

Deh Salm Irrigation System

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1 Part I: Static Analysis - Collective action

Deh Salm is a geographically isolated village of 99 families, situated on the extensive arid plains of Khorasan, eastern Iran. Almost completely disconnected from any regional market economy, the villagers of Deh Salm are primarily dependent on intensive irrigation agriculture for their subsistence, supplemented by opportunistic pastoralism. Intensive irrigation agriculture is practiced on small plots, and fed by a single qanat (a tunneled groundwater spring that feeds into irrigation channels/canals) and wells. This case study is based upon ethnographic research conducted by anthropologist Brian Spooner in the village of Deh Salm during the summer of 1970, and was part of the original Common-Pool Resource (CPR) database. Spooner's analysis of the Deh Salm case simultaneously analyzes the ethnographic context ca.1970 and the preceding historical trajectory, showcasing considerable change over time. His approach is ecological and provides a number of analytical distinctions that should be made in the anthropological study of populations dependent on irrigation. As such, the following institutional analysis represents an idealized representation of the structure of the system. The resources in the system (natural infrastructure) are arable land, groundwater from the qanat, and ephemeral pasture (contingent on sufficient rain). The key resource relevant to the commons dilemma faced by the community is irrigation water (common-pool). Hard public infrastructure includes irrigation canals and the qanat, and individual plots of irrigable land comprise the system's hard private infrastructure. Resource users include both the small community of agriculturalists, (sometimes absentee) landlords, and their livestock. 'Public infrastructure providers' is a diverse group, comprised of a small community of agriculturalists, a village headman, village policemen, wealthy landed elite patrons, and the regional sub-governor.

The initial case representation was conducted based on Spooner's analysis during the 70s. A major political incident in 1979 and a change in the central government led to long-standing effects on many rural communities in Iran and Deh Salm is not an exception. The status of small-scale communities became the result of revolutionary policy implementations by changing the decentralized and indigenous knowledge-based governance structures to poly-centric governance. These implementations were mainly aligned with the motto of "Empowering the Weak" which was focused on providing economic welfare for isolated and rural communities, in particular. Additionally, exogenous drivers perfectly addressed by Spooner's have shown to be a tipping point for the transitions to the current state of the systems. The major change in the system could be described as a transition from fully dependent on the public infrastructure (Qanat) for harvesting the resource based on the social infrastructures built upon mutual trust to a competitive landscape in which private and human-made infrastructures (Wells) emerged as tools for harvesting maximum benefit

without proper attention to historical soft infrastructures for development plans.

The village has been turned into a tourism attraction after the Lut Desert nomination for the UNESCO Biosphere Reserves Programme

1.1 The Commons Dilemma

The common pool resource dilemma can be divided into 3 parts: the maintenance of canals and basin plots, the allocation of irrigation water, and the maintenance of the qanat. In order to feed themselves, households depend on functioning common irrigation canals and neighboring basin plots. These are achieved through the institutions of private property and communitarian labor reciprocity. In addition to private land ownership, water is privately owned in terms of standardized time-based units (see “scope rules” in section 1.4, below). In order to meet household economic needs, farmers must maintain and clean the irrigation channels leading to their property to maximize the flow of water to their plots. For this reason, farming households are often dependent upon their neighbors for mutual labor reciprocity during the agricultural season, enabling them to achieve greater labor allocation efficiency (and thus personal benefit) than would be possible on their own.

Irrigation agriculture depends on mutual cooperation in water allocation. Water access is allocated through clear property rights and the clear visibility of water use, both of which lead to mutual trust in conjunction with communitarian norms of reciprocity. Because water units are privately owned, it is the responsibility of cultivators to keep track of their start time and shift the flow of water to their land. This enables a decentralized chain of water access transfers. Time is supposed to be measured for each water unit, but this method is no longer followed. Nobody is in charge of switching water – when a man considers it time for his share, he merely diverts the stream. In some cases of this approach, the distribution of water does not fit the distribution of land, especially when someone’s land is shared in many places and receives a particular share of water. This inequality of distribution leads to a great deal of swapping of water among friends. Water units are often traded, pooled, rented, or sold among the fragmented patchwork of landholdings to optimize household economic efficiency, so community members informally share public knowledge of their neighbors’ water access rights. Although plots closer to the source obtain much more water per temporal unit than those further away, this economic hierarchy is accepted as normal, and formal juridical positions are not necessary to enforce the rules. Spooner noted that no disputes over water were evident during his fieldwork. Cheating or free-riding are prevented in practice through the ubiquity of monitoring in physically and socially small villages. Because the channels run among the small plots cultivated by the villagers, and because they must work together to irrigate, the natural infrastructure facilitates effective monitoring. Although it is a norm among the villagers to clean the channels, either individually or in groups, it is not mandatory. The clean channels maximize the flow of water to the land, so the villagers take part in maintaining the channels. Likewise, labor reciprocity among neighbors facilitates mutual monitoring of water allocation.

