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Aspects of Scientific Study of Ancient Hydrotechnical Structures

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Abstract: This article analyzes the issues of scientific study of ancient hydraulic structures, their history of creation, functional tasks and their relationship with modern hydrological research. The inextricable link between the structures and the socio-economic needs, technological capabilities and natural conditions at the time of their creation is revealed. Also, their role in aspects such as water resources management, irrigation systems and erosion control is shown, and approaches to their study using archaeological, geological and cartographic methods are analyzed. The article shows the relevance of re-evaluating these monuments using modern geospatial technologies, the prospects for their preservation and study as a scientific heritage.

Keywords: Ancient hydraulics, water structures, irrigation system, archeology, geological research, historical heritage, hydrology, geospatial technologies, erosion control, irrigation, cartography, hydraulic structures, scientific analysis, water resources, architecture, geosystem, hydraulic engineering, infrastructure.

Introduction: Among the people, in addition to scientists, there were specialists, that is, masters of each job. They reached the level of a special person-specialist with great skills, knowing the values of the people passed down through the centuries. Mirabs or abishikasandas are the owners of such rare skills. That is why the Arabs who conquered Sebistan (a region between Iran and Afghanistan) in the 7th century deliberately picked up specialists in hydraulic engineering structures - abishikasandas, took them to

Mecca and used them to create irrigation systems there (V.V. Bartold, 1965, p. 105). The same story was repeated by the Arabs in Bukhara. More than a thousand Bukhara water specialists were exiled to Arabia as prisoners. This event took place in 677. At that time, the governor of Bukhara was a woman, and her son, Tagshoda, who was still a child, ruled the people in his name. When the city was besieged by the Arab commander Said ibn Usman, Bukharkhudat managed to make peace by giving seventy of the noble princes as hostages to Said. Said promised to keep them in Merv for a while and then send them back to their homeland. However, he did not keep his word and took them all to Medina and ordered the development of irrigation works there (A. Narshahi, 1991, p. 119). It is no secret that the princes were undoubtedly educated people who sought to master every field thoroughly. This sad history also shows that they were knowledgeable about water science, along with many other specialties. The master of the Koryz diggers was called a "miner" in Khorasan (Ovanesov, 1928, p. 135). The Ottoman Turks called such specialists "kuruk", while the Arabs later called them "khorim" (Barthold, 1965, p. 120). The ancient Turkic peoples living in Central Asia and adjacent regions called the specialist who distributed spring water equally to the villagers "tuzun" (Mahmud Kashgari, vol. III, 1963, p. 186). It is known that they expressed every good, auspicious event with the word "tuzuk". In Nurota, the masters who mastered the work of digging kariz were called "karizchi" and "karizgar".

Aspect of the representatives of the ancient knowledge. The experience of building ancient hydraulic structures was developed by some representatives of the ancient knowledge, some types of which were reflected in their works. Herodotus (1st century BC), Vitruvius Pollio (1st century BC), Polybius (2nd century BC), Al-Farghani (9th century), Abu Rayhan Al-Biruni (11th century), Abu Ali Ibn Sina (11th century), among them. Al-Farghani (9th century) was an astronomer who mastered the art of making astronomical instruments, which were used not only for skylights, but also for digging and building dams and canals. The astronomical instrument is “asturlab” in Arabic, and it is believed that its origin is Greece. Therefore, it is called “astrolabia” (meaning star catcher) in Greek. The Greek astronomer Hipparchus determined the coordinates of 1022 stars with this instrument in the 2nd century BC. It is difficult to say anything about the model of the compass used by Hipparchus, but the original Greek astrolabe may have been simpler than the compasses used by later scientists. Because scientific terms such as "alidade", "almuqatarat", "azimuth", "zenith", "nadir" have Arabic meanings and undoubtedly spread to the world of science through the works of Al-Farghoni (A.Azamov-1998). Although the great scholar was an expert in astronomy, mathematics, and geometry, we also know him as a great geographer and a powerful instrument maker of his time based on his works. In 861, Al-Farghoni, on the instructions of the Caliph Mutawakkil, went to the city of Fustat to repair and reinstall the instrument (nilometer) that measured the changes in the water level of the Nile River. During that period, Al Farghani improved measuring instruments. He has scientific works such as "Al-kamil fil usturlob", ("The perfect book about usturlobs"), "Tatmim amal al Usturlob", ("The end of usturlob's work") (A. Nizomov-2008, p. 99).

