THE MORPHOGENESIS OF IRANIAN CITIES*

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ABSTRACT. Traditional Iranian cities have an orthogonal network of streets which does not conform to the maze of irregular, twisting lanes postulated for the ideal Islamic city. The grid system did not develop from an outgrowth of streets around rectangular religious buildings or from the orientation of Iranian houses to maximize seasonal usage, but rather it is due to irrigation systems. The orthogonal network of water channels corresponds to the slope of the land. Passageways follow these channels to reach various plots of cultivated land. Cities have expanded along the existing streets and water channels. The basic morphology of traditional Iranian cities was created by houses filling in adjacent rectangular fields and orchards.

THE concept of the "Islamic City" evolved from the formulations of Orientalists, a group of scholars versed in the languages and religions of the Middle East.[1] In their view Islam is an all-encompassing value system which underlies behavioral patterns and social organization and determines the physical morphology of settlements. For them the city is a by-product of Islamic faith and only by understanding Islam can one understand the city. Islam is an urban religion, and by definition "a town was a settlement in which [a Muslim's] religious duties and his social ideals could be completely fulfilled."[2] Because the Arabs spread this urban faith, they fostered urbanism throughout the Middle East. The fact that Bedouin warriors helped to extend this new religion into areas which had a long heritage of urbanism has not deterred acceptance of this notion.[3]

Gustave E. von Grunebaum's influential article, "The Structure of the Muslim Town," provided a descriptive schema of the Islamic city; it is as perfunctorily quoted as Sjoberg's *The Preindustrial City*.[4] Relying heavily on earlier French Orientalists, von Grunebaum formu-

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[1] For an excellent discussion of the growth and impact of Orientalism see Maxime Rodinson, "The Western Image and Western Studies of Islam," in Joseph Schacht and Clifford E. Bosworth, eds., *The Legacy of Islam*, 2nd edition (London: Oxford University Press, 1974), pp. 9–62. A discussion of the Islamic city with further references is found in Michael E. Bonine, "From Uruk to Casablanca: Perspectives on the Urban Experience of the Middle East," *Journal of Urban History*, Vol. 3 (1977), pp. 141–80; specifically pp. 148–57, 173–75.

[2] Gustave E. von Grunebaum, *Islam: Essays in the Nature and Growth of a Cultural Tradition* (London: Routledge and Kegan Paul, 1955), p. 142. This volume was originally published as a special issue of *The American Anthropologist*, Vol. 57, No. 2, Part 2 (April, 1955).

[3] For criticisms of the notion that the Arabs fostered urbanism in the Middle East see Ira M. Lapidus, "The Evolution of Muslim Urban Society," *Comparative Studies in Society and History*, Vol. 15 (1973), pp. 21–50.

[4] von Grunebaum, op. cit., footnote 2, chapter 8, pp. 141–58, originally published as "Die islamische Stadt," *Saeculum*, Vol. 6 (1955), pp. 138–53; and Gideon Sjoberg, *The Preindustrial City: Past and Present* (New York: The Free Press, 1960).

lated a model of a "full-fledged" Muslim town.[5] Characteristics of his Islamic city included two central institutions—the Friday mosque and the market—with a hierarchy of trades outward from the mosque, the division of residential space into numerous wards or quarters, a maze of twisting streets, and a series of other, less clearly defined features. Recently the entire concept of an idealized "Islamic" city has come into question.[6] But one feature—the maze of twisting streets—continues to be accepted as valid even by geographers with considerable field experience.[7] In Iran, and particularly in the central plateau, this commonly accepted description of the Middle Eastern urban environment has been misinterpreted.

LABYRINTHS OF TWISTING ALLEYWAYS

The French geographer, Xavier de Planhol, in his *The World of Islam* states that "irregularity and anarchy seem to be the most striking qualities of Islamic cities," while Paul Ward English has called the labyrinth of twisted alleys a hallmark of the Islamic city.[8] The prevailing viewpoint is that "the organic, irregular plan . . . is universal in the Muslim world," and that "Moslem towns grew so spontaneously and haphazardly as to prevent the development of a systematic street pattern."[9] Although planned cities existed in the Islamic Middle East, these are viewed as geometric exceptions to the irregular organic town configurations.[10] And even these designed cities gradually become irregular due to "decadence," and the encroachment of houses on the public passageways.[11]

Iranian cities also are seen as fitting this pattern.[12] In Kerman there is a pronounced irregularity of the street patterns, a "maze of dark, twisting passageways, alleys, and cul-de-sacs," and "the residential quarters . . . are chaotic; there is no pattern to the lanes."[13] The old city of Kermanshah is composed of "winding *kuchehs* [alleyways] and numerous cul-de-sacs."[14] Shiraz has "narrow twisting alleys."[15] Semnan has winding and narrow alleys, and in Herat "the streets and lanes are narrow and

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[5] The French brothers William and Georges Marçais were instrumental in formulating the concept of the Islamic city. See William Marçais, "L'Islamisme et la vie urbaine," *Comptes-rendus de l'Académie des Inscriptions et Belles-Lettres* (1928), pp. 86–100, reprinted in Marçais, *Articles et conférences*, Publication de l'Institut d'Etudes Orientales, Faculté des Lettres d'Alger, No. 21 (Paris: Adrien-Maisonneuve, 1961), pp. 59–67; and Georges Marçais, "La conception des villes dans l'Islam," *Revue d'Alger*, Vol. 2 (1945), pp. 517–33.

[6] See A. H. Hourani, "The Islamic City in the Light of Recent Research," in A. H. Hourani and S. M. Stern, eds., *The Islamic City: A Colloquium* (Oxford: Bruno Cassirer, 1970), pp. 9–24; and Eugen Wirth, "Die orientalische Stadt: Ein Überblick aufgrund jüngerer Forschungen zur materiellen Kultur," *Saeculum*, Vol. 26 (1975), pp. 45–94.

[7] Recent exceptions by geographers of this viewpoint include Wirth, op. cit., footnote 6, pp. 61–74; and Paul Wheatley, "Levels of Space Awareness in the Traditional Islamic City," *Ekistics*, Vol. 253 (1976), pp. 354–66; see pp. 362–65.

[8] Xavier de Planhol, *The World of Islam* (Ithaca: Cornell University Press, 1959), p. 22; and Paul Ward English, *City and Village in Iran: Settlement and Economy in the Kirman Basin* (Madison: University of Wisconsin Press, 1966), p. 46.

[9] Paul Ward English, "The Traditional City of Herat, Afghanistan," in L. Carl Brown, ed., *From Madina to Metropolis: Heritage and Change in the Near Eastern City* (Princeton: The Darwin Press, 1973), pp. 73–90; reference on p. 78; and E. A. Gutkind, *International History of City Development*, Vol. 8: *Urban Development in Eastern Europe: Bulgaria, Romania, and the U.S.S.R.* (New York: The Free Press, 1972), p. 395.

[10] The classic planned city during Islamic times was Baghdad. See Jacob Lassner, *The Topography of Baghdad in the Early Middle Ages: Text and Studies* (Detroit: Wayne State University Press, 1970). Wirth (op. cit., footnote 6, pp. 61–68) notes a great number of Islamic and pre-Islamic towns which had been planned.

[11] de Planhol, op. cit., footnote 8, p. 22.

[12] Comparative and general discussions of Iranian street patterns in the Orientalist tradition have been published by German scholars. See, for example, Kurt Scharlau, "Moderne Umgestaltungen in Grundriss iranischer Städte," *Erdkunde*, Vol. 15 (1961), pp. 180–91; Helga Anschütz, "Perische Stadttypen: Eine vergleichende Betrachtung der Städte Teheran—Isfahan—Abadan—Chorramschahr und Buschir in Iran," *Geographische Rundschau*, Vol. 19 (1967), pp. 105–10; and K.-G. Gauglitz, "Eigentümlichkeiten des Wegesystems in iranischen Städten: Die Entstehung von Gassen und Sackgassen," *Orient* (Opladen), Vol. 10 (1969), pp. 162–69.

