

# 古代水利基础设施比较研究对新兴城市的意义

## Comparing Ancient Water Infrastructure for New Cities

### 摘要 ……

在新兴城市发展水利基础设施时，对其他城市先前的水利模式和运行效果进行比较具有借鉴意义。本文由中国古代城市水利系统与南亚、北美古代水利基础设施的比较研究受到启发，每一个案例皆包含丰富的考古、历史和地理佐证；然而21世纪的新型城市化却甚少从中汲取经验以作参考。其中，正面案例包括长期强调的城市选址、流域保护、溪流恢复、漫滩管理和灾后重建等工作。失败案例则包括水源枯竭、退化、灾害和破坏性冲突等，在某些情况下，这些失败的基础设施正是导致城市被遗弃的原因之一。本文提出六项原则，依此说明对古代水城市主义的比较研究对当代城市景观设计挑战的重要意义。

### 关键词 ……

古代水利基础设施；中国；南亚；北美

### Abstract ...

When developing water infrastructure for new cities, it is useful to compare the water patterns and performance of distant cities in earlier times. This paper takes its inspiration from research on ancient urban water systems in China which it compares with ancient water infrastructure in South Asia and North America. In each case, there is a wealth of archaeological, historical, and geographical evidence, which is only occasionally drawn upon to inform new urbanization in the 21st century. Positive examples include the enduring emphasis on urban siting, watershed protection, stream restoration, floodplain management, and post-disaster reconstruction. Infrastructure failures include water depletion, degradation, disasters, and destructive conflict that have in some cases contributed to the abandonment of cities. The paper offers six principles by which comparative study of ancient water urbanism can have relevance for contemporary urban landscape design challenges.

### Key words ...

Ancient Water Infrastructure; China; South Asia; North America

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## 1 引言

在新兴城市发展水利基础设施时，研究古代其他城市的水环境系统到底有无意义？考古学家、历史学家、工程师和设计师们对此争论不已。有些观点认为古代城市的水系统可以启发并警示现代社会，其他观点则认为工业化之前的城市与现代化城市天差地别，若是认为两者在特定方面能够彼此启发，不是谬论就是天真浪漫的想法。从已出版的研究和规划文件可以判断，大多数人甚至从未考虑过这个问题。本文的第一部分回顾了上述争论以及这些观点如何塑造了当代的思维方式。

在撰写本文的研究过程中，笔者发现指出古代城市供水、排水和洪水管理对中国、美国和其他

地区的水利建设具有借鉴意义的文章数量之多，令人震惊。中国有一些水利学家认为，古代城市的水利系统能够为21世纪新兴城市的水利选择带来启发<sup>[1]-[3]</sup>。传统技术被应用于现代城市中，其更加强调整生态健康和水质。这方面的景观设计案例包括俞孔坚教授在“与洪涝共生：黄泛平原洪水适应性景观”这篇文章中提出的防洪减灾类型——“水在城中、城在水中、阴阳水城”<sup>[4]</sup>。城市水利化过程的中间阶段可以帮助解决诸如沉积和河床淤积等长期性问题。透过了解这些过程并再创造性地进行利用，如山东省菏泽市的案例，即俞孔坚教授所谓的“生存的艺术”。景观设计师凯利·香农和陈义勇在题为“（恢复）中国的城市河流作为公共空间”一文

## 1 Introduction

When developing infrastructure for new cities is it useful to study the water and environmental systems of distant places and ancient times? This question is debated by archaeologists, historians, engineers, and designers. Some think ancient urban water systems can inform, inspire, and warn modern societies. Others argue that there are such fundamental differences between pre-industrial and modern cities that it is a fallacy or romantic sentiment to think that one can inform the other in any practical way. To judge from published research and planning documents, however, most people do not even consider this question. The first part of this paper offers a review of these debates and how they have shaped current thinking.

When researching this paper I was struck by the number of articles stating that ancient urban water supply, drainage, and flood management are indeed relevant for new cities in China, the U.S.A., and elsewhere. Some water scientists in China argue that ancient urban water systems can shed light on alternatives for new cities of the 21st century<sup>[1]-[3]</sup>. Traditional technologies are being adapted for modern cities, with increased emphasis on ecological health and water quality. Examples in landscape architecture include Professor Kongjian Yu's article on "Living with Water: Flood Adaptive Landscapes in the Yellow River Basin of China", which put forward a flood mitigation typology of the "city-in-water, water-in-city, and the ying-yang water city"<sup>[4]</sup>. These intermediate stages of water urbanism can help address long-term processes of subsidence and riverbed aggradations. Understanding those processes and creatively addressing them at cities like Heze in Shandong province are part of what Professor Yu calls the "art of survival". An article by landscape architects Shannon and Chen titled "(Recovering) China's Urban Rivers as Public Space" compares historical relationships between cities and water with innovative urban river restoration in cities like Ningbo, Kunming and Qian'an<sup>[5]</sup>. Similar propositions have been put forward in other regions, including South Asia and North America<sup>[6]-[8]</sup>.

The later sections of this paper compare ancient water infrastructures in regions where I have lived and

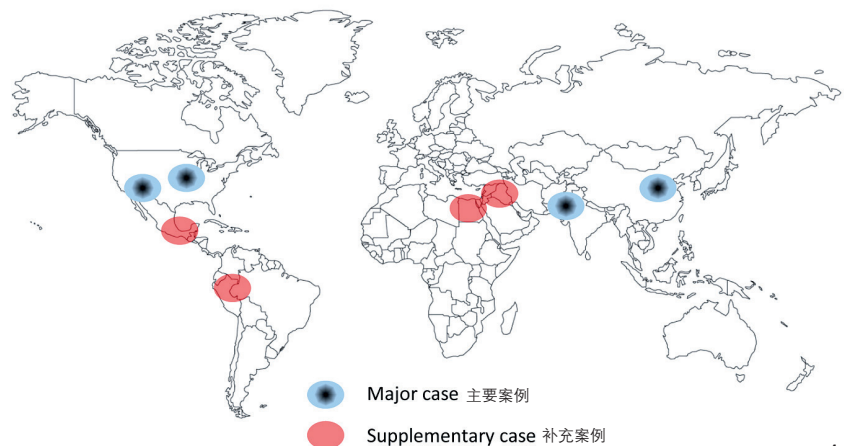
worked — in South Asia which is home to Harappan cities of the Indus Valley civilization; and North America which gave rise to Mississippian floodplain settlement and Hohokam canal irrigation settlement. These examples can help broaden our imagination of socio-ecological infrastructures for new urbanization in the 21st century. The concluding section of the paper draws these case studies together to articulate general propositions for future comparison of water urbanisms in China, South Asia, and North America (Fig. 1).