Alternatively, the central government imposed new institutions to manage the water quantity and quality in urban and rural areas after 1979. The idea was to secure centralized decision-making processes with localized implementation. The development plans also pro-

vided enough benefits and incentives for the rural communities to increase their harvests. With the increase in harvest superpositioned by the lack of investment in the maintenance of the in-place public infrastructure (Qanat), the farmers started to build private human-made infrastructures to maintain their irrigation and to benefit from the governmental incentives.

The qanat is vulnerable to both slow degradation over time (reducing flow), as well as rapid tunnel blockage caused by storm runoff, erosion, and collapse. In theory, the qanat itself is supposed to be maintained by its private owner. Islamic law states that the person who invested in the qanat's construction owns the qanat. Over time, however, clear ownership is diffused through generations of property ownership transfers, partible inheritance, and population movement, such that the qanat becomes a *de facto* common pool resource. The institutional role of qanat maintenance in eastern Iran thus normally falls upon the paramount wealthy tribal patron (the *khan*), who can afford repairs, and whose landed profit is derived from the qanat. Qanat maintenance is a highly specialized skill, and smaller towns like Deh Salm lack the economic infrastructure (demand) to maintain a local specialist in residence. If the village has no such paramount patron (*khan*), if the landed elites of the village cannot afford to repair the qanat, or if the landed elites of the village are unwilling to invest in the qanat (e.g. costs \downarrow benefits), then the village is at the mercy of bribing outside investors/benefactors to solve their problem with land and water ownership rights. This was the case in the 1970s, when the landed elite patrons comprised a diffuse bunch of smaller-scale absentee landowners.

The political governance of the rural areas also changed from the full authority of the elites to more systematic and centralized governance. In these conditions, the paramount patrons started to lose authority and as a result, the maintenance of the qanat lost priority to the central system. In contrast, the central system started to modernize the irrigation infrastructures with more incentives for the farms.

1.2 Biophysical Context (IAD)

1.2.1 Natural infrastructure (NI):

Rainwater is completely insufficient for agriculture, so small, intensively cultivated fields must be irrigated from the single qanat by way of common channels in its immediate hinterland. For agricultural purposes—the main economic interest of the population as a whole—rain is simply a bonus if it falls at an agriculturally useful time. Whenever it falls, however, it brings peripheral and indirect benefits by transforming the surrounding countryside into a good pasture. Because the village is the only population near the qanat, sociocultural boundaries to resource user membership are *de facto*. Although not considered members of the community, absentee landlords own the majority of water units and landholdings—the legitimacy of which is conferred through historically embedded hierarchical agrarian class institutions. Irrigation water is scarce, but this scarcity is imposed not by 'using up' a finite water supply, but rather by the time necessary to allocate the low-velocity stream at times when crops need water. Lands closer to the source receive much more water per unit time due to relative rates of velocity, evaporation, and infiltration, so the price of land closer to the qanat is many times higher. The groundwater resources are also limited in the region due to the warm and dry climate. The farmers use private wells for irrigation without proper monitoring of the aquifer levels.

1.2.2 Hard human-made infrastructure:

Hard human-made infrastructures include the qanat, the irrigation channels, and individual plots. Individual plots must be dug into the ground so that water can flow into them, constructing a basin for crops to be inundated. Likewise, raised earthen bands (walls) surrounding each plot must be formed to keep water in and demarcate plot boundaries. The qanat is a series of channels dug into the top and side of a hill (leading aquifer water out of the ground) at a slight angle to facilitate the flow of water. Furthermore, the central government's policy shift of providing incentives for increased harvesting resulted in an increase in private deep wells and metered pumping.