[13] English, op. cit., footnote 8, pp. 41–42.

[14] John I. Clarke and Brian D. Clark, *Kermanshah: An Iranian Provincial City* (Durham: University of Durham, Department of Geography, Research Paper Series, No. 10, 1969), p. 127.

[15] John I. Clarke, *The Iranian City of Shiraz* (Durham: University of Durham, Department of Geography, Research Paper Series, No. 7, 1963), p. 18.

twisting, often subterranean, with many sharp turns and frequent cul-de-sacs."[16]

In a discussion of Iranian city plans, de Planhol stated:[17]

> Except for the timid attempts at modernization by Nasr-ed-Din Shah in Tehran in the last third of the nineteenth century, there was not a single street in any Iranian town which ran more than sixty feet in a straight line until Reza Pahlevi assumed the throne [1925], and then suddenly great square grill-works of streets were imposed on cities as on the tops of gigantic cakes, with a minimum of consideration for even the largest complexes of public buildings.

Scharlau echoes the same sentiment, stating that until Reza Shah's time in almost all Iranian towns no main street ran straight, even for a short distance.[18]

The typical Islamic (and Iranian) city, then, is described as a maze and jumble of twisting, narrow alleyways, a disordered array of dark streets and blind alleys. Reasons for such chaos range from the need for protection to the lack of wheeled vehicles.[19] The principal explanation, however, has been that cities lack a defined status in Islamic law, and thus civil authorities did not have the capacity to impose a regular plan on the urban environment or to prevent encroachments by private houses upon the regular network of streets which may have been inherited from antiquity.[20]

[16] Jennifer A. Tavernor and John Connell, "Semnan City," in John Connell, ed., *Semnan: Persian City and Region* (London: University College, London, Expedition to Iran, 1969), pp. 17–46; reference on pp. 32–33; and English, op. cit., footnote 9, p. 78. Herat is included in this essay because western Afghanistan is part of the traditional Iranian sphere.

[17] de Planhol, op. cit., footnote 8, p. 32.

[18] Scharlau, op. cit., footnote 12, p. 182.

[19] de Planhol, op. cit., footnote 8, p. 18; and Richard W. Bulliet, *The Camel and the Wheel* (Cambridge: Harvard University Press, 1975).

[20] de Planhol, op. cit., footnote 8, pp. 19, 22; von Grunebaum, op. cit., footnote 2, pp. 149–50; and English, op. cit., footnote 8, p. 42. Wheatley (op. cit., footnote 7, p. 363) surmises that Sauvaget was somewhat responsible for the prevailing notion of "some anarchic principle inherent in Islamic urban evaluation" by showing how the neat orthogonal Hellenistic lattices in Damascus, Aleppo, and Ladhiqiyah were transformed into irregular patterns during Islamic times. See Jean Sauvaget, "Esquisse d'une histoire de la ville de Damas," *Revue de Études Islamiques*, Vol. 8 (1934), pp. 421–80; "Le plan antique de Damas," *Syria*, Vol. 26 (1949), pp. 314–58; *Alep: Essai sur le développement d'une grande ville syrienne, des origines au milieu du XIXe siècle* (Paris: Librairie Orientaliste Paul Geuthner, 1941); and "Le plan de Laodicée-sur-Mer," *Bulletin d'Études Orientales*, Vol. 4 (1934), pp. 81–114.

IRANIAN CITIES: A SPATIAL ALTERNATIVE

In 1898–99 an astute Russian doctor, N. Shetalov, lived in Yazd in central Iran and noted that in the city "as a general rule, the streets are not arranged by whimsy, but are oriented in two general directions, to the northeast and to the northwest, crossing at right angles."[21] He stated that there are certain streets in which he could walk for ten to fifteen minutes essentially in a straight line.[22]

In contemporary Yazd, a city of approximately 140,000 inhabitants, what at first appears to be confusion in the street plan upon closer inspection shows a clearly defined pattern (Fig. 1). A number of rather straight streets, some of them more than a kilometer in length, intersect at right angles. There are many blind alleys, but they usually are short and they branch off the longer linear streets at right angles. The long, straight streets are almost always wider than the shorter ones. The entire system is basically an orthogonal pattern oriented in a northwest-southeast and northeast-southwest direction crossing at right angles, as Shetalov had observed. The wide avenues built through the city in the twentieth century follow the same orientation as the older linear streets.

Street plans of other Iranian cities suggest that the geometry of Yazd is not unique. The traditional quarters of Sabzevar, Shiraz, Kerman, and Ardekan contain similar street patterns (Fig. 2). The main streets of Shiraz and Kerman are oriented in a northeast or northwest direction; those of Sabzevar and Ardekan are in cardinal directions. The new, wide avenues constructed during the rule of Reza Shah (1925–41) essentially parallel the existing street pattern and, although some mosques, shrines, bazaars, and residences were swept away, destruction was minimized.

The grid network in Yazd and other Iranian cities is clearly not the classic grid pattern town of the Indus, of ancient Greece and Rome, or of modern Western cities.[23] It lacks the rigid

[21] N. Shetalov, "Gorod Iezd," *Obschchestvo Vostokovendeniia Sredne-Aziatskii Otdel: Sbornik*, Vol. 1 (1907), pp. 44–197; reference on p. 60 (translation).

[22] Shetalov, op. cit., footnote 21, p. 61.

[23] See Dan Stanislawski, "The Origin and Spread of the Grid Pattern Town," *Geographical Review*, Vol. 36 (1946), pp. 105–20; Ferdinando Castagnoli, *Orthogonal Town Planning in Antiquity* (Cambridge: The MIT Press, 1971); and, for example, E. A. Gutkind,

