

In Praise of *Qanats*: Towards an Infrastructural Urbanism in Yazd

VINAYAK BHARNE

University of Southern California

BIAYNA BOGOSIAN

Columbia University

The mainstream perception of urban infrastructure as a utilitarian footnote has denied it of any larger role in the process of city making. Over the last decade, however, emerging rubrics such as “Infrastructural Urbanism” and “Green Infrastructure” have challenged this reading. In attempting to merge the technical and representational qualities of city making, they have suggested conceptual frameworks wherein public works such as utilities and roads are not simply functional constructs to be worked around, but active agents in the design of the built urban environment. They have re-conceived the idea of reading infrastructure not through its performance efficiency, but through its intersection with geography, ecology, architecture and place.

This intersection has seen various formal and methodological paradigms. Projects such as Stan Allen’s kilometer-long Taipei waterfront are visionary and polemical in their engagement of existing infrastructure.¹ Here, the existing flood control wall is replaced with a system of elevated levee structures organized by a serpentine crest creating a variety of spaces and programs along the waterfront. Others such as William Morrish and Catherine Brown’s enrichment exercise for Phoenix, Arizona offer grass-root approaches.² Here, the amelioration of public infrastructure through public art results in a new cognitive system, ameliorating the vast distances of modern sprawl by co-opting the very transportation and irrigation networks that have

enabled it. Such efforts however diverse are unified in their approach to infrastructure as a catalyst for generating urbanism.

This paper intends to expand the rubric of intersecting infrastructure and urbanism through a slightly different question: What is the role of vernacular infrastructure in contemporary city making? In a time when the re-emergence of sustainable prerogatives has re-surfaced vernacular urban traditions as didactic formal and methodological constructs, can vernacular infrastructure transcend the perception of mere anachronism and offer practical alternatives towards sustainable and holistic habitats?

The setting for this exploration is the city of Yazd in Iran, located at the confluence of the Dasht-e-Kavir and the Dasht-e-Lut deserts.³ Despite its notorious historic cityscape of lanes, domes, terraces and wind-towers, the ingenuity of its urban workings remains relatively less known. Buried beneath this compact desert habitat lies an ancient network of water channels stretching some 10 miles from the urban core. They tap water from the distant mountain aquifers and guide it into the peripheral fields, the subterranean reservoirs within the fabric, and eventually the individual wells and tanks within the monuments and dwellings. If Rome had its aqueducts and Spain its *asequias*, then Yazd has its *qanats*, an antediluvian web of dendritic hydro-infrastructure that explains its seemingly counterintuitive origins and sustenance away from a river, lake or stream.⁴ In this sense the entire historic city of

