importance of the Grand Canal became particularly clear in the aftermath of the Mongol conquest of northern China. Early Mongol military campaigns, rooted in steppe warfare practices, often resulted in the mass slaughter, displacement of populations, and destruction of agricultural infrastructure following the capture of cities. As a result, the north experienced severe demographic decline and long-term agricultural collapse, leading to widespread grain shortages that persisted for decades. By the time Kublai Khan formally established the Yuan dynasty, the consequences of earlier campaigns had become untenable. Recognizing this, the court undertook the restoration and expansion of the canal system as a solution to northern food insecurity. Following the conquest of the Southern Song and the unification of the empire, this strategy became even more urgent (Ji, 2008, p. 1062).

At the same time, the newly unified empire required a strong military presence to secure southern China, and the Yuan's ongoing external campaigns demanded a continuous supply of grain (Guo, 1997, p. 212). Maintaining military strength required a reliable and rapid transport system capable of delivering provisions efficiently and responding to emergencies or sudden deployments. In agricultural regions, major means of transportation such as horses, oxen, carts, and boats were largely controlled by the Yuan government and allocated for use in the postal relay system and grain transport (Chen and Shi, 2011, p. 390).The Directorate of Canal Transport (都漕运使司) was responsible for overseeing the transportation and storage of grain and supplies. In the second year of the Zhongtong reign (AD 1261), the Military Supply Directorate (军储都转运使司) was established, with appointed directors and deputy directors tasked with the requisition and allocation of military provisions (Chen and Shi, 2011, p. 71-72).

In addition to its administrative and commercial functions, the Grand Canal also facilitated significant social and cultural mobility. Among those who traveled along its route were southern scholars journeying northward in search of official positions, merchants engaged in domestic and international trade, as well as foreign envoys and guests making diplomatic or religious visits. For many southern literati, canal travel was not only a means of physical movement but also a source of aesthetic and intellectual inspiration. Their journeys northward often gave rise to poetry praising the scenic beauty of the canal's banks, reflecting both the grandeur of the landscape and the emotional breadth of their personal ambitions. These experiences expanded their horizons and fostered a shared cultural geography across formerly divided regions (Pan, 2020, p. 12).

The significance of this function was clearly observed by foreign travelers such as Marco Polo, who journeyed along the Yuan Grand Canal from Dadu through cities like Jining, Xuzhou, Huai'an, Yangzhou, and Guazhou. He described the canal system as one that linked rivers and lakes through artificial channels, with waters “broad and deep like great rivers,” capable of carrying fully loaded cargo ships from Guazhou all the way to the imperial capital (Dang, 2010, p. 43). He also noted the construction of raised embankments formed from dredged soil, which served as roads running alongside the canal, facilitating land travel and inspection. In Huai’an, Polo recorded intense boat traffic and the collection of goods, especially salt, which was redistributed to over forty cities, providing the Yuan government with substantial tax revenue. In Guazhou, he observed the annual accumulation and northbound transport of grain, most of which was destined for Dadu to supply the imperial court (Dang, 2010, p. 44).

Caoyun **System and the Fall of the Yuan Dynasty**

Though the *caoyun* system via the grand canal served as a critical infrastructure sustaining Yuan political stability, economic centralization, and cultural exchange, its long-term effects also contributed considerably to the dynasty’s eventual downfall. Fundamentally, *caoyun* was an extractive mechanism. Its monopolistic operation—designed to channel enormous quantities of grain and resources from the economically productive south to the political center in the north—placed tremendous pressure on core regions such as Jiangsu, Zhejiang, Jiangxi, and Huguang. These provinces alone accounted for more than half of the national grain tax, with Jiangsu and Zhejiang contributing over a third. While the system relied on the economic dynamism of the south, it also stifled its development. Heavy burdens of extraction exacerbated social tensions in these regions, contributing to widespread hardship which included peasant flight, development stagnation, and persistent unrest (Wu, 2000, p. 13-14).