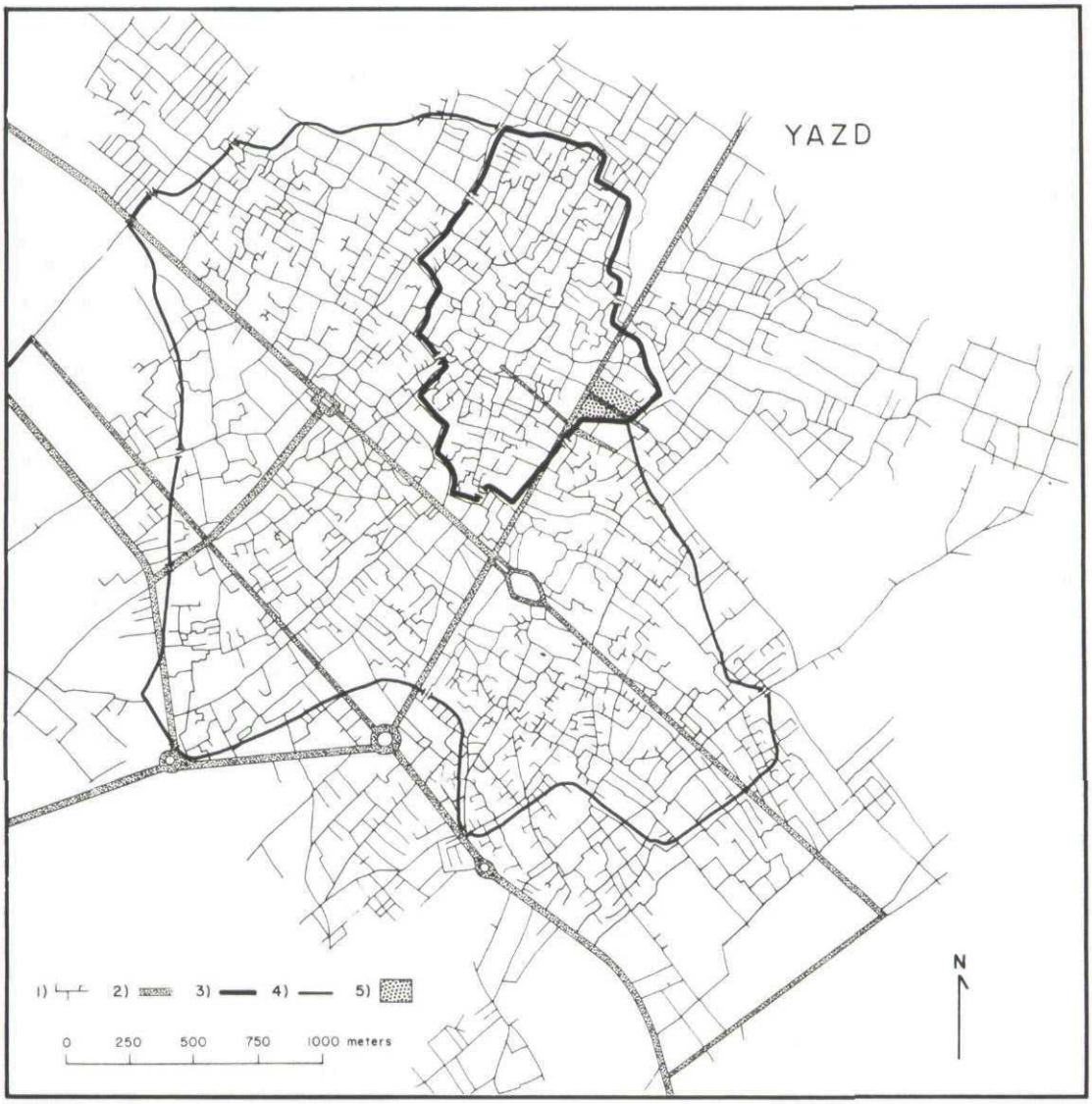

FIG. 1. Street plan of Yazd. 1) traditional streets and alleyways, widths not to scale; 2) modern avenues, constructed in the twentieth century; 3) inner or old city wall, constructed in the fourteenth century (still mostly standing); 4) outer or new city wall, construction date unknown but before the nineteenth century (now mostly destroyed); 5) former citadel area (now destroyed). Source: Iranian National Cartographic Center, "Yazd" (Scale 1:2,500), 24 sheets, 1346 [1967/68]; checked and corrected by the author in the field. Location of walls and gates (open spaces in the walls) by field survey, interviews, and the map in Shetalov, op. cit., footnote 21.

symmetry of such planned cities. Yet there is a distinctly geometric configuration to these Iranian cities. The rectangular system of lanes with long, straight streets is not the labyrinth of twisting passageways postulated for the Islamic city. Several explanations are possible: cultural, climatic, and ecological.

Religious Prescriptions

The orthogonal network of most Iranian cities is in noncardinal directions. This could possibly derive from religious practices, and if true, would add a new dimension to the signifi-

International History of City Development, 8 vols. (New York: The Free Press, 1964–1972).


SABZEVAR
N
0 100 200 300 m.
SHIRAZ
N
0 100 200 300 m.
KERMAN
N
0 100 200 300 m.
ARDEKAN
N
0 100 200 m.

cance of Islam in urban structure. Muslims must face Mecca when praying and so the *mihrab* or niche of a mosque must face in the direction (the *qibla*) of that Holy City.[24] Iranian mosques are rectangular with open courtyards and the qibla wall must be to the southwest, in the direction of Mecca.[25] Streets often parallel the mosque and the grid system might have developed from an extension of streets around a mosque—oriented perpendicular to and toward the southwest. Even in cities founded in pre-Islamic times, when mosques were later established, the same principle might apply to nearby, newly established quarters.

Such reasoning is not unprecedented. Donald Wilber postulated that two factors influenced the orientation of Iranian cities in medieval times: 1) a major artery between the palace and the Friday mosque, and 2) the "necessity of turning the mosque so that the qibla wall would be in the direction of Mecca."[26] Elsewhere in the Middle East, de Planhol notes that in Meknès and Taza (both in Morocco and Muslim in origin), "one sees more or less clearly that the streets have been laid out according to the qibla . . . of the mosque or to its perpendicular."[27]

Directions of traditional linear streets of Iranian cities when compared with the direction to Mecca show limited correspondence (Table 1). Several of the cities, such as Bandar Abbas, Kerman, Kermanshah, Nain, and Qom, do have streets similar to the direction of the Holy City, but it is likely that these cities' main streets are oriented toward Mecca because of other factors. Isfahan, Mashad, Rezaiyeh, and Tabriz do not have linear streets oriented predominantly in one direction, although individual sections of these cities have orthogonal street networks in various orientations. The location of the qibla wall and the orientation of the mosque appear to have had little influence on the location and direction of major streets in traditional Iranian cities.

TABLE 1.—IRANIAN CITIES, DIRECTION TO MECCA AND DIRECTION OF TRADITIONAL LINEAR STREETS

City[a]	Mecca Direction[b]	Linear Streets Predominant Direction[c]
Ardekan	S 52° W	S 10° W & S 85° W
Bandar Abbas	S 73° W	S 75° W & S 85° W
Boshruyeh	S 58° W	S 75° W
Bostam	S 47° W	S 10° W
Damghan	S 40° W	S 70° W
Gonabad	S 57° W	S 35° W
Isfahan	S 47° W	Complex
Kashan	S 45° W	S 60° W
Kashmar	S 55° W	S 30° W
Kerman	S 65° W	S 70° W
Kermanshah	S 31° W	S 30° W
Malayer	S 34° W	S 80° W
Mashad	S 55° W	Complex
Nain	S 52° W	S 55° W
Qazvin	S 36° W	S 10° W
Qom	S 40° W	S 35° W & S 40° W
Rafsanjan	S 64° W	S 60° W
Rezaiyeh	S 20° W	Complex
Sabzevar	S 51° W	S 5° W
Shahrud	S 47° W	S 30° W
Semnan	S 40° W	S 65° W
Shiraz	S 59° W	S 35° W
Tabas	S 56° W	S 65° W
Tabriz	S 22° W	Complex
Tehran	S 40° W	S 5° W & S 85° W
Yazd	S 57° W	S 35° W & S 40° W
Zahedan	S 72° W	S 80° W

[a] Cities selected on basis of having city plans available for determining street directions.
[b] Bearing, rounded to nearest degree.
[c] Bearing, rounded to nearest five degrees, direction estimated by author.

Climate and Housing Structure

A second possible explanation for geometric street plans is climatic; streets might follow the

[24] The *mihrab* is the niche placed in the wall of a mosque in the direction of prayer while the *qibla* technically refers only to the direction of Mecca. However, the latter term also is used for the wall of the mosque which has the mihrab. See "kibla," "masdjid," and "mihrab," *The Encyclopaedia of Islam*, 1st edition. Vols. 2 and 3.

[25] See, for example, the plans in Arthur Upham Pope and Phyllis Ackerman, ed., *A Survey of Persian Art: From Prehistoric Times to the Present*, Vol. 3 (Tokyo: Meiji Shobo, 1964–65 [reprint of the Oxford University Press edition, 1938–9]); and André Godard, "Les anciennes mosquées de l'Iran," *Athar-e Iran*, Vol. 1 (1936), pp. 187–212.

[26] Donald Wilber, Contribution on Qazvin, in E. E. Beaudouin and Arthur Upham Pope, "City Plans," in Pope and Ackerman, op. cit., footnote 25, Vol. 3, pp. 1402–04; reference on pp. 1402–03.

[27] de Planhol, op. cit., footnote 8, p. 17.

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FIG. 2. Street plans of sections of four Iranian cities. Stippled streets indicate the modern avenues built in the twentieth century. Source: Iranian National Cartographic Center, "Sabzevar," "Shiraz," "Kerman," and "Ardekan-e Yazd" (Scale 1:2,500), 1345–46 [1966/67–67/68]; the latter map was checked and corrected by the author in the field.