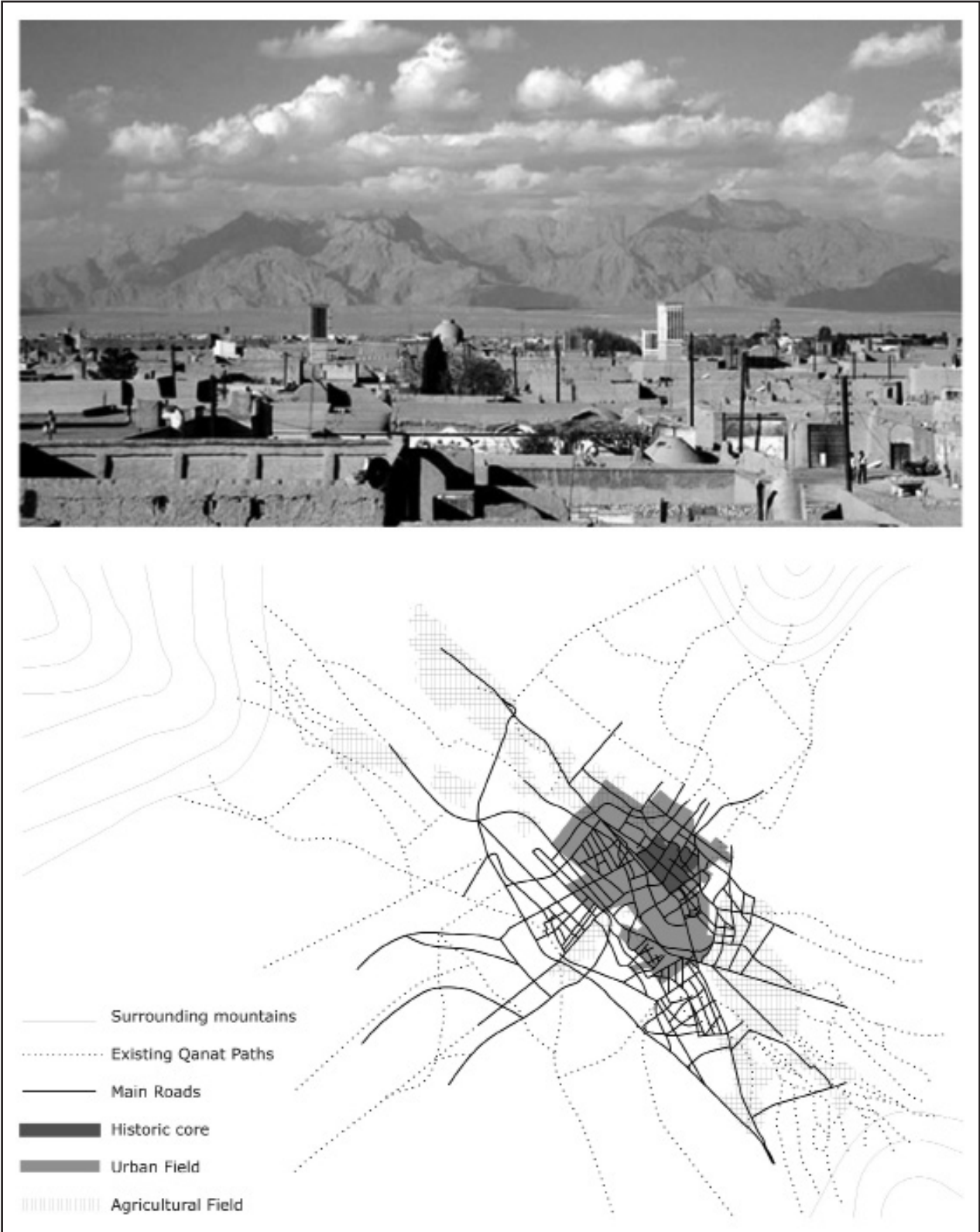


Figure 1 - Above: Historic cityscape of Yazd with Zagros Mountains in the background (Photo by Brian McMorrow). Below: Current morphology of Yazd (Drawing by authors).

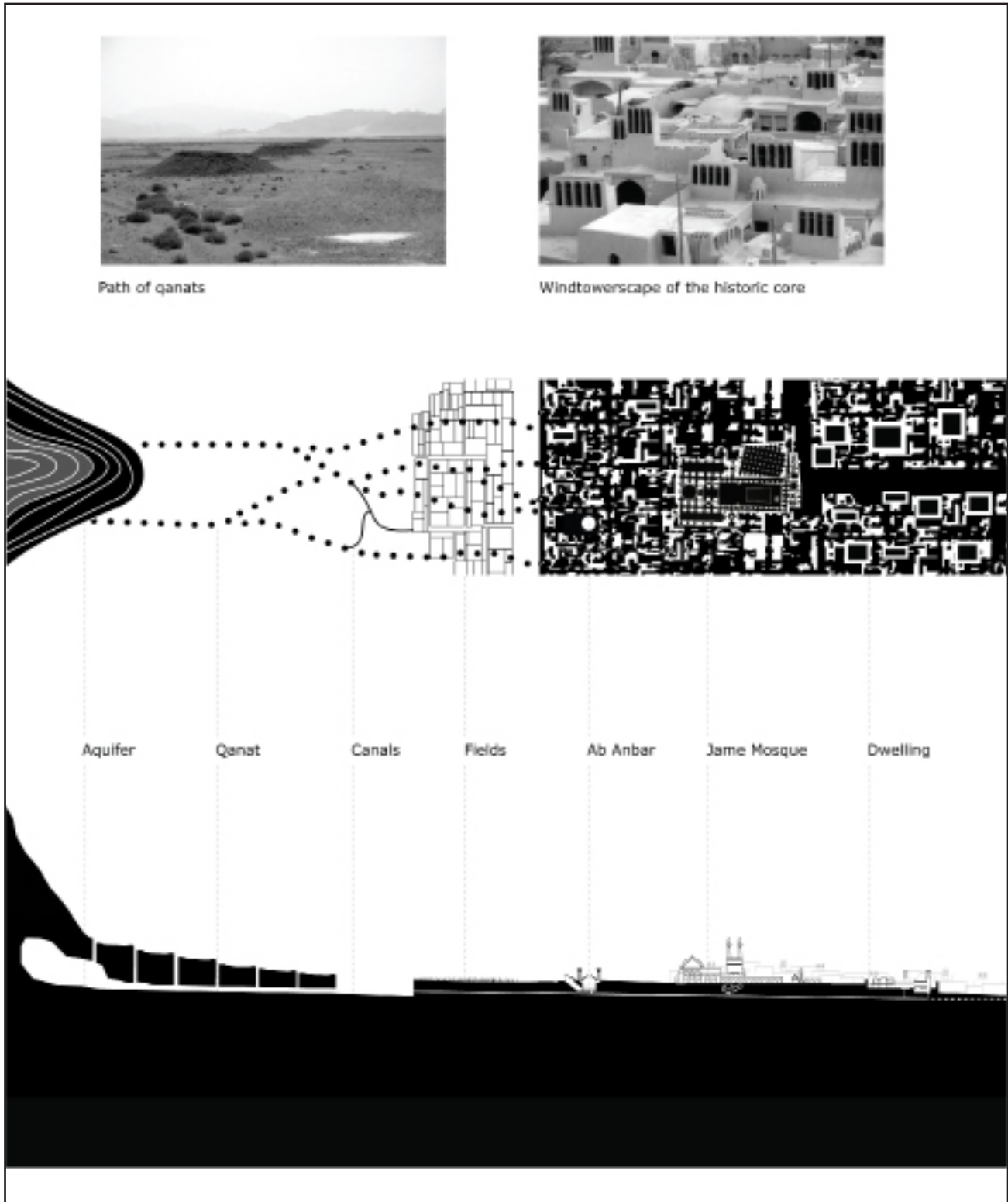
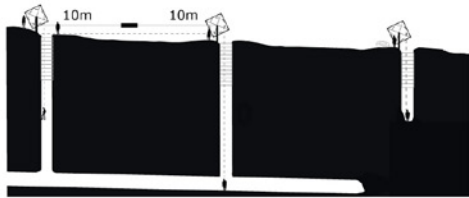