## 2 Water in the Ancient Cities of China

### 2.1 Reflecting on *The Pivot of the Four Quarters*

The 2014 Beijing Forum theme on the harmonization of cultures led me to reflect upon Professor Paul Wheatley's book titled, *The Pivot of the Four Quarters: A Preliminary Enquiry into the Origins and Character of the Ancient Chinese City*<sup>[9]</sup>. This book surveys the origins and evolution of Shang and Zhou Dynasty urbanism in China, and it compares a broad range of theories about the origins of the city in other regions of the world. In geographical terms, Wheatley argued that in comparative research on ancient cities, China had been neglected. Theoretically, he reviewed the history of ideas and comparative research on urban origins, showing that while the functional aspects of ancient cities had received substantial attention, the symbolic forms and meanings of cities had been neglected. His approach linked urbanism, defined as the culture of cities, with urbanization, which is the process

1. 本文所讨论的古代城市水文化区域所在地示意图
1. Ancient urban water cultures discussed in this paper



中,对具创新河流生态修复的城市如宁波、昆明、迁安<sup>[5]</sup>其水文与城市本身的历史关系进行了比较研究。类似的命题也已在包括东南亚和北美在内的其他地区相继提出<sup>[6]-[8]</sup>。

本文的后半部分将对我曾生活和工作过的地区的古代水利基础设施进行相互对照,这些地区包括属于印度河流域文明的南亚哈拉帕市,以及北美密西西比冲击平原聚落和霍霍卡姆运河灌溉聚落。这些案例可以帮助我们拓宽对21世纪新型城市化中社会-生态基础设施的想象。本文的结论部分对上述案例进行了总结,并对照未来中国、南亚和北美城市水利发展给出普适性的建议(图1)。

## 2 中国古代城市中的水

### 2.1 反思《四方之极》

2014年北京论坛的主题是文化的统一,这使我对保罗·惠特利教授的《四方之极——中国古代城市起源及特点初探》一书进行了反思<sup>[9]</sup>。这本书研究了中国商周时期城市化的起源与演变,并大范围比较了世界其他地区有关城市起源的理论。从地理角度看,惠特利教授认为在古代城市的比较研究中,中国一直被忽视了。他从理论上回顾了城市起源的观点与比较研究的历史,指出虽然古代城市的功能受到了极大的关注,但却忽视了城市的象征形式和意义。惠特利教授的研究方法将城市主义(城市文化)与城市化进程(城市发展壮大的过程)联系起来。《四方之极》一书否定了另一位汉学家卡尔·魏特夫的观点,魏特夫认为强制在干旱地区实施大型灌溉系统导致经济剩余,从而促使城市与官僚社会组织的形成。

### 2.2 反思魏特夫的水利假说

1957年,魏特夫出版了《东方专制主义:对于极权力量的比较研究》,他在书中指出社会的强势成员强制弱势成员建设大规模的水利基础设施,从而形成农业经济剩余并富集在城市中,而这就是城市的起源<sup>[10]</sup>。许多批评者反驳魏特夫对于考古和历史证据的使用以及他的意识形态观点。罗伯特·亚当斯指出,是由于城市的产生才使古代的美索不达米亚平原发展灌溉成为可能,两者的先后关系不能调换<sup>[11][12]</sup>。亚当斯认为城市的形成从根本上说是社会过程而非环境过程(部分回应了当时颇具争议的“环境决定论”)。他还把讨论重点从魏特夫强调的仪式性空间,转移到公共空间与广场在城市化进

程中所起的作用上来。根据逐渐积累的比较证据,几乎所有的考古学家和古历史学家都认为魏特夫提出的灌溉基础设施促使城市产生的说法是错误的。

尽管魏特夫的理论存在这些谬误,但他仍有一些不可磨灭的贡献。他将水利基础设施的环境层面与社会层面联系起来,而以往的学者都是将其分开考虑的。例如,他认为气候、水文与基础设施技术、物权、经济生产、国家结构、社会权力关系和阶层息息相关,并且他从漫长的历史与地理的时间角度对其进行了研究(表1)。

魏特夫的第二个贡献(尽管有缺陷)在于他大力主张水系统对渐进的社会变革具有重要意义。水利研究人员将他的理论框架应用于当代南亚灌溉组织的社会层面<sup>[13]</sup>。还有一些人运用魏特夫的框架,来批判强大的国家机构和私人利益是如何利用基础设施项目,造成洛杉矶等城市不公平与非可持续性<sup>[14]</sup>的发展。

### 2.3 近期关于古代城市水利基础设施的比较研究

当然,几十年前对中国古代水聚落的比较研究及其对新型城镇化的意义可能已经时过境迁。中国古代城市聚落的起源,可以一直追溯到新石器时代的黄河中游以及长江三角洲北部和南部地区。在距今8 000至4 000年间随着时间推移,因气候、水文和海平面波动,河流下游流域的聚落形态随之发生变化。最近有研究揭示了迁移性聚落根据狩猎、聚居与农耕等生存策略,阶段性地靠近和远离海岸线的适应性过程。逐渐远离海岸线使滨海平原的聚落