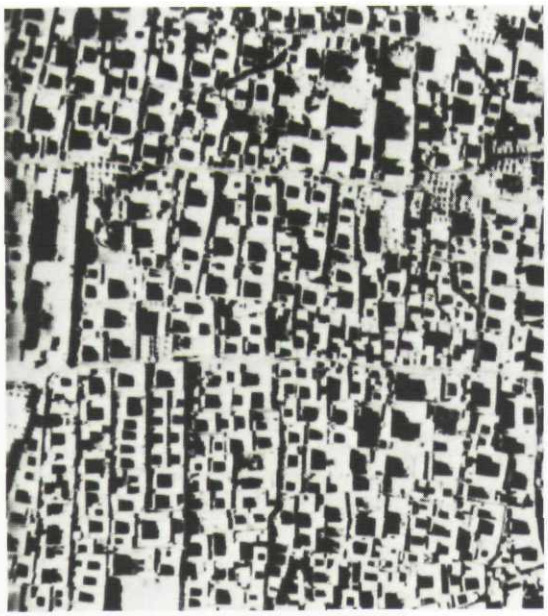

FIG. 3. Linear streets and linear rows of open courtyard houses in Yazd.

optimal orientation of the Iranian central plateau house. Shetalov believed that Yazd had long linear streets because every house was aligned in one direction to maximize seasonal usage (Fig. 3).[28] The houses of Yazd, similar to most of the Middle East, are one-story structures built around an open courtyard and certain sections are inhabited only part of the year.[29] Enclosed rooms are used in the winter while an open vaulted iwan is used in the summer and the warmer parts of spring and fall (Fig. 4). During extremely hot summer afternoons families reside beneath the iwan in a cool underground basement, the *zirzamin*.

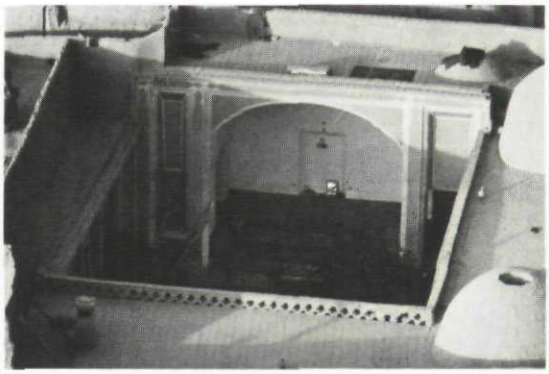

FIG. 4. Open courtyard and vaulted iwan of a traditional Iranian house in Yazd.

To maximize warmth in the winter the enclosed areas need high levels of solar energy; the iwan, on the other hand, should be shaded as much as possible in summer. As a result, the enclosed house is located on the north side to gain maximum solar exposure and the iwan is found along the shaded south wall. If only one side of the household compound were enclosed, a cardinal orientation would maximize the winter heat and summer shade. But when two adjoining sides are enclosed, solar exposure is improved when the house is not oriented in a north-south direction. Tehran's streets are laid out in cardinal directions, which is explained by de Planhol by the fact that houses face north to take advantage of the summer breezes coming off the Elborz Mountains.[30]

The climatic influence on the internal structures of Iranian houses has not been fully determined, but climate can not have been crucial in creating geometric street plans. Wherever streets within a city vary from the common direction, the courtyards vary as well (Fig. 5). What is significant about houses and street patterns is that they are oriented in the same direction. The streets determine residential patterns, not the reverse.

Jubs and Alleys

English analyzed several of the alluvial fan villages of the Kerman basin.[31] These villages,

[28] Shetalov, op. cit., footnote 21, p. 60.

[29] For plans and further descriptions of typical Iranian houses see Arthur Upham Pope, "The Safavid Period," in Pope and Ackerman, op. cit., footnote 25, Vol. 3, pp. 1219–25; Mohsen Moghadam, "An Old House in Tehran," idem, Vol. 14, pp. 3193–95; Hans E. Wulff, *The Traditional Crafts of Persia: Their Development, Technology, and Influence on Eastern and Western Civilizations* (Cambridge: The MIT Press, 1966), pp. 102–35; Rafi Samizay, "Herati Housing of Afghanistan," *Ekistics*, Vol. 227 (1974), pp. 247–51; Mary Boyce, "The Zoroastrian Houses of Yazd," in C. E. Bosworth, ed., *Iran and Islam: In Memory of the Late Vladimir Minorsky* (Edinburgh: Edinburgh University Press, 1971), pp. 125–47; and Michael E. Bonine, "Aridity and Structure: Adaptations of Indigenous Housing in Central Iran," in Kenneth N. Clark and Patricia P. Paylore, eds., *Arid Zone Housing: An Architecture of Minimums* (Tucson: University of Arizona Press, forthcoming).

[30] Xavier de Planhol, "Geography of Settlement," in W. B. Fisher, ed., *The Land of Iran*, Vol. 1 of *The Cambridge History of Iran* (Cambridge: Cambridge University Press, 1968), pp. 409–61; reference on pp. 454–55.

[31] English, op. cit., footnote 8, pp. 49–60.

FIG. 5. Irregular streets and open courtyards oriented to the direction of the streets in Yazd.

called linear settlements, are each aligned along a major watercourse, a *jub*. This stream is the surfaced channel of a *qanat*, a subterranean conduit which taps water in an alluvial fan at a higher elevation and emerges near settlements and cultivated fields.[32] The houses are strung out in a line parallel with the water channel. In these villages, which are on steeper slopes than the cities of Kerman or Yazd, the dry wadis which incise the alluvial fans are the major thoroughfares. Hence some irregularity prevails, and "the linear pattern of households becomes confused in [the lower] part of the settlement, because the main watercourses have split into numerous smaller channels to irrigate the wide area of cultivated land below the settlement."[33]

There are a number of suburban villages in the Yazd area that could be described as linear

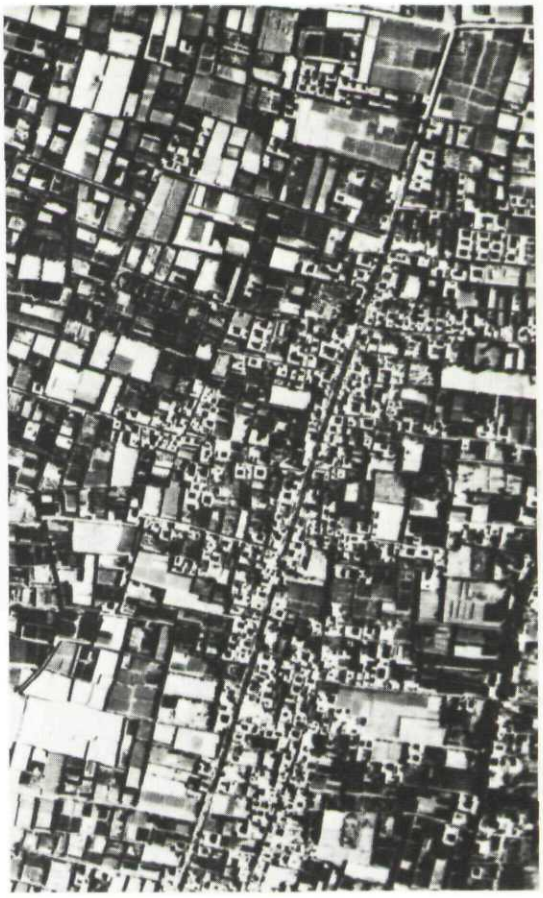

FIG. 6. Suburban linear village south of Yazd, showing the branching of streets and houses perpendicular to the main axis.

settlements. These villages are oriented along major roads and irrigation channels. But unlike the smaller mountain villages, a number of other streets branch off the main avenues at right angles in these settlements, and houses extend along the side passages (Fig. 6). Secondary jubs branch off from the main channel and run downslope. Perpendicular lanes and houses also run upslope from the main irrigation channel. Houses and fields in such areas are supplied from a different branch of the jub which split off at a higher elevation before reaching the village or, alternatively, by a jub from a different qanat. In some instances, secondary channels extend a short distance in the upslope direction, incising ever deeper into the slight grade. As a village expands the houses are built along the linear axis and along the perpendicular side streets; these thoroughfares usually are in conjunction with water channels.

