CHAPTER 4

IRRIGATION AND SOCIETY
The Iranian Plateau

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Every anthropologist needs to start out by considering just how much of the culture with which he is faced can most readily be understood as a direct adaptation to the environmental context including that part of the context which is man-made. [Leach 1961:306]

Although it is generally taken for granted that "irrigation societies" constitute an obviously valid category for cross-cultural study and sociological and historical generalization, the results so far have been notably meager. For this reason alone it might prove useful to trace the categorization back through the literature, to see how it arose, and to consider whether a different or at least a modified categorization might facilitate generalization.

As a category for anthropological study, the term "irrigation civilizations" appears to owe its currency to the symposium edited by Julian Steward under the title *Irrigation Civilizations: A Comparative Study, a Symposium on Method and Result in Cross-cultural Regularities* (1955). This symposium was organized at the 1953 Annual Meeting of the American Anthropological Association at Tucson, Arizona with the explicit aim of testing the "basic methodology" of studies in cultural evolution (Steward 1955:1). The interest which generated the proposal for such a symposium is traced to Leslie White's neo-evolutionary theories and to V. Gordon Childe's efforts to "interpret Old World archaeology according to a general evolutionary approach." The particular theme "irrigation civilizations" was chosen because of "the seeming parallels in the development of the early irrigation civilizations of Mesoamerica, Peru, China, and the Near East" (Steward 1955:1-2):

The hypothesis that these civilizations had developed through similar periods for fundamentally the same reasons provided the hypothesis to be tested. This hypothesis is evolutionary, but it arises from a special conception of cultural development known as multilinear evolution. . . .

The concept of multilinear evolution was provisionally formulated in "Culture and Process" prepared for the 1952 symposium of the Wenner-Gren Foundation (Steward 1953). The germ of this concept, however, was stated nearly twenty years earlier in "The Social and Economic Basis of Primitive Bands" (Steward 1936). This approach received tremendous stimulus when Karl Wittfogel formulated the cross-culturally recurrent characteristics of the type that John Stuart Mill had called the "Orient State." After devoting many years to detailed analysis of Chinese culture history and thoroughly aware of the importance of water control in several key world areas, Wittfogel (1938) described this type of state as an Hydraulic Society or Hydraulic State.

In 1949, I undertook to extend Wittfogel's formulation by exploring the possibility that the hydraulic or irrigation societies began a parallel evolution with the first use of domesticated plants and that the development of local communities, technology, and even intellectual, aesthetic and religious achievements as well as the economic and political patterns ran similar courses.

At first sight the subject fits the proposal perfectly, and of course the resulting symposium was an excellent arena for the extension of Wittfogel's theories. However, quite apart from the merits or demerits of the Wittfogelian hypothesis, neither "irrigation society" nor "irrigation civilization" was explicitly defined, and none of the contributors to the symposium suggested any logically consistent reasoning for the definition of such a category for anthropological inquiry – beyond the "seeming parallels" of development. In fact the symposium was concerned exclusively with historical populations that depended economically upon types and scales of irrigation engineering requiring a relatively high level of investment; examples of populations depending on irrigation technologies that require relatively low levels of investment were not considered.

Since the publication of Steward's symposium, there has been a considerable increase in both the quantity and the quality of available data (ethnographic and archaeological) on populations practicing

irrigation, and Steward (1960:323) himself has revised his position. However, very little, if any, advance has been made in the theoretical or conceptual framework in which they have been published, and (to the best of my knowledge) the literature still contains no definition or justification of the categorization. This essay attempts to clarify these issues. The approach is ecological, and the method is first, to suggest a number of analytical distinctions which should be made in the anthropological study of populations dependent upon irrigation, and second, to illustrate their usefulness in brief accounts of two villages on the Iranian plateau. In so doing I hope to make some small contribution in general terms to our understanding of the systemic relationships between traditional technologies of irrigation and the organization and structure of the societies that have depended upon them.

ON THE STUDY OF "IRRIGATION SOCIETIES"

Irrigation implies a three-way relationship – men-land-water – in a temporal dimension. It therefore represents excellent subject matter for an anthropological study under the heading of "ecology and social structure" (cf. Forde 1971). For the present purpose we may define it as a problem: how much water must be led on to each of how many parcels of land by how many men how often. It is immediately obvious that we have four problems in one. The consideration of each of these problems in relation to the others should allow the formulation of basic criteria for a typology of irrigation systems. Typology is not, of course, an end in itself. It is, however, at least implicit in the first stage of generalization. In this context, it is well to make it explicit, since it is the underlying thesis of this essay that the anthropological literature on irrigation has suffered from implicit and inadequately thought out typology.

The first distinction that must be made is between *irrigation* and *inundation*. Inundation is the technique of maintaining a certain depth of slowly but continuously moving water as in wet rice cultivation in southeast Asia, where the crop acquires most of its nutrients not from the soil but from the water (see Geertz 1963:28-37). In irrigation, the nutrients come primarily from the soil, and the crop is watered at certain intervals to make up for deficiencies in the rainfall. This essay is concerned with irrigation rather than inundation. However, in certain cases inundation systems will be cited as examples of technologies which could be used for inundation or irrigation.

The next distinction which must be made is between three subsystems which are present in any system of irrigation. These are the distribution of water flow over the land parcels, the distribution of water rights among the population and investment. The first of these is temporal, the second social, and the third economic. All three subsystems are of course closely interrelated, but their relative significance in the relationship between irrigation and society varies according to the total technological context.