表1 魏特夫的水-社会关系类型  
Table 1 Wittfogel's Typology Of Water-Society Relations

变量 VARIABLE	亚洲模式 ASIATIC MODE	↔	资本家模式 CAPITALIST MODE
气候 Climate	核心(干旱) Core (Arid)	边缘(湿地) Margin (Mesic)	靠近边缘(湿润) Submargin (Humid)
水利技术 Water Technology	灌溉 Irrigation	水力农业 Hydro-agriculture	雨养 Rainfed
水密度 Hydraulic Density	紧凑(国家) Compact (national)	松散(区域) Loose (regional)	松散2(本地) Loose 2 (local)
属性关系 Property Relations	单一(国家) Simple (state)	中等复杂 Semi-Complex	复杂(私有) Complex (private)
政治组织 Political Organization	专制 Despotic	寡头政治 Oligarchic	民主 Democratic
国家功能 State Functions	水利工程 Hydraulic Works	国有产业 State Industries	防御 Defense
人类经验 Human Experience	恐惧 Terror	管制 Regulation	自由 Freedom

by which cities grow and develop. *The Pivot of the Four Quarters* rejected the ideas of another Sinologist, Karl Wittfogel, who argued that coercive large-scale irrigation systems in arid regions led to the production of an economic surplus that supported the formation of bureaucratic social organization and cities.

## 2.2 Reflecting on Wittfogel's Hydraulic Hypothesis

In 1957, Wittfogel published *Oriental Despotism: A Comparative Study of Total Power* where he argued that cities arose when powerful members of a society forced weaker social groups to construct large-scale water infrastructure, which produced an agro-economic surplus that was extracted and accumulated in cities<sup>[10]</sup>. Numerous critics refuted Wittfogel's use of archaeological and historical evidence, along with his ideological arguments. Robert Adams showed that it was cities that enabled irrigation development in ancient Mesopotamia, rather than the reverse<sup>[11][12]</sup>. He argued that city formation is fundamentally a social rather than environmental process (responding in part to controversies over "environmental determinism" at that time). He also shifted from an emphasis on ceremonial spaces of the sort that Wheatley emphasized to the role of public spaces and forums in urbanization. On the basis of this accumulating comparative evidence, almost all archaeologists and ancient historians rejected Wittfogel's argument that irrigation infrastructure gave rise to the origin of cities.

Notwithstanding these errors, Wittfogel made several lasting contributions. He brought together environmental and social aspects of water infrastructure that had previously been treated separately. For example, he argued that climate and hydrology were linked with infrastructure technologies, property rights, economic production, state structure, social power relations and stratification — and he examined them over long historical and geographic timescales (Table 1).

Wittfogel's second contribution, albeit flawed, was that he argued forcefully about the relevance of water systems for progressive social change. Later water researchers have applied his framework to social aspects of modern irrigation institutions and organizations in South Asia<sup>[13]</sup>. Still others have adapted Wittfogel's

framework to criticize how powerful state agencies and private interests have used infrastructure projects to promote unsustainable and inequitable growth of cities such as Los Angeles<sup>[14]</sup>.

## 2.3 Recent Comparative Research on Ancient Urban Water Infrastructure

Of course, much has changed since these studies decades ago on ancient water settlements in China, comparative research, and its relevance for new urbanization. The origins of urban settlement have been extended back to the Neolithic cultures in the middle Yellow River basin and northern and southern deltaic plains of the Yangtze River. Lower basin settlement patterns varied over time in relation to climate, hydrology, and sea level fluctuations between 8,000 and 4,000 before present. Recent studies have shed light on the adaptive processes of moving settlements based on mixed subsistence strategies of hunting, gathering, and cultivating toward and away from the coastal margins<sup>[15][16]</sup>. A receding shoreline opened the coastal plains for increased settlement and ultimately urbanization, bounded by salinity and coastal inundation. As in upstream regions, early settlements concentrated at relatively stable locations near small perennial water bodies on diluvial tablelands, gentle alluvial fans, and former meanders, rather than in dry uplands, major river channels, or lowland floodplains<sup>[17]</sup>.

Arguments for the modern relevance of ancient urban water infrastructure have also increased. Research on Chinese cities in technical journals such as *Water Science and Technology* underscore the formative role of water infrastructure in the siting and layout of the Chang'an capital on the Weihe River. They draw attention to early systems of masonry pipelines, valves, and sediment traps in Yangcheng in the eastern Zhou Dynasty; and to historical drainage systems that combined gravity flow piping with open channel flows; not to mention the impressive water storage and drainage systems of later cities such as Beijing<sup>[18]-[20]</sup>. These and other recent studies in China argue for the modern relevance of historical technologies. As mentioned at the beginning of the paper, environmental designers and planners offer similar arguments in China,

扩张成为可能，最终形成了以含盐量和沿海洪水为界的城市。在上游地区，早期的聚落集中在洪积台地、平缓的冲积扇和早期河曲地带中终年不断的小规模水体附近相对稳定的地点，而非聚居在气候干燥的高地、主要的河道、洼地或者漫滩<sup>[17]</sup>。

对于古代城市水利基础设施对现代是否还具意义的讨论也有所增加。诸如《水利科技》此类科技期刊，针对中国城市的研究更加重视，例如关注水利基础设施对于古都长安在渭河选址与城市布局方面扮演了什么样的角色。这些研究使我们开始关注到东周时期阳城的石质管道、阀门、沉积阱，以及将重力流管道与明渠合一的古代排水系统，更不必说后来形成的城市中（如北京）令人印象深刻的蓄水和排水系统<sup>[18]-[20]</sup>。中国这些最新的研究认为古代技术仍具有现代意义。正如本文在引言中所述，中国和其他地区的环境设计师和规划师都提出了上述观点。

从社会基础设施角度来看，现代学者批判性地在魏特夫的框架基础之上，将现代城市水系统制度现状表述为“碎片化的水利国度”，其拥有社会与政治的等级和权力，但只发挥有限的集中官僚统治<sup>[21]</sup>。组织结构的碎片化跨越多个水利分支、各级政府、资金流与各种类型的用水组织。有学者形容这种情况是存在“太多的龙”，这使我想起赵启光教授对文学作品中神话中的龙（水的统治者）、龙王（天气的主宰）和民间传说中的龙（本地水神）的差异的研究<sup>[22]</sup>。城市水系统由一个至高的“龙”统辖，而水坝、灌溉、水质和防洪则在不同的体制层级下运行。其他大国（如印度和美国）也有类似的模式，但到目前为止鲜有对这些国家水利基础设施的比较研究。

