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Editorial

WATER IN AGRICULTURE: A HISTORICAL PERSPECTIVE

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Though agriculture began to be practiced in geographically disparate regions of the world, but majority of the historical records concur at its origin about 12 thousand years ago, when watersheds in the upper reaches of Euphrates and Tigris witnessed some domestication of wild einkorn, emmer wheat, barley, etc. (Fuller, 2007). Indispensability of water for agriculture gave birth to water management or water technologies. The early humans learned to manage water efficiently by aligning planting seasons with rainy season, leveling land for retaining soil moisture, catching basins, digging reservoirs and canals, etc. It was not only the agriculture segment of the economy that drove water management but other sectors like drinking water, municipal use, construction, etc. also played a pivotal role in spurring water management. Mohenjo-Daro city of the erstwhile Indus Valley (Harappan) civilization demonstrated well-planned water supply and sewerage system. However, when monsoon shifted east, its agriculture slid from wheat and barley into millets. This shift bred a progressive outmigration of communities and eventually the entire civilization caved in to the pressure of repeated failures of rainfed agriculture (Ryan *et al*., 1997).

This pivotal interest in water helped in evolution of hydraulic engineering over the millennia. This priceless natural endowment made people to exhibit territoriality around it. History reports the first water war about 4500 years ago between two Sumerian city-states of Lagash and Umma, in today's southern Iraq (Gleick, 2023). This war simmered over many generations until the most dominant ruler Mesalim effected a treaty between the two. The Mesalim Treaty entailed building a canal for carrying water from the Tigris river. Therefore, by that time canals were an established waterway technology.

Ancient hydraulic engineering technologies rose up on three pillars: human muscle, animal power and gravity. To begin with, *shadoof* – a lever assembly with a bucket tied to one end of the long pole whose other end was pulled down to draw water out of a stream or reservoir, gained considerable traction. Likewise, underground channels, known variously as *qanats* in Iran and as *Karez* in Afghanistan and China, dug to get water from mountainous aquifers over several miles remained popular for eons. An Iranian survey, conducted in 2014, had pegged the number of active *qanats* at more than 37 thousand (Yazdi and Khaneiki, 2017). These *qanats* still pitch in appreciably to distribute groundwater supplies in different parts of the country.

After annexation of Punjab by the British in 1849, concerted efforts were made towards tapping the agricultural potential of the region. A major transformational push came through the establishment of nine 'canal colonies' in the western Punjab during the period 1885-1940. The policy had a twin focus: developing a vast canal network and land colonization by settlers from other provinces (Ali, 1979). Enterprising nature of Punjabi farmers, honed by their exposure to advanced farming techniques at French farms by way of their predominance as recruits in the British army, further helped in making the region an agricultural hub.

Dam technology evolved considerably over the years with China in the lead. However, in order to restore natural river flow and habitability of aquatic systems for fish and other threatened species, the momentum has gone into reverse: dam removal has picked up pace in some parts of the world, especially the USA.

A real milestone in water management was marked by the invention of a tubewell. Its first prototype came in the form of a quintessential handpump, which was developed by Mr. J. L. Norton in the USA. However, its subsequent adoption and refinements were more visible in military campaigns of England. It paced up groundwater development across the globe, especially in the developing countries. Some scholars even place it at an equal or higher footing than the high yielding varieties as an important enabler of Green Revolution of 1960s (Subramanian, 2015; Pleick, 2023). It evolved as an instrument of water security against drought and invited water intensive crops like rice to otherwise unfit ecologies. The well technology kept evolving and hounding for fossil groundwater from deeper and deeper aquifers. This is how this technology sunk from a livelihood support for millions of farmers to a sustainability threat.

Large scale abstraction of groundwater in food producing regions of northwest India, Pakistan, North China plain, and Central and California regions of the USA (Famiglietti, 2014) is a major sustainability concern. About 11% of the depleted groundwater used for irrigation is embedded (virtual water) in international food trade and about two-thirds of this water exits from

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Pakistan, India and USA alone (Dalin *et al.,* 2017). As a result, groundwater depletion in these regions may have a cascading effect on global food security. The situation plays out a Malthusian spectre in our minds, but current superfast pace of technology may help us in keeping at bay a crisis of the Malthusian scale, For instance, the Gravity Recovery and Climate Experiment (GRACE) programme of the National Aeronautics and Space Administration (NASA, USA), launched in 2002, has drastically come of age and has found significant application in remote monitoring of groundwater especially changes over the time (https://svs.gsfc.nasa.gov/4134). Rigorous groundwater governance is a major need of the hour. For tangible outcome, this governance should span the groundwater-energy-food ecosystem. As an example, grid based solar energy may engage sustainability issues in energy domain, but may aggravate groundwater depletion concerns. Unfortunately, by and large, proper regulation of the groundwater continues to remain elusive even in advanced countries like the USA (https://www.nytimes.com/interactive/2023/08/28/climate/groundwater-drying-climate-change.html).

Centrality of water in agriculture and other spheres of life on this earth along with water poverty in some regions warranted recycling of wastewater. According to Lofrano and Brown (2010), wastewater treatment evolution track commenced from Mesopotamians who paid special attention to the drainage system. Indus civilization demonstrated the first evidence of settlement pond based system. Such technologies went on refining under Egyptian, Greek and Roman civilizations till the present era of environmental standards when treatment plants are mandated to release water fully suitable for irrigation or other purposes. However, wastewater treatment technology still continues to be challenged by certain complex industrial and pharmaceutical wastes. Real application of science in treating water, though for drinking purposes, was triggered by the deadly cholera epidemics that had invaded different parts of the world starting with the Bengal region in 1816. Dr. John Snow had found cholera to be a water-borne disease; though like Galileo's heliocentrism theory, his research took a lot of time in its validation by his peers. Chlorine went on retaining its leadership in water treatment ever since its first use in 1820s.

Bottled water industry marks another important milestone in the journey of this elixir of life. Idea of carbonated water technology conceived by Joseph Priestley, an English Chemist, during 1767 was commercially exploited as 'mineral water'. Availability of cheap plastic container technology down the road gave a big fillip to the industry. Meteoric rise of this industry may have implications in curtailing groundwater availability for agriculture.

Real nudge to assigning editorial space to this history account came from the recent extreme weather events that played havoc with agriculture and other sectors of the economy in Himachal Pradesh, Punjab, Haryana and other adjoining regions. As is obvious from the above account, water scarcity continues to have a predominant share in the research on water resources. Punjab and Haryana region faced a double whammy of deficient rainfall and floods. Scientific evidence on the role of climate change in making these weather anomalies a commonplace is mounting day by day. The recent floods have laid bare some important knowledge gaps like contingency interventions for re-planting, management of fresh alluvial deposits, etc. The situation calls for re-orienting research across the entire hydrological regime and at all scales –watershed, stream and field.

Tremendous sense of camaraderie witnessed during these tough times for management of stream bunds needs to be promoted through state support on the pattern of levee districts in the USA. Dredging and riparian vegetation need special attention. Also, irrelevance of geo-political boundaries in such flood scenarios, where downstream regions had to bear the brunt, highlights the need for making river maintenance a national financial responsibility. Federated response to the management of such disasters remains divided due to political misalignments and territorial sense.

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