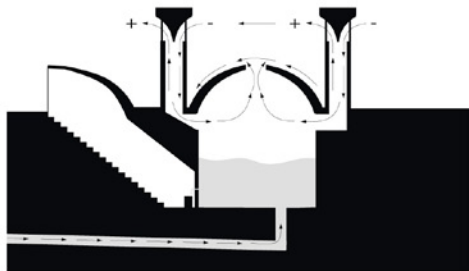
Figure 2 – The Qanat Transect (Photos by Dr. Masoud Abtahi. Drawings by authors)



Construction process of qanats



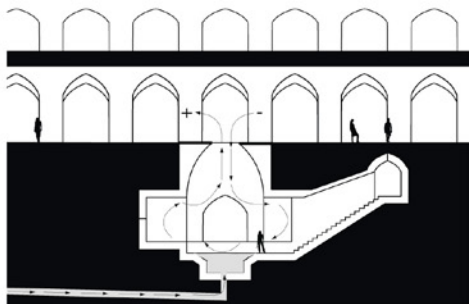
Stone lined qanat



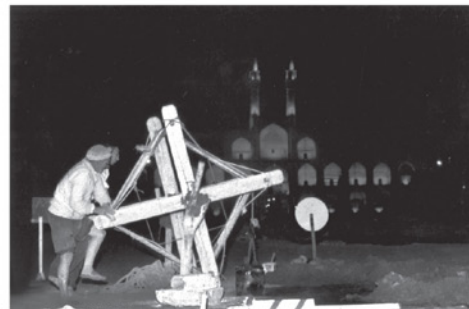
Structure of the Ab Anbar



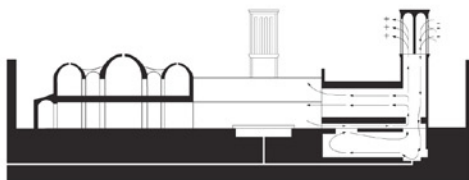
Ab Anbar



Public tank below Jame Mosque



An active qanat in front of the Jame Mosque



Section through typical dwelling



Typical dwelling in the historic core

Figure 3 – Components of the Qanat Transect (Photos by Dr. Masoud Abtahi. Drawings by authors)

Yazd can be read as a natural to urban infrastructural transect unified by the *qanat* (Figure 1).

Today Yazd is a sprawling metropolitan landscape some thirty times its historic size. Its *qanats* remain largely limited to its historic core affirming their losing battle against modern infrastructure. Yet as a dominant preservationist and environmentalist subject - with ongoing attempts to renew this ancient knowledge base - they also stand at the critical juncture of Yazd's past and future. Studying the *qanats'* potential is therefore not just about contemplating Yazd's future, but also about the cultural dilemmas of tradition versus modernity, characteristic of several cities across the world.

This paper is structured in three parts: The first examines the *qanat* in retrospect, re-evaluating its presence as more than a utilitarian construct with social and civic dimensions. The second explores the status of the *qanat* today and the reasons for its decline. The third reflects on the *qanat's* future, going beyond the linear preservationist rhetoric into dialogues on engaging vernacular systems and processes into contemporary urban practices.

THE QANAT IN RETROSPECT

Yazd's *qanats* have evolved over centuries with the overarching goal of transferring water from source to destination while minimizing evaporation and retaining potability. This is a significant challenge in Yazd's hot, dry climate, where its distance from the Oman Sea and Persian Gulf results in minimal rain and high evaporation. Diurnal temperatures fluctuate from 50 to -20 Celsius within 24 hours, and seasons vary from a long hot summer (mid-March to mid-September) to a cold winter (October to February). However, the Zagros Mountains crossing the province gather snow in the winters and trap water in their crevices forming a subterranean aquifer. This is where the *qanat* transect takes its birth.

The traditional process of *qanat*-making began in the mountains. Experts surveyed the mountain vegetation and soil deposits mapping potential water sources. Digging typically began prior to the cold and wet season before a fresh annual installment of mountain-water had been generated. *Qanat*-builders typically worked in two pairs: one pair did the excavation, the other using wooden windlasses and leather buckets, removed the soil and

piled it around the opening. The diameter of a typical opening was no larger than 3 feet, but depths varied from 50 - 300 feet depending on the location of the existing aquifer.

