

Medieval (Islamic) Cities in India (1206–1764): An Environmental Review and its Contemporary Relevance

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Abstract

This article examines the medieval (Islamic) cities in India from an environmental and technological perspective. The main objectives of this article are (a) to identify and evaluate characteristic features of the cities that were closely linked with the natural environment, (b) to examine the environmental conservation measures, sustainable practices and eco-friendly technologies adopted in these cities, (c) to assess the environmental impact of these cities and (d) to explore those eco-friendly measures and technologies that are relevant even at present. This is a first of its kind review of the Islamic cities in India that flourished from the thirteenth to eighteenth century. Some of the important findings are the following: (a) water had a dominant role in the establishment of these cities, (b) gardens, canals, water-harvesting structures and sanitation were important characteristics of these cities that were profoundly integrated with the natural environment, (c) despite numerous environmental conservation measures adopted, several of these cities declined or were abandoned ironically due to environmental factors and (4) in response to natural environment, some exemplary eco-friendly technologies were introduced, particularly the *karez* technology for water-supply, which is worth considering to make contemporary Indian cities ecologically sustainable.

Keywords

Islamic cities, planning, environmental conservation, eco-friendly technologies, environmental impact

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Introduction

The medieval (Islamic) phase of urbanisation in India, which spanned over six centuries beginning with the establishment of Delhi Sultanate in 1206, was an important era of urban development in India. Cities emerged as market towns for grain-trade and manufacturing centres during the early Sultanate period (1206–1526).⁴ The weakening of Delhi Sultanate in the fourteenth century caused the proliferation of cities in the eastern as well as southern parts under Bengal (1342–1538) and Bahmani (1347–1527) Sultanates.⁵ Urbanisation gained momentum during the Mughal period (1526–1739) due to the growth of indigenous industries and external trade, continued migration of artisans to the cities, a strong agrarian base and improvement of the quality of life in urban centres.⁶ Delhi was the epicentre during the entire phase of Islamic urbanisation in India, where seven cities were built successively.⁷

Innately urban, Islam favoured the development of cities right from its inception,⁸ giving rise to a new form of urbanism in India, explicit in some of the most magnificent cities built during this period. The cities comprised exquisitely designed buildings such as mosques, palaces, mausoleums, *hammams* (Turkish baths), *bazars* (markets) and *sarais* (rest-houses) built at a monumental scale, safeguarded by impressive fortifications.⁹ This phase of urbanisation ended with the establishment of the British East India Company in 1764.¹⁰

Among the innumerable compact, walled cities built during this phase, some were ‘larger than Paris or London’.¹¹ Agra and Fatehpur Sikri, for instance, were described as ‘two very great cities’ while Bijapur was admired for its prosperity¹² and was considered as ‘the most magnificent city of India’.¹³ Shahjahanabad was regarded as ‘the most splendid’ among these.¹⁴ Many of the towns evince characteristics of *Vastu Shastra* (the traditional Hindu system of town planning).¹⁵

The splendid cities, their monumental buildings notwithstanding, invoke questions of whether Islamic cities were ecologically sustainable. What were the major ecological concerns in the siting and planning of these cities? How did they impact their natural environment and what challenges did they pose to urbanism? How did the society overcome these challenges and mitigate the impacts? Did these cities

⁴ Blake, *Shahjahanabad*.

⁵ Kulke and Rothermund, *A History of India*.

⁶ *Ibid.*; Ramachandran, *Urbanization*.

⁷ Blake, *Shahjahanabad*; Kulke and Rothermund, *A History of India*; Ramachandran, *Urbanization*.

⁸ Abu-Lughod, ‘The Islamic Cities’. While a quintessential city in Islamic traditions comprised a congregational mosque, a bath and a bazaar as its vital components, an additional and important feature of its counterpart in the sub-continent was a *qasbah*. Saoud, *Introduction to the Islamic City*.

⁹ Saoud, *Introduction to the Islamic City*.

¹⁰ Kulke and Rothermund, *A History of India*.

¹¹ Adas, *Machine as Measure*, p. 42.

¹² Rizvi, *The Wonder that Was India*, p. xxxi.

¹³ Kulke and Rothermund, *A History of India*, p. 172.

¹⁴ *Ibid.*, p. 158.

¹⁵ Abu-Lughod, ‘The Islamic Cities’; Dutt, *Town Planning in Ancient India*; Havell, *Indian Architecture*.

leave behind a legacy with regard to environment and technology? What can the contemporary generation of urbanists learn from this legacy in making Indian cities ecologically sustainable?

This article examines these aspects through an exhaustive review of literature. The main objectives of this article are (a) to identify and evaluate the characteristic features of the cities that were closely linked with the natural environment, (b) to examine the environmental conservation measures, sustainable practices and eco-friendly technologies adopted in these cities, (c) to assess the environmental impact of these cities and (4) to explore those eco-friendly measures and technologies that are relevant to the present towards making Indian cities ecologically sustainable.

Ecological Aspects of Urban Development

Ecology had a dominant role in the establishment of these cities. The siting, planning, water supply, hygiene and sanitation were the characteristic features that were profoundly integrated with ecological systems. These were also the crucial determinants of the impact on the natural environment.

Siting: The Dominant Role of Water

New Islamic powers customarily founded new cities¹⁶ in India at strategic locations¹⁷ that were shaped by ‘sacred, spatial, ecological and socio-economic’ factors.¹⁸ Water was the most important factor in their siting—its collection, storage and distribution predominated the settlement pattern.¹⁹ Indian cities built earlier were invariably located near a source of fresh water such as a lake or a river; on the contrary, early Islamic cities were located away from them. While ‘pre-Islamic towns went to the water, Islamic towns brought it to themselves’.²⁰

Delhi—a triangular area in the semi-arid zone surrounded by the Aravalli ranges on two sides and River Yamuna on the third (east)—exemplifies a unique strategic location that compelled ‘many dynasties throughout the ages to build their capitals more or less on the same spot’,²¹ particularly in terms of heights as vantage surveillance positions, stones for construction, ‘the river for water supply, navigation and defence’²² and abundant forests for fuel. Water assumed an important role in determining the location of its seven cities, which manifested a shift from those near the headwaters of the Aravalli Ridge to the Yamuna Riverfront.²³ Water availability near the Ridge was ensured by building hydraulic structures for harvesting and storing rainwater and

¹⁶ Abu-Lughod, ‘The Islamic Cities’; Shokoohy and Shokoohy, ‘Tughluqabad, the Earliest Surviving Town’.

¹⁷ Rizvi, *The Wonder that Was India*.

¹⁸ Barau, ‘Islamic Instruments’.

¹⁹ Bloom and Blair, *The Grove Encyclopedia*; Petersen, *Dictionary of Islamic Architecture*; Tayyibji, ‘Ancient Stepwells of Ahmedabad’.

²⁰ Mate, ‘Daulatabad’.

²¹ Kulke and Rothermund, *A History of India*, p. 10.

²² Ali, ‘Capital of The Sultans’.

²³ Wescoat, *The Water and Landscape Heritage*.

recharging groundwater²⁴ since the establishment of Lal-Kot (1052), the capital of Tomars, which was served by Surajkund, a reservoir built in Mehrauli.²⁵

Prithviraj Chauhan's Rai-Pithora (1180) was transformed into a magnificent city of the sultans²⁶ with the establishment of Hauz-i-Shamsi (1231) and Gandhak-ki-Baoli for additional supply of water,²⁷ and it became a magnet for further urban development in its vicinity. Ala-ud-din Khilji's oval-shaped Siri (1303)—Delhi's first complete Islamic city—was located close to Rai-Pithora.²⁸ Tughluqabad (Figure 1) (1320–1325), built by Ghiyas-ud-din Tughluq near Surajkund, was located on 'a hill surrounded by a basin' just 8 km east of Rai-Pithora.²⁹

However, Shahr-i-naw (the new town) (1287) at Kilokhri (or Kailughari)—the first attempt at city-building by an Islamic ruler—driven by the perennial availability of water, was instead located along River Yamuna,³⁰ where several cities, prominently Firuzabad and Shahjahanabad, were later established.

Bidar (1427), the capital of Bahmani Sultanate, was located on the foothill of Deccan plateau along Godavari River.³¹ Bijapur was 'located on an arid plateau between the Krishna and Bhima rivers'.³²

Badalgarh (1475), established as Agra, the capital of Delhi Sultanate in 1506 by the Lodis,³³ was built on an elevated area flanked by two villages—Pya and Basih—on the bank of Yamuna River.³⁴ Agra was also the first Mughal capital until the establishment of Dinpanah (1533) (now Purana Qila) which was built supposedly over the site of Indraprastha (of *Mahabharata* era).

Fatehpur Sikri (1569), built on the broad top of a rocky ridge of Vindhya hill ranges as an irregular quadrangle, had high fortification on three side and Kol Lake on the fourth (northwest).³⁵ Shahjahanabad (1639) (Figure 2) was built on a bluff along Yamuna River in the northern part of the Delhi triangle.³⁶

The primary aspect of Islamic cities in India was to provide safety and security to the rulers and noblemen for which they were characteristically built on high grounds such as hilltops, ridges or a bluff. However, ensuring water availability became the predominant factor in their siting and planning.

²⁴ Narain, *Excreta Matters*.

²⁵ Blake, *Shahjahanabad*; Narain, *Excreta Matters*; Rizvi, *The Wonder that Was India*; Wescoat, *The Water and Landscape Heritage*.

²⁶ Kulke and Rothermund, *A History of India*.

²⁷ Narain, *Excreta Matters*.

²⁸ Blake, *Shahjahanabad*

²⁹ Shokoohy and Shokoohy, 'Tughluqabad, the Earliest Surviving Town'; Shokoohy and Shokoohy, 'Tughluqabad: Third Interim Report'.

³⁰ Haider, 'A Lost City in Delhi'.