1.3 Attributes of the Community (IAD)

1.3.1 Social Infrastructure:

Due to the very small size of Deh Salm, and its spatial isolation from other villages, The community is culturally homogeneous with a well-mixed and interpersonal network. The average household owns some land and water rights, works as a tenant on more land, and owns a few animals, and a few date palms. Poorer families must migrate during slack seasons to find work. The largest landowners ca. 1970 were absentee, owning fragmented plots across the village area. The identity of the village is a function of the unity of the land area cultivated rather than the sociocultural or political structure—a man is a member of a village community by virtue of the fact that he owns and works part of that land. The community routinely bathes together (segregated by gender) in the channel waters emanating from the qanat as a sociocultural ritual fostering a common identity. Neighbors practice regular labor reciprocity during the agricultural season, help each other maintain and repair channels and basin plots, and sometimes also pool, swap, or rent resource access (land and water) with each other. Egalitarian institutions of low-cost (quasi-charitable) labor lending exist for those households unable to provide sufficient labor to cultivate their own land—only a daily ration of food is required for a day's work. Public irrigation channels are maintained by nearby households in their effort to maximize flow to their property or tenure during their allotted water time period. In this way, the incentive structure of flow maximization given water scarcity enables the common pool resource to be maintained, and villagers are so much more concerned with maximizing water that the fairness of labor allocation (free riding) is not considered. Formal juridical infrastructure in Deh Salm is minimal. De jure politico-juridical authority is provided by the state, whose nearest official, the regional sub-governor, is over 100km away. De facto political power and judicial responsibility in Eastern Iran have therefore traditionally gone to landed elite patrons, whose influence comes from their capital ownership and position atop regional kinship hierarchies. Often this role is consolidated in a single person, known as a Kahn, but can also be diffused among multiple Kahns or multiple smaller-scale landed elite patrons. Because its wealthiest and best-connected landowners were smaller and absentee ca.1970, Deh Salm lacked a Kahn. Instead, a village headman is chosen by the more prominent landowners (in consultation with the regional sub-governor), and is in charge of security against raiding nomads and crop policing. Four policemen are appointed by the village headman from among the poorer families, who are tasked with keeping livestock away from irrigation water (channels) and crops.

Village disputes mostly result from this issue of animal grazing (i.e. paying damages), as well as from the slow shift in field borders due to erosion (i.e. over property boundaries). It is unclear how these disputes are resolved from Spooner's analysis, although he does make it clear that irrigation management is completely decentralized. Tenants pay rent to landlords, and property owners pay taxes to the regional government, but the details of these processes are also not elaborated on by Spooner.

Each farmer should request a new well in their private lands and upon the approval of the rural water management utility, they are able to build their well. This has been more restricted due to major groundwater depletion in the region. New deputies emerged as the result of the decisions of farmers for maximizing the harvest.

1.3.2 Human Infrastructure:

Aside from the skills necessary for agriculture, Deh Salm is notable for the lack of a qanat specialist due to the paucity of local economic infrastructure (demand).

1.4 Rules in Use (IAD)

1. Position Rules: 99 families of village tenants and smallholders (not mutually exclusive) of land, water, and livestock; a small number of wealthy (absentee) landlord patrons; the regional sub-governor; the village headman; 4 policemen.
2. Boundary Rules: Community members: defined by their residence in the village and the cultivation of lands there. Landlord patrons: defined by ownership of large amounts of land in the village. Village headman: Since most of the men of the village are occupied primarily as tenants of resources owned by landlord patrons, the prominent owner, in consultation with the sub-governor, chose the village headman from community members. Policemen: chosen by the village headman and landlord patrons from among community members (usually poorer ones).
3. Choice Rules: Tenants must cultivate and irrigate their tenure, and pay rent; Neighbors may engage in neighborly labor reciprocity; Community members may provide/hire labor for those in need, in return for a day's food with meat; Village headman must provide security and policing for the village; Policemen must protect crops from animals; All must respect property rights; All must pay taxes to the regional Government.
4. Aggregation Rules: None. Decentralized private property relations, communitarian social institutions, and hierarchical political-economic structures make crucial decisions independent of group rules/consensus.
5. Scope rules: Water access is allotted via the private ownership of standardized temporal water units, which are independent of and separable from land ownership. These water-time units are distributed using a repeating 12.5-day cycle (a day being sunrise to sunset), which is divided into half-day periods (called meh), and meh are further subdivided into 25 shares (khomma) each, making 625 khomma per 12.5-day cycle. Each khomma is owned by someone, and the length of each khomma is determined in practice by the position of the sun.

The groundwater management act limits the amount of water extraction for each farmer using metered pumping stations.

6. Information Rules: Rural water utilities are obliged to provide information about the groundwater levels in the area. In addition, any informant has a general understanding of which social or political groupings of families control the water flow at any given part of the cycle. And this knowledge is sufficient for the smooth working of the system.
7. Payoff Rules: The government guarantees the purchase of agricultural products to maintain the livelihood of the farmers

1.5 Summary

Deh Salm is a primarily agricultural village, geographically isolated from other populations, and dependent on groundwater irrigation from a single qanat. The village had 40 resident households ca. 1970, comprising a spectrum of smallholders and tenants for absentee landlords. Water access and land are both owned privately, while irrigation channels are commonly held. The qanat is not owned by a single person, and therefore reverts to a common pool resource, under the customary jurisdiction of landed elite patron(s). Formal politico-juridical institutions (the state) have a minimal presence because of the village's size and isolation, leaving customary de facto politico-juridical authority to the landed elite patron(s). As of ca.1970, wealthy landlords were absentee, so these appointed a village headman (in conjunction with the regional-sub governor) with the powers of security and policing animal grazing. The commons dilemma is broken into the issues of water allocation, irrigation infrastructure, qanat maintenance, and groundwater management. Successful allocation of irrigation water is maintained through its ownership (private property) and monitoring, and communitarian socio-economic institutions. Irrigation infrastructure is maintained via community labor reciprocity and the economic incentive to maximize flow by maintaining canals. Qanat maintenance is the responsibility of landed elites who are capable of doing so because the villagers do not have the resources, skills, or labor organization to do so. Because the absentee landlords ca.1970 have insufficient resources and/or incentive to invest in qanat maintenance, irrigation is vulnerable to both slow long-term blockage and rapid collapse caused by storms/floods.