The next step was the construction of the horizontal subterranean channel to guide the flow of water. With the depth of the source-well determined by a rope, vertical shafts of successively increasing depths were dug at 150 foot intervals and oriented towards the desired flow direction. Their first 20 feet or so would be reinforced with baked clay hoops and bricks to avoid landslides. These shafts were then horizontally connected by subterranean tunnels some 3 feet wide and 6 feet high, typically sloped at around 1:1000 feet to ease flow.⁵ The length of a *qanat* thus resulted from both the quantity of water within the aquifer, and the relative destination and topography of the concerned terrain. It could range anywhere from 1 to 10 miles. Its first destination was the agricultural fields surrounding the historic city, where the water was collected within open-to-sky ponds and distributed into the various agrarian lots on a carefully monitored basis. The remainder was directed towards the city.

Historically, the first contact of *qanat* and city happened at *ab anbars*, subterranean cylindrical reservoirs designed to stabilize a low water temperature, withstand water pressure and resist earthquakes. Typically, a linear stairway descended from the *sardar* (entry) to the *pasheer* (platform) at the foot of the faucet used to retrieve the water. The specific faucet depth determined the water temperature, with some *ab anbars* accommodating multiple faucets at various intervals along the stairway. A semi-circular brick-lined dome with central escape vents helped cool the water through convection while protecting it from dust and pollution.⁶ And *badgirs* (wind catchers) helped maintain fresh air circulation and prevent water deterioration. No one was given direct access to the water; it was always drawn beneath the ground level using the *pasheer*, thereby minimizing water contamination.

These *Ab anbars* played a pivotal role in the urban structure of Yazd. Distant *qanats* split into a distribution network of smaller canals called *karez* bringing water to a hierarchy of city-center and neighborhood-specific *ab anbars*. Their specific locations within this hierarchy determined both their size and character: smaller neighborhood reser-

voirs were usually endowed with fewer *badgirs*; larger city-center reservoirs often served by six or more. Each *ab anbar* provided water to a limited number of streets and houses, defining a distinct community shed around it.⁷ While there are no verifying records, it is apparent that the formal complexity of Yazd's historic communities was in fact ordered around existing *qanats* and *ab anbars*. Each dwelling was located within easy reach of their only water source, the community incrementally evolving around this infrastructural armature. As evident from the extant examples within the historic core *ab anbars* thus configured the formal structure Yazd's historic neighborhoods in as much as its numerous mosques and *madrassas*.

As the *qanat's* eventual destinations, Yazd's traditional dwellings each had their own domestic *ab anbars* located within enclosed courtyards. They held around 50 cubic meters of water. They would be filled once every two weeks, and cleaned of sediments once a year. When a domestic *ab anbar* needed filling, the *meerab* (local water manager) would record the formalities and open up the specific *qanat* or *karez* from the reservoir leading to the dwelling.⁸ The water would first fill the pool within the courtyard, and then the storage tanks located in the basement.

The spatial organization of the dwelling was a climatic diagram of summer and winter spaces centered on this domestic water source. In the hot, dry summers, inhabitants spent the day in the cooler basements connected to the *badgirs* (wind towers), or in the vaulted summer rooms around the courtyard oriented north to keep the sun away. At night they would sleep on the roof under warm quilts while the cool night winds would circulate through the open doors and wind-catchers, drawing the heat from within the house. In winter, the wind catchers were closed off to prevent heat loss. The activity shifted to the south-facing winter rooms around the courts. Their glass doors captured the low winter sun storing heat within their thick walls helping to maintain a warmer temperature during the cold nights.⁹

Yazd's infrastructure network thus had larger formal and social dimensions. The *qanats* that brought water depended on and thereby nurtured the guilds that made, monitored and maintained them. The *ab anbars* as visually conspicuous urban artifacts were the centers and local monuments of

various communities. And the *badgirs* and domes, beyond their climatic dimensions, marked the desert town's distinct roofscape. As an infrastructural system unifying the regional and dwelling scales, Yazd's *qanats* represented a complex intersection of urbanism, formalism and capitalism and all in one (Figures 2 & 3).

THE QANAT TODAY

By 1500 CE, the historic core of Yazd had expanded to more than twice its size, avoiding the northern desert and dissolving into the outer agrarian villages. Further growth continued due south-west until circa 1925, and by 1979 (towards the end of the White Revolution in Iran) it had enclosed the historic core to the east and west. Over the last three decades, rapid urbanization has transformed Yazd into a sprawling modern city some thirty times its original size.

But amidst this urban explosion, no new *qanats* have been built using traditional methods since 1963.¹⁰ This is also apparent in the shrinking numbers of *ab anbars* relative to the spread of urbanized land. According to Dr. Reza Abouei, of the 3,300 *qanats* within the Yazd Province, around 3,000 though active are increasingly polluted from industrial discharge. Meanwhile less than 500 *badgirs* don the city's historic roofscape.¹¹ Evidently, it is not just the *qanat's* infrastructural dimension, but its holistic urban paradigm that has been gradually eroded.