³¹ Shokoohy and Shokoohy, 'Tughluqabad, the Earliest Surviving Town'.

³² Petersen, *Dictionary of Islamic Architecture*, p. 35.

³³ Blake, *Shahjahanabad*; Anonymous, *City Development Plan Agra*.

³⁴ Farkhi, 'The Process of Urbanization'.

³⁵ Havell, *Indian Architecture*; Petersen, *Dictionary of Islamic Architecture*; Rezavi, 'Hydraulics'.

³⁶ Asher, *The New Cambridge History*.



Figure 1. Tughluqabad

Source: Adapted from Shokoohy & Shokoohy, 'Tughluqabad: Third Interim Report'.

Disclaimer: This image is for representational purposes only. It may not appear well in print.

Urban Planning

The essential components of Islamic cities were mosques, *hammams*, *bazaars*³⁷ and a *qasbah* (fortress or citadel)—usually located on higher grounds within its own high-walled fortification and moat.³⁸ Houses had courtyards connected by narrow curvilinear streets and cul-de-sacs with public areas separate from the residential quarters that were segregated based on ethnicity; each quarter comprised its own public area.³⁹

³⁷ Abu-Lughod, 'The Islamic Cities'.

³⁸ Ramachandran, *Urbanization*; Saoud, *Introduction to the Islamic City*.

³⁹ Saoud, *Introduction to the Islamic City*.

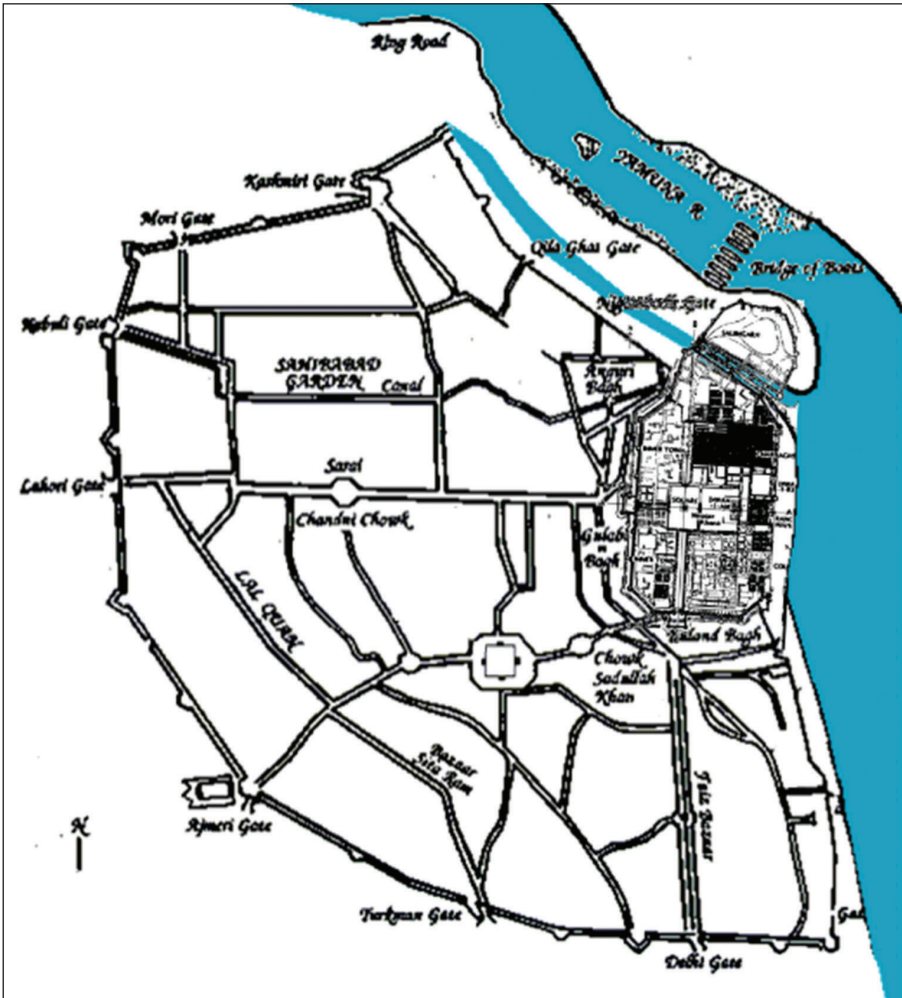


Figure 2. Shahjahanabad

Source: Adapted from www.columbia.edu and www.wikipedia.org

Disclaimer: This image is for representational purposes only. It may not appear well in print.

Tughlaqabad, designed by Ahmad-ibn-Ayaz on a typically Khorasani plan, had ‘three fortified areas – the *arg* (citadel), the *bala hisar* (fort) and the *bala shahr* (lower town)’ planned based on the contours of the site instead of a predetermined geometry to form an irregular trapezium. Local quartzite used for its massive ‘sophisticated three-tiered defence system’—comprising battered walls, usually ‘set directly against the living rock’—and the palace, was quarried from the site itself. The quarries were subsequently used as moat and reservoirs. Its cardinally oriented principal streets had a rough grid-iron pattern.⁴⁰

⁴⁰ Shokoohy and Shokoohy, ‘Tughluqabad, the Earliest Surviving Town’.

Daulatabad (1327), built by Muhammad-bin-Tughluq, was laid out with a class-based division into quarters—each well defined and self-sufficient, comprising its own facilities.⁴¹ The spatial hierarchy of the palace complex in the citadel, the formal outer walled town, its processional streets and grand public buildings find similarities in the layouts of Gulbarga, Bidar and Ahmadabad.

Bijapur (1490) was designed with the *Arquila* (citadel) at the centre of a concentric plan,⁴² surrounded by massive walls and a moat.

Gardens and hunting parks were important creations of the Sultanate period, with over 1200 laid out during Firuzshah Tughluq's reign alone,⁴³ remnants of which survive in Firuz Shah Kotla and Vasant-Vihar in Delhi.⁴⁴ These were replicated and expanded in the capitals of Deccan, Gujarat and Bengal Sultanates,⁴⁵ as well as in the Mughal cities.⁴⁶

By establishing *char-baghs* (cross-axial four-part gardens) along both sides of Yamuna River at Agra, a new kind of urban landscape was created by Babur, reminiscent of Kabul. Such Timurid-style settlements comprising 'waterfront gardens and fortresses became hallmarks of Mughal urbanism'.⁴⁷ This tradition of creating a *char-bagh* out of natural surroundings, from Babur to Shah Jahan, was undertaken to transform *Hindustan* (Indian sub-continent) into an imperial garden.⁴⁸ 'Planned like miniature Indian villages',⁴⁹ these *char-baghs* also represent a fusion of the Islamic urban design concepts with the traditional Indian system of town planning, as manifested in several Islamic cities, most notably in Fatehpur Sikri, designed by Tuhir Das⁵⁰ and Shahjahanabad, by Ustad Ahmad and Ustad Hamid.⁵¹

Shahjahanabad was based on 'Persian organicist concepts' and *Vastu Shastra*, which suggests a *Karmukha* (bow-shape) for a riverfront site. A large, deep moat, with a rough stone facing filled with water from River Yamuna, surrounded Shahjahanabad's fort.⁵² Its suburbs comprised extensive gardens and open spaces. Designed on a monumental scale with open squares, winding lanes, quiet cul-de-sacs, water channels and a population of over a million, Shahjahanabad became one of the greatest cities in the world.⁵³

Islamic urban development in India was largely based on models prevalent in the homelands of invaders. However, since the inception of Tughluqabad, the convoluted street pattern of Islamic cities gave way to a more regular, grid-iron pattern of straight streets, evident in the plans of Firuzabad, Lahore, Agra and so on. Gradually, a system

⁴¹ Mate, 'Daulatabad'; Rizvi, *The Wonder that was India*.

⁴² Shokoohy and Shokoohy, 'Tughluqabad, the Earliest Surviving Town'.

⁴³ Bloom and Blair, *The Grove Encyclopedia*; Wescoat, *The Water and Landscape Heritage*.

⁴⁴ Crane, 'Influence of Persian Gardens'.

⁴⁵ Bloom and Blair, *The Grove Encyclopedia*.

⁴⁶ Wescoat, *The Water and Landscape Heritage*.

⁴⁷ Wescoat, 'Conserving Urban Water Heritage'.

⁴⁸ Koch, 'My Garden Is Hindustan'.

⁴⁹ Havell, *Indian Architecture*.

⁵⁰ Harris, *The First Firangis*.

⁵¹ Asher, *The New Cambridge History*.

⁵² Blake, *Shahjahanabad*.

⁵³ Blake, *Shahjahanabad*; Gayer and Jaffrelot, *Muslims in Indian Cities*.

of planning development that combined Central Asian systems with the traditions of *Vastu Shastra* indigenous to the sub-continent intended to derive advantages of both.

Water Supply

Since ensuring water availability in the cities was a major concern, extensive hydraulic structures were created throughout the sub-continent. Innumerable reservoirs, *hauzes* (tanks), wells, *baolis* (step-well), canals and *karezes* (subterranean water-supply channels) harvested water from a variety of sources including rainwater, river and ground-water to provide a steady supply of water for irrigation and urban needs.