The essay by Netting (this volume) and the example of Deh Salm later in this essay adequately show that the maintenance of an efficient temporal distribution system not only does not require explicit or centralized control, but no one person need be aware of the full details of the system. In the case of Deh Salm, this may be explained by reference to the systems of inheritance and bridewealth, the transferal of property at marriage. The total number of shares is immediately divided into blocks which are controlled within groups of families who are more closely related internally than they are with other similar groups. I found that any informant had a general knowledge of which social or political grouping of families controlled the water flow at any given part of the cycle.[1] This knowledge was sufficient for the smooth working of the system; the method of division within the grouping was irrelevant to people outside it. Moreover, keeping the distribution system working – and the water flowing – never required more than one man to work at a time. No cooperation of individuals, let alone groups, was needed. Even cleaning the main channels could be accomplished by individuals. Therefore, no organization was required to facilitate the cooperation. During a three-month field season, I did not encounter any case of one individual infringing upon the rights of another by keeping the water flow beyond the time limit of his share. I was told it never happened, and I deduce that it is in every individual's interests to keep the system working smoothly. Thus rights to a particular feeder channel or small water source could be shared by two spatial communities (whether or not they are socially or politically separate villages, cf. Netting, this volume, and below, the case of Nayband), without generating any explicit authority system for central control. However, in these and similar cases of complex temporal distribution (cf. Lambton 1953, Chap. 10; Leach 1961), there is always the ultimate sanction, at least at the time when the studies were carried out, of appeal to a higher authority – police, law,

government. This authority, however, is not directly concerned in the maintenance of the irrigation system, and it is difficult to find examples of its employment. It might perhaps be argued that the Sonjo provide a unique case of local systems of centralized control, where without them there would have been no ultimate sanction (Gray 1963). However, even in this case, it is not clear whether the social structure developed primarily in response to the irrigation system or to the external Masai threat (cf. Millon 1962:62). In any case, it seems possible to propose as a minimum generalization that since any disturbance of the temporal distribution system affects all shareholders adversely, the normal premium on social order is increased.

With regard to the social distribution of water rights among the population, the situation is similar. Once again the data do not support the hypothesis that centralized policing or authority is necessarily generated. This aspect of the effects of irrigation technology on the organization of society must be sought in another direction – the process of individuation of rights in relation to resources. In recent years there has been a tendency to discuss such evolutionary processes in the context of population growth (e.g. Boserup 1965, Flannery 1969, Spooner 1973). In this context the most apposite statement so far has been made by Dumond (Spooner 1973:300-1):

> . . .pressure on basic resources tends to tighten concepts of tenure, so that in place of free use of plentiful land, the rights of use are ultimately vested in a corporate group that itself has rights of reversion when usable land is not employed. If this is true, it seems reasonable to think that continued pressure will further increase both the demand for land and the temptation to control it privately (see Boserup 1965:86-87). *The temptation should be especially great when land is irrigated.* Irrigation can be seen as a population-density-related, labor-produced capital improvement, that adds to the value of the land. Its importance is that it sharply defines an area of high land value. It is important in its influence on matters of land tenure, but not because of the managerial requirements of the irrigation system itself. . . . (Emphasis added)

On the basis of this brief discussion of the temporal and social subsystems, it may be argued that the features of irrigation technology which are most significant in the organization and structure of irrigation-based societies derive from the economic subsystem, or the investment factor, and it is on this factor that the remainder of this essay is focused.

The decision to irrigate, like the decision to cultivate, represents a decision to increase the productivity of a piece of land. It invariably involves some degree of capital improvement or investment. These two factors of the economic subsystem – increase in productivity and creation of investment – either in combination or severally, lead to certain predictable social consequences, which are more tangible than the order and individuation predicated for the temporal and social subsystems. We might expect that the greater the investment the greater the emphasis on title and control, and, consequently, the greater the degree of individuation and stratification in the particular society. Similarly, different types of investment might be expected to generate different systems of ownership and control.

For instance, in the study of the traditional systems on the Iranian plateau, it is possible to argue that an increase in productivity and investment brings about an increase in the value of land, and creates problems of differential access and title. Title tends to be individuated. The greater the investment required to ensure a continuous flow of water for irrigation, the more valuable will be title to water compared to title to land. There are examples in which the available cultivable land is as restricted, and even requires as much investment, as the water flow, and (as we might expect) title to land automatically includes title to water (for example, in the case of Nayband, below). Where the available land is less restricted than the water, title to land may be separate from title to water, and in extreme cases where the available land is far greater than the available water, title to land may be included in title to water. In small irrigation systems, especially where the engineering problem is to start and keep the water flowing (e.g., qanat, see English 1968 and Neely, this volume) and not simply to provide channels for water (as in, for example, Mesopotamia and the really "hydraulic" systems which attracted Wittfogel's avowedly "geohistorical" rather than ecological interest), the tendency is for water to become the object of individual title. In such situations, the effects on society of the process of individuation of title to resources is intensified. Generally, if a man owns land by a river, he gets water anyway, but if he owns land by a qanat, he does not necessarily get any water from it. Qanats are privately owned, but rivers are not. The formulation of this situation in Islamic law is both logical and instructive (Lambton 1953:210-11):

According to Islamic theory water is divided into three categories: that coming from (1) rivers, (2) wells, and (3) springs. Rivers are further subdivided. First are great rivers, such as the Tigris, the Euphrates, and other large rivers, the water of which suffices for all the needs of cultivation and from which anyone can lead off a channel to irrigate his land. These are owned in common by all Muslims. Secondly, there are lesser rivers, subdivided again into (1) those the water of which is sufficient to be led off without dams to irrigate the land situated along the river banks, and from which canals to irrigate other lands can only be led off if such action does not prejudice the position of the lands situated along the banks, and (2) those in which barrages have to be made, in which case lands situated higher up the river have a prior right to those situated lower down. The amount of water which can be taken off depends upon circumstances, local needs, and custom. Thirdly, there are canals dug to bring water to dead lands. These belong to those who dug them.