### 3 南亚历史名城的社会水文

我大部分的研究集中在南亚中世纪后期和近代早期的印度—伊斯兰时期的城市（即12~17世纪，现在的印度和巴基斯坦）。然而，早在至少4 000年以前，大印度河流域就已经出现城市聚落和基础设施了<sup>[23]-[25]</sup>。在现代殖民时期和后殖民时期以前，南亚至少经历过三个城市化时期：哈拉帕青铜时代；早期佛教王国时期；中世纪晚期的军事和宫廷文化时期。由于这三个城市化时期的水利基础设施对南亚早期的社会—水工具有一定影响，以下将对此进行简要的介绍，并将之与中国和其他地区进行比较。



#### 3.1 大印度河流域聚落：新石器时代至哈拉帕青铜时代

与中国相同，南亚的新石器时代遗址主要集中在当地的地质、水文、生态资源皆宜的交汇点。例如，在东移进入印度河平原、建设大型砖石径流控制结构之前，新石器时代的聚落已沿着印度河流域的山地边缘发展起来<sup>[26]</sup>。哈拉帕文明与印度河流域息息相关，因为哈拉帕文明中的两个最大的城市聚落都是沿印度河（摩亨约-达罗城市遗址）和其支流如拉维河和比亚斯河（哈拉帕城市遗址）分布的。如同在中国和北美，城市沿着终年不断的支流分布比沿大江大河主要河道分布（如印度河、黄河、长江、科罗拉多河、密西西比河等）更加稳妥、危害更小。在原史时代，摩亨约-达罗创造出非常复杂的古水井、浴室、水池、水箱、排水渠。在印度河流域，由于气候、洪水和构造变化的相对重要性，致使像摩亨约-达罗这样的城市被废弃，这一争论长期以来一直存在。

然而，在河道变迁引起城市被遗弃的案例中，最具戏剧性的例子发生在流经乔里斯坦地区的噶噶尔-哈克拉河道<sup>[27]</sup>。遥感研究已证实聚居点和这条古河道之间的密切联系，并显示聚落迁移有可能是由古河道改变引起，或者河道干涸导致聚落点被遗弃。而古吉拉特聚落点之所以消亡得更为缓慢，很可能与沿海贸易有关。哈拉帕时代后期的城市在拉什特拉地区选址建成，如阿姆拉、瓦赛、偌吉地，这些城市都可以归类为“后城市”（Post-urban），

2. 哈拉帕“后城市”坐落在印度偌吉地稳固的河边石滩。  
© James L. Wescoat, Jr.
2. Harappan "post-urban" site on a stable rocky river bank at Rojdi, India. © James L. Wescoat, Jr.

and other regions.

In terms of social infrastructure modern scholars have built critically upon Wittfogel's framework when they describe the institutional situation in modern urban water systems as those of a "fragmented hydraulic state", which has social and political hierarchy and authority but only limited central bureaucratic control<sup>[21]</sup>. Institutional fragmentation extends across many water subsectors, levels of government, funding streams, and types of water user organizations. Some scholars describe this situation as having "too many dragons", which brings to mind Professor Qiguang Zhao's study of literary distinctions among mythological dragons (water authority figures), dragon kings (weather deities), and folklore dragons (vernacular water spirits)<sup>[22]</sup>. Urban water systems are governed by one hierarchy of "dragons," while dams, irrigation, water quality, and flood control operate under different institutional hierarchies. Analogous patterns may be observed in other large countries like India and the United States — but there have been few comparisons of their water infrastructures to date.

### 3 Socio-Hydrology of Historic Cities in South Asia

Most of my research has concentrated on late medieval and early modern cities of the Indo-Islamic period in South Asia (that is, the 12th to 17th centuries in what are now the countries of India and Pakistan). However, urban settlement and infrastructure began at least four millennia earlier in the greater Indus river valley<sup>[23]-[25]</sup>. South Asia had at least three periods of urbanization prior to the modern colonial and postcolonial periods: the Harappan Bronze Age; the early historic period associated with Buddhist kingdoms; and the late medieval period of military and courtly cultures. The water infrastructures of these three periods of urbanism are briefly discussed below for the insights they give into early socio-hydrologic processes in South Asia, and in comparison with China and other regions.

#### 3.1 Neolithic to Harappan Bronze Age Settlements in the Greater Indus Basin

As in China, Neolithic sites in South Asia were concentrated at favorable conjunctions of local geologic,

hydrologic, and ecological resources. For example, they developed along montane margins of the Indus basin, before moving eastward into the Indus plains and constructing large masonry runoff control structures<sup>[26]</sup>. Harappan civilization is associated with the Indus River valley due to the occurrence of two of its largest urban settlements along the Indus (Mohenjo-Daro) and major tributaries such as the Ravi and Beas rivers (Harappa). As in China and North America, locations along perennial tributaries were more reliable and less hazardous than along the main channels of large rivers such as the Indus, Yellow River, Yangtze, Colorado, or Mississippi. Mohenjo-Daro developed some of the most sophisticated ancient wells, baths, pools, tanks, and drains in the proto-historic period. A long-running debate in the Indus concerned the relative significance of climate, flooding, and tectonic change for the abandonment of cities such as Mohenjo-Daro.

However, the most dramatic example of river channel failure followed by settlement abandonment occurred along the Ghaggar-Hakra channel in Cholistan<sup>[27]</sup>. Remote sensing research has confirmed the close association between settlements and palaeo-channels, indicating cases where palaeo-channels change may have given rise to shifts in settlement, or settlement abandonment in cases where channels dried up. Gujarat settlements declined more slowly perhaps due to coastal maritime trade. Later Harappan sites in Saurashtra such as Amra, Vasai, and Rojdi are actually classified as "Post-urban," and were sited where small roads cross a small stream (Fig. 2). Interesting comparisons can thus be drawn between the Neolithic transitions of India and China, which involved different patterns of water supply and infrastructure (for example, flood defense in northern China vis-a-vis inundation canals in the Indus).