This erosion is as much a cultural as a political phenomenon. With the advent of the White Revolution and its Land Reform Program against feudalism in 1963, the government had begun purchasing agricultural land from feudal owners and selling it back to the peasants at a much lower price. Yazd's water distribution and ownership traditionally controlled by a select few now came under a much larger purview. Subsequent government intervention had to be geared towards giving this larger demographic their fair share. With increased agricultural production necessitating the drilling of source aquifers, many *qanats* began to dry out or became seasonal, even as the drilling industry attracted more people into the city.

Today, despite continuing preservation efforts, active historic *qanats*, remain undesirable due to their unpredictable water supply and high mainte-

nance and repair costs, eventually leading to their neglect and abandonment. Today, houses in Yazd are no longer organized around a courtyard, but a central covered hall with a separate entrance from the front garden to ensure privacy for women. This hall often has a higher ceiling to buffer the dwelling from the sun, with operable clerestory windows to expel hot rising air. The traditional north facing *avivan*, (the raised veranda for enjoying morning and evening breezes) though present is often air-conditioned, making it in-effect, a year round living room for the family. Meanwhile *ab anbars* both within and beyond the historic core lie abandoned, with emerging development increasingly oblivious to their presence.

But despite their increasing replacement by modern wells, surviving *qanats* and *ab anbars*, however few, continue to serve Yazd's agricultural lands, bazaars, schools and mosques, embodying the resilience of this ancient tradition. Their presence remains a dominant magnet for continuing tourist activity, encouraging ongoing preservation and restoration efforts. And they continue to garner attention as pointers to alternative sustainable urban practices.

THE QANAT IN PROSPECT

If *qanats* and *ab anbars* were more than utilitarian infrastructure, can these larger ideas suggest alternative models of development today? The following reflections on this question are incipient and represent only part of a larger dialogue on Yazd's future encompassing other social-economic dimensions that are beyond the scope of this study. But they do attempt to outline plausible transformations of the growing city (or at least parts of it) through parallel development processes and scenarios unified by the *qanat*.

Incentivizing Preservation: The *Qanat* as Culture

If *qanats* remain undesirable, how can its preservation be successfully incentivized and implemented?

Beyond normative preservation efforts, opportunities for civic engagement and participatory governance can serve to enhance *qanat* awareness. Select neighborhoods in New Mexico for instance are mandatorily served by traditional *asequias* offering citizens an alternative lifestyle by choice. They are

owned and managed by public and private organizations, and maintained through regulated community participation.¹² Such actions within and around Yazd's historic core can deepen the appreciation of *qanats* through new choices – such as paying rents partially or fully through contributions towards their upkeep.

Qanat renovation is a viable option, but its long-term sustenance is only possible through communal willingness and participation, a challenge hardly limited to Yazd. The 2000 pilot *qanat* renovation effort in the village of Shalalah Saghirah, east of Aleppo, Syria, is a case in point. Inter-clan disputes and ambiguous ownership patterns deterred initial communal consensus on the *qanat's* restoration. It was only after much discussion and field work that the *haqoun* ("holders of the right") settled their differences during the *Id-al-fitr* (Islamic holiday marking the end of *Ramadan*, the holy month of fasting).[□] The *qanat* was cleaned, its technical impact was measured by a flow meter, and sixteen young members of the community were trained for *qanat* cleaning and maintenance. But when the project team returned in summer 2002, though the *qanat* was providing a substantial amount of water, the community was again divided with social tensions, and the *qanat's* future remained dubious. Communal consensus remains critical to *qanat* preservation and should therefore be studied on a case by case basis.

But preserving *qanats* is one thing, preserving their larger cultural dimensions is another. In his 1973 study of Yazd's old town, architect Mehdi Kowsar had observed that its dominant low-income demographic had suffered due to the increasing departure of the wealthy middle class and the municipality's subsequent disincentive towards maintaining the old town's infrastructure and facilities.[□] Today, the dominant demographic within the core remains low-income, but with the restoration of the historic Sahlebne-Ali quarter and the Malek-o-Tajjar house in 2000, the value of Yazd's historic monuments has increased tenfold.[□] Today the situation seems reversed, in that ongoing preservation efforts if misdirected can land up displacing the indigenous community and its micro-economy making it little more than a co-opted world for a tourist industry.

Subsidized housing alternatives, such as the 1975 master plan's unimplemented recommendation for reducing property taxes by 20 % for 10 years for

restored fabric represent positive steps in this direction. The point is that the culture of the *qanat* is larger than its physical structure. It encompasses the processes, rituals, and most importantly the people who build, use and appropriate them. The preservation rubric needs to be expanded to include these dimensions.

Empowering Re-use: Qanats and Grey Water Recycling

Today, *qanats* cannot compete with Yazd’s modern infrastructure. They are not capable of fulfilling the ever-increasing water demands of the sprawling modern city. They are less reliable due to their dependence on the source aquifer. And they require recurrent maintenance. While the *qanats*’ continuing negligence seems like a pragmatic inevitability, the question remains: can this antiquated infrastructure be re-used for another tandem role within the modern city?