[32] For descriptions of qanat construction and technology see George B. Cressey, "Qanats, Karez, and Foggaras," *Geographical Review*, Vol. 48 (1958), pp. 27–44; Hans E. Wulff, "The Qanats of Iran," *Scientific American*, Vol. 218, No. 4 (April, 1968), pp. 94–105; Paul Ward English, "The Origin and Spread of Qanats in the Old World," *Proceedings of the American Philosophical Society*, Vol. 112 (1968), pp. 170–81; and Peter Beaumont, "Qanat Systems in Iran," *Bulletin of the International Association of Scientific Hydrology*, Vol. 16 (1971), pp. 39–50.

[33] English, op. cit., footnote 8, p. 54.

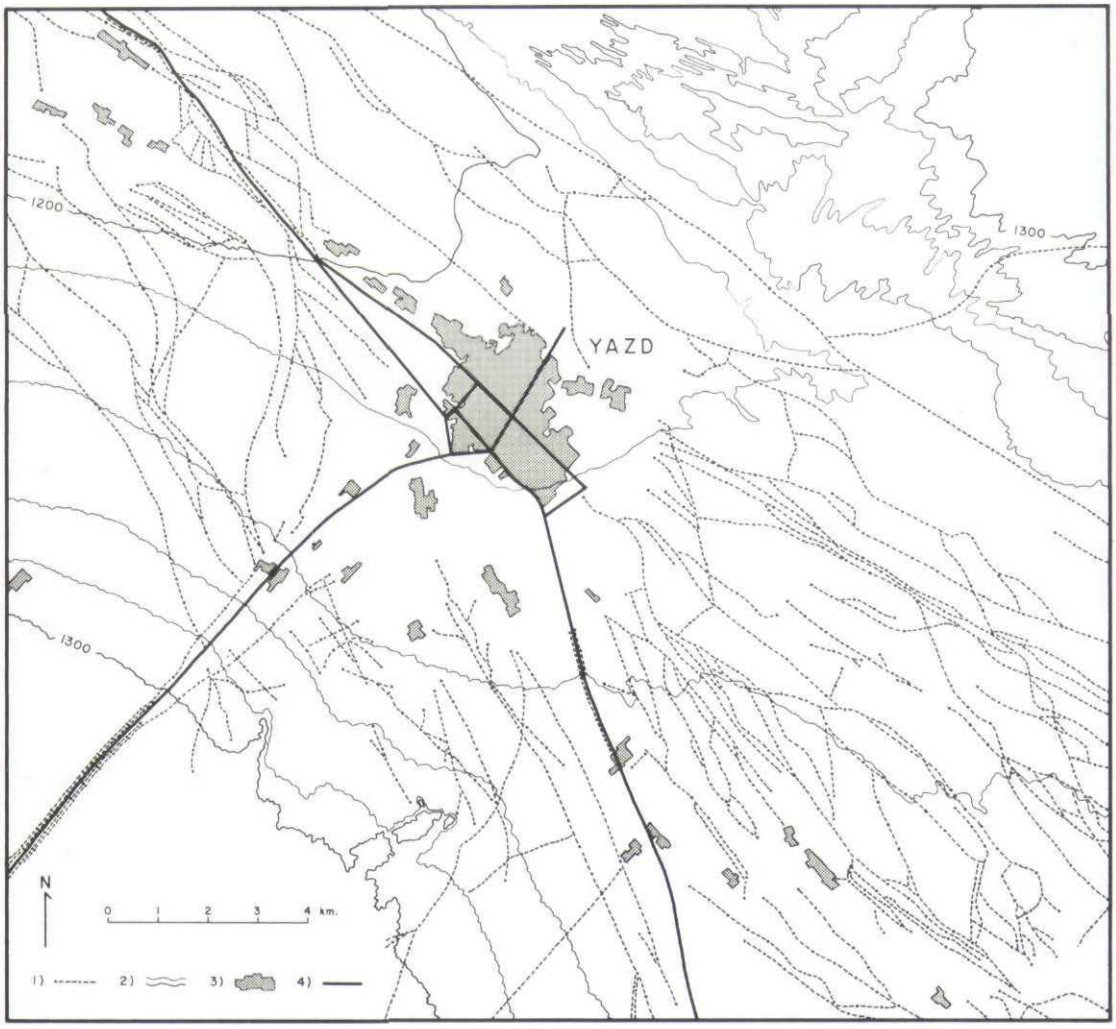

FIG. 7. Yazd and its immediate hinterland. 1) underground qanat channels; 2) contour lines, twenty meter intervals; 3) settlements; 4) major roads and avenues. Source: U.S., Army Corps of Engineers, Army Map Service, "Iran" (Scale 1:50,000), Series K753, Edition 1-AMS, Sheet 6853 I, "Yazd," 1966.

But what about the cities? English mentions that in Kerman some of the lanes are used as water channels and these were cobbled over with small openings every twenty to thirty yards. At least until the early 1960s these channels were the major source of water for most of the population.[34] In Herat, English notes that "the alleyways tend to follow slight contours of the land along which water is channeled."[35] Sewage is emptied into the lanes and the channels are needed to wash away the waste and garbage. In Semnan, the old water channels run in the alleyways and this network of channels was fed by four reservoirs which were constructed in the early nineteenth century.[36]

In Yazd there is an extensive network of qanat channels beneath the city, often at different depths. Many of these flow to cultivated lands around the city or to villages at greater distances downslope, but the city dwellers usually had access to this water. Within Yazd there are almost no open channels in the old alley-

[34] English, op. cit., footnote 8, p. 33.
[35] English, op. cit., footnote 9, p. 78.
[36] Eamon Murphy, "Water Supply and Urban Agriculture," in Connell, op. cit., footnote 16, pp. 70–78; reference on pp. 74–76.