Tanks harvested rainwater through water-control devices that ranged from simple earthen, occasionally stone-clad, check dams across rivulets and streams to advanced ones comprising multiple masonry dams and channels along contours into adjacent sub-watersheds to feed larger tanks.⁵⁴

The Hauz-e-Alai (Hauz Khas) with a catchment area of 24.29 hectares⁵⁵ in the plains of Siri comprised elaborate masonry works for regulating and channelling rainwater from the Aravallis.⁵⁶ Such water resources during Ala-ud-din Khilji's reign (1296–1316) reportedly resulted in incredible prosperity to the Sultanate as well as food sufficiency of Delhi, achieved through intensive agriculture over a hinterland that covered 'a radius of 100 miles around the capital', which is considered as 'one of the great miracles of that time'.⁵⁷

The surroundings of Tughluqabad were transformed into a large lake by sophisticated waterworks that collected rainwater from the ridge.⁵⁸ However, during the dry season, 'the level of water would decrease severely', with the possibility of drying up of the entire lake during a long drought.⁵⁹

A modest monsoon failure in the 1330s resulted in the establishment of some of the most monumental water-regulating structures in Delhi,⁶⁰ for instance, the *Satpula* (seven-arched bridge) comprising seven sluices that formed a 65-metre stretch of the Jahanpanah enclosure.⁶¹

Mughal capitals also reportedly had remarkable waterworks such as Anguri Bagh (Agra) and Kol Lake (Fatehpur Sikri).⁶² The latter, a perennial natural depression towards north of the Sikri ridge, fed by Utangan River (Khari Nadi) and monsoon runoff, was dammed in 1579 by two barrages—Terah Mori (thirteen sluices) and Bawan Mori (fifty-two sluices)—for supply to Fatehpur Sikri. Rainwater harvesting

⁵⁴ Wescoat, *The Water and Landscape Heritage*.

⁵⁵ Narain, *Excreta Matters*.

⁵⁶ Wescoat, *The Water and Landscape Heritage*.

⁵⁷ Kulke and Rothermund, *A History of India*, p. 164.

⁵⁸ Shokoohy and Shokoohy, 'Tughluqabad, the Earliest Surviving Town'; Shokoohy and Shokoohy, 'Tughluqabad: Third Interim Report'; Wescoat, *The Water and Landscape Heritage*.

⁵⁹ Shokoohy and Shokoohy, 'Tughluqabad: Third Interim Report'.

⁶⁰ Pandey et al., 'Rainwater Harvesting'.

⁶¹ Narain, *Excreta Matters*; Wescoat, *The Water and Landscape Heritage*.

⁶² Wescoat, *The Water and Landscape Heritage*.

had particular significance in these cities due to semi-arid climate and brackish groundwater in this region.⁶³

Water harvesting is an age-old tradition in Gujarat, achieved by creating *vavs* (stepwells) or by accumulation of rainwater in natural depressions called *talvadi* (lake/pond/tank).⁶⁴ Tanks were built in large numbers in the cities of Gujarat, such as Palanpur, Ahmedabad, Bharuch, Surat and Vadodara, during the fifteenth century.⁶⁵ Ahmedabad had numerous *vavs* and *talvadis*, apart from the thirty-four-sided *Hauz-i-Qutb* (1451) (now Kankariya Lake).⁶⁶

Hussain Sagar (1562) was the earliest source of water supply to Golconda fort.⁶⁷ Mandu Fort's elaborate rainwater-harvesting systems comprised lotus-shaped pools.⁶⁸

Wells and *baolis* harvested shallow groundwater resources. Since they utilised water-lifting devices such as Persian wheels, they were located amidst dense urban settlements.⁶⁹ Apart from agriculture and urban water-supply, *baolis* were also built to commemorate victories, to provide running water to the gardens⁷⁰ and to seek refuge from the fierce summer heat in their labyrinth of underground chambers,⁷¹ displaying 'a special fondness' of Muslims for water and awareness of 'the cooling effect of tanks and cisterns of cold water within and around their dwellings'.⁷²

Although Firuzabad was founded far north on the Yamuna waterfront for easy access to water⁷³ which filled its moat, a multi-storeyed circular *baoli* within the citadel supplied water for domestic uses.⁷⁴ Shahjahanabad had over 100 *baolis*⁷⁵ and about 600 private and 400 public wells.⁷⁶

Technological improvements in the ancient Indian *araghatt*, the precursor of the Persian wheel for irrigation purposes, made it 'mechanically more sophisticated' by the time Babur arrived in India.⁷⁷

A major development in the irrigation system was brought about by harnessing large rivers. Canals were laid out or repaired to fulfil irrigation and urban water requirements in response to several periods of drought which occurred during the medieval period in India.⁷⁸ 'A double system of canals' was introduced by Firuzshah Tughluq. These canals

⁶³ Rezavi, 'Hydraulics'.

⁶⁴ Tayyibji, 'Ancient Stepwells of Ahmedabad'.

⁶⁵ Gupta and Agrawal, 'Rainwater Harvesting in Ancient Times'.

⁶⁶ Pandey et al., 'Rainwater Harvesting'.

⁶⁷ *Ibid.*

⁶⁸ Asher, *The New Cambridge History*.

⁶⁹ Wescoat, *The Water and Landscape Heritage*.

⁷⁰ Asher, *The New Cambridge History*.

⁷¹ Havell, *A Handbook to Agra*.

⁷² Cousens, *Bijapur*, p. 9.

⁷³ Bloom and Blair, *The Grove Encyclopedia*; Wescoat, *The Water and Landscape Heritage*.

⁷⁴ Wescoat, *The Water and Landscape Heritage*.

⁷⁵ Narain, *Excreta Matters*.

⁷⁶ Mann, 'Delhi's Belly'.

⁷⁷ Rizvi, *The Wonder that Was India*, p. 313.

⁷⁸ Pandey et al., 'Rainwater Harvesting'.

drew water from Yamuna and Satluj rivers.⁷⁹ Excavation of new canals and renovation of old ones such as the Great Western Yamuna Canal improved agriculture and enabled elimination of Delhi's food and water shortage.⁸⁰ The canal was renovated by Akbar in 1568 and was extended further up to Shahjahanabad by Shah Jahan as *Nahr-i-Faiz*,⁸¹ the main source of water to Shahjahanabad, along with *Nahr-i-Bihisht* and *Nahr-i-Hayat*.⁸² Canal irrigation was introduced in the Deccan by Bahamani Sultans. An extensive network of canals was built in Kashmir by Zain Uddin (1420-70).⁸³ These canals were major achievements of the Islamic period and an important feat of medieval engineering.⁸⁴

In most of the cities, water was supplied from a combination of different sources to ensure availability. Tughluqabad had seven reservoirs, three huge *baolis* and numerous wells for water supply.⁸⁵ Several *hauzes* and *baolis* were created in Daulatabad for harvesting rainwater.⁸⁶ Dinpanah was served by numerous wells, a step-well and River Yamuna, whose water filled its moat.⁸⁷ Kol Lake, two underground reservoirs, numerous *baolis*, wells and tanks located on the ridge fulfilled drinking, irrigation and other requirements of Fatehpur Sikri by raising water to the level of the imperial complex atop the ridge in five stages through an intricate system of intermediate storage tanks and wells using human or animal-powered Persian wheels at each stage.⁸⁸ Similar arrangements in Agra supplied water within the fort where three deep tanks on the roof of Shahi *hammam* were filled by water of River Yamuna brought into a well outside the walls, 70 feet below, drawn by *Rehant* (water wheel) near the *khizri* (water gate).⁸⁹ A system of canals, wells and *dighis* (a reservoir with steps and sluice gates) was created in Shahjahanabad. The canals charged the wells, and *dighis* provided water for domestic use.⁹⁰

A unique water-supply system known as *karez* (technology of water harnessing through subterranean channels) was introduced in India by the Bahmani sultans in Bidar due to the ephemeral nature of rivers, unreliable monsoon rains and hard sub-surface strata that rendered drilling of wells extremely difficult.⁹¹ *Karez* (Figure 3), a Persian technology comprising a network of sloping subterranean aqueducts interspersed with vertical shafts for regular maintenance,⁹² harnesses groundwater sources

⁷⁹ Rizvi, *The Wonder that Was India*, p. 206.

⁸⁰ *Ibid.*; Siddiqui, 'Water Works'; Wescoat, *The Water and Landscape Heritage*.

⁸¹ Rizvi, *The Wonder that Was India*; Wescoat, *The Water and Landscape Heritage*.

⁸² Wescoat, *The Water and Landscape Heritage*.

⁸³ Pandey et al., 'Rainwater Harvesting'.

⁸⁴ Siddiqui, 'Water Works'.

⁸⁵ Narain, *Excreta Matters*.

⁸⁶ Rizvi, *The Wonder that Was India*.

⁸⁷ Blake, *Shahjahanabad*; Wescoat, *The Water and Landscape Heritage*; Wescoat, 'Conserving Urban Water Heritage'.

⁸⁸ Bloom and Blair, *The Grove Encyclopedia*; Rezavi, 'Hydraulics'; Sumra, 'Fatehpur Sikri: Ciudad de aguas'.

⁸⁹ Havell, *A Handbook to Agra*.

⁹⁰ Narain, *Excreta Matters*.

⁹¹ Anonymous, *The Karez System in Bidar*; Masani, 'Resurrecting the Karez'.

⁹² Petersen, *Dictionary of Islamic Architecture*.