Qanats are privately owned because they are constructed by private individuals. By similar reasoning, rivers may not be privately owned, and since they cannot be private property, individuals do not invest in improving their efficacy for irrigation, even if it is within their means. The improvement is done only by states, which by definition own all land and water within their territory that is not privately owned, as well as holding reversionary rights over privately owned land and water. The only exception to this rule is the small river or stream in which the amount of water flow produced by the investment does not greatly exceed the requirements of one man's cultivation. Streams may, however, be used to produce "hydraulic" systems – as, for example, in Ceylon (Leach 1961:16) where the classical Sinhalese kingdom, with its capital at Anuradhapura, was a striking and characteristic example of what Wittfogel has called "hydraulic civilization" (Wittfogel 1957; cf. Leach 1959). Here a region of poor natural fertility was made to support a large and flourishing population by resort to irrigation engineering. In this case, however, the engineering problem (Leach 1961:17-18) was different from that in Iran:

> The modern irrigation works of Nuvarakalaviya, like their ancient predecessors, fall into two distinct categories. There are the small reservoirs (tanks) associated with individual villages and the very much larger central reservoirs and feeder canals which now, as formerly, are under the control of the central government.... Pul Eliya is not today connected with any central irrigation system and, so far as can be judged, it never has been so connected in the past.
>
> Of the smaller reservoirs – the village tanks – there are today several thousand in actual use. Almost all are of ancient origin, but only a few have been in continuous use over the centuries. The great majority have been abandoned at various times and then restored again.
>
> In this economy the basic valuable is scarce water rather than scarce land....
>
> A village tank is created by damming up a natural stream and building a long earthwork wall to hold the water up behind it. The resulting reservoir (when full) is usually about seven feet deep immediately behind the earthwork ('bund'). Very roughly, the full tank covers much the same area of ground as the land below it which it is capable of irrigating....
>
> The village of Pul Eliya today has a main tank of about 140 acres.

In this study of Pul Eliya, Leach (1961:1, 20) exaggerated the role of the land and water tenure system in social organization in such a way that he ensured that it should never again be ignored. It was not his aim to contribute to the type of discussion which is the theme of this volume. Nevertheless, he includes the information that at least the older part of the system is not really centralized (cf. Millon 1962:64) even though it is highly complex. The fact that it is complex (in terms of the relationship between division of land, division of water, and distribution of rights to both among the population) is particularly significant here, because it is at least partly for this reason that despite the smallness of scale (the total population was only 146, and the irrigated acreage 135), repairs to the tank had to be government-assisted. It is argued below, in the case of Deh Salm, that small complex systems tend to have investment problems which require or invite political or economic interest from outside the community.

It follows from these considerations that when discussing types of investment, a third distinction must be made between the engineering of 1) *conveyance,* by channelling water which is already naturally flowing on the surface, 2) *storage,* by means of dams or tanks, of water which although already on the surface is not always available when it is needed, and 3) *bringing to the surface* groundwater by qanat or wells. Many systems must cope with more than one of these problems. Nevertheless, one generally tends to be more characteristic of a system than the others.

At this stage it may be useful to draw up a rough typology of irrigation systems based on source, in order to bring out the relationship between the source, the primary engineering problem, and the other criteria which emerge from the discussion:

I. Permanent flow surface sources
   A. Large permanent rivers
      1. Basin irrigation, e.g. the Nile[2] (cf. Kees 1961:52-60; Hamdan 1961).
      2. Canal irrigation – perhaps the most common of all, e.g. Mesopotamia (cf. Jacobsen and Adams 1958, Adams 1965, Fernea 1970), the Indus (Leshnik 1972), China (cf. Te-K'un III:xxx-xxxi, Chi 1936), Mesoamerica (Steward 1955; Price 1971), Peru (Steward 1955), Khwarazmia (Frumkin 1970, Chapter 5), Sistan (cf. Le Strange 1905, Chapter 24).
   B. Small rivers and streams, e.g. the Sonjo (Gray 1963).
   C. Springs, e.g. Nayband (see below).

II. Intermittent or extremely variable-flow surface sources
   A. Sheet run off or wadi flooding, e.g. Hadhramaut (Hartley 1961, Bujra 1970), Baluchistan (Raikes 1965).

III. Ground Water
   A. Qanat (kariz, foggara), e.g. Iranian plateau (cf. English 1968), Sahara (Briggs 1960: 10-12), cf. Deh Salm, below.
   B. Wells, etc. which require lifting techniques such as the shaduf (cf. Drower 1954).

The fourth distinction, which may be introduced now, is that of scale. This is of course not a new distinction, and it has been implicit already in this discussion. However, the distinctions of scale that have been made in the literature are unsatisfactory because they are either arbitrary or have been derived from the theory they were designed to prove, rather than from the technology. Wittfogel (1957:3) made the distinction between a "farming economy that involves small-scale irrigation" which he called "hydroagriculture" and "one that involves large-scale and government-managed works of irrigation and flood control" which he designated "hydraulic agriculture." The distinction is of course not without validity, but requires more careful definition based on ecological rather than bureaucratic premises. Wittfogel (1957:17-18) is not concerned with hydroagriculture:

> Irrigation farming always requires more physical effort than rainfall farming performed under comparable conditions. But it requires radical social and political adjustments only in a special geohistorical setting. Strictly local tasks of digging, damming, and water distribution can be performed by a single husbandman, a single family or a small group of neighbors, and in this case no far-reaching organizational steps are necessary. Hydroagriculture, farming based on small-scale irrigation, increases the food supply, but it does not involve the patterns of organization and social control that characterize hydraulic agriculture.

Though the "hydro-" terminology has found only limited acceptance, the "large-scale/small-scale" distinction is common in the literature, and has been modified only slightly, for example, by Millon (1962) who also distinguishes single village systems from multi-community systems. I wish to introduce a further modification, or rather set of modifications, for in the context of the relationship between irrigation and society, the criterion of scale works differently depending upon whether we are considering the economic, temporal, or social distribution subsystems of the total irrigation system. The latter two have been treated briefly above.

In the consideration of the economic subsystem, there is a more obvious case to be made for the type of scale distinction that has generally been used. But Wittfogel's equation of "large scale" with "government-managed" is unnecessary and misleading. I suggest that if we start from ecological premises, since we have seen that centralized authority is not necessarily generated by the water distribution systems, we have no grounds for positing that it should be generated by the investment subsystem. We should look instead at the degree of cooperation that is required to keep any given subsystem going, and whether or not, when we find cooperation, we also find organization of cooperation. In the temporal and social distribution subsystems, positive or organized cooperation is not required, whereas in the economic subsystem it often is required.