#### 3.2 Early Historic Cities in Northern India

The early historic period of urbanization arose to the north and east in the Indo-Gangetic plains of northern and central India, from the famous Buddhist monastic city of Taxila in the West to Kanauj and Magadha in the East. These early historic cities arose in more well-watered regions<sup>[28]</sup>. Some of them were symbolic ceremonial centers as well as trade and specialized

并且都选址在有多条小路穿过一条水流的地点（图2）。因此可以就印度和中国在新石器时代的过渡进行有趣的比较，包括两者在供水和基础设施上所采用的不同模式（例如就中国北方的防洪策略与印度河的洪水渠进行对比）。

### 3.2 印度北部早期的历史名城

印度早期的城市化起源于其中北部，恒河平原的北部和东部地带，明确范围从印度西部著名的佛教寺院城市塔克西拉到位于东部的卡瑙季城和摩揭陀国。这些早期的历史名城诞生在水源充足的地区<sup>[28]</sup>，其中包括具有象征意义的仪式中心、贸易中心或专业化生产中心。尽管寺院间接地依赖王权、税收管理、运输和贸易机构，但佛教寺院群往往远离贸易中心。

这个时期产生了一些具有实用意义的城市建筑书籍，如《政事论》、《古印度建筑经典》、《印度住宅建筑与图解》。其中《政事论》由商羯罗（约公元前350~283年）在塔克西拉市的佛教寺院里汇编完成，描述了城市应如何孕育牢固的建筑、稳定的社会关系和良好的政治管理。它指出了水资源、季风降雨和防洪之间多种多样的关系，以及城市和其管辖下的村庄之间的关系<sup>[29]</sup>。例如：

II/34/8：在极旱地区[国王]应修建水井、建立供水工程、开挖泉水、建设花园和果园。

III/9/33：新建贮水池与堤岸时，（应准予）豁免五年（税赋）；整修被毁坏和被遗弃的贮水池与堤岸时，豁免四年税赋；清除杂草丛生的贮水池与堤岸时，豁免三年税赋；开垦干旱的土地时，豁免两年税赋。

IV/3/17：遇有饥荒，国王应贮存种子和食料并施予子民，或（实行）建设堡垒和供水利工程时发放食品，或（与他们）分享（他自己的）储备，或将国家托付给（另一位国王）。

在此期间到访印度的中国人留下了关于印度城市、河流和景观的记录，这些都具有重要的历史地理价值<sup>[30]</sup>。

### 3.3 新兴的中世纪城市（9~16世纪）

由于货物贸易、艺术交流与旅行游历的日益增多，中世纪晚期和现代早期的新兴城市在城市设计上融入了国际视野<sup>[31]</sup>。例如，从9世纪起，印度河中游与下游的城市一再发生印度—伊斯兰冲突<sup>[32]</sup>。像哈拉帕文明一样，这些城市建在河流和陆路贸易



3

路线的交叉点，即建在战略性的河流交汇处。和平时期，它们是繁荣的国际大都会；战乱时期，它们会遭到双向攻击，但如果贸易路线被保留下来，它们又能迅速被重建。12世纪克什米尔的史诗《国王河》记录了国王和宫廷的更迭，这部史诗可与中国历史和哲学文本中水的隐喻相提并论<sup>[33]</sup>（图3）。

在德里，城市（如杜格拉卡巴德古城堡）沿着亚穆纳河的细小支流分布。德里山脉滋养着亚穆纳河，其包含多个控水结构和贮水池<sup>[34]</sup>，这些贮水池配有进口与出口，用于城市用水供给（图4）<sup>[35]</sup>。短命的莫卧儿王朝的礼仪之都法泰赫普尔西克里是一个例外，传闻16世纪末其水库爆裂，水质低劣且供水不足（图5）<sup>[36]</sup>。不幸的是，无论是伊斯兰教君主，还是印度教宫廷，或是后来的莫卧儿王朝，几乎没有留存下任何这个时代城市建筑的文字记载。

将古代城市水系统的现代南亚视角的解读与前文引用的中国研究进行对比非常有趣。印度古代雨水收集系统由于具有历史遗产意义和现代规划借

3. 位于克什米尔斯里那加的杰赫勒姆河 © James L. Wescoat, Jr.
4. 伊斯兰教君主时期印度新德里的哈兹-沙姆西贮水池 © James L. Wescoat, Jr.
5. 位于法泰赫普尔西克里的阿努普-塔劳贮水池 © James L. Wescoat, Jr.
3. Jhelum River in Srinagar, Kashmir © James L. Wescoat, Jr.
4. Sultanate period Hauz-i-Shamsi tank in Delhi, India © James L. Wescoat, Jr.
5. Anup talao tank at Fathpur Sikri © James L. Wescoat, Jr.



4

production centers. Buddhist monastic complexes were often constructed distant from trading centers, though they relied indirectly upon institutions of kingship, revenue administration, transport and trade.

This period produced pragmatic texts on city building, such as the *Arthashastra*, *Silpa Sastra*, and *Mayamata*. The *Arthashastra*, compiled by Chanakya (350 ~ 283 BCE) in the Buddhist monastic city of Taxila, described how cities should serve as sites for sound building, social relations, and governance. It notes the varied relationships between water resources, monsoon rainfall, and flood protection; and the relationship between cities and the villages under their administration<sup>[29]</sup>.

II/34/8: In waterless regions, [the king] should establish wells, water-works and springs, also flower- and fruit-enclosures.

III/9/33: When tanks and embankments are newly constructed, an exemption (from taxes) for five years (should be granted), when those that are ruined and abandoned are renovated, an exemption for four years, when those that are over-grown with weeds are cleared, for three years, when dry land is newly brought under cultivation, for two years.

IV/3/17: During a famine, the king should make a store of seeds and food-stuffs and show favour (to the subjects), or (institute) the building of forts or water-works with the grant of food, or share (his) provisions (with them), or entrust the country (to another king).