Meanwhile, from the Tang and Song dynasties onward, the Yangtze River valley had become an epicenter of accelerated commercialization. In areas like Jiangnan, the focus of agricultural production shifted from subsistence farming toward the cultivation of more profitable cash crops and the development of household industries (e.g. porcelains, handicrafts), leading to a decline in local grain self-sufficiency and a corresponding increase in market demand for grain. (Hu, 2019, p. 41). From a long-term perspective, several problems emegred. The overwhelming grain outflow demanded by *caoyun* inhibited the development of internal markets. Rather than supporting local consumption or trade, grain was redirected northward, depriving these regions of surplus to fuel their own economic development (Wu, 2000, p. 15). This created a situation where agricultural production remained concentrated in the south, but wealth and political power became increasingly centralized in the north. Meanwhile, because farmers shifted away from growing grain for their own consumption and became dependent on the market for food, thus if the market experienced disruptions, such as warfare, natural disasters, or price fluctuations, local grain supplies could be severely affected. Moreover, if grain prices suddenly rose, farmers would have to pay more to buy their own food. In years of famine, this created serious risks and vulnerabilities, as farmers who no longer produced their own grain could neither access affordable food nor ensure their survival.

The prosperity that *caoyun* brought to canal-side towns was also inherently unstable. These towns flourished as transshipment centers for redistributed goods, thriving on the flow of grain and other materials. But their economic vitality was heavily dependent on the continuation of the transport system. Many such towns engaged primarily in transit-based trade, lacking robust productive foundations of their own. Once the flow of *caoyun* slowed or ceased—as it eventually did—these towns declined rapidly (Wu, 2000, p. 15-16). Their economic rise and fall reveals the canal's own fortunes, demonstrating the fragility of an infrastructure-driven prosperity. Therefore, the *caoyun* system was a state-controlled project embedded in the logic of centralized extraction, wherein the state maintained a monopoly over the canal routes, grain movement, and associated hydraulic infrastructure (Wu, 2000, p. 15).

This framework reconfigured southern China's agrarian economy, integrating local producers into broader imperial and global trade networks and increasingly subjecting them to forces beyond their immediate control. As agricultural production in some regions shifted toward cash crops or commodity grains, many households became reliant on market purchases for subsistence, exposing them to price fluctuations and food insecurity. This process was not driven solely by state intervention, rather, it reflected an uneven configuration of state priorities and market pressures, both of which contributed to new forms of dependency and vulnerability. The wealth generated in the productive south was systematically redirected toward the political center in the north, exacerbating regional inequality. While the Grand Canal facilitated long-distance trade, its function under the *caoyun* system constrained the development of autonomous local markets and embedded economic life within the shifting priorities of imperial bureaucracy.

By the late Yuan period, the limits of this model became increasingly apparent. In AD 1329, the *caoyun* system reached its peak, transporting over 105 million kilograms of grain northward—a historical record. But this volume proved unsustainable. As widespread rebellions erupted across the empire, the transport network was disrupted, and grain movement along the canal ground to a halt (Wu, 2000, p. 17). Even though the Yuan implemented a joint transport model combining inland *caoyun* and maritime shipping, it was ultimately unable to prevent systemic collapse.

Attributing the decline of the Grand Canal system solely to imperial extraction risks falling into a teleological narrative that assumes state systems naturally collapse after reaching a peak of resource extraction. In reality, the fall of complex polities is rarely driven by a single cause; it typically results from a combination of political fragmentation, military defeats, fiscal strains, environmental challenges, and transformations in economic networks. A comprehensive analysis of the Yuan dynasty's collapse lies beyond the scope of this study. However, it is crucial to acknowledge that the canal's decline must be understood within this broader context, where infrastructural vulnerability, rather than extraction alone, exposed the system's dependence on political stability and centralized maintenance.

Conclusion

Building on this research, several avenues for future investigation emerge. First, further study could explore the logistics of sustaining the Mongol capital in the north, particularly how military expansion and administrative consolidation shaped transportation priorities. Second, the economic and social connections that developed in the south under the Yuan dynasty warrant closer examination, especially in relation to the long-term impact of establishing Beijing as the political center. How this decision reshaped the economic landscape and political orientation of the traditionally prosperous southern regions remains a crucial question.

Additionally, the social life of the Grand Canal—captured in poems, travel accounts, and other textual sources—offers a valuable window into everyday experiences of mobility, labor, and commerce. Future research might also further explore the tension between local and global dynamics: how localized canal systems supported village and regional economies while simultaneously facilitating long-distance imperial and international trade. Finally, tracing the economic and social transformations prompted by the Yuan's infrastructural policies could shed light on broader patterns of state-building, integration, and societal change in late medieval China.

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