So long as the investment required to maintain the system is within the means of the individual operators, it may remain a village system. However, when a differentiation of wealth arises in the population to the degree where a single operator is able to take on a broader investment role in the community, a qualitative sociological change may take place. Assuming that the incentives are there, one or more men may, through investment, acquire controlling influence over productivity and labor beyond their subsistence requirements. Thus, an economic elite is formed which, though it may not lead to explicit differentiation of political status and centralization of power, must affect the political situation.

Such differentiation of individuals may take place without affecting the status of the system as a single

village irrigation system, operated, maintained, and controlled from within. However, in many such cases the differentiation did not develop within the system, but was imposed upon it from without. This exogenous imposition of a "class" system can take place by political or economic means – by conquest or by economic imperialism. Such cases are typically based on the control and diversion of larger rivers. However, it is necessary to note first, that not all large rivers are exploited exclusively by large scale systems (e.g., basin irrigation on the Nile, in Kees 1961:52-61), and second, in qanat systems it is possible for one man to acquire a controlling interest in the qanat of several villages – a situation which was common in Persia before Land Reform. It should also be noted that this latter case is essentially one of economic, not political, centralization. It requires a great degree of financial investment, but it does not require a high degree of organization of men and materials, for qanat construction takes much time, but cannot utilize large numbers of men. Of course, ownership of the water supply of even one village – let alone of many villages – cannot be without political significance. However, this political significance is of the order discussed above in relation to the social distribution subsystem. It is indirect, not direct political control as in the Wittfogelian scheme.

Large scale systems, therefore, tend to differ from smaller systems in the degree of centralized organization – of money, men, or materials – which they require for maintenance and expansion. Therefore, from the sociological point of view, rather than distinguishing according to size (small scale and large scale or single village and multi-village systems), it would seem more fruitful to make an economic distinction based on complexity. Systems in which the individual operator can control and maintain his own part, whether or not he knows the details of the total system, I call "simple systems." Whereas, "complex systems" require engineering and maintenance beyond the ability of individuals or groups involved in actual cultivation.

To return now to the typology given above: in type I, permanent flow surface source, the engineering problem consists of conveying the water by gravity flow in a controlled manner from the source to the fields. In type I.A.2, canal irrigation involves the digging, maintenance, and cleaning of canals or channels (cf. Fernea 1970:57-162). It is in this category that we find the greatest range of scale, but in the terms proposed above, this category comprehends both simple and complex systems. In type II, intermittent or extremely variable-flow surface sources, the engineering problem lies in the storage and control of water which would otherwise not be available at the desired season or in the desired quantity. In type III, groundwater, the problem is to bring the water to the surface. In terms of absolute scale, systems which fall within types II and III are generally small, and would be accounted "small scale" according to the traditional large scale/small scale criterion. However, they may be either simple or complex. Qanat systems do not generate centralized authority on any scale, and have therefore been distinguished conceptually from the hydraulic systems which would fall into type I.A. This distinction is, however, quantitative, not qualitative, and from the anthropological point of view, it is primarily the qualitative distinctions that are significant, since any useful model of the relationship between irrigation technologies and other aspects of culture and society must be constructed in generative terms, and the basic typology or scheme of definitions must be subservient to the generative model.

As soon as the necessary degree of organization of labor, materials, or money is beyond the means of the individual operator, some degree of political or economic centralization becomes adaptive. However, centralization does not always develop, and it is in fact very difficult to show that any centralized system has actually evolved in this way. It is much easier to demonstrate the reverse, for example, that centralized political systems have been able to initiate and maintain complex irrigation systems because of their ability to organize investment on a large scale.

If the argument so far has been valid, and the analytical distinction between simple and complex irrigation systems is as far as we can go in generating social organization from ecological considerations in societies that depend on irrigation, then the situation in societies with simple irrigation technology but centralized political or economic systems must be explained by factors other than irrigation. Further, if there is nothing inherent in irrigation per se that has predictable effects in other aspects of society and culture but only in the organization of labor and materials involved in certain types of irrigation, then there could logically be other technological systems which are comparable in their social effects. It seems likely, however, that no other such technologies evolved before the modern industrial age.

TWO ETHNOGRAPHIC SKETCHES

These sketches illustrate the application of the simple/complex criterion in the analysis of two small oasis villages on the Iranian plateau in eastern Iran.[1]

Deh Salm

The village of Deh Salm lies in an extensive arid plain some 100 kilometers west of Neh, which is the southernmost administrative center (*bakhsh*) of the province of Khorasan in eastern Iran (see Neely, this volume, Fig. 1). It has a population of forty families. There is no other settlement in the plain, and only a few small villages in the mountains to the north and northeast. To the east, between Deh Salm and Neh, over a range of mountains and a difficult pass, lies a plain where pastoralists formerly practiced small-scale grain cultivation with the excess water from wells (Chah Dashi) used to water their animals. Chah Dashi has recently been developed for grain growing by means of diesel pumps. In the remaining arc from the southeast round to the northwest, there is no further settlement until the other side of the desert, a minimum straight distance of 150 kilometers. To the south, the territory has traditionally been under the control of Baluch tribes of nomadic pastoralists. Deh Salm therefore represents the southwestern outpost of settled agriculture in eastern Iran. Its geographical isolation has been an important factor in its history. However – and this is the primary point that the following ethnographic and historical summary serves – it represents a type of agricultural settlement which cannot exist for long in economic and political isolation.

There are no rainfall records for the area; however, I estimated it to be well below 100 millimeters per year, with great variation from year to year and highest probability in spring and autumn. For agricultural purposes – the main economic interest of the population as a whole – rain is simply a bonus if it should fall at an agriculturally useful time. Whenever it falls, however, it brings peripheral and indirect benefits by transforming the surrounding countryside into good pasture (on the rather low local standards), especially for goats and camels.

Rainfall does provide the main source of drinking water. Runoff is channelled into small domed tanks (*hauz*; elsewhere called *āb anbār*; for details of construction, see Siroux 1959), where after the sediment has settled it remains fresh and clear for many months. This water is referred to as "the water of God's mercy" (*āb-i rahmat*), and should be used only for drinking, not cooking, washing, or irrigation.