Recent concerns over dwindling groundwater reserves and costly sewage treatment have generated increasing global interest in the reuse or recycling of grey water, for domestic use and commercial irrigation. Grey water is the wastewater generated from domestic activities such as dish washing, laundry and bathing, and is significantly less contaminated than black water that contains fecal matter and urine.

In Yazd, such grey water could come from a number of sources. Besides domestic sources, rain water collection from roofs particularly in Yazd’s modern concrete developments is something that would not have been possible in its historic adobe habitats. Ablution water from Yazd’s numerous mosques also offers a unique opportunity with the

five daily calls to prayer serving to integrate sustainability with cultural practices.

Could a possible scenario for the *qanats* then be that of a parallel infrastructure for grey water harvesting and distribution? If modern steel pipes can supply potable water, why cannot *qanats* carry reusable wasted grey water for filtration and reuse?

Abandoned *qanat* networks already in place could be reactivated, saving significant expenditure on what would otherwise be an infrastructural installation from scratch. They could carry grey water to short or long distances for adequate processing. Other *qanats* in turn could bring back this processed gray-water to *ab anbars* for storage. And still others could return the water to the homes and buildings for flushing toilets, or watering gardens, or direct it instead to larger destinations such as urban parks (Figure 4).

The idea of *qanats* an *ab anbars* as grey water infrastructure could retain its original workings for a contemporary cause, empowering their reuse, rebuilding and maintenance. They could be built to localize water collection on a neighborhood basis, with their capacities and performance monitored with modern technology. They could significantly reduce the load on Yazd’s current water supply through large-scale waste water management, merging a desert culture’s reverence for water with a contemporary sustainable distribution system nurturing a variety of functions.

“Beautiful Co-existence”: Qanats and Ab Anbars as Civic Art

The idea of a “cultural” infrastructure can create an unparalleled opportunity for city making with si-

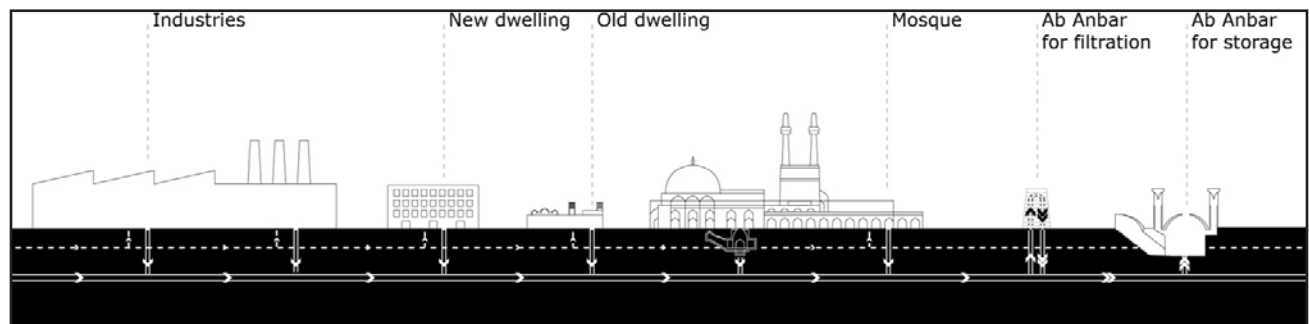
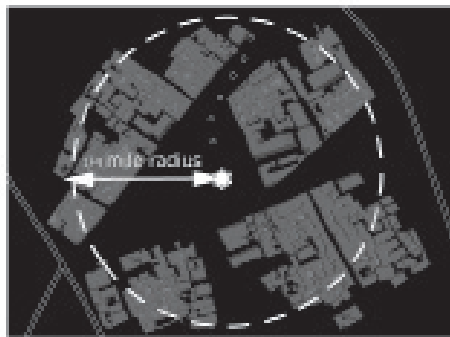


Figure 4: Qanats as a parallel grey water infrastructure. The horizontal lines at the base indicate the qanat; the dotted line indicates modern water supply. (Drawing by authors)

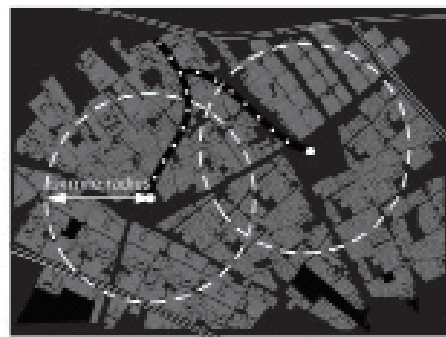


I

II.



III.



IV.



V.

Figure 5 – Towards a Qanat based urbanism:

I: Repair, reactivation and multiplication of extant qanats beyond the city limits.