Chinese travelers to India during this period have left valuable accounts of the historical geography of these Indian cities, rivers, and landscapes<sup>[30]</sup>.

### 3.3 New Medieval Cities (9th ~ 16th centuries)

An international perspective on urban design is also warranted for the late medieval and early modern new cities that were increasingly shaped by trade goods, artistic exchange, and travel<sup>[31]</sup>. For example, from the 9th century onwards, extraordinary Indo-Islamic encounters occurred in cities of the lower and middle Indus River basin<sup>[32]</sup>. Like their Harappan antecedents, they lay at the intersections of riverine and overland trade routes, that is, at strategic river crossings. They prospered as cosmopolitan centers in peaceful times, suffered from both avenues of attack in unstable times,

but rebuilt rapidly if the trade routes endured. The *Rajatarangini* (River of Kings) a poetic historical text from 12th century Kashmir recounts the rise and fall of kings and courts that bears comparison with metaphors of water in Chinese historical and philosophical texts<sup>[33]</sup> (Fig. 3).

In Delhi, for example, cities such as Tughluqabad were located along micro-tributaries of the Yamuna River fed by the Delhi Ridge watershed, which had multiple water control structures and tanks<sup>[34]</sup>. The tanks were modified with inlet and outlet works to serve urban water uses (Fig. 4)<sup>[35]</sup>. Another exception is the short-lived Mughal ceremonial capital of Fathpur Sikri, whose reservoir burst and water supply reportedly proved inadequate in quality or quantity in the late 16th century (Fig. 5)<sup>[36]</sup>. Unfortunately, almost no city building texts have survived from this era, whether in Sultanate documents, Hindu courts, or later Mughal documents.

It is interesting to compare modern South Asian perspectives on ancient urban water systems with the Chinese research cited earlier in the paper. Ancient rainwater harvesting systems in India have been studied for their heritage and modern water planning relevance<sup>[37]</sup>. Those studies along with community mobilization and policy advocacy have led to the adoption of urban rainwater harvesting policies in most water-scarce cities. Policy enforcement varies but the adaptation of ancient water harvesting systems



鉴意义，早已受到研究与关注<sup>[37]</sup>。这些研究与社群动员和政策宣传一同，促使大多数缺水的城市执行城市雨水收集政策。虽然政策执行不一，但古老的雨水收集系统的适用范围不断扩大，并且越来越多地与低成本分布式池塘和用于废水处理的植被系统并用。如果我们把这一分析扩大到地球另一端的美国，相对年轻的文明，又将是如何的情形呢？

#### 4 古代北美的水城市主义发展

12 000年前，人类才从亚洲出发穿越陆桥来到美洲，因此美洲的聚落历史起源较晚。水与聚落的关系类型广泛，从河流阶地到冲积平原，从依赖灌溉渠的城市到迁徙性利用的季节性池塘（表2，图6）。而唯有在终年流淌不断的支流汇合处修建灌溉渠系统这样的组合方式下催生了城市，如在盐河与希拉河交汇处形成了今天亚利桑那州的凤凰城。

##### 4.1 美国亚利桑那州中部的霍霍卡姆灌溉渠

盐河与希拉河的交汇处哺育了霍霍卡姆印第安部落的史前城市聚落，他们大约于公元前200年起，在之后的1 000年时间内扩大并统一了灌溉渠道系统，直到公元1450年这些定居点才被渐被遗弃。公元1000年至1200年之间见证了与灌溉息息相关的城市发展<sup>[38]</sup>。

14世纪的气候变化与可能存在的社会矛盾缩小了聚落的规模、降低了其发展水平。随着人们迁移到湿润的冲击平原和高地地区，亚利桑那州的中部城市就此被遗弃了。然而，就像神话中的凤鸟，伴随19世纪和20世纪后续两次运河灌溉的扩张，凤凰城在这片城市的旧址之上得以崛起。伴随着欧洲移民、贸易、工业化的增加及最终形成的娱乐发展，凤凰城得以重建，并形成了河岸主要的灌溉水渠，这些灌溉渠道现已成为日益增多的城市街区的景观休闲廊道<sup>[39]</sup>。

##### 4.2 密西西比河漫滩文明

北美其他与水相关的文明，都分布在密西西比河主河道及支流沿线，其中最大的要属俄亥俄河与密苏里河。密西西比文明是北美大陆上幅员最广的文明，包括密西西比河三角洲的渔耕聚落与沿着河流主干道分布的主要交通走廊，这些交通走廊连接着各个围绕土丘结构而建的巨大仪式城市中心（图7）。

与干旱的西部相同，密西西比河主要的聚落

表2 美国西南部的的水与聚落模式  
Table2 Water-Settlement Patterns In The American Southwest

水体 Water body	基础设施 Livelihood/Infrastructure	聚落类型 Settlement Type	位置 Location
主河道 Major river channels	洪水汇集 Flood gathering	迁徙性聚落 Migratory bands	科罗拉多河下游 Lower Colorado River
中等冲积平原 Medium floodplains	洪泛区农耕 Flood farming	印第安人原始城市 Proto-urban pueblos	格兰德山谷中部 Middle Rio Grande Valley
常流支流 Perennial tributaries	运河灌溉 Canal irrigation	城市中心 Urban centers	盐河与希拉河交汇处 Salt-Gila confluence
间歇性河流 Intermittent streams	混合生计 Mixed livelihoods	流动的聚落 Mobile bands	希拉河分水岭上游 Upper Gila watershed
季节性水体 Ephemeral water bodies	拦水坝区 Check dam fields	小型村落 Small villages	科罗拉多高原 Colorado Plateau
梅西奇高地 Mesic uplands	径流与地面覆盖 Runoff and mulching	小型村落 Small villages	格兰德阶地中部 Middle Rio Grande terraces