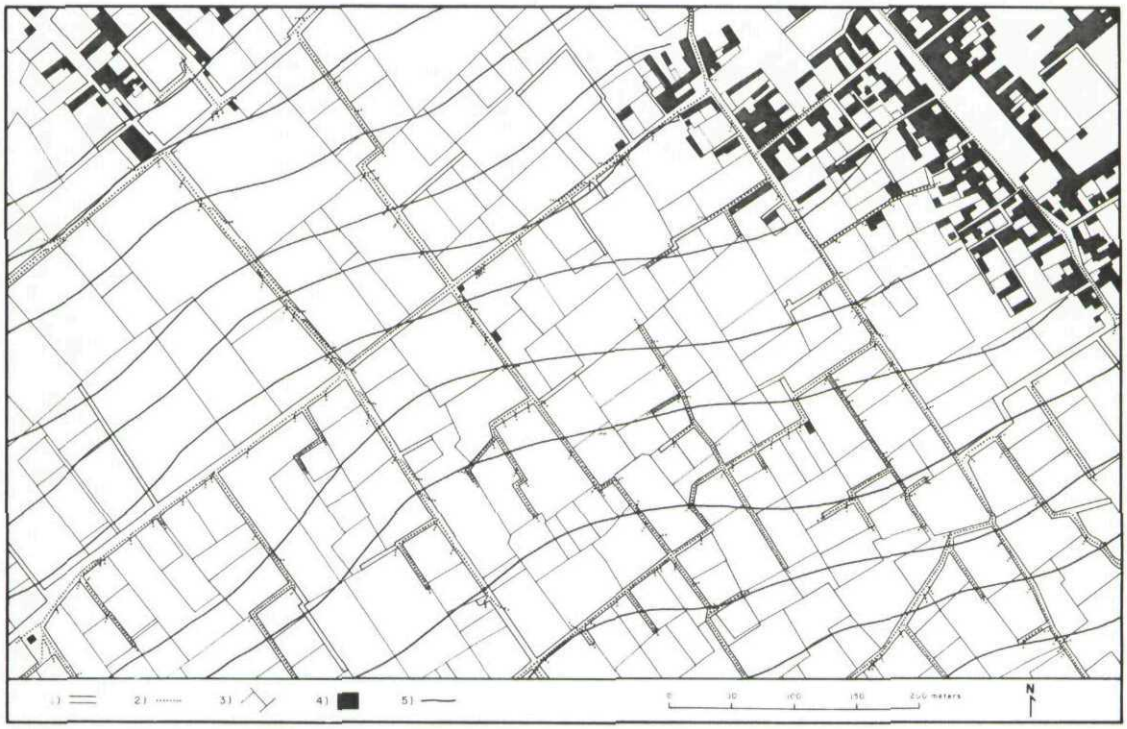

FIG. 8. Streets and irrigation channels among walled fields in Mehriz. 1) streets and alleyways, including cul-de-sacs; 2) water channels, shown only in public space and where entering fields; 3) walled fields and orchards; 4) residential and public buildings; 5) contour lines, one meter intervals decreasing in elevation to the southeast. Source: Iranian National Cartographic Center, "Mehriz (Yazd)" (Scale 1:2,000), Sheet 5, 1346 [1967/68]; street pattern checked and corrected, and irrigation channels added by the author in the field; contour lines were interpolated from spot elevations on an unknown datum.

ways, and it cannot be determined if they existed earlier. However, what is evident is that there are a number of qanats which flow to Yazd and the direction of these qanats within the basin is usually in the same orientation as the major streets of the city, both being related to the slope of the land (Fig. 7).[37]

Topography affects the orientation of most traditional Iranian cities. Orthogonal networks follow the land surface slope. Hence Kerman, Kermanshah, Qom, and a few other cities have one axis of their street pattern oriented toward Mecca because the direction of slope happens to be congruent (Table 1). Kermanshah, Qom, and Zahedan even have major wadis which flow in the same direction as the streets (and Mecca). Traditional linear streets in Rezaiyeh and Tabriz have no common direction because of rough and irregular topography.

Slope is important for the orientation of streets and the morphology of Iranian settlements because of the water distribution systems. The street network is comprised of linear passages oriented toward or perpendicular to the main slope; water channels are usually associated with these streets. Which came first? If the water supply system came first the jubs and lanes should conform to the topography, winding and twisting slightly to follow the exact slope of the land. If the street pattern had been laid out first, its direction would not necessarily relate to the topography. The pattern most frequently observed is an orthogonal network oriented toward the slope of the land.

RECTANGULAR FIELDS AND STREET NETWORKS

The familiar rectangular network of streets is apparent in Mehriz, a dispersed town south-

[37] Bulliet also has noted that in medieval Nishapur the streets were parallel and perpendicular to the slope, the same direction of the qanats and stream beds. See Richard W. Bulliet, "Medieval Nishapur: A Topographic and Demographic Reconstruction," *Studia Iranica*, Vol. 5 (1976), pp. 67–89; reference on p. 74.

FIG. 9. A major irrigation channel and street in Mehriz.

east of Yazd (Fig. 8). The main slope is to the southeast. Although there is a linear group of houses, the significant feature is that this intricate, orthogonal pattern of streets, similar to what has been observed in Iranian cities, is present without any houses. Long, linear streets run in the direction of the main slope, to the southeast; other major lanes intersect at right angles. Smaller perpendicular passages and cul-de-sacs also are present. And this pattern is found among cultivated fields and orchards!

The field patterns are square or more commonly rectangular and they run in the same direction as the streets. Each quadrangle is comprised of cultivated land which is separately owned from adjoining plots, and most are surrounded by high mud walls. Water channels accompany the major linear streets and even most of the smaller ones (Figs. 8, 9, and 10), although some of the minor lanes are used only for access to fields.

The example of Mehriz reveals the significant relationship between streets, water channels, and walled fields; all are oriented in the same direction. The major streets have irrigation channels while smaller passageways provide entry to the walled plots. Wider streets are associated with the main channels and smaller lanes follow the secondary jubs. Hence, a grid network of irrigation channels and streets exists to reach a quadrangular field system—or else such plots are designed to conform to an orthogonal irrigation distribution. It appears, then, that the rectangular, irrigated walled fields are a possible key to the street patterns. But why are plots walled and rectangular?

FIG. 10. A minor irrigation channel and lane (cul-de-sac) in Mehriz.

Central Plateau Irrigation Practices

Irrigation in the Iranian central plateau is of the border or strip variety.[38] The cultivated area is divided into a series of rectangular strips (*korts*) by low, parallel levees or border ridges (Fig. 11). The korts are constructed with their long axis in the direction of greatest slope. Water is diverted into the upper end of each strip and then advances downslope in a thin sheet. The size of a kort depends upon the flow

[38] For a discussion of border irrigation see James C. Marr, *The Border Method of Irrigation*, University of California, College of Agriculture, Circular 408, no date; U.S., Department of Interior, Bureau of Reclamation, *Irrigation Adviser's Guide* (Washington, D.C.: U.S. Government Printing Office, 1951), pp. 178–183; and U.S., Department of Agriculture, Soil Conservation Service, *Irrigation on Western Farms*, Agriculture Information Bulletin No. 199 (Washington, D.C.: U.S. Government Printing Office, 1959).

FIG. 11. Typical rectangular fields or korts in central Iran.

of water and infiltration rate of the soil, which, in turn, is related to the degree of slope.[39]

Ideally, the border irrigation system is designed so that the required amount of water has been delivered to the field by the time the water reaches the far end of the strip. Hence, the kort should be made as large as efficiently possible; if it is too small, time and water are wasted diverting water from kort to kort; if it is too large, too much water is absorbed by the time the water reaches the end—or else it may not reach the end. Although dimensions of korts usually are similar within one village, changes in one or more of the variables produce different sizes of korts in different regions.

Proper leveling and sizing of korts require skilled labor and planning. The downslope must be a gentle, uniform grade to prevent erosion and to spread the water evenly. The cross slope (the width or short axis of the kort) must be level to prevent the water from flowing down one side of the strip. Where there is a considerable incline, as in mountain villages, terraces may be used in conjunction with the border strips. In flatter areas the long axis of the korts may run either downslope or else perpendicular to the main slope.

Water is conveyed to the rectangular kort system in open ditches or jubs which branch from the main irrigation channel. The primary channel exits from the qanat and runs down the gradient. Hence there is a grid pattern of channels parallel and perpendicular to the main slope—the same directions in which the fields run. Even though the network of channels may be optimal for irrigating the rectangular field system, an irrigation system totally conforming to the topography with irregular fields should be more efficient for irrigation. Hence rectangular fields and property lines which conform to the direction of main slope appear to be the major constraint for the irrigation channels.

Rectangular Fields and Walled Orchards

Why are fields and orchards in central Iran so consistently rectangular? It has been recognized in West Africa, for example, that the more valuable, private cultivated plots are more rectangular than communal ones, and that population pressure may result in intensification of agriculture and the development of more permanent and regular field patterns.[40] Land surrounding Iranian cities is privately owned and the walled orchards comprise some of the most valuable agricultural land. Certainly square or rectangular fields are more conveniently measured than irregular ones which enables such plots to be taxed more easily or divided for inheritance, selling, or exchange. In Europe, for instance, "wherever the system of inheritance permits division of land among heirs, there is a tendency towards strips."[41]

Plowing methods offer few solutions. Nail or scratch plows are used in Iran, which should suggest square fields instead of rectangular ones

[39] A more extended discussion of irrigation specifically in Iran can be found in Ann K. S. Lambton, *Landlord and Peasant in Persia: A Study of Land Tenure and Land Revenue Administration* (London: Oxford University Press, 1953); and Michael E. Bonine, "Traditional Irrigation Systems and Practices in Central Iran," in *Proceedings of the International Seminar on Popular Traditions in Iran* (Tehran: Soroush Press, forthcoming).