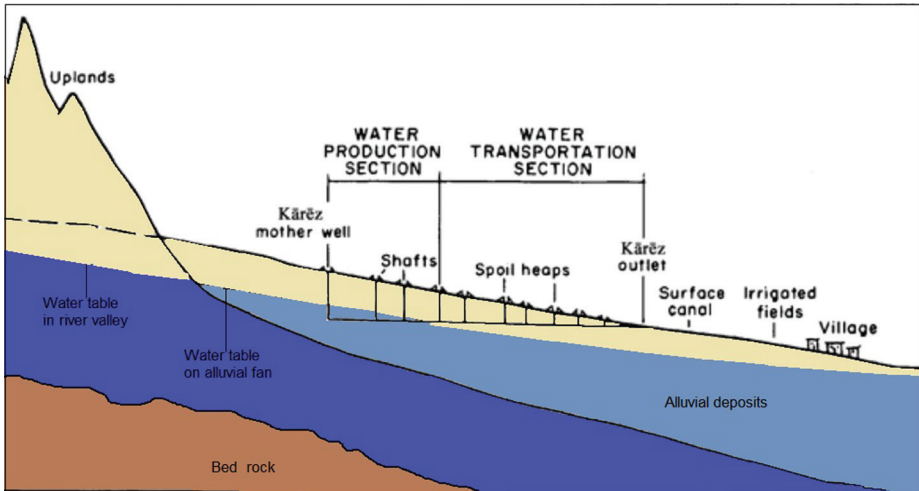


Figure 3. Cross-section of a Karez

Source: Adapted from Planhol, 'Kariz'.

such as natural springs, upland aquifers, lakes or wells and transports water by gravity to settlements.⁹³ Bidar *Karez* comprise six subterranean canals laid in the heart of the rock by widening the natural rift. Similar systems were also established in Gulbarga, Bijapur, Golconda, Burhanpur, Ahmednagar and Aurangabad, though their sources of water varied. In Bijapur, water collected in 16 *Talaos* (lakes) was supplied through subterranean earthen pipes, which also interlinked 200 *bawadis* (step-wells) and 300 wells constructed throughout Bijapur to ensure water availability.⁹⁴ The *karez* system of Burhanpur (1615), a military outpost of the Mughal Empire along Tapti River with enemy territory in the upstream, used natural faults and comprised long lines of sub-surface aqueducts, infiltration galleries and vertical wells that tapped the subterranean flow of water from the underground springs of densely forested Satpura hills to Tapti⁹⁵ despite ample availability of water in this perennial river. Subterranean conduits carried water in *bhandaras* (storage tanks) linking several wells to a collection chamber from where it reached the town through clay pipes within gravity-based tunnels connecting the shafts.⁹⁶ Golconda's semi-arid climate necessitated rainwater harvesting, achieved through a cascading system of tanks connected by a network of subterranean canals for supply, either directly or from open wells recharged by these tanks. In Ahmednagar fifteen channels were dug by the Nizam Shahi rulers for water supply from the bottom of deep wells at the foot of the nearby hills.⁹⁷ The hydrology of the surrounding hills of

⁹³ Anonymous, *The Karez System in Bidar*.

⁹⁴ Siddhanti, 'Water Management and Conservation System'.

⁹⁵ Gupta and Agrawal, 'Rainwater Harvesting in Ancient Times'; Pangare, 'Mughal System'; Wahurwagh and Dongre, 'Burhanpur'.

⁹⁶ Pangare, 'Mughal System'; Wahurwagh and Dongre, 'Burhanpur'.

⁹⁷ Government of Maharashtra, *Maharashtra State Gazetteer*.

Aurangabad comprising basalt formations and numerous natural springs was utilised in 1617 to create Khair-e-Jari or Nahr-e-Ambari (the *karez* system of Aurangabad) for irrigation and domestic water supply. Over fourteen *nahrs* (subterranean earthen pipelines) and numerous smaller concealed cisterns around the city built during 1617–1803 carried cool, potable water to its households, pools and fountains.⁹⁸

*Karez*s not only eliminate possibility of contamination or evaporation loss,⁹⁹ are resistant to disasters particularly earthquakes and floods, are immune to the possibility of intentional destruction in wars, are unaffected by rainfall variations¹⁰⁰ and are sustainable due to gravity instead of energy for a steady flow that has nominal operational costs.¹⁰¹

Ensuring water availability was of immense importance to Islamic cities due to their location atop hills and ridges devoid of a perennial source. This increased their dependence on rain and groundwater for which structures were built based on the prevailing indigenous technologies, which manifested gradual improvement during this period. An extensive network of canals was established in the sub-continent and *karez*, an ingenious Persian technology, was introduced in Deccan cities, to provide sustained availability of water at negligible costs.

Hygiene and Sanitation

Islamic cities were provided with several urban amenities and infrastructure for hygiene and sanitation, at both personal and at community levels. These included *hammams*, toilets, drains and sewers, based on the technologies prevalent in the Islamic world, manifesting a gradual evolution with time.

Hammams

The practicality of *hammams* for ritual ablutions five times daily¹⁰² ensured their location near a mosque, which together became essential components of Islamic cities.¹⁰³ These Islamic variants of Roman *thermae*, differed from the latter in the absence of *frigidarium* (cold plunge pool)—preparatory and foremost in Roman baths—were replaced instead by a cold room located at the end with running water for bathing, which was considered more hygienic than bathing in pools.¹⁰⁴ Introduced in India in the Sultanate period, *hammams* were located in the ‘cool subterranean vaults’ of their palaces,¹⁰⁵ for instance, Tughluqabad, Firuzabad, Bijapur and so on. Although over 100 were built by Firuzshah Tughluq,¹⁰⁶ *hammams* gained popularity during the Mughal period when they were built throughout the sub-continent.

⁹⁸ Joshi, *Indian Archaeology*; Karad, ‘In Aurangabad’..

⁹⁹ Anonymous, *The Karez System in Bidar*.

¹⁰⁰ Masani, ‘Resurrecting the Karez’.

¹⁰¹ Nasiri and Mafakheri, ‘Qanat Water Supply Systems’.

¹⁰² Antoniou et al., ‘Evolution of Toilets’; Maheshwari, *Life of an Afghan Hammam*; Petersen, *Dictionary of Islamic Architecture*.

¹⁰³ Maheshwari, *Life of an Afghan Hammam*; Pal, ‘Demystifying the 18th Century Hammam’; Petersen, *Dictionary of Islamic Architecture*.

¹⁰⁴ Maheshwari, *Life of an Afghan Hammam*.

¹⁰⁵ Cousens, *Bijapur*.

¹⁰⁶ Bloom and Blair, *The Grove Encyclopedia*.



Figure 4. The Hypocaust System at Purana Qila

Source: Deshpande, *Indian Archaeology*.

Water and interior chambers of *hammams* were heated by a hypocaust system (Figure 4) of underfloor heating and circulation of hot air or smoke through channels concealed in the walls, which were released through the chimneys in the roof, without polluting the interior spaces.¹⁰⁷ The temperature gradually decreased from 60 Celsius in the hot chamber to the ambient temperatures outside.¹⁰⁸ Water was heated in large copper pots and supplied through terracotta and copper pipes systematically set into the masonry walls. Wastewater was discharged through open drains in the floor into the city's drainage system.¹⁰⁹

Hammams were not only important to the social life of Muslims but also provided therapeutic benefits, merits of which are found in *Al-Qanoon* (Canon on Medicine) by Ibn-e-Seena¹¹⁰ in 1025. Apart from being the only source for many to clean oneself after a hard day's labour,¹¹¹ *hammams* also provided respite from excessive summer heat.¹¹²

The public *hammams* proved beneficial to a vast majority of the population since running and maintaining a private one was expensive—a luxury available only to royals and nobles. However, due to their heavy-weight masonry construction, extensive use of (hot) water, poor efficiency of water-heating systems and the need to maintain constant and appropriate indoor temperature in the warm and hot rooms year round were unsustainably

¹⁰⁷ Maheshwari, *Life of an Afghan Hammam*; Orehounig and Mahdavi, 'Energy Performance'..

¹⁰⁸ Orehounig and Mahdavi, 'Energy Performance'; Pal, 'Demystifying the 18th Century Hammam'.

¹⁰⁹ Campbell, *Architecture and Identity*.

¹¹⁰ Pal, 'Demystifying the 18th Century Hammam'.

¹¹¹ Maheshwari, *Life of an Afghan Hammam*.

¹¹² Havell, *A Handbook to Agra*.

water, labour and energy intensive.¹¹³ The hypocaust system unearthed at Purana Qila,¹¹⁴ Fatehpur Sikri, Lahore, Srinagar and in the innumerable *hammams* constructed throughout the sub-continent was functional throughout the year by burning wooden logs,¹¹⁵ which were supplied in huge quantity for heating water and internal spaces.¹¹⁶

Toilets

Sanitary installations emerged from bucket privies to squat types of toilets with raised edges or those flanked by foot-rests and a triangular/key-hole-shaped opening in the bathroom floor, connected to sewage pits placed underneath by vertical ceramic drain-pipes, without a flushing system. The pit space was kept hollow for disposal of excreta¹¹⁷ manually by human scavengers.¹¹⁸ To prevent unhygienic conditions, toilets were usually located at remote locations within mosques, *madrasas* (Islamic educational institutions), *sarais*, *hammams* and houses.¹¹⁹ At Champaner, latrines had broad U-shaped structures in series, with small platforms between them for water jars, located invariably near the wastewater drains and built usually on the side of the house or in a corner of the garden, where the soak-pit was located.¹²⁰ However, a *Sandas*-like structure found at Maner, common toilets with soak-pits at Daulatabad¹²¹ and latrines with seats on a raised platform with soakage-pits just below the latrine found at Fatehpur Sikri¹²² reveal their gradual evolution. Such toilets were common even in the cities of the Deccan, for instance, at Golconda where a residential complex unearthed had a bathroom and latrine towards the rear, connected by a covered drain leading into a soak-pit.¹²³ The Mughal forts also displayed toilets akin to present-day flush-type toilets through the discovery of small openings in *hammams* used as toilets that were service latrines of flush types where water passed into them through covered drains, removing waste by water and gravity to the moat.¹²⁴

Drainage and Sewerage

Drainage systems in Islamic cities comprised open drains along streets, which ultimately drained into the city's moat. The ruins of Tughluqabad provide the earliest evidence of drains in an Islamic city in India.¹²⁵ Daulatabad had an 'elaborate drainage system' consisting of 'open channels with their alignments and slopes carefully laid out' with the inner surfaces 'covered with smooth lime-plaster'.¹²⁶ At Champaner, a

¹¹³ Orehounig and Mahdavi, 'Energy Performance'.

¹¹⁴ Deshpande, *Indian Archaeology*.

¹¹⁵ Ishfaq-ul-Hassan, 'Rs. 70 Lakh Spent'; Pal, 'Demystifying the 18th Century Hammam'.

¹¹⁶ Mahdavi and Orehounig, 'Energy and Thermal Performance'.