都坐落在之前的河曲带与终年不断的支流沿线，这些位置的河道相对稳定。卡霍基亚是其中最盛大的礼仪中心，毗邻冲积平原上一个废弃的河曲带——“美国之底”，密苏里州的现代城市圣路易斯市与之隔河相对。这些聚落能够方便地获取丰富的湿地资源并利用河道运输，而在洪水暴发又因地处高地而十分安全。这些宏伟的聚落大约与西南部的聚落在同一时期被遗弃。关于遗弃原因，有各种类似的假设互相组合、互为解释，包括与社会分层相关的社会冲突、气候变化、环境恶化及无法成功地适应等<sup>[40]</sup>。

设计师们对土丘景观的象征意义及其历史、物

6. 新墨西哥陶斯印第安普韦布洛阿塞基亚灌溉渠 © James L. Wescoat, Jr.
7. 密西西比河上游流域的卡霍基亚土丘 © James L. Wescoat, Jr.
6. Acequia irrigation canal in Taos Indian Pueblo, New Mexico © James L. Wescoat, Jr.
7. Cahokia mounds in the upper Mississippi River valley © James L. Wescoat, Jr.



is expanding and is increasingly linked with low-cost decentralized pond and vegetation systems for wastewater treatment. What happens when we extend this analysis to a much younger civilization half-way around the world in what is now the United States?

#### 4 Water Urbanism in Ancient North America

Settlement history of the Americas began much later with humans traveling over the land bridge from Asia some 12,000 years before present. The types of water-settlement relations ranged from river terrace and floodplain occupation to canal irrigation cities and migratory use of ephemeral ponds (Table 2, Fig. 6). The only combination that gave rise to cities were canal irrigation systems constructed at the confluence of perennial tributaries, such as the Salt and Gila rivers, at the location known today as Phoenix, Arizona.

##### 4.1 Hohokam Canal Irrigation in Central Arizona

The Salt-Gila confluence supported prehistoric urban settlements of Hohokam Indian tribes, originating around 200 BCE, expanding and consolidating their canal irrigation systems over a period of about 1,000 years, before abandoning those settlements by 1450 CE. The period between 1000 CE and 1200 CE witnessed urban growth associated with canal irrigation<sup>[38]</sup>.

Climate variability and possible social tensions in the 14th century reduced settlement sizes and prosperity. Cities were abandoned in central Arizona with migration to more mesic floodplain and upland locations. Like the mythical phoenix bird, however, the city of Phoenix arise out of its ashes in at least two subsequent waves of canal irrigation expansion in the 19th and 20th centuries. Rebuilding was associated with increases in Euro-American migration, trade, industrialization, and ultimately recreational development. The latter process led to major irrigation canal banks being turned into landscape recreation corridors for increasingly urban neighborhoods<sup>[39]</sup>.

##### 4.2 Mississippian Floodplain Civilization

The other major region of water-related civilization in North America developed along the Mississippi River main stem and its tributaries, the largest of which are



the Ohio and Missouri Rivers. Mississippian civilization was the most extensive of the North American continent. It ranged from fishing-farming settlements in the Mississippi River delta to major transportation corridors along the main stem of the river that were linked with monumental ceremonial urban centers upstream that revolved around earthen mound structures (Fig. 7).

As in the arid west, major Mississippian settlements were located on former meanders and small perennial tributaries that had relatively stable channels. One of the grandest ceremonial centers known as Cahokia was sited adjacent to an abandoned river meander in a floodplain known as the American Bottom, across the river from the modern city of St. Louis, Missouri. The settlements had access to rich wetland resources and river channels for transportation, with ready safety in upland areas during flood events. These magnificent complexes were abandoned about the same time as those of the Southwest. A similar mix of hypotheses have been put forward, ranging from social conflict associated with stratification to climate change, environmental degradation, and diminishing capacity to adjust to them successfully<sup>[40]</sup>.

Designers have given particular attention to the symbolic dimensions of mound landscapes, as well as to their historical, material, and ecological dimensions<sup>[41]</sup>. Although it is not yet part of the canon of design precedents from North America, it complements

质、生态层面给予了特别关注<sup>[41]</sup>。尽管它不属于北美设计的经典先例，但它补充了后续的欧美裔城市起源的理论，并对未来的蓝绿基础设施建设具有借鉴意义。密西西比河流域的现代城市的弹性与脆弱性各不相同，有繁华的明尼阿波利斯，也有位于不稳定的下游的新奥尔良<sup>[42]</sup>。

## 5 中国、南亚及北美古代城市水利系统的比较意义

本文展示了不同地域、不同年代、不同文化背景下的城市发展与水源系统之间的关系。随着生态和文化景观规划的进步，各地的规划设计吸收了越来越多的古代城市的先例。通过比较不同地区的景观规划手法，又能从中得到哪些启示呢？

首先，比较中国、南亚、北美的古代城市的社会水文地理，需要从更深层次的考古和进化的角度着眼，而这比复杂城市本身的发展还要早很多。对早期古人类演化和新石器时代聚落形态的研究揭示了人类和相对稳定的水体之间的密切关系。水城市主义最初根源于人类进化本身<sup>[43][44]</sup>，因此，当代城市规划中对于更新本地供水的渴望可能有着非常深厚的渊源。

其次，古代城市最成功的水利系统最长能够支撑数百年的时间，却无法长达千年，考虑到这一点很重要。一套成功的城市水利基础设施服役数十年后，它就必须适应新的挑战。如果它能够很好的适应这些挑战，那么这个城市便可于被新城市形态或模式替代前存在数百年。因此对比这三个国家中拥有存续了数百年的文化遗产的城市具有重要意义。无论是从文化意识角度，还是从被遗弃城市的失败教训对新兴城市的警示作用的角度出发，比较和保护诸如摩亨约-达罗和卡霍基亚这样遭遗弃的城市的文化遗产都是十分重要的。

第三，具有弹性的水利系统，是维持城市发展和城市文明的充分条件，但不是绝对必要条件。供水不足或水质不安全会导致城市衰退，但很少能真正毁掉一个城市。基于此原因，水利设计师在城市崛起、发展和灾后重建的过程中充当着重要的支撑角色。某些城市被社会所遗弃，并不是因为战争或瘟疫，而是由于他们缺乏可持续性的生态与社会关系。在调整水利系统的过程中，通常情况下社会将更加缺少凝聚力，但并不是完全丧失凝聚力。事实证明，某些富有强韧生命力的城市，在经历了最惨重的灾难之后他们会“重建得更好”，有时甚至能