[40] See W. B. Morgan, "Farming Practice, Settlement Pattern, and Population Density in South-Eastern Nigeria," *The Geographical Journal*, Vol. 121 (1955), pp. 320–33; reference on pp. 328–29; and M. B. Gleave and H. P. White, "Population Density and Agricultural Systems in West Africa," in M. F. Thomas and G. W. Whittington, eds., *Environment and Land Use in Africa* (London: Methuen and Co., 1969), pp. 273–300. The topic of agricultural intensity and population pressure has been stimulated especially by Ester Boserup, *The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure* (London: Allen and Unwin, 1965); and one of the more recent statements on the thesis is B. L. Turner II, Robert Q. Hanham, and Anthony V. Portararo, "Population Pressure and Agricultural Intensity," *Annals*, Association of American Geographers, Vol. 67 (1977), pp. 384–96.

[41] Lynn White, Jr., *Medieval Technology and Social Change* (London: Oxford University Press, 1962), p. 47.

FIG. 12. Rectangular walled fields and orchards in Taft. Note also the irregular terraced fields, which are located in an area of steep topography in this dispersed valley town.

because of the need for cross-plowing.[42] Within much of the central plateau, as in Yazd province, the plow is not used; spades are used instead.[43]

Permanent and more valuable fields commonly have fencing or walls to protect the crops from animals and humans.[44] Walled fields and orchards in Iran have wooden entrance doors which can be locked. In some instances thorns and broken glass are placed along the top of the walls. Since walled fields usually are orchards and since walls are found mostly around major settlements, these enclosures probably surround more valuable plots. Walls serve mainly to protect property.

FIG. 13. Diverting water from a main channel into a walled orchard in Mehriz.

In spite of not being able to identify the exact rationale for the field system, the important fact is that channels and fields are orthogonal and they are oriented in the direction of greatest slope.[45] The scheme is most consistent where there are extensive walled orchards and gardens, as on land surrounding the towns and cities of the Iranian central plateau (Fig. 12).

Irrigation Channels and Streets

The main irrigation jub and branch channels are associated with streets or alleyways because the jubs need to be accessible to persons who divert water to channels and fields (Fig. 13). Especially among walled fields and orchards the straight public jubs and passages are advantageous for keeping a watch on the channels and preventing any theft of water. In some areas of the Middle East, Islamic water law has required a *harim* [sacred area] as public space beside the channel to provide access to the

[42] For information on the nail plow see Wulff, op. cit., footnote 29, pp. 262–66; and the works cited in English, op. cit., footnote 8, p. 176, n. 12. White, Jr. (op. cit., footnote 41, pp. 41–57) discusses the relationship of field patterns and plow types, and concludes that "in plough structure and field arrangement there are many elements, no two of which have any constant and necessary relationship" (p. 48).

[43] Wulff, op. cit., footnote 29, pp. 260–62; Lambton, op. cit., footnote 39, p. 360; and Bonine, op. cit., footnote 39.

[44] Fencing also is one of the responses to the intensification of agriculture on permanent plots. See Morgan, op. cit., footnote 40, p. 329.

[45] One further explanation of field patterns in Iran has been presented by Bobek. He recognizes several major systems, such as regular blocks, irregular blocks, and strips. He attributes these types to differences in land ownership systems and landlord-peasant relationships. See Hans Bobek, "Entstehung und Verbreitung der Hauptflursysteme Irans—Grundzüge einer Sozialgeographischen Theorie," *Mitteilungen der Österreichischen Geographischen Gesellschaft*, Vol. 118 (1976), pp. 274–304; Vol. 119 (1977), pp. 34–51.

FIG. 14. Erosion of walls by a water channel in Mehriz.

water.[46] Although the present-day inhabitants of the central plateau are not aware of any such prescription, this does not preclude the possibility that it once may have been important.

A more practical consideration, however, is that there must be a space between the walls and the jub or the mud walls will be eroded away by the water (Figs. 10, 13, and 14). The larger the jub, the greater the distance there must be between the channel and the wall. Hence wider streets are associated with the main irrigation channels. A similar utilitarian regard is that individuals and animals cannot walk in the jubs and the existence of walled fields limits public thoroughfares to land alongside the channels. The existence of other passages would waste considerable land. The streets along the main channels are more heavily traveled and so the wider pathways are most practical.

There are, then, a number of factors which might contribute to the existence of streets in association with water channels and which would lead to an orthogonal network of passageways. The question remains as to why street patterns in cities are similar to those found among fields and orchards.

AGRICULTURAL SYSTEMS AND URBAN MORPHOLOGY

The basic morphology of traditional Iranian cities was created by the expansion of original core settlements into adjacent cultivated fields and orchards. Rectangular fields surrounding the settlement already had a system of flood irrigation with water channels laid out in a grid pattern which maximized the slope characteristics. Orchards were especially common around cities, often owned by members of the urban elite. The walls around these rectangular plots suggest an orthogonal street pattern. Houses were built outside the core settlement along existing lanes and water channels, filling in the orchards and cultivated fields. When houses were constructed in the fields between major streets, a few more blind alleys were created to provide access to the new structures.

Suburban villages also were incorporated into an expanding city. Because of the slope characteristics and a similar process of growth for the villages, these settlements often conformed to the morphology of the city. On the other hand, villages, as field patterns, may be oriented differently when topography varies, and village street networks may become part of a divergent city structure.

The urban morphology of Yazd reflects expansion into surrounding agricultural areas. The city was established several centuries before Islam as one of the frontier outposts of the Sassanian empire (224–641 A.D.), but it remained a small settlement until the fourteenth century when the city wall was extended, doubling the size of the town.[47] Much of this structure, called the inner or old city wall, remains today. What is apparent by the location and configuration of the wall is that it enclosed a city which already was circumscribed by a grid system of roads (Fig. 1). Except for the eastern section near the citadel, the wall conforms to the predominant direction of the streets.

[46] For example, this is the practice in Asir province in southwestern Saudi Arabia. Personal communication, Michael E. Norvelle, Office of Arid Lands Studies, University of Arizona.

[47] Ja'far ibn Mohammad ibn Hassan Ja'fari, *Tarikh-e Yazd* [History of Yazd], Text of 15th Century A.D., ed. by Iraj Afshar (Tehran: B.T.N.K., 1960), pp. 29, 50–51. A brief account of the evolution of the city of Yazd can be found in Michael E. Bonine, *Yazd and its Hinterland: A Central Place System of Dominance in the Central Iranian Plateau*, unpublished doctoral dissertation, University of Texas at Austin, 1975, pp. 16–23.

FIG. 15. Field patterns in the suburbs of Yazd.

The lanes which radiate outward from the inner city wall constitute part of the orthogonal street system. The city slopes to the northwest at a rate of four meters per kilometer; the slope to the northeast is more gentle, about three meters per kilometer (Fig. 7). The linear streets, then, probably were built in conjunction with irrigation channels and the rectangular field system. After the fourteenth century, housing expanded beyond the old city wall into most of the area that was enclosed by a new, but less imposing, outer city wall which was constructed sometime before the nineteenth century (Fig. 1).[48] Cultivated land was included within the boundaries of the outer city wall, a pattern typical of traditional Iranian and Central Asian cities.[49]

Agricultural land still surrounds the city of Yazd, and expansion into these areas continues today. Villages also are located in these suburbs, especially on the higher slopes toward the south, and most of the cultivation consists of walled orchards and fields (Figs. 7 and 15). Contemporary Yazd is expanding mainly to the south and the suburbanization of the rectangular plots has increased considerably within the last several decades. The process is very evident among several noncontiguous rows of houses which conform to the widths and lengths of adjoining fields and where the preexisting pattern of major streets remains among the fields and houses (Figs. 6, 12, and 16). Several irregular areas can be discerned among the field patterns south of Yazd, and as the city expands and engulfs this terrain these anomalies

[48] Shetalov (op. cit., footnote 21, pp. 59–60) discusses this outer wall which already was in ruins by the late nineteenth century. His map of Yazd shows this city wall, although almost none of the wall remains today.