II: Strategic introduction of ab anbars

III: Incremental growth of neighborhood within a ¼ mile pedestrian shed around ab anbar

IV: Multiple neighborhoods coalesce into larger towns

V: Potential growth of Yazd with compact communities along existing qanats and thoroughfares

(Drawings by authors)

multaneous utilitarian and aesthetic dimensions. It can celebrate what landscape architect Kathy Poole has called "Beautiful Coexistence",¹⁶ the idea of utilitarian infrastructures contributing to the image and identity of a place by providing iconic landmarks and direction.

Qanats are visible above ground only through their sequential intermittent wells, creating a unique land pattern at various scales. Communal gardens and open spaces if incorporated around these existing patterns can both increase awareness of these systems and celebrate the idea of the *qanats* as local or regional civic art.

The dramatic formalism of *ab anbars* can likewise lend itself to generating a parallel cognitive system throughout the city. Such *ab anbars* could be both old and new. They could more than storage tanks. They could collect, store, treat, circulate and recycle water. They could be located on a block, street or neighborhood basis. They could be free-standing artifacts or appendages to buildings. They could accommodate a number of other communal uses from internet cafes to restaurants. Their formal specificity could help identify their particular function such as the treatment of storm versus grey water. They could be built through communal collaboration. And they could be designed to offer citizens an opportunity to witness these processes first hand.

Catalyzing Development: *Ab Anbars* as Urban Centers

Mosques have historically been the principal ordering elements of Islamic cities. Their locations were often determined - as shown by Nezar Alsayyad in his doctoral dissertation on Cairo - by the auditory circumference of the *muezzin's* (priest) call to prayer from atop the minaret. Yazd was unique in this regard, in that *ab anbars* added a parallel formal order to the city, with various communities organized around their local water source.

Is it conceivable that new *ab anbars* could help establish a similar spatial order of contemporary neighborhoods and districts? Their locations within new developments could help establish pedestrian sheds akin to Clarence Perry's ¼ mile radius "Neighborhood Unit."¹⁷ And several such compact communities could coalesce to form larger hamlets and towns.

Thus extant *qanats* beyond the city could become formal armatures for new development. They could be reactivated and multiplied using traditional construction techniques. New *ab anbars* could be strategically introduced around existing thoroughfares as catalysts for future development. In low income schemes, a "sites and services"[□] approach could regulate the layout and funding of the *qanat* apparatus through a public agency, with incremental habitats built through "self-help-self-build" processes. The same extant ex-urban infrastructure that could be engulfed in sprawl could now become the framework for sustainable urban growth (Figure 5).

Codes and Performance Standards: Designing for the Desert

Policies encouraging passive climate control through the timeless lessons of Yazd's traditional building types and architectural elements can help create a contemporary fabric that is climatically responsive yet diverse. Traditional *badgirs* for instance were the formal resultants of a climate-sensitive design seeking to balance the heat gain and loss between earth and wind. Yazd's ubiquitous domed roof-form was likewise a response towards minimizing solar gain - with half its surface consistently in shade save the noon hours when the sun is directly above its apex.

Such ideas however obvious can only be effective through their consistent use in mainstream development. Incentivized planning codes can encourage such approaches through public-private partnerships, density bonuses and government subsidies. In turn prospective buyers and residents could pay rents or mortgages through the amount of energy saved. In essence, the success of transforming Euclidian use-based-zoning into sustainable form-based and performance-based codes as seen in other cities around the world, can chart new directions in balancing sustainable design and cohesive urban form.

Collaborative City-Making: *Qanat*-Builders as Urbanists

Ongoing efforts such as the 2007 UNESCO-organized "International Training Course on *Qanats*" are helping to increase awareness on their cultural and technical aspects. The good news is that *qanat*-building skills are receiving renewed attention.

The bad news is that there continues to be no administrative mechanism to incentivize these skills within mainstream development.

The idea of *qanat*-builders as intrinsic participants in city-making is in fact an echo of their ancient tradition. They could be involved in the early planning phases as experts on the location and viability of old or new *qanats* and *ab anbars*. Such trends could generate a significant employment base within Yazd's real estate market allowing the amalgamation of traditional building techniques with modern methods.

The challenge, of course, is that such ideas will need significant political and administrative incentives to get them off the ground. Effective branding among other things will constitute a key part of this effort, with new developments involving *qanats* and *qanat*-builders needing to find ways to inspire citizens to want to live in them. But no planning effort can anticipate the vagaries of public sentiment. If *qanats* and their builders can remain marginalized on the one hand, they can also become the force behind a renewed public environmental consciousness. People can come to realize that infrastructure should and can be more than purpose driven.

EPILOGUE

Yazd's future growth has many potential scenarios: Selective infill through the reclamation of underutilized industrial sites, and densification of its transit nodes can limit growth within its current boundaries. Conversely, compact new neighborhoods and hamlets or autonomous new towns surrounding the existing city can extend them. Whatever the case, the most sustainable thing Yazd can do is curb sprawl, design compact communities, prioritize two legs over four wheels and manage its water resources. The *qanat* as discussed above can intersect all of these dimensions.

