HIGH-ELEVATION URBANISM AND HYDROLOGICAL LANDSCAPES IN EARLY MEDIEVAL CENTRAL ASIA

Mirae Jo

(PhD candidate, SAIE Lab, Department of Anthropology,

Washington University in St. Louis)

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Abstract. *This article examines the hydrological landscape and water-management system of the medieval city of Tugunbulak (6th–11th centuries CE) in Uzbekistan. The study focuses on strategies of water capture, storage, and distribution in a highland environment. Using hydrological modeling, remote sensing, and archaeological evidence, it highlights the role of water infrastructure in sustaining one of the largest known high-altitude urban centers in Central Asia.*

Keywords: *Tugunbulak, hydrology, water management, highland urbanism, Central Asia, medieval period, LiDAR.*

Аннотация. *В статье исследуются гидрологический ландшафт и система водоснабжения средневекового города Тугунбулак (VI–XI вв.) на территории Узбекистана. Основное внимание уделяется изучению способов накопления, хранения и распределения водных ресурсов в условиях высокогорья. На основе гидрологического моделирования, дистанционного зондирования и археологических данных раскрывается значение водохозяйственной инфраструктуры в развитии одного из крупнейших высокогорных городов Центральной Азии.*

Ключевые слова: *Тугунбулак, гидрология, водное хозяйство, высокогорные города, Центральная Азия, средневековье, LiDAR.*

Annotatsiya. *Maqolada O‘zbekiston hududidagi VI–XI asrlarga oid Tug‘unbuloq shahrining gidrologik landshafti va suv boshqaruvi tizimi tadqiq*

etiladi. Tadqiqot tog‘li hududlarda suv resurslaridan foydalanish, ularni yig‘ish, saqlash va taqsimlash usullarini aniqlashga qaratilgan. Gidrologik modellashtirish, masofadan zondlash va arxeologik ma’lumotlar asosida Tug‘unbuloqning yirik tog‘ shahri sifatida faoliyat yuritishida suv ta’minoti tizimining ahamiyati yoritiladi.

Kalit so‘zlar: *Tug‘unbuloq, gidrologiya, suv boshqaruvi, tog‘li shaharlar, Markaziy Osiyo, o‘rta asrlar, LiDAR.*

For millennia, people have aggregated into settlements around water in both arid and resource-rich regions, transforming natural hydraulic landscapes through technological innovations of artificial water systems. Therefore, the study of ancient hydrological systems provides insight into long-term socio-cultural processes and environmental pressures that shaped human adaptation.

Often regarded as inhospitable because of their unsuitability for agriculture, rugged mountain areas of Central Asia have been settled by nomadic pastoralist populations for at least 5,000 years or more (Frachetti 2012; Taylor et al. 2021). As mountain pastoralists practiced nomadic or transhumant lifestyles, past scholarship largely overlooked their role in the formation of the early urban centers due to assumptions that urban areas require intensive, stable agriculture to sustain large populations and accumulate surplus (Adams 1962; Lucero et al. 2015; Styring et al. 2022).

The recent discovery of the medieval urban site of Tugunbulak (TGB) in Uzbekistan provides the first case study to research large-scale highland water systems within a context of planned urban architecture in Central Asia. Located 2,000 m.a.s.l. and dating to the 6th-11th centuries CE, TGB covers no less than 120 ha with hundreds of identified structures, making it one of the largest known medieval highland cities documented in this region (Frachetti et al. 2024). Unlike other medieval cities, TGB is neither situated near any major rivers, oases, or lakes, nor in a high-precipitation zone, indicating that past communities required an

organized water management system to sustain the city. This raises a question: how did inhabitants manage water resources in this challenging mountain environment?

This research reconstructs the hydrological landscape of Tugunbulak (TGB) to investigate how natural water availability influenced urban development and how humans engineered water-management systems to sustain a large highland population. I propose that water was derived primarily from seasonal surface flows associated with snowmelt and precipitation, supplemented by springs, and that inhabitants strategically construct infrastructure for capture, conveyance, storage, and drainage of water.

To investigate these questions, the research integrates hydrological reconstruction, remote sensing, archaeological survey, excavation, and comparative regional analysis. First, I examine seasonal patterns of water availability through hydrological modeling based on climatic, topographic, and vegetation data to evaluate timing and distribution of water resources across the landscape. Second, I investigate potential water-management strategies through comparative analyses of archaeological water technologies documented across Central Asia and beyond. These datasets are combined with high-resolution Lidar map (Frachetti et al., 2024) to identify and contextualize potential types and locations of hydrological features at Tugunbulak (TGB). Together, these approaches provide a framework for understanding the relationship between natural hydrology and technological adaptation in a highland environment.