

# Indigenous Knowledge and Agricultural Sustainability

## A Case Study in (Semi-) Arid Regions of Iran

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### 1. Introduction

Traditional agriculture is believed to have been sustainable. This stimulates conservationists to analyze and, if possible, benefit from the wisdom of indigenous knowledge, at least what has remained from it or can still be remembered by local people. The reason to such a search is clear: world population is steadily increasing, poverty is growing and natural resources are degrading (Barkin, 1995). Some 550 millions of the 1370 million hectares of global arable land have suffered degradation as a result of non-sustainable cultivation (GLASOD, 1991; DCID, 1993).

The green revolution technologies, which partly solved the problem of food and fibre needs, appeared to be too expensive, as the costs of technology transfer, soil erosion and loss of plant genetic materials that were resistant to diseases are high (Davis and Ebbe, 1993). Traditional agriculture, as it was originally applied, can neither be fully resumed nor would it satisfy the food needs of the increasing world population. It is however useful to preserve and mobilize local knowledge, which reflects expertise in and understanding of the environmental aspects, gained over thousands of years.

### 2. Historical Development of Agriculture in Iran

Studies conducted on artifacts found in rice fields in Southeast Asia have revealed a 15,000 year-old agriculture (Butzer, 1964). In the Middle East, the two villages of Jarmo and Sarabin, respectively located within the present Iran and Iraq, have been identified as the oldest of the region, where people started cultivating land about 10,000 years ago (Badiei, 1991). People had gone through different phases of hunting and taming animals, before they began recognizing the productivity and value of land for sedentary agriculture.

### 3. Social Structure

#### 3.1 The People

Iran's civilization has its own character. The geographical location of the country, bridging east and west, has contributed to enrich economy and culture. In the course of time, many groups entered Iran and were soon absorbed by and became part of Iranian civilization. The most striking example is the way Mongols were incorporated. They entered the country as barbarians, but after two generations of settled existence became fervent admirers of every aspect of Iranian life (Wilber, 1950).

**Table 1. A summary of the sequence of the main dynasties, political periods and trends of agricultural development in Iran (Farshad, 1977)**

Dynasties and political periods	Trends of agricultural development	Significant events and examples of the relics
Medes – Achaemenids and the Zoroastrian religion (625 BC to 336 BC)	Initial stages	<ul style="list-style-type: none"> <li>* Alfa-alfa was known and exported to Greece</li> <li>* Raising cattle and horses was common practice</li> <li>* The Achaemenid kings promoted agriculture by giving land to farmers without charging them for five generations</li> <li>* Construction of irrigation infrastructure such as dams on the Kor and the Karoon rivers</li> <li>* Cyrus prized people cultivating bare lands</li> <li>* Avesta, the holy book of Zoroastrians, states that bare land is occupied by evil forces. Farming and cattle raising were recognized as the respected activities</li> </ul>
Parthians-Sassanids (248 BC to ca 600 AD)	Irrigation development and improvement	<ul style="list-style-type: none"> <li>* Water distribution and irrigation networks were developed from the modern Khorasan, where Parthians originally came from, to Mesopotamia</li> <li>* Saffron, jasmine, wine-trees and alfalfa were exchanged against Chinese silk