Essentially, Deh Salm depends upon a single water source – a qanat (see Chap. 3). The qanat enters the village from the north, and surfaces in a stone-lined pool which is used for general washing purposes by the men. From here it passes into another similar pool surrounded by a higher wall, for the use of the women. Beyond this pool, the qanat divides into two main channels which serve the two tongues of cultivated area (*keshmun*) and palm plantations which stretch out to the south. The short stretch of some fifteen yards from the men's pool, past the enclosed women's pool, to the division of the channels is the hub of the village. All changeovers between shares of water flow for irrigation are taken from here.

The most significant factor in the pattern of land distribution and use is the distance from the point where the channel divides (*sar-i ju*). The farther the water has to flow to the crop, the more water is lost through seepage and evaporation on the way. (However, no time of flow is lost, since the next man – even if his plot is adjacent – must start his flow also from *sar-i ju*.) Therefore, the land closest to the divisor (*sar-i ju*) is the most valuable, and may sell for as much as 5000 Rials per *faran* (approximately 600 square metres; 75 Rials = approximately $1.00; the price of a kilogram of wheat varies from 10 to 15 Rials). Land farthest away may sell for only a fifth of that price. Palms are grown throughout the cultivated area (*keshmun*) along the sides of channels and on land unsuitable for cultivation, but they are raised only on cultivable land on the cheaper stretches at the limits of the *keshmun*. The land has had to be dug down, in some cases several feet, in order to lower the surface to a level which is irrigable by gravity flow from *sar-i ju*. This leveling represents the only major investment entailed in the creation of fields. All that remains to be done is to divide the land into irrigable segments (*kal;* elsewhere in eastern Iran, *khid*) connected by feeder channels (*ju*). The ideal segment size is considered to be about half a *fārān*, i.e. approximately 30 x 10 meters, although many are smaller. Each segment is separated by a ridge of earth (*pal, bāza*), and when a segment is owned by different people, stones are laid along the top (*sang-i bāza*). A simple scratch plough is sometimes used by men who have large holdings, but digging with spades is considered preferable. A common type of dispute arises when a man ploughs or digs consistently a little too close to the ridge so that a little earth falls over it onto his neighbor's side. As a result, the ridge itself gradually moves over. It was noticeable that ridges generally tend to meander slightly. Digging is done to a depth of six inches or more and is extremely hard work, especially in summer temperatures of well over 100 degrees F. in the shade.

Land is fallowed every other year. The summer is the main time for digging because the land has to be prepared for the sowing of the autumn crop. The young men work together in informal teams of three or four, digging each other's land. Older or richer

men, or women whose men are away, hire a digger at the cost of a day's food, including an evening meal with meat. A man starts early in the morning, works till nine or ten A.M., and returns for about two hours in the afternoon. An able man might finish half a *fārān* within the day.

Before digging, each segment is watered to soften it. After digging, it is left to take in the sun (*āftāb bokhorad*) for a month or so before being planted. The major crops are wheat and turnips. Several crops may be sown on one piece of land in the course of the year, starting with turnips in the autumn and finishing with melons in the summer. Then the land will be left fallow for a year. Cotton is grown on the same land several years running without the intervention of other crops, except that melons may be grown amongst it in the summer. Garden vegetables are not grown in the village except by a gendarme on borrowed land, with borrowed water.

There are an estimated 25,000 date palms in Deh Salm. If the count is not too far out, in an "average" year the palms should yield approximately 1,250,000 kilograms of dates of varying species and qualities. The best dates sell at 10 Rials per kilogram. The best trees are priced at 5,000 Rials, though an average price would be in the region of 3,000 Rials. Like tree crops generally, dates require very little labor for a high return. They must be artificially pollinated in the spring and picked in the late summer or early autumn according to species. Apart from these two operations, which require large amounts of labor for short periods, one man can tend literally thousands of palms. According to their situation, date palms may require occasional irrigation. Dead or excess branches and clusters of fruit should be removed, and during the ripening season care should be taken that the heavy clusters are properly supported. Because of the low labor requirement, palms with potentially large annual produce, however important they could be in a market-oriented economy, do not provide the principal occupational focus of the population. Similarly, they are marginal to the irrigation system.

Besides land, water, and date palms, the average family owns a few goats and perhaps a cow and a camel. Many more camels belonging to non-villagers (estimates range from one to three thousand) roam the surrounding plains. These find their own pasture, returning to the village for water at intervals from a day to several weeks according to the season and the state of the pasture. Occasionally their owners come from elsewhere and round them up to sell as meat.

Scarcely anything is known of the history of Deh Salm, but it is generally considered to date from at least the early Islamic period. The circumstances of the construction of the qanat are unknown. It is approximately three kilometers long, and it was necessary to use pottery hoops along at least part of its length to strengthen the roof of the channel. However, routine maintenance has not been carried out in it for some time since there are no professional qanat-diggers (*moqanni*) in the village, nor anyone with any special interest or expertise in qanat construction or maintenance. Throughout the period I spent in Deh Salm, I could elicit no data about routine maintenance, and I am confident that if ever anything had to be done to the qanat it would require help from outside the village, both for labor and financing.

The flow of water is distributed according to a twelve-and-a-half-day cycle. The cycle is divided into twenty-five periods (*meh*) of half a day each, from sunrise to sunset or sunset to sunrise, and each period is divided into twenty-five shares (*khābiya or khomma*, literally "pitcher"), making 625 shares in all. When evaluated according to the clock, each share is considered to last half an hour.