建设出更好的蓝绿基础设施。对黄河与密西西比河流域的洪灾及大规模创新性的防洪减灾策略进行对比，将具有巨大的未来意义。

第四，尽管最早的城市水利系统在内陆地区得到发展，新的城镇化发展却多集中在沿海地区。早期的城市发展依赖终年不断的中等规模水体，而非难以控制的大型河道。人类不断开发出有效的防洪减灾策略，比如归功于大禹的黄河治水工程，及早期的密西西比聚落。随着新的城镇化沿海岸发展，城市更易受到海平面变化和灾难性风暴的破坏，相应问题也随之产生——即这些地区的居民能否部分借鉴古代沿河居民的经验，用以增强沿海城市的洪水适应能力与应变能力。

第五，随着古代城市水利基础设施的发展，水利基础设施与当地水资源之间形成了深远的象征关系与物质关系。这种本地化的水利关系是象征意义与实用功能的融合，这其中有一部分原因是由于城镇化的特征之一就是建构象征意义。这也是保罗·惠特利在研究中国早期城市并与其他古代文明进行对比时所强调的要点。这种早期关系是如何衰退或消失的、而后又如何真正恢复的——这个问题对如何建设持久的生态社会基础设施的可能途径至关重要。

总之，尽管新兴城市与古代城市相比，在年代、地理位置和社会形态方面存在着本质区别，但原则上，新兴城市可以通过类比的方法依照古代经验进行成功的创新。对世界各地具有不同水利特征的古城市进行类比，也许具有重要意义<sup>[45]</sup>。例如，我们目前正在对比孟买、新加坡和波士顿的城市水利系统，已发现了它们之间多种多样的历史渊源，并获得了一些有意义的设计类比。凭借经验可知，遥远的城市之间间接地相互借鉴，并且从其本身历史中学习，但我们也从这项研究中得出结论：相较于目前已产生的影响，详细比较古代城市水利系统，对催生新型城镇化有着更为深远的意义。LAF

### 注释

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those of subsequent Euro-American origins and has relevance for future blue-green infrastructure proposals. Modern Mississippian cities likewise have variable levels of resilience and vulnerability, from prosperous Minneapolis to precarious New Orleans downstream<sup>[42]</sup>.

### 5 Comparing the Relevance of Ancient Urban Water Systems in China, South Asia and North America

This paper has shown how cities developed in relation to water resources across a wide range of regions, time periods, and cultures. As ecological and cultural landscape planning advance, they are likely to draw increasingly upon ancient precedents in their own regions. What additional lessons might they draw from a comparative landscape approach?

First, comparing the ancient urban socio-hydrologies of China, South Asia, and North America requires a deeper archaeological and evolutionary perspective, which begins long before the development of complex cities per se. Research on early hominin evolution and Stone Age settlement patterns reveals close relationships between humans and relatively stable water bodies. The earliest roots of water urbanism lie in human evolution itself<sup>[43][44]</sup>. The desire in contemporary design to renew local water supplies may thus have very deep roots.

Second, it is important to consider that the most successful ancient urban water systems were sustainable on timescales of centuries but not millennia. Successful urban water infrastructure endures for several decades before it must adapt to new stresses. If it adapts well the city can survive for centuries before it is superseded by new forms or patterns of urbanization. Thus, it is important to compare cities in China, India, and the U.S. that have retained their living heritage on timescales of centuries. Comparing and conserving the cultural heritage of abandoned cities like Mohenjodaro and Cahokia is also important — both for cultural consciousness and for adapting lessons from abandoned places for new urbanization.

Third, resilient water systems are necessary but not sufficient to sustain urbanization and urbanism. Inadequate and unsafe water can degrade but rarely destroy a city. For that reason, water designers play

an important, yet supporting role in the emergence, growth, and reconstruction of cities after disaster. When societies abandon their cities, it is not due to conquest or epidemic, but due to their unsustainability in eco-social terms. They often suffer a greater insufficiency of social cohesion to adapt their water systems, more than absolute scarcity. Some cities have proven resilient to even the most catastrophic disasters, after which they “build back better”, sometimes with enhanced blue-green infrastructure. Comparison of flood hazards and innovative large scale flood risk reduction strategies on the Yellow River and Mississippi has enormous promise.

Fourth, while the earliest urban water systems developed in continental interiors, new urbanization is concentrating on the coasts. Early cities developed on perennial medium-scale water bodies, rather than on large uncontrollable river channels. They developed effective river flood risk reduction strategies, as in the Yellow River works ascribed to Yu the Great, and to early Mississippian settlements. As new urbanization develops on the coasts, which are vulnerable to sea level fluctuation and catastrophic storms, the question arises as to whether they can develop coastal flood adaptation and resilience practices that draw in part upon ancient riparian precedents.

Fifth, when ancient urban water infrastructure developed, it had meaningful symbolic as well as material relationships with local water resources. Local water relationships are jointly symbolic and functional, in part because part of what characterizes urbanism is its construction of symbolic significance. This was the main point that Paul Wheatley underscored for early cities in China, and in comparison with other ancient civilizations. The question of how these early relationships are lost or degraded — and how they can later be authentically recovered — is crucial for understanding the potential paths for creating an enduring eco-social infrastructure for new urbanization.

In conclusion, although new cities are fundamentally different from those that preceded them in ancient times, places, and societies — they can in principle adapt successful innovations from these ancient precedents

by analogy. There may be useful analogies with ancient cities in other parts of the world which had profoundly different water characteristics<sup>[45]</sup>. For example, we are currently comparing of urban water systems Mumbai, Singapore, and Boston— and are discovering all sorts of historical connections as well as promising design

analogies. We know from experience that distant cities have learned from one another and from their pasts indirectly, but we also conclude from this study that detailed comparison of ancient urban water systems have far more relevance for inspiring new urbanization than it has to date. **LAF**

#### NOTE

A longer version of this article is presented to the 2014 Beijing Forum.

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