¹¹⁷ Antoniou et al., 'Evolution of Toilets'; Pathak, *Road to Freedom*.

¹¹⁸ Pathak, *Road to Freedom*; Shyamalal, *The Bhangi*.

¹¹⁹ Antoniou et al., 'Evolution of Toilets'.

¹²⁰ Thapar, *Indian Archaeology*.

¹²¹ Singh, *Indian Archaeology*.

¹²² Tripathi, *Indian Archaeology*.

¹²³ Thapar, *Indian Archaeology*.

¹²⁴ Akhter, 'Gutter History'.

¹²⁵ Bloom and Blair, *The Grove Encyclopedia*.

¹²⁶ Mate, 'Daulatabad'.

drain found in a residential area had sub-drains meeting at right angles at the periphery of the area. Wastewater reached the drains from holes provided in the walls of houses.¹²⁷ Agra's drainage system was intended for rainwater disposal into River Yamuna through open drains along roadsides, underground drains and two canals.¹²⁸ Fatehpur Sikri had 'an efficient drainage and water management system'.¹²⁹ At Shahjahanabad, a network of narrow, open drains throughout the walled city facilitated drainage of storm-water and wastewater into the moat—which itself was a large drain.¹³⁰ Its water, 'stocked with fish',¹³¹ ultimately discharged into River Yamuna.¹³²

Shahjahanabad also had an exceedingly efficient, subterranean network of sewers made of masonry conduits comprising sidewalls of flat-stone and flat-bottomed, unplastered bed. Sewage was flushed by the water from River Yamuna and the canal was facilitated by the natural slope of the bed. The water pressure prevented silting of the drains. Secondary sewers were connected at intervals to the main sewer, which ultimately discharged into the river near Nigambodh Ghat through two smaller drains in front of Red Fort. However, the system deteriorated after the decline of Mughals due to insufficient water and a fall in the water level of Yamuna.¹³³

Refuse collection and disposal

Sanitation in Islamic cities since the Sultanate period was dependent on 'street sweepers to remove refuse using carts and brooms'. Trash and night-soil was collected from the households in the morning by the *mehtars* (manual scavengers), shoved into jute sacks and placed on bullock, horse and donkey carts that arrived at a fixed time, and carried away to the dumps located at the outskirts of the city, where it was trenched for conversion into manure which was used or sold for agriculture.¹³⁴

Street sweepings and refuse from Shahjahanabad, were collected and transported in bullock carts beyond the walls to Malkaganj, where the night-soil was layered with ash and street sweepings and packed in by applying pressure on the heap. Leaves were laid on top, as in a compost heap, to prevent refuse from spreading. Although this system was land and labour-intensive, both were readily available in these cities.¹³⁵

The merits of night-soil trenching was in its requirement of shallow digging, not exceeding a foot to prevent any odour which is absorbed by the earth to deodorize the night-soil, which is spread in the trench as a thin coating not more than two or three inches instead of a foot or more for quick conversion into manure and to prevent failure to amalgamate well with the earth by formation of scum and drying on the surface whilst remaining moist below.¹³⁶

¹²⁷ Thapar, *Indian Archaeology*.

¹²⁸ Bloom and Blair, *The Grove Encyclopedia*.

¹²⁹ Anonymous, *Fatehpur Sikri*.

¹³⁰ Wescoat, *The Water and Landscape Heritage*.

¹³¹ Blake, *Shahjahanabad*, p. 38.

¹³² Wescoat, *The Water and Landscape Heritage*.

¹³³ Mann, 'Delhi's Belly'.

¹³⁴ Prashad, 'The Technology of Sanitation.'

¹³⁵ Prashad, 'The Technology of Sanitation.'

¹³⁶ Voelcker, *Report on the improvement of Indian agriculture*.

Although the Islamic cities used pre-existing solutions of personal hygiene, toilet technology, disposal of refuse, wastewater and sewage in cities,¹³⁷ these manifested significant technological improvement over time based on the needs of the Muslim population.

Construction Materials

Timber was used generously for building construction during the Sultanate period. The ceilings of the public and private audience halls and courts in Tughluqabad were built with timber. Adilabad, connected to Tughluqabad by a causeway, had its Hall of Thousand Pillars with columns of oiled wood and a timber ceiling decorated with paintings.¹³⁸ Adaptability with regard to building materials was manifested in the increased use of stone for building construction due to shortage of timber.¹³⁹

By virtue of their location on rocky ridges and hill-tops, for instance, of Tughluqabad and Bidar, contour-based planning utilised living rocks for fortification, and building stone was quarried on the site, with quarry sites converted to moat and reservoirs that harvested rainwater to fulfil urban water needs. Stone for construction of Bidar's long and winding fort walls was obtained from excavation of its distinctive triple-channelled moat.¹⁴⁰

The use of salvaged materials for construction of buildings was also common during this period. The practice of reusing building materials is evident from the complete physical disappearance of Kilokhri, use of bricks from seven forts built by seven kings (from Iltutmish to Balban) at Rai-Pithora in the construction of Firuzabad¹⁴¹ and demolition and reuse of materials from Siri's surviving structures in Dinpanah.¹⁴²

Selection of sites for Mughal cities such as Fatehpur Sikri, Agra, Delhi and so on over others such as Burhanpur was often determined by the abundant availability of good-quality building stones locally.¹⁴³ Agra was re-established in 1558, replacing the old Pathan brick masonry fort of Badalgarh, with red sandstone from Barauli (Rajasthan).¹⁴⁴

Urban Farms, Orchards, Gardens and Grain Silos

Large areas of gardens, orchards and farms allocated within the cities not only embellished them and added charm to the palaces, but also produced abundant fruits and food grains.

Numerous gardens, orchards and farms within and around Firuzabad transformed it into a garden city.¹⁴⁵ These orchards produced grapes in abundance.¹⁴⁶ Bidar encompassed one of the largest cultivated areas within its fortifications.¹⁴⁷

¹³⁷ Antoniou et al., 'Evolution of Toilets'.

¹³⁸ Shokoohy and Shokoohy, 'Tughluqabad, the Earliest Surviving Town'.

¹³⁹ Rizvi, *The Wonder that Was India*.

¹⁴⁰ Shokoohy and Shokoohy, 'Tughluqabad, the Earliest Surviving Town'.

¹⁴¹ Haider, 'A Lost City in Delhi'.

¹⁴² Haider, 'A Lost City in Delhi'; Petersen, *Dictionary of Islamic Architecture*.

¹⁴³ Havell, *Indian Architecture*.

¹⁴⁴ Anonymous, *City Development Plan Agra*.

¹⁴⁵ Tracy, *City Walls*.

¹⁴⁶ Rizvi, *The Wonder that Was India*.

¹⁴⁷ Shokoohy and Shokoohy, 'Tughluqabad, the Earliest Surviving Town'.

Grain silos were built in the cities to facilitate storage of surplus for distribution during times of siege and disasters such as flood and famine. The presence of a large number of silos in Tughluqabad next to the fortifications is a remarkable precautionary measure against possibilities of famine or sieges by Mongols,¹⁴⁸ which enabled grain distribution during Delhi's famine.¹⁴⁹

Parks, gardens, orchards, farms and granaries were provided within the cities for abundant food supply. Such features provided food security in these cities and made them resilient.

Discussion

In recent decades concern over the depletion of natural resources and environmental pollution has prompted environmentalists like J. R. Kenworthy to sound warning bells to use resources in a sustainable manner since very soon 'the ecological processes that underpin all of humanity's activities on earth (will) become so severely threatened that the situation will pit nation against nation in a struggle to access the remaining ecological services and resources that support life.'¹⁵⁰ Others consider water to be the cause of the next world war. The foremost task for mankind is therefore (a) to prevent environmental degradation, (b) to prevent depletion of natural resources for ensuring their continued availability for future generations and (c) to ensure sustained availability of water in the cities through eco-friendly techniques. Since the onus for these consequences rests primarily upon the cities, a great deal of sensitivity and sensibility is required in their planning, development, management and control such that the vital resources are not exhausted and a healthy environment is ensured.

Through this review of the Islamic phase of urbanism in India some important lessons can be learned with regard to those aspects of urban development that had a detrimental impact on the natural environment and proved to be the root cause of decline of several cities as well as the legacies of sustainable practices, eco-friendly technologies and ecological conservation measures, some of which are immensely relevant at present and are worthy of revival for ecologically sustainable urban development in India.

Urban Environmental Impact

A preference for urban living led to the creation of a large number of cities in the Indian sub-continent during six centuries (from the thirteenth to the eighteenth centuries) of the Islamic period one after the other, with an ever-increasing size. Tughluqabad, for instance, was slightly larger than Siri,¹⁵¹ the latter soon became part of a much larger Jahanpanah (1325)—a walled enclosure around the suburbs of Delhi which also included Rai-Pithora.¹⁵² Firuzshah Tughluq's emphasis on urbanisation resulted in

¹⁴⁸ Shokoohy and Shokoohy, 'Tughluqabad: Third Interim Report'.

¹⁴⁹ Shokoohy and Shokoohy, 'Tughluqabad, the Earliest Surviving Town'.

¹⁵⁰ Kenworthy, 'The Eco-city'.

¹⁵¹ Shokoohy and Shokoohy, 'Tughluqabad, the Earliest Surviving Town'.

¹⁵² Blake, *Shahjahanabad*; Shokoohy and Shokoohy, 'Tughluqabad, the Earliest Surviving Town'.

numerous manufacturing hubs (*karkhanas*) and over thirty new towns including Firuzabad (1354).¹⁵³ The 12-mile periphery of Firuzabad absorbed 18 villages. Its massive stone wall made of rubble masonry encompassed nearly 600 hectares to form an irregular octagon.¹⁵⁴ While earlier Islamic cities such as Agra and Fatehpur Sikri only comprised forts built exclusively for the royal entourage and the army, Shahjahanabad, in striking contrast, was a complete walled city.¹⁵⁵ The Red Fort of Shahjahanabad enclosed an area twice that of Agra Fort.¹⁵⁶ The rapidity of increase in the number of cities as well as their population, the sheer enormity of these cities and their elaborate fortifications encompassing innumerable monumental buildings are themselves evidence of the quantum of resources consumed in their construction.