Record of the distribution of shares is said to have been kept in a book. However, if this is historically true and the book still exists, no one seems to know where, and it has not been seen for many years. In day-to-day distribution, the length of each share used to be measured in the conventional way by letting a small metal bowl with a hole in it sink in a larger bowl filled with water. Each clink of the smaller bowl hitting the bottom of the larger bowl signalled the end of a unit of water flow. However, this method is no longer practiced. Instead, the time is estimated according to the sun, and when there is any doubt, someone is sent to ask the time of the gendarmes, or of myself! Such vagueness is possible because in only very few cases does the ownership change at the end of only one share, and when it does, it is either rented to someone else who owns at least one share before or after it in the cycle, or the owner forms a "company" (*sherkat*) with those owning the shares on either side. In the latter case, a number of men agree to pool their shares of water and cooperate in the cultivation of their land. It might, therefore, be argued that the poor are obliged by the temporal subsystem to surrender part of their autonomy.

The use of a twelve-and-a-half-day cycle cancels out the inequalities which resulted from the varying lengths of the night and day during the year. Sunrise and sunset are always used as the points of reference from which the shares were estimated in terms of hours and half hours.

Time estimation is not the only element of vagueness in the operation of the system. No one owner – so far as I could tell – knew the total distribution system. Though disputes are a regular part of daily life in Deh Salm, they were never (while I was there) occasioned by differences over the distribution of water. However, while no one can recite the succession of owners through the total cycle, every member of the community measures time in terms of twelve-and-a-half-day cycles and associates different parts of the cultivated area (*keshmun*) and social groups in the village with different parts of the cycle.

The system has no overseer or referee. When a man considers that it is time for his share, he proceeds to the divisor (*sar-i ju*) and either diverts the flow from one channel to the other, or if that is not necessary, follows the flow to the point where the change has to be made. He walks along the channel in front of the water, clearing it out to improve the flow at points where animals have trodden or the sides have collapsed, until he arrives at the set of segments (*kal*) he wishes to irrigate. Depending on the distance of the segment from the division, it might take as much as an entire half hour share (*khomma*) to water the first segment, for if the channel is dry it absorbs a great deal of the water on the way. Once the channel is saturated, however, one share will be sufficient for at least two segments.

One share of water sells for 4,000 Rials, but it may be rented for a whole year for a fixed rate of 36 kilograms (12 *man*) of wheat. However, if land and water are rented together, the owner takes two-thirds of the crop. In many cases the distribution of water does not fit the distribution of land: an individual's land shares may be distributed in several different parts of the cultivated land, whereas his water shares may come one after the other. This inequality of distribution leads to a great deal of swapping of water between friends.

As might be expected, the actual situation is more complicated than this description would imply. The complications arise from the way title to the shares of land and water fit the pattern of operation. Approximately one-half of the water and land is held by members of the community of Deh Salm. Likewise, villagers own merely one-tenth of the date palms and a negligible number of the camels. The average family has only a little land, a little water, and a few palms, acts as a tenant for more, and owns a few sheep or goats, and perhaps a cow and a camel. Before Land Reform was begun in 1962, this situation would not have been unusual in Iran. However, Deh Salm was untouched by Land Reform because the resources which are owned outside the community are distributed among a large number of piecemeal owners – not held in one block by one or a few large absentee land-owning families. The picture is further complicated by the fact that several of the families of Deh Salm own small pieces of property in the mountains north and northeast of the village, and some of the poorer men migrate to find work in Chah Dashi and elsewhere in slack seasons. The way this unusual situation arose is of especial interest in the context of this volume.

In order to run smoothly, the Deh Salm irrigation system requires, besides a minimum annual maintenance, provision for organizing repairs after irregular disasters, as, for instance, when runoff engulfs one or more of the qanat well openings and fills in part of the qanat. In similar systems where the greater part of the qanat belongs to a single owner, such disasters present no great difficulties, but where shares in a qanat are fairly evenly distributed throughout a community, very few communities show a successful maintenance record. This problem has been perennial among small holders in Persian villages based on qanats, and was one of the main arguments used by landowners against Land Reform in the early sixties. This problem is particularly acute in eastern Persia, where there is less provision for corporate action in village communities than elsewhere on the Iranian plateau.

This lack has been compensated to some extent by the development of a form of political organization based on what I choose to call the "dynastic family" (Spooner 1969). In the manner suggested by Parsons (1964:161-2), groups of villages in eastern Persia tend to be politically integrated by a small elite oligarchical superstructure of families who maintain their status and identity by forming a network of marriage alliances with other families of similar status over a certain area, rather than marrying within the village which they largely control (see especially the case of Gunabad in Spooner 1965). The villages themselves are otherwise largely endogamous. Where there is a "core" village, larger than the rest, this village is invariably the seat of a leading dynastic family with minor lines or allied lines in subsidiary villages in outlying areas. Thus, during the last century, first Qā'en, and later Birjand, was the home of the major dynastic family in eastern Persia, while subsidiary, politically allied lines were dominant in Tabas, Gunabad, and Neh. The dynastic families claimed tribal origin, typically justified by a genealogy going back to their entry into the area in the seventeenth or

the eighteenth century. The agricultural population which they dominated was not genealogically organized. Because of their dominant position, they gradually acquired title to large amounts of property distributed throughout the hinterland of their agricultural centers, but this title was not the original basis of their position. Their position was rather of a feudal nature, in that they exacted political allegiance and a portion of the agricultural produce from their respective areas in return for political patronage, military protection, and a certain amount of redistribution of wealth.

A subsidiary line of the family which dominated Neh (the largest center in Khorasan south of Birjand) lived in Deh Salm. As long as there was a khan, a dynastic head, resident in Deh Salm, his relationship with the dynastic family in Neh insured the defense of the village. He provided a focus within the community for leadership, and – more important – for the organization and investment of labor and materials in the maintenance of the qanat. But at some point in the latter half of the nineteenth century, the khan left Deh Salm.