[49] Central Asian and probably Iranian cities were divided into three parts: the citadel, internal city, and outer city, each with their own walls. Considerable cultivated land was included within the outer city. See Vasilii Vladimirovich Barthold, *Mussulman Culture* (Lahore: The Book House, 1971), pp. 31–33; and Otar Tskitishvili, "Two Questions Connected with the Topography of the Oriental City in the Early Middle Ages," *Journal of the Economic and Social History of the Orient*, Vol. 14 (1971), pp. 311–20. In Samarqand, for example, at least two-thirds of the outer city was under crops.

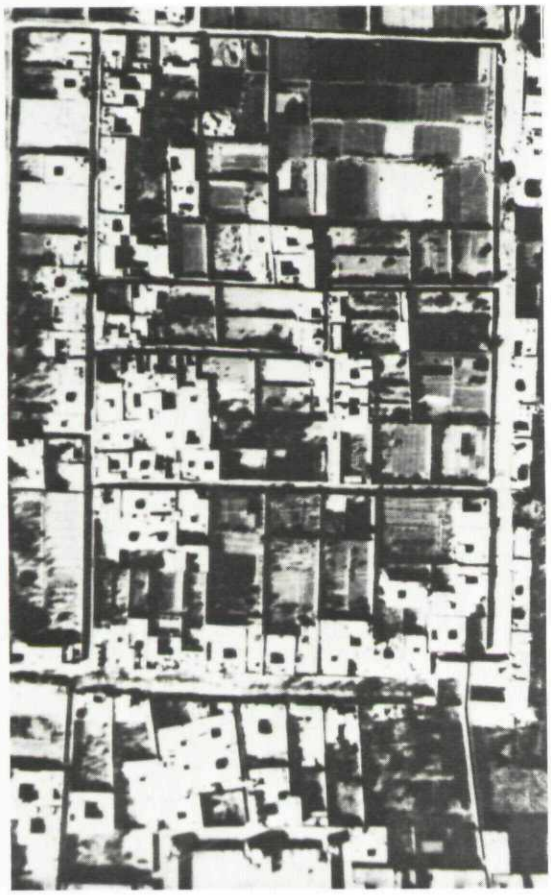

FIG. 16. Houses filling in fields in the suburbs of Yazd.

will be rendered into urban morphology (Fig. 15).

The orthogonal street plans of Sabzevar, Shiraz, Kerman, and Ardekan were formed by similar processes.[50] The direction of the linear streets conforms to the predominant slope, or its perpendicular, and the urban morphology results from expansion into the contiguous agricultural land. Tehran's road system is oriented in cardinal directions not due to the cool breezes of the mountains but because water flows directly south from the Elborz.

CONCLUSION

Street systems in Iranian cities were constructed rationally given the environment and the preindustrial economy. A grid pattern of main streets was established in conjunction with a system of channels used to irrigate agricultural land. The orientation of this network was determined by the need to arrange the rectangular fields and orchards to the slope of the land. Major streets, as well as many blind alleys, already existed within the field patterns before houses spread into these areas. Even the sizes and shapes of new suburban houses were governed by the preexisting system of fields and passageways.

In gradual and uniformly sloping terrain, irrigation channels, streets, and houses are all oriented in this orthogonal configuration. In irregular topography, jubs, field patterns, and houses are also irregular. Topography and water thus constitute the elementary principles of Iranian settlement geography.[51]

Contrary to the view postulated by Orientalists for the ideal Islamic city, the Iranian city is not "a tangle of blocks badly ventilated by a labyrinth of twisted alleys and dark courts."[52] There is no need to explain street patterns in terms of the tenets of Islam or the preferences of civil authority. Even though more blind alleys develop as houses fill in fields between major streets, this is not symptomatic of "decadence." Rather it denotes a reasonable solution to the practical problem of providing access to a compact assemblage of houses.[53]

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[50] The 1:2,000 and 1:2,500 scale maps of Iranian cities produced in the 1960s by the Iranian National Cartographic Center may be used to see the interrelationships of streets, houses, and fields. A number of these maps for cities surrounding the Dasht-e Kavir have been reproduced at smaller scales in *Dar Rahgozar-e Kavir* [Along the Edge of the Desert] (Tehran: Special Office of the Queen of Iran, 1353 [1974/75]). The more readily available city maps by Sahab Geographic and Drafting Institute of Tehran are too general and inaccurate in most cases for these purposes. Although difficult to find, aerial photographs of Iranian cities also are important for analyzing these interrelationships. See Erich F. Schmidt, *Flights over Ancient Cities of Iran* (Chicago: University of Chicago Press, 1940); and some of the monographs on individual Iranian cities cited in Michael E. Bonine, *Urbanization and City Structure in Contemporary Iran and Afghanistan: A Selected Annotated Bibliography*, Exchange Bibliography, No. 875 (Monticello, Illinois: Council of Planning Libraries, 1975).

[51] The importance of field patterns, water systems, and topography on the morphology of settlements has been recognized. See, for example, Gabriele Schwarz, *Allgemeine Siedlungsgeographie* (Berlin: Walter de Gruyter, 1966), pp. 191–254; however, when discussing the Middle Eastern city, Schwarz reverts to the Orientalists' viewpoint (see pp. 517–20).

[52] de Planhol, op. cit., footnote 8, p. 1.

[53] The development of cul-de-sacs is more complicated within built-up cities, although it is doubtful if they result from "some natural or social calamity, a

Irrigation and agricultural practices, then, play an overriding role in the layout and morphology of traditional Iranian cities. One must be careful, however, in postulating similar processes and patterns elsewhere in the Middle East. Many cities in this cultural region are built on mounds or tells and other principles may influence street networks—although many cities certainly have expanded beyond an original mound. Street patterns in new garrison and royal cities remain as a problem. Planned cities in the Islamic Middle East certainly were common, as Wirth has noted.[54] The interesting question, however, is whether city designs resulted from urban planning or whether they developed from planning for irrigation and agriculture systems.

The morphology of traditional Middle Eastern cities needs to be reevaluated. A single model for this cultural region—at least the Islamic city model as popularized by von Grunebaum and de Planhol—is inadequate.[55] Winters, for example, has shown major differences for the structure of cities in the north central Sudan, partly because of elements of a Black African urban "archetype" but also because the stereotyped model of the Islamic city is used for comparison.[56] Urbanism in this region developed over many millennia, and Islam is only one of the factors which has contributed to the form and structure of Middle Eastern cities.

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fire, an invasion, epidemic, or other disaster" or represent "a logical expression of certain quasi-religious values inherent in the Muslim way of life" (Wheatley, op. cit., footnote 7, pp. 364–65). Wirth (op. cit., footnote 6, pp. 69–75) gives examples of blind alleys developing within built-up areas, both in Islamic and pre-Islamic cities. He also shows several examples of planned dead-end streets in North African cities (pp. 70–72). It would be interesting to know what the role of water channels is within these cities.

[54] Wirth, op. cit., footnote 6, pp. 61–74.

[55] von Grunebaum, op. cit., footnote 2, pp. 141–58; and de Planhol, op. cit., footnote 8, pp. 1–41.

[56] Christopher Winters, "Traditional Urbanism in the North Central Sudan," *Annals*, Association of American Geographers, Vol. 67 (1977), pp. 500–20. The problem of using the stereotyped Islamic city model is illustrated by the street patterns. Irregular streets are given as one of the characteristics of the Islamic city by Winters (p. 512). He then stresses that "urbanism in the Sudan did not involve, as it sometime did in the Middle East, an element of control over . . . the flow of water," and he cites an example of irregular streets in a Sudanese city which followed ravines (p. 519). Streets are irregular in Sudanese cities because the technology of water control was not available and hence in this case irregularity is a characteristic of the Black African urban archetype instead of the Middle Eastern archetype!