The most significant impact due to Islamic urbanisation has been on the forests and wildlife. Ever since the construction of Kailughari, where innumerable trees were reportedly cut down and a vast expanse of the Earth was bereft of foliage, much to the agony of Hazrat Nizamuddin Aulia,¹⁵⁷ deforestation for making land available for the establishment of cities became a normal practice, particularly since most of these cities were established on previously unbuilt sites.

It therefore evokes little surprise that huge forests were cleared during the six centuries of Islamic rule in the sub-continent for the establishment and enlargement of settlements, for creation of arable land, for chasing out rebels, for development of roads and for extraction of timber for construction and export as well as for fire-wood.¹⁵⁸ Forests were also cleared to facilitate 'military movement and trade' and to break 'the isolation of villages from the towns'.¹⁵⁹ 'Valleys, low-lying areas and plains' where the rainfall was low 'were the first to be denuded for agriculture', which could be easily done in these areas compared to the forests of moist parts of the sub-continent.¹⁶⁰ The gradual but steady deforestation during the Sultanate period had a marked impact by the beginning of the Mughal period. Evidence of deforestation and aridity due to an already depleting forest cover comes from some powerful indicators such as stifling heat, strong winds and dust experienced by Babur in India. Lack of greenery forbade him to make a garden house in Agra, although compelled to do so later for lack of options.¹⁶¹ This is in sharp contrast to the thick forests encountered along River Yamuna by the Pandavas of the *Mahabharata* era,¹⁶² which had to be burnt to clear land for the settlement of Indraprastha (located just 300 kilometres upstream of Agra and only 3 millennia earlier). During the Sultanate period, except some customary protection of the sacred groves, 'peasants were constantly clearing the forests for settled cultivation,' whereas in some regimes, such as those

¹⁵³ Rizvi, *The Wonder that Was India*, p. 52.

¹⁵⁴ Blake, *Shahjahanabad*.

¹⁵⁵ Asher, *The New Cambridge History*.

¹⁵⁶ Blake, *Shahjahanabad*.

¹⁵⁷ Jaffer, *The Book of Nizamuddin Aulia*.

¹⁵⁸ Rizvi, *The Wonder that Was India*.

¹⁵⁹ *Ibid.*, p. 312.

¹⁶⁰ Rangarajan, *India's Wildlife History*, p. 17.

¹⁶¹ Havell, *Indian Architecture*.

¹⁶² Thapar, *The Penguin History*.

of Muhammad-bin-Tughluq, they ‘were even rewarded for clearing the forest cover in order to make way for agriculture.’¹⁶³ This history of deforestation persisted at a significant rate throughout the Islamic period, particularly with the clearing of dense forests in the Gangetic basin¹⁶⁴ apart from the basins of Yamuna, Chambal and Narmada Rivers.

That timber was already an expensive material and its scarcity an important issue in 1761, when apprehensions about the misuse of timber—much required by the British East India Company for house and ship building—were discussed before Governor’s Council at Fort William in Calcutta¹⁶⁵ and provide evidence of the extent of deforestation due to urban development during the six centuries of Islamic rule.

Hunting, which became a ritual during this period, led to considerable decline in wildlife. Palam—the location of the airport of Delhi—was a hunting ground in 1634, where Shah Jahan hunted ‘black antelopes with the royal gun’.¹⁶⁶ Jahangir, in just the first 12 years of his reign, ‘killed over 17,000 animals’—including ‘889 nilgai, 86 tigers and lions and 1,670 gazelle and antelope’. He possessed 12,000 elephants caught mainly ‘from parts of central India like Hoshangabad, Raisen and Chanderi’.¹⁶⁷ The mountain ranges that were habitats of large wild animals were fragmented due to deforestation,¹⁶⁸ which resulted in their dwindling numbers.

High water consumption in these cities also amounted to a high volume of wastewater generated, necessitating efficient drainage and sewerage systems.¹⁶⁹ However, such services were limited to the capital cities.¹⁷⁰ Despite an advanced level of sanitation in these cities, environmental problems such as contamination of water due to stagnation, piling of garbage or overflow of cesspools near residential areas were common. While sewerage was limited to a few important cities, river courses were used as *cloacae* (open sewers) in most of the cities,¹⁷¹ although river water was used for consumption even by emperor Shah Jahan.¹⁷² The absence of basic amenities such as drainage and water supply made living conditions intolerable. Even cities like Shahjahanabad and Agra—with population exceeding 500,000—appeared unclean, shabby and filthy.¹⁷³ Although horses, elephants and other pack animals provided energy-efficient modes of transportation and communication, animal dung on streets and highways must have been a source of nuisance, necessitating regular cleaning and maintenance. Use of wood as fuel in households, *hammams*, *karkhanas* (industries) and so on must have caused considerable air pollution.

¹⁶³ Swami, *Environmental History and British Colonialism in India*.

¹⁶⁴ Poucheпадass, ‘Colonialism and Environment in India’; Rizvi, *The Wonder that Was India*.

¹⁶⁵ Grove, *Green Imperialism*.

¹⁶⁶ Rangarajan, *India’s Wildlife History*, p. 11.

¹⁶⁷ Rangarajan, *India’s Wildlife History*, p. 14.

¹⁶⁸ Rangarajan, *India’s Wildlife History*.

¹⁶⁹ Sumra, ‘Fatehpur Sikri: Ciudad de Aguas’.

¹⁷⁰ Ramachandran, *Urbanization*.

¹⁷¹ de Feo et al., ‘The Historical Development of Sewers Worldwide’.

¹⁷² Havell, *A Handbook to Agra*.

¹⁷³ Ramachandran, *Urbanization*.

Despite being an egalitarian society that exemplified social inclusion and appreciation of individual and collective rights and responsibilities,¹⁷⁴ Islamic cities in India displayed extreme contrast between rich and poor. The huge forts, the large mosques and the well-planned gardens were largely for the ruling classes and the nobles. Their objective was to showcase pomp, grandeur and might of the rulers in order to subdue the ruled rather than any concern for the welfare of masses. In Shahjahanabad, for instance, larger residences were made of brick masonry, but most of the city comprised small huts made of mud, wood and thatch, where incidents of fire were frequent.¹⁷⁵ Dwellings of 'peasants and urban poor were wretched hovels'.¹⁷⁶ The society was also segregated based on religion, which resulted in a 'cultural hiatus' during this period¹⁷⁷ manifested in the siting and planning of cities, their building types, design, materials used and construction techniques. Also, since the arrival of Muslims in the sub-continent, sweeping and scavenging became a formal profession. Prisoners and slaves were compelled to clean toilets, bucket privies and dispose night soil. These scavengers constituted a separate caste later called *bhangis* (manual scavengers).¹⁷⁸ Marginalisation and social inequality, as chronicled by European travellers, had a profound impact on the environment and ecology in these cities throughout the sub-continent, a misery that has continued till present times.

The Islamic cities contributed to environmental degradation particularly through continuous destruction of both flora and fauna in the subcontinent, consumption of enormous quantities of building materials, extravagance and wastefulness in water use, marginalisation and social inequality in terms of housing conditions and urban amenities, resulting in insanitary conditions, water and air pollution.

Ecological Causes of Decline/Abandonment of Islamic Cities

That the Islamic cities in India were ecologically unsustainable is evident from the fact that many either declined or were abandoned due to ecological reasons, prime examples being Kailughari, Tughluqabad-Adilabad, Daulatabad, Gauda, Bijapur and Fatehpur Sikri. Considering that these were planned cities constructed with enormous resources, an insight into the causes of their decline and abandonment due to ecological factors holds immense significance.

Water scarcity has been cited as the main reason for the abandonment of Tughluqabad-Adilabad, Daulatabad and Fatehpur Sikri.¹⁷⁹ Despite numerous structures for harvesting rainwater from the Aravali ridge, water remained a deterrent for expansion of even Rai-Pithora, since Hauz-i-Shamsi had gradually become insufficient and dried-up due to dams constructed on its feeding channels upstream.¹⁸⁰ Even the

¹⁷⁴ Abu-Lughod, 'The Islamic Cities'; Barau, 'Islamic Instruments'.

¹⁷⁵ Ramachandran, *Urbanization*; Rizvi, *The Wonder that Was India*.

¹⁷⁶ Adas, *Machine as Measure*, p. 42.

¹⁷⁷ Ramachandran, *Urbanization*, p. 51.

¹⁷⁸ Shyamlal, *The Bhangi*.

¹⁷⁹ Narain, *Excreta Matters*.

¹⁸⁰ Ali, 'Capital of The Sultans'; Haider, 'A Lost City in Delhi'.

wells outside Badaun Gate had reportedly dried up.¹⁸¹ Fatehpur Sikri was abandoned due to water scarcity caused by the drying up of Kol Lake in 1585.¹⁸²

Since water was the crucial factor in the siting of these cities, their abandonment due to water scarcity seems ironical, raising doubts on the effectiveness of siting, planning as well as management of their water resources. An investigation of the causes of water scarcity of such enormous proportions that caused abandonment and decline of such meticulously sited and planned cities one after another revealed that water scarcity was the manifestation of a combination of climatic and anthropogenic factors and their consequences.