The circumstances of the khan's move from Deh Salm are unclear. Historical events are difficult to fix chronologically, and information about them is difficult to elicit beyond the manner in which they affect the community. It is evident that the plain in which Deh Salm is situated once held a considerably larger and more prosperous population than it does now. The remains of three qanats are still visible within five kilometers of the village. There are signs of earlier cultivation and isolated ruins of relatively well-constructed buildings. According to oral tradition, an earlier and more prosperous settlement had been located in the southeastern part of the cultivated area (*keshmun*) of Deh Salm. Here and a hundred yards or so beyond, small broken potsherds are strewn. Several men spoke of finding beads when they dug in that part of the *keshmun*. The oldest villager claims to remember that a line of palms once stood at the end of one of the derelict qanats. It is possible, therefore, that the decline which led to the neglect of these investments was associated with the move of the khan away from Deh Salm, although, since there is no way of dating the ruins with any certainty, they may relate to a much earlier period. The khan's residence in Deh Salm is now in a state of ruin similar to that of the buildings out in the plain, but the dilapidation could have been accelerated by the practice of transporting mud from abandoned houses to the fields.

After the khan's departure, the villagers were left with no superstructure of authority. They were thus immediately deprived of their means of organization for defense, their primary structural relationship with the larger, protective settlement of Neh, and their means of organizing labor and materials for maintenance and repair of the qanat.

There were also other factors (the importance of which has been overlooked or underestimated) which developed at about the same time, and must have added to the plight of the village. One of these was the introduction of tea, which gradually became a staple element in the diet of the ordinary peasant throughout Iran. Since the peasants could not grow their own tea, they became, for the first time, dependent on an outside market source for a staple item of their diet. The second factor was the introduction of opium, which was soon used as a panacea. Since malaria was endemic and caused great hardship, particularly in the summer, addiction became commonplace. This situation seems to have led to a few of the more affluent families of the village acquiring small *kalata* (small water sources, often intermittent, which would support a few square meters of cultivation – usually fruit, vegetables, and alfalfa – and a small flock in the summer) in the mountains to the north. Every year about mid-June, when the harvest and threshing were over, all those who could would take off to the mountains with their flocks to avoid the heat and the malaria.

Barring disasters requiring major repairs, the qanat would continue to flow without maintenance for many years, though after a time the volume would probably diminish. The villagers tell of regular raids on their harvest and personal belongings by marauding Baluch from the south, who also ranged far to the north of Deh Salm and plundered much larger settlements. Forced to borrow in order to survive the year, the villagers gradually mortgaged and sold the title to much of their land, water, and palms, and stayed on as tenants on their own land. Because of the risks involved, it was not an attractive investment for large absentee landlords, who would fulfill at least some part of the function of the former khan. Instead, the land was sold to the people in the mountains, for whom the relatively lush property of Deh Salm had value despite its insecurity.

Finally, however, natural disaster also came. Sometime during the 1920s, after an unusually heavy rainfall, debris from runoff almost completely closed the qanat, leaving only a trickle. Without the injection of a major investment of labor – that the

villagers were totally incapable of organizing – Deh Salm would have ceased to exist. The landowners in Neh were not interested. Finally, the khan of Birjand (200 kilometers to the north), the souzerain of the whole of southern Khorasan, was persuaded to reopen the qanat at the price of nine *meh* of the resulting flow of water (4½ days out of the 12½-day cycle).

After some years, the khan sold his share, and it eventually reached the hands of six brothers in Neh (about 1940). Perhaps the markedly increased security under the reign of Reza Shah (1925-41) had made investment in Deh Salm look more attractive again. These brothers financed more work in the qanat, and with the increased flow set about bringing more land under cultivation. They began to stake out land in what is now the southeastern tongue of cultivation, where the pottery and beads mentioned above have been found on it. Sense of the common identity of land and community, however, was sufficient for the villagers to rise up against what they considered to be the brothers' infringement of their territorial rights. A compromise was reached whereby land already staked out was left with the claimant, and the remainder of the cultivable land in that sector which could be irrigated was divided up among the community of shareholders in the qanat according to the amount of their share. Since that time some of the brothers have sold out, and others or their heirs have settled on one side of the village and become resident cultivators, performing some, if not all, of their own cultivation.

Until I became familiar with the situation in this village, I assumed that in the Persian situation a resident landowner was by definition a member of the village community. However, in Deh Salm the investing brothers and their descendants, whether or not they have become resident in the village, are not considered to be members of the community. The village community has retained its exclusive identity despite the decline of recent generations. Investment in the qanat, with or without residence, did not bring membership in the community.

Nayband[3]

Deh Salm was essentially incapable of functioning without either (1) centralized authority or (2) a centralized investment system. The situation contains many features which are commonplace in qanat-based villages on the Iranian plateau – a region in which very few traditional agricultural villages were viable without a qanat. Nevertheless, some villages on the Iranian plateau depend on irrigation systems which are not so investment-intensive. The case of Nayband, approximately 150 kilometers northwest of Deh Salm, serves as an example of these. Nayband is also an oasis, but the two villages differ in almost every other respect.

Nayband has a larger population (around eighty families) and a smaller cultivated area. Instead of depending on a single source of water which represents a relatively major investment, it depends upon one major and several minor springs. These of course require no investment, and the channels which carry the water from them to the terraced fields require only a minimal amount. The village appears to have enjoyed a continuous existence since before the advent of Islam. Its economy is highly diversified, including besides agriculture and pastoralism, the trade of goods and services to passing caravans and migrant labor in mines. However, the village could not continue to exist without agriculture, and agriculture is impossible without irrigation.

In the Nayband irrigation system, the temporal and social subsystems are complex, but the economic subsystem is simple. Nayband is really a group of villages, arranged in the foothills and on the lower slopes around the base of a mountain of the same name approximately in the center of the deserts of eastern Iran. The name is applied to the whole community, the mountain, and the main village according to context. In what follows, the name Nayband is used to denote only the main village, where the great majority of the population resides. The remainder of the population is distributed in groups of one to ten families in settlements (*kalata*) around the mountain. The distance by foot around the mountain, taking in all the *kalata,* is approximately 60 kilometers. All the families in the *kalata* have title to property in Nayband, and all the dead are brought to Nayband and buried in one or another of the cemeteries there. Nayband and the *kalata* together, therefore, though spatially separate, form a single social universe or community. This community is neither politically nor economically stratified.

