Supplementary Material

S1. Water Supply Systems in Iran Over Time

Numerous researchers have investigated water transfer systems in Iran and their mechanisms [8-11]. Some have specifically focused on “qanats”, exploring their history, construction methods, and components, and clarifying the process of water conveyance from trenches through canals and dams. Other studies provide detailed insights into the traditional material, known as Kaval, a large tanbushe used as a covering in qanat galleries and water conveyance systems [12], detailing its preparation and application. Fakhar Tehrani [8] specifically examined the primary materials employed in aqueduct construction.

Furthermore, researchers have also explored topics such as hydrology, water resources, qanats, canals, sealing bridges, and water channels using clay pipes for installation [1,10]. A comparative structural analysis [13] of water transfer methods in specific systems in Isfahan examined various types of water wheels and cow-powered water wheels (Gav-Chah or a well from which water is drawn by a cow), along with related elements in historic structures, illustrating diverse approaches to surface and groundwater transfer. This study [13] revealed the utilization of water transfer and sewage disposal systems in ancient edifices, showcasing varied forms based on water access, quantity, and storage sources.

Some researchers have also focused on the water supply network designed in the Nogonbad desert caravanserai [14]. This study was based on the results obtained from the archaeological survey of the Nogonbad-Arkan region in Nain (located near Isfahan). The results revealed that engineers constructed a canal to transfer water to the accommodation centers, taking into account the topographic status, ground slope measurement, groundwater resources, and geographical location. Two notable techniques involved the construction of a stone canal to carry water from a spring located seven kilometers from Ain al-Rashid Caravanserai, and the establishment of a water transmission network using the qanat system, which involved using tanbushes to transport water to the Nogonbad residential complex over a distance of 15 kilometers. These achievements showcase Iranian engineers' expertise in water extraction, transmission, storage, and distribution technologies. The stony canal was erected during the late Timurid period (1370-1506) and functioned as a water transmission network in the Mongol era (1206-1294), overseen by Iranian ministers. This construction was used until the end of the Qajar period (1794-1925).

To illustrate the Pre-modern water paradigm, consider the agricultural practices in Iran, which were managed for over 3000 years. When residents had to live in mountainous areas and in dry regions, they developed a system to collect the water of snowmelt through the channels they made underground: it was called Qanat. Qanat started in the mountains and through its channels it carried the water down to the grasslands, farms, gardens and towns. The flow was caused by gravity [15]. The channels have been usually with a width of 50 to 80 cm and a height of 90 to 150 cm. The length varied from several hundred meters to more than 100 Km. This irrigation system based on original knowledge and experimental hydrology, was a remarkable engineering achievement.

Water was channeled into towns through "qanats" - a system for transporting water from aquifers or wells to the surface through underground aqueducts or channels [16]. To benefit from Qanats, numerous significant cities emerged in central Iran. This is why the culture centered around the utilization of Qanats, also known as Kariz (qanat), is dubbed "Kariz Civilization" or "hydraulic civilization". Construction of qanat had a positive social impact by generating job opportunities within the local community. It is crucial to note that Qanat systems play a significant role in influencing local communities regarding the organization and utilization of their water resources, especially for agricultural purposes [17]. To avoid any conflict between farmers there were many different methods employed to measure the water

distribution. One of the optimal ways to gauge the distributed water volume from the Zayandehroud river for agricultural purposes was pioneered by Sheikhbahayee, an Iranian scientist, with his technique known as Tumare Shikhbahayee [18].

Another method utilized to create underground water reservoirs for drinking water in ancient Iran is Ab Anbars (a traditional reservoir or cistern of drinking water in Greater Iran in antiquity). These structures were designed to meet the water requirements of caravans and local residents. The reservoir typically sat in a dry region and occasionally employed wind towers to maintain the coolness of the water within this cylindrical reservoir. The components utilized in constructing these reservoirs included a blend of Sand, Clay, Egg whites, Lime, Goat hairs, and ash, known as Sarooj (a traditional water-resistant mortar used in Iranian architecture, used in the construction of bridges and yakhchāl, ancient Persian ice houses). The bricks utilized for constructing this storage were crafted in a specific manner and were referred to as Ab Anbar bricks. Iran has a long history of dam building. The process involved three vital considerations: selecting an optimal location, assessing the foundation conditions, and choosing suitable materials. They carefully considered the design and the technology, and the river diversion during the construction of dams. Various kinds of dams exist, including Gravity dams, Arch dams, and Buttress dams. The construction of contemporary dams commenced around three decades back [19]. The construction of dams and reservoirs along rivers from Alburz and Zagros mountains in Iran has boosted the utilization of surface water. In the central, northeastern, and southern regions of the country, groundwater serves as the primary source of drinking water [20,21]. An examination of the pre-modern era reveals that the traditional water paradigm reflects the interconnectedness between humans and nature.