As is known from the pseudonym of Soghani Usturlobi (10th century), the instruments created and improved by Usturlobi played an important role not only in observing the movement of celestial bodies, but also in complex processes such as leveling, and therefore were also used in complex hydraulic engineering works such as the construction of aqueducts, cisterns, reservoirs, and gulfak ponds. Abu Rayhan Beruni (1973-1048), a scientist who, along with mathematics, astronomy, geodesy, pharmacology, mineralogy, geography, hydrology, geology, and philosophy, studied the nature of groundwater, in particular, the construction of certain hydraulic structures such as wells and springs. Natural observation, vision, experiment, analysis of oral traditions, careful study of written monuments, critical attitude to information and sources, comparison, knowledge of different languages and writings were characteristic of many advanced scientists of the Middle Ages, and Beruni was not far from these qualities. As a result, a number of his works, such as “Monuments of Past Peoples” and “Mineralogy”, were created, and they still have not lost their value and scientific value. In these works, Beruni deeply analyzed the situations that occur in connection with the normative indicators, pressure, and direction of groundwater flow. As a result, solutions to some problems faced by specialists in the formation of pressurized groundwater (boilers), canals, culverts, and wells were discovered for the first time in science thanks to Beruni's ideas (A.Nizomov-2018).

Although most of the works of Abu Ali Ibn Sina (980-1037) are related to medical science, he also provides valuable scientific information about normative indicators of ancient hydrotechnical structures, especially their drinking level, medical significance, as well as literature, music, and philosophy.

Tourism aspect. Ancient hydraulic structures were recognized by the first traveling scientists as wonderful structures and water sources and were recorded in "Travelogues". The works of Chang-Chun (13th century),

Nasir Khisrav (11th century), Istakhri (13th century), Maqdisi (10th century), Ibn Battuta (13th century), Rashiduddin (13th century), Juvaini (13th century), Badriddin Kashmiri (16th century) are among them. "Travelogues" are written only in very short lines about some types of ancient hydraulic structures located along caravan routes, such as cisterns, wells, and ponds, but they are significant as the earliest works (A. Nizomov-2008, p. 23).

Some detailed information about ancient hydraulic structures belongs to the work of the traveler Nasir Khisrav (1004-1088). Nasir Khisraw traveled to Iran, Armenia, Azerbaijan, Syria, Egypt, Arabia, Iraq, Tabriz, Cairo, Jerusalem, Mecca, Medina, Lakhsa, Yemen, Basra, Isfahan and a number of other cities and regions for seven years, describing his impressions in his work "Safarname". Along with the wonderful nature and unique economic features of those countries, he also wrote about their ancient hydraulic structures. According to the traveler, the most characteristic feature of all of them, even in those times, was the presence of wells, underground reservoirs, ponds, as well as cisterns of various sizes.

Regional studies aspect. Representatives of this group, which was mainly composed of European citizens, such as N.V. Khanikov (1843), A. Lehmann (1852), A. Tatarinov (1865), M.N. Galkin (1868), L.F. Kostenko (1871), A. Arandarenko (1874), N. Mayev (1879), V.V. Krestovsky (1887), A. Burns (1893), I.I. Geyer (1909), V. Ereshenko (1911), D.N. Lagofet (1913), V. Masalsky (1913), V.N. Gorteveld (1914), along with various unique monuments specific to the region, also made the impression of a system of crypts built along caravan routes as extremely interesting monuments. Therefore, most of these researchers left important information in science by describing the state of the cisterns at that time. In particular, the Austrian biologist A. Lehmann (1852) drew a black pen drawing of the Raboti Malik cistern and the Raboti Malik caravanserai, which stood opposite it and has survived in ruins to our time, of great scientific importance.

After Uzbekistan gained independence, its ancient hydraulic structures, like all its valuables, and in particular some of their types, such as cisterns, began to be studied by local historians (teachers, journalists, etc.). A. Khotamov, Sh. Khalilov (1995), O. Jurakulov (1996), M. Bozorova (2000) are among them. However, all of these works are characterized by their general informational value.

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