Most of the *kalata* depend upon small springs, and are from the point of view of irrigation, entirely separate from Nayband. One of them, however, Zardgah (or Ziyaratgah), shares the major spring of the region with Nayband, which is two kilometers away. Water from this spring, which accounts for some 90 percent of the cultivation of Nayband and all the cultivation of Zardgah, is distributed according to a ten-day cycle. The water of two consecutive days remains in the cultivated area of Zardgah. During the

remaining eight days of the cycle it flows untapped along an open channel down a wadi to the cultivated area of Nayband. On the irregular and infrequent occasions that the wadi floods, the channel is completely erased in parts, but can be redrawn within a few hours.

The flow is divided into shares called *fenjan* (literally "cup") by the holed-bowl method previously described. There are 85 shares in one day's flow, making 850 altogether in the ten-day cycle. One share sells for 1,000 Rials, and the price is said to be rising. The day's flow is sufficient to irrigate twenty to twenty-five irrigation segments (here called *pella*), which are the minimal land parcels, and vary enormously in size because of the terrain.

The water flow is measured by the women, and for most of the cultivation it is measured into small ponds or tanks, each located above land owned by a distinct grouping of families whose shares occur together in the cycle. This empoundment allows it to be released on to the terraces with greater pressure.

All cultivable land in Nayband is named after the source of its irrigation water. Every possible square inch is prepared for cultivation by building terraces out from the hillside and up from the wadi bed. The creation of these terraces represents the most considerable investment involved in the system, but this investment is still within the capabilities of the individual operators. One sizable segment (*pella*) of the better land (perhaps 200 square meters in area) sold for 10,000 Rials and required two to three shares (*fenjan*) to irrigate it adequately, depending on its situation.

The major crops in Nayband are wheat, millet, and alfalfa. There is also a large number of date palms, but because no attention is paid to their cultivation, the fruit they produce is fit only for making syrup, a staple item in the diet, or for fodder. There appear to be two reasons for this lack of attention. First, the area was traditionally insecure, and the villagers never knew whether they would be able to harvest the trees. Secondly, however much attention they paid to cultivation, the village economy could probably never be viable from agriculture alone because of the quality and quantity of the soil and water. The area is climatically marginal for date cultivation. Even the wheat and millet is of very poor quality, and often fail altogether and are used for fodder. The alfalfa is, of course, cultivated as a fodder crop for flocks of goats which are grazed on and around the mountain.

In practice, the relationship between subsistence and the social subsystem in Nayband is complex. Although every member of the community owns shares, the nature of the resources are such that few if any own enough to subsist from agriculture alone. Traditionally, they have supplemented their income by catering to the caravan traffic (apparently including confidence trickery, smuggling, and outright robbery), but since the advent of the motor age, this traffic has disappeared. As a result, the adult men have had to look for other resources to supplement their subsistence, and the gap has mostly been filled by migrant laboring in the few small mining concerns operated in the deserts by the government and certain city-based investors. Work in the mines requires extended absence from the village and precludes agricultural work. The result has been that a varying proportion of the men conduct all the cultivation according to intricate individual agreements involving renting, sharing, and swapping, while the remainder of the shareholders tend the flocks or work in the mines.

In effect, therefore, the people of Nayband were primarily pastoralists, who irrigated largely in order to supplement by cultivation the insufficient natural pasture of the region. The single most important *raison d'être* for the settlement was probably its situation as an isolated, reliable watering point on the only caravan route which crossed the desert from Kerman in the southwest to Meshed in the northeast.

CONCLUSION

In other studies, Deh Salm and Nayband would both be termed "small scale irrigation societies." However, in the terminology proposed in this essay, the irrigation system of the former (which incidentally has only half the population of the latter) is complex, while that of the latter is simple. This distinction allows us to predict – correctly – that the former contains elements of stratification and centralization, while the latter does not. Likewise, the criterion of size allows us to predict that because of the size of its annual product in relation to the amount of investment that its irrigation system is likely to need (albeit irregularly), Deh Salm cannot remain economically independent. I submit that this prediction is more obvious and less interesting than the first. However, since we have arrived at it, we may note that if the village of Deh Salm had been larger, it could have supported its own independent khan or large landowner. As it was, when the village lost its dependent khan, it was only a matter of time before it had to attract outside investment in order to survive. We may, therefore, deduce that the village must always have been a dependent colony – unless,

as the ruins in the plain suggest is possible, it had once received sufficient capital investment and population to make it large enough to be economically and politically independent.

In the consideration of the simple system of Nayband, on the other hand, the criterion of size is actually irrelevent. Not only did Nayband not require any investment from outside, but there is virtually no way that an outsider could have invested in the system, unless of course modern changes were made in the traditional technology. Nayband appears always to have remained economically and politically independent and unstratified. The Khan of Tabas (historically, the nearest political center, 100 kilometers to the north) remitted Nayband's taxes in consideration of its function as a military outpost of his demesne, and welcomed the Naybandis individually when they had occasion to visit his court. One suspects that his magnanimity was hopeful rather than compensatory: it was not worth the effort to try to collect taxes from such a poor oasis, and remission was a cheap way to buy friends in a strategic situation.

These two small isolated villages, only 150 kilometers apart in the Iranian deserts, both dependent upon irrigation, could hardly be less alike. I have sought to show that the more significant sociological differences between them can be predicted from ecologically oriented studies of their technological systems. In such studies it is essential to proceed according to a typology and a set of analytical criteria which are derived from the same ecological approach, and not to adopt these criteria ready made from a different set of premises – as Steward did from Wittfogel.

NOTES

[1]The field data referred to in this essay are from pilot ethnographic studies carried out in Nayband and Deh Salm June-August 1969 and June-August 1970 respectively. This research was made possible by grants and other assistance from the University Museum of the University of Pennsylvania, the Social Science Research Council, and the Office of Health, Education, and Welfare, to whom I am happy to record my gratitude.

[2]The Nile of course also provides examples of canal irrigation. Similarly, many of the systems cited contain examples of more than one of the types listed.

[3]The sketch of Nayband given here focuses on the operation of the irrigation system. Similar sketches written for different themes may be found in Spooner 1971 and 1972.

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