Even as the *qanat's* future faces an uphill climb, it arguably rests not within an exclusive preservation cocoon, but at the complex intersection of infrastructure, urbanism and public life. The task at hand is to generate a policy framework that can reposition this indigenous infrastructure with multifarious new yet practical applications for its modernity. In a world where the conceptual status quo of urban infrastructure continues to be a footnote,

Yazd's *qanats* seen this way can affirm that infrastructure in all its seemingly disparate parts, can in fact be defined less through its age or function and more through its larger social message that public life matters.

ENDNOTES

1. For more see <http://www.stanallenarchitect.com>.
2. For more see Brown Catherine and Morrish William, *Western Civic Art: Works in Progress*, published in Places, Vol. 5, No. 4.
3. While the reasons behind Yazd's isolation remain unknown, its speculated origins range from a transitional node along the silk route, to a town founded by Alexander the Great to retain prisoners of war, to the site of Alexander's own imprisonment. These positions however dubious, do affirm the presence of a habitat even before Marco Polo's visit circa 1272 or before it was captured by Timur who expanded its military walls circa 1393. Yazd's seclusion and harsh climate spared it of foreign invasion, and it also became the adopted enclave of the Zoroastrians who made it their artistic and intellectual habitat.
4. The *Qanat* is a provincial name for specific to Yazd. Various places have their own nomenclatures: *Karez* (Afghanistan), *Khotara* (Morocco), *Foggara* (North Africa), *Auyoun* (Egypt), *Manbo* (Japan) etc.
5. For more on *qanat* construction, see A.A. Semsar Yazdi, *Qanat from Practitioners' Point of View*, Mohandesin Moshaver Setiran, Tehran 2005. Also see by same author, *Proceedings of International Symposium on Qanat*, Volume Two, Sherkat Sahami Ab Mantaq, Yazd, 2001.
6. Builders are known to have first constructed the storage space and fill it up with hay and straw up to where they could start constructing the dome. After the dome's completion, the straw would be set on fire clearing the interior.
7. As is often with secular, public use structures, one cannot trace the precise origin or patron of most *ab anbar* reservoirs in Yazd. Though the earliest urban water supply constructions in Yazd are believed to date from the Sassanid period and many others have been continually repaired and used, most extant *ab anbars* can be today traced to the late Safavid and Qajar periods. The Shesh Badgiri *anbar* or 'Six wind catcher' reservoir was constructed in the Qajar period, while the Khan Bazaar *anbar* can be more accurately dated to Qajar ruler Nasr al-Din's reign. There are approximately 75-90 surviving *anbars* in Yazd today, and some of the important ones are the Seyed Va Sahra, Masoudi, Hadji Ali Akbari, Khajeh, Golshan, Rostam Geev, Kolah Doozha, Malekotojar and Mirza Shafi reservoirs.
8. For more see Javad Safi-Nejad, *Qanat- Selected Scientific Articles*, Sherkat Sahami Ab Mantaq, Yazd, 2001.
9. Ibid
10. See Hossein Kalantari and Hossein Hatami Nejad, *Renovation Planning of Historical Area of Yazd*: Faragostar Publishing, Tehran, 2007, Pg 200.
11. See Abouei Raza *Conservation of Badgirs and Qanats in Yazd, Central Iran*, published in The 23rd Conference on passive and Low Energy Architecture Proceedings, Geneva, Switzerland, 2006
12. For more in this see The Middle Rio Grande Conservancy District, <http://www.mrgcd.com>
13. See Wessels Joshka & Hoogeveen R.J.A., *Renovation of Qanats in Syria*, Lightfoot, 1996

-
14. See Kowsar Mehdi, *A Master Plan for Yazd*, published in *Environmental Design: Journal of the Islamic Environmental Design Research Centre* 1-2, 1989 P. 80-85.
15. See Abouei Raza *Conservation of Badgirs and Qanats in Yazd, Central Iran*.
16. See Poole Kathy, "Potentials for Landscapes as Infrastructure, Part I: Six and a Half Degree of Infrastructure", KERB, RMIT, Melbourne, Australia, 2004
17. The Neighborhood Unit was conceived in 1929 by Clarence Perry. It represents a fundamental human habitat within a ¼ mile pedestrian-shed. In its ideal form, it is a compact urban pattern with a balanced range of living, working, shopping, recreational and educational accommodation. For more on the Neighborhood Unit and its derivatives, see Duany Andres, Plater-Zyberk Elizabeth and Alminana Robert, *The New Civic Art: Elements of Town Planning*, Rizzoli, 2003, Pg 84-90
18. Sites and services approaches have been successfully implemented in several parts of Asia. Perhaps the most published project of this nature is Balkrishna Doshi's "Aranya" Low-Cost Housing in Indore (1983-1986). Commissioned by the Indore Development Authority, the project comprising about 6500 housing units built primarily for the poor, also include other income groups and has been planned to grow to house 40,000. For more see Steele James, *The Complete Architecture of Balkrishna Doshi*, (London: Thames & Hudson Ltd., 1998), P. 114 - 129.