2 Part II: Dynamic Analysis - Robustness

Spoooner compared his contemporary (the 1970s) analysis of Deh Salm to its historical trajectory over the prior 150 years, which enabled him to evaluate how the structure and functions of local institutions were related to dynamic processes. As such, this dynamic analysis is not a subsequent update on a CPR case, but rather Spoooner's own evaluation of the institutional dynamics of Deh Salm given its history. The following robustness analysis addresses the qanat itself as the focal system and performance measure, rather than the social system of Deh Salm because it lies at the heart of the commons dilemma.

2.1 Exogenous Drivers (social, political, economic, etc.) Shocks, Capacities, Vulnerabilities

The primary vulnerability of Deh Salm irrigation is the degradation and collapse of the qanat. As noted in the institutional above, Without a functioning qanat, there can be no irrigation agriculture in Deh Salm. The qanat functions best immediately after it is (re)constructed or repaired, losing functionality over time. Since scheduled maintenance is not undertaken—regardless of whether sufficient authority, labor, skills or resources are available to repair the qanat—the system dynamics are governed by the factors that endogenously contribute to the degradation and collapse of the qanat itself (see above), and the factors that exogenously impact whether or not it is repaired following a collapse. When collapse occurs, the Kahn(s) and other wealthy patrons must invest in its repair. If there is currently no Kahn or sufficiently wealthy and politically capable elite patrons, the community must try to lure wealthy patrons to Deh Salm to invest in the reconstruction of the qanat. Because the small, isolated village can be fairly unattractive to outside investors, villagers must bribe outsiders to help. If they cannot, village agriculture must be abandoned. Therefore, it should be noted that this is essentially one of economic, not political centralization. Additionally, because the investment and technological introduction are controlled from outside the village, they are more abrupt and less reversible, which increases the uncertainty in the system. Thus, a reduction in the capital ownership (land and water) of villagers reduces the short and long-term robustness of the qanat over time. This is caused by the following:

- Loss of landed elite patrons (causes lack of patronage [i.e. investment], lack of qanat repair investment)
- Collapse of state authority (causes vulnerability to nomadic raids) Raids by nomadic tribes (causes economic decline via: inducing costly repairs, inhibiting commerce, discouraging outside investment, making herding and travel unsafe)
- Demographic saturation (causes economic decline via labor over-abundance, increased aggregate food needs)
- Market integration (causes economic decline via increased personal expenditure[opium and tea], vulnerability to outside price volatility, wealth extraction)
- Economic stratification (causes increased absenteeism, lack of financial buffer against perturbation/risk; leads to more economic decline and stratification, and loss of local property ownership [land, water])
- High Inflation rate and bad management of rural areas posed by the centralized government leading to immigration and/or poor livelihood for the resource users Impacts income sources and total capital of the village
- Groundwater management act limits the utilization of privately owned wells

2.2 Robustness Summary

The focal system for robustness analysis is the continued functioning of the qanat and not the social system of Deh Salm. The qanat is impacted by endogenous and exogenous fac-

tors. The endogenous factors are the slow environmental degradation of the qanat channels themselves, as well as the sudden collapse of the qanat through floods and storms. Exogenous processes include all social factors related to repairing the qanat. Repair is undertaken if there is a Kahn or patron, but if there is no Kahn or patron then the town must sell of its land and water property to bribe an external patron to come to fix the qanat. The geographical isolation of Deh Salm contributes to the loss of paramount patrons (kahns), as well as makes the town undesirable to new ones moving in. Then, when the qanat collapses, the amount of capital ownership of the community is the key variable in securing a new landed elite patron. Capital ownership is impacted by a positive feedback loop (diminishing villager capital ownership over the long term via both slow and fast-moving processes) consisting of nomadic raids, centralized state collapse, market integration, demographic growth, and economic stratification resulting from imbalanced class and ownership relations.

Since the mentioned focal point of the fragility of the system (Qanat) lost its function due to lack of maintenance and prolonged droughts, the system first started to function by short-sighted policies regarding the over-exploitation of groundwater resources. This shifted the critical point of the system from the Qanat water supply system to groundwater resources. Without any attention to the social capital and collective actions already in place, the community has been facing major economical issues due to a lack of water for irrigation. They started to change their income sources from agricultural activities to tourism services in recent years.

3 Case Contributors

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