- Safety and security considerations made hill-tops, ridges and bluffs the most preferred locations for cities. However, such locations also posed challenges in terms of their survivability, water being the most crucial, since they were inconveniently distant from perennial sources of water.
- Rocky surfaces rendered digging wells difficult and groundwater in the region was known to be brackish.¹⁸³ This made the cities, all located in semi-arid regions, heavily dependent on the harvesting of scant seasonal rainfall, which proved inadequate to sustain a large urban population.
- Built on high grounds, these cities were labour intensive since sophisticated technologies were necessary for raising water to the required height using human/animal power for maneuvering.¹⁸⁴ Much importance is attached in their abandonment to the maintenance of the systems of water supply to hill-top cities, for instance, Fatehpur Sikri, where water was raised in five stages by mechanical means and perhaps with Akbar shifting his court; the authorities responsible for maintenance of such an elaborate and labour-intensive system also vanished.¹⁸⁵
- The Islamic cities were characteristically water intensive. Regular supply of water was required within and around the cities for various functions in palaces and households, innumerable private and public *hammams*, orchards, gardens, farmlands, moat(s) and in Shahjahanabad for flushing sewers—each vied for the limited quantities of water available. Considered as a gift of nature by Muslims, this resource was used extravagantly and wastefully, particularly by the elite,¹⁸⁶ that went beyond primary urban water needs. Enormous quantities of water was supplied on regular basis in each city to cater to urban water requirements.
- Also, there were reportedly several modest monsoon failures in the past, as a manifestation of climate change, including the decades in which some of the important cities were abandoned (1330s, Tughluqabad-Adilabad and Daulatabad and 1590s, Fatehpur Sikri).¹⁸⁷ Deforestation may have caused disruption of hydrological cycle, increased frequencies of disasters such floods and droughts

¹⁸¹ Ali, 'Capital of The Sultans'.

¹⁸² Havell, *Indian Architecture*; Petersen, *Dictionary of Islamic Architecture*.

¹⁸³ Bloom and Blair, *The Grove Encyclopedia*.

¹⁸⁴ Rezavi, 'Hydraulics'.

¹⁸⁵ Sumra, 'Fatehpur Sikri: Ciudad de Aguas'.

¹⁸⁶ Rezavi, 'Hydraulics'.

¹⁸⁷ Pandey et al., 'Rainwater Harvesting'.

and an increase in the rapidity of climate change, which could be a major reason for climate-change-led modest monsoon failures reported by Pandey et al.¹⁸⁸

- Despite numerous water-harvesting structures built in these cities, those located in rocky areas with low retention and recharge capability and high evaporation loss due to heat and aridity that led to the shrinking of forest cover during continued drought would have caused the harvested water to evaporate rapidly and ultimately their drying up.
- Continued drought must have acutely affected agriculture and the surplus on which the cities depended. An important consequence of water shortage was famine which was another major reason for the decline and abandonment of Tughluq-era cities¹⁸⁹ within a span of just a decade (1330s).

Such water scarcity in the face of the rising population was perhaps a compelling reason for the siting of Shahr-i-naw along River Yamuna at Kailughari where water was available perennially.¹⁹⁰ However, proximity to the River, which had a history of destructive flooding in this particular area, and distance from Rai-Pithora, not only caused its abandonment¹⁹¹ but also prevented the next few cities of Delhi such as Siri, Tughluqabad, Adilabad and Jahanpanah to be built along its banks until Firuzabad was founded—once again along Yamuna River, but far north of the Delhi triangle where flooding was perhaps less violent and where water availability was ensured from the River as well as a canal. Subsequent cities including Shahjahanabad were built along Yamuna River further north for safety from floods.¹⁹²

Water was the most crucial factor in the planning of Bijapur, abundantly supplied throughout the city by means of *karez* systems.¹⁹³ Yet due to 'inadequate water supply in the dry season' the seat of government was proposed to be shifted in 1599 to its new suburb of Nawraspur.¹⁹⁴ Increased frequency of droughts led to creation of two reservoirs in 1633.¹⁹⁵ A virulent type of bubonic plague erupted in Bijapur in 1688 claiming 150,000 persons or half the city's population caused commencement of decline of the city. Two severe famines – the scull famine in 1718, which continued for six years and decimated the city's population, and the second in 1818-19 – reduced this flourishing city's population to just a 1000. Bijapur remained ruined and desolate since.¹⁹⁶ Although there was water available within the city there was no vegetation or trees around the capital and a lack of water on the route. A severe plague outbreak ended half the city's population.¹⁹⁷

Another major city that declined due to ecological factors was Gauda, located along River Ganga in Bengal and among the two initial pivots of Islamic rule. Although

¹⁸⁸ *Ibid.*

¹⁸⁹ Shokoohy and Shokoohy, 'Tughluqabad, the Earliest Surviving Town'; Rizvi, *The Wonder that Was India*.

¹⁹⁰ Haider, 'A Lost City in Delhi'.

¹⁹¹ Tracy, *City Walls*.

¹⁹² Asher, *The New Cambridge History*.

¹⁹³ Petersen, *Dictionary of Islamic Architecture*.

¹⁹⁴ Burton-Page, 'A Study of Fortification'.

¹⁹⁵ Pandey et al., 'Rainwater Harvesting'.

¹⁹⁶ Bosworth. *Historic cities*.

¹⁹⁷ Ray, *Towns and Cities*.

catapulted to ‘one of the greatest cities of India in the sixteenth century’ under the Mughals,¹⁹⁸ Gauda reportedly deteriorated due to weather, earthquakes, a great plague in 1576¹⁹⁹ and an effective reclamation of forests and wastelands by its rulers for intensive rice cultivation. Change of course of River Ganga due to the siltation caused its demise by the end of the sixteenth century.²⁰⁰

Dearth of irrigation infrastructure due to lack of maintenance and repair caused the decline of agriculture during Aurangzeb’s reign. Cultivation was minimal and undertaken only under compulsion.²⁰¹ Extensive warfare after his death ‘exacerbated natural calamities; famine, disease and banditry spread across the subcontinent’ causing degeneration of once prosperous cities and towns.²⁰²

Whatever the reasons, abandonment of several cities in quick succession during this period resulted in a tremendous waste of resources. Exhaustion of resources also caused the ultimate decline of the Mughal Empire.

Sustainable Practices and Ecological Conservation Measures

Sustainable practices in Islam began with Prophet Muhammad, which was propagated through *Sharia* (the Islamic cannon of law), where ecologically oriented requirements are outlined for the design of human settlements aimed at protecting the environment and ensuring ecological sustainability.²⁰³ Numerous environmental conservation measures and eco-friendly technologies were adopted in the Islamic cities to ensure their survival.

The Indian Islamic cities comprised several features, practices and techniques that were positively integrated with the natural environment and were ecologically favourable. Advancement in many existing technologies was also brought about in this period.

Unlike those established earlier, the Islamic cities in the Indian sub-continent were characteristically built on high grounds or within valleys surrounded by hills on all sides, which provided greater security, immunity from annual floods, protection from river actions such as erosion and cutting of banks as well as respite from mosquitoes.

However, the foremost feature that made these cities ecologically sustainable was their compact and densely built environment.²⁰⁴ Narrow winding streets and lanes with two- and three-storeyed buildings on both sides provided mutual protection by cutting off the exposure to heat which predominated most parts of the year. They also enabled ready access to services and facilities with minimal energy required for transportation since they could be easily traversed on foot. Houses had courtyards, terraces and gardens with fountains and water channels, for a cooling effect, while the interiors were well lit and well ventilated, revealing that houses and buildings were designed to suit to the climate. These effects were enhanced with the application of *Vastu Shastra* in

¹⁹⁸ Havell, *Indian Architecture*, p. 123.

¹⁹⁹ Havell, *Indian Architecture*.

²⁰⁰ Eaton, ‘Islam in Bengal’.

²⁰¹ Wescoat, *The Water and Landscape Heritage*.

²⁰² Adas, *Machine as Measure*, pp. 95–96.

²⁰³ Barau, ‘Islamic Instruments’.

²⁰⁴ Saoud, *Introduction to the Islamic City*; Wahurwagh and Dongre, ‘Burhanpur’.

the planning of the cities, particularly to maximise benefits of the prevailing winds as well as solar radiation. Therefore these cities utilised the positive aspects of both Hindu and Islamic systems of planning, as exemplified in Daulatabad, Fatehpur Sikri and Shahjahanabad.

Cities such as Daulatabad²⁰⁵ and Shahjahanabad²⁰⁶ had densely packed *mohallas* (residential quarters), determined by ethnicity, class and occupation.²⁰⁷ While such divisions of residential areas have variously been criticised, the ‘system kept alive not only the traditional arts and crafts but also a cohesive community’, generated ‘a model of self-sufficiency’.²⁰⁸

However, it was in ensuring the availability of adequate water to cities, where the use of some of the most eco-friendly techniques have been observed. Challenges posed by water scarcity led to considerable technological development during the medieval period in India. A large number of hydraulic structures such as step-wells, numerous reservoirs and dams were created throughout the sub-continent as eco-friendly and sustainable means of harvesting rain, river and groundwater. Despite the lack of alternative sources of water, it was efficient rainwater harvesting which made Rai-Pithora flourish as the ‘forest capital of the Sultanate’ when other newly created Islamic cities either declined or were abandoned.²⁰⁹ Hauz-i-Shamsi was re-excavated by Ala-ud-din Khilji and the upstream dams were demolished by Firuzshah Tughluq to ensure water supply. Firuzshah also built canals and waterworks in Firuzabad, making it the first Islamic city without water problems.²¹⁰ The creation of such varied systems ensured that water was harnessed from a combination of sources—groundwater, river water and rainwater—to prevent depletion of any particular source.²¹¹ The quest for sustainable sources of water supply led to appreciation of wisdom of prevailing indigenous systems.

While most of the techniques during the medieval period manifested a continuity in the use of time-honoured indigenous technologies prevalent in the sub-continent, it was the introduction of energy-efficient and eco-friendly Persian technology—*Karez*—in the Sultanate capitals of Deccan for urban water supply that is the highlight of ecological sustainability during this period. These waterworks stand testimony to the sophistication of engineers of that period. The apt use of topography in the siting of cities (within fertile basins amidst hills instead of hill-tops) in Deccan such as Gulbarga, Bidar and so on that favoured introduction of *karez* technology in these cities ensured their survival despite similar problems that gripped the cities of North India in those times.

Innumerable *hamams* and toilets in residential as well as public buildings reveal emphasis on personal hygiene. Drains for discharge of wastewater and the water-borne

²⁰⁵ Rizvi, *The Wonder that Was India*.

²⁰⁶ Gayer and Jaffrelot, *Muslims in Indian Cities*.

²⁰⁷ Saoud, *Introduction to the Islamic City*.

²⁰⁸ Sinha, ‘Learning from Precedents’.

²⁰⁹ Pandey et al., ‘Rainwater Harvesting’.

²¹⁰ Tracy, *City Walls*.

²¹¹ Sumra, ‘Fatehpur Sikri: Ciudad de aguas’.

underground masonry conduit sewer network of Shahjahanabad²¹² established by mid-seventeenth-century depict an advanced level of sewerage developed in an Islamic city in India. In these aspects, the medieval Indian Islamic cities were far advanced when compared to the European cities in those times, which were grappling with unsanitary urban environments due to excreta being dumped on streets and outbreaks of plague as a consequence. For these reasons, this period in Europe was also known as the 'Dark Ages'.²¹³ The first sewer system was established in a European city two centuries later.

Tree plantation along roads and highways initiated by Sher Shah Suri and Jahangir was intended to bring respite to travellers from the sweltering heat, dust and strong winds. Some forests were reserved for hunting by the royals, which resulted in their conservation. Establishment of *char-baghs*, gardens, orchards and intensive farming within the cities are among the major contributions of Islamic cities to urban ecology since some of these have lasted as pockets of greenery within the heavily built-up cities of present times as their most tangible legacies much valued for their eco-system services, which otherwise would have similarly been engulfed by habitation.

This review of Islamic cities has revealed some important ecological considerations in their planning and development and displays several environmental conservation measures and management practices adopted. Features such as compact, dense urban layouts, amalgamation of Islamic and Hindu systems of planning, use of locally available materials for construction of monumental buildings and elaborate fortifications and initiatives such as tree plantation, laid-out *char-baghs*, gardens and orchards, the excavation and repair of several perennial canals and establishment of innumerable hydraulic structures for rainwater harvesting reveal ecological considerations in their urban planning. Networks of drains, soak-pits and sewers (in Shahjahanabad) catered to health, hygiene and sanitation within the cities. Parks, gardens, orchards, farms and granaries were provided within the cities for abundant food supply. Amenities such as *hammams*, toilets, drains and sewers not only improved the health and well-being of urban dwellers and improved the quality of life in these cities but also had a profound impact on the prosperity of these cities. These interconnected eco-friendly systems established based on geographical, geomorphological and climatic considerations transformed some of the cities, for instance, Firuzabad and Shahjahanabad, into garden cities and ensured the survival of others such as Rai Pithora, Ahmednagar, Bidar, Bijapur and Aurangabad, located in semi-arid regions devoid of perennial rivers and the presence of difficult sub-surface geology.

Contemporary Relevance

This review on the environmental and technological aspects of medieval (Islamic) cities in India provides credence to the fact that urban development without concern for the natural environment results in abandonment and decline. Despite ecologically oriented principles for siting, planning and resource use in various aspects of urbanism adopted in Islamic cities, there were practices and techniques that proved detrimental

²¹² Mann, 'Delhi's Belly'.

²¹³ Douglas, *An Environmental History*.

to the natural environment, making cities ecologically unsustainable to the extent of being the most important reasons for their decline.

However, these cities have also demonstrated some exemplary sustainable practices, technologies and conservation measures adopted/introduced in these cities in response to ecological factors. These sustainable practices are important facets of Islamic cities in India offering great lessons to the urban planners of present day with respect to those practices that should be avoided and those that must be retained, implemented and proliferated, with state-of-the-art technological improvements, if necessary, to make Indian cities ecologically sustainable.

Among the practices that were detrimental and should be avoided is wastefulness of water, since it is one of the most important natural resources that must be conserved in order to ensure urban sustainability. Wastewater must be treated in eco-friendly ways and reused to reduce the pressure on municipal water supply. Deforestation is another phenomena which should be avoided at any cost, with replenishment, particularly in cities, by way of parks, gardens, urban farming, roadside plantation and so on. Deforestation is known to cause a chain reaction as it amounts to destruction of the associated life forms, acceleration in the rate of soil erosion, hampering of economic and eco-system benefits and most importantly contributes to global warming.

Inequality in urban areas must be removed and access to urban amenities must be provided to each and every citizen. Though a task of mammoth proportions in a densely populated country like India, it will amount to overall improvement in health, hygiene, sanitation and ultimately the quality of life of urban dwellers.

Compact, high-density cities favour ecologically sustainable development as well as make Mass Rapid Transit Systems (MRTS) in urban areas the most viable and economical transport option, when compared to urban sprawl.

The *hammams*, which offered therapeutic and social benefits, particularly to those who were unable to afford this luxury within their homes, also deserve a revival. The *hammams* need to be made water and energy efficient by using modern techniques of water and space heating, thermal insulation,²¹⁴ renewable sources of energy as well as treatment and recycling of wastewater. Retrofitting of the Islamic period *hammams* such as the recent restoration of the 393-year-old Shalimar *hammam* near Dal Lake²¹⁵ also has the potential to boost tourism.

Regular availability of adequate water for diverse but vital urban functions is a cause of concern since it has been predicted that the next world war will be fought for water. While canals are already a major source of irrigation in the country at present, community-level tanks and lakes are also being revitalised since they harvest rainwater and are eco-friendly techniques for irrigation and water supply in view of the present and estimated shortage of water in Indian cities. Rainwater harvesting is indeed a part of government policy. Protection and restoration of the unique *karez* technology, one of the most ecologically sustainable practices found in just a few cities in the Deccan region, from extinction in India, has been initiated in recent years in Bidar through rejuvenation of Naubad and Jamuna Mori channels²¹⁶ as a recognition of its ecological

²¹⁴ Orehoung and Mahdavi, 'Energy Performance'.

²¹⁵ Ishfaq-ul-Hassan, 'Rs. 70 Lakh Spent'.

²¹⁶ Masani, 'Resurrecting the Karez'.

sustainability. While one may lament that such an ecologically sustainable and resilient technology was installed in only seven cities within the sub-continent located in Deccan, according to Planhol,²¹⁷ favourable topography and hydrology existed in several areas in the Gangetic plain for such developments. The merits of this technology, particularly disaster resistance, ecological sustainability and invulnerability to pollution and seasonal fluctuation, make it a highly sustainable and cost-effective water-harnessing technique.

Indian cities are facing a major crisis that is threatening their environmental sustainability. It has also emerged as a source of conflicts. Experts are predicting water scarcity 'to become Asia's defining crisis by midcentury' that can potentially compromise India's prosperity, 'stoking new interstate tensions over shared basin resources'. It is the most critical resource, which has no substitute.²¹⁸ Exploration of suitable topography and hydrology needs to be undertaken for further development of *karez* technology in India. These eco-friendly technologies are especially important in fulfilling the urban and irrigation needs since climate change is likely to pose fresh challenges due to its impacts on the hydrologic cycle.

Recycling and reuse of wastewater, use of renewable energy, eco-friendly techniques of solid waste management, sustainable landscaping and so on are important aspects of ecological sustainability of cities. Building inclusive cities by providing quality housing at affordable prices by the use of cost-appropriate building materials and techniques, regular supply of potable water and availability of basic infrastructure to every citizen are also keys to ecological sustainability. Use of intelligent technologies can strategize sustainability. Feature and phenomena that proved detrimental to ecology must be curbed.

This review is neither comprehensive nor complete in terms of both spatial or temporal coverage of cities and environment or technology. Instead it is intended to provide an overview based on the most significant cities, developments, degradations, important changes and improvements in technology that came about during this period as well as legacies that deserve revival towards contemporary urban development. The authors hope that this review will be appreciated for its attempt towards better understanding planning and development in the cities in the context of environmental conservation and management and an important contribution towards triggering future researches with regard to eco-friendly technologies towards making Indian cities ecologically sustainable based on the concepts applied in medieval (Islamic) cities in India.

Conclusion

Authors have presented a comprehensive, original review of Islamic cities in India with regard to environment and technology. This article has ascertained the major ecological concerns of these cities by identifying and examining the characteristic features that were entwined with the environment.

²¹⁷ Planhol, 'Kariz'.

²¹⁸ Chellaney, *Water*, p. 1.

Some of the important findings of this review are the following: (a) water had a dominant role in the establishment of these cities, (b) gardens, canals, water-harvesting structures and sanitation were important characteristics of these cities that were profoundly integrated with the natural environment, (c) despite numerous environmental conservation measures adopted, several cities declined or were abandoned ironically due to environmental factors and (d) in response to the natural environment, some exemplary eco-friendly technologies were introduced that are worth considering to make contemporary Indian cities ecologically sustainable.

The authors have also examined the environmental factors that contributed to the decline of some of the important cities constructed with huge resource and planning inputs and have concluded that while the major cause of decline of these cities was water scarcity, this scarcity was a result of the combined effect of a number of factors.

The authors have highlighted those practices and techniques adopted in these cities that were detrimental to the natural environment as well as those that proved beneficial and made the cities ecologically sustainable. Some of these eco-friendly techniques have not only long served as models for subsequent development and roused interest in present times but are also worth revival and exploring possibilities of extending them to other regions to make contemporary Indian cities ecologically sustainable.

Since water scarcity was the most important reason for decline of these cities, a major finding of this review is *karez*, the Persian-origin technology which is immensely sustainable and cost effective and resilient. Although provided in just a handful of Islamic cities in Deccan, it is worthy of revival and adoption for ecologically sustainable urban development in India since it has the potential for development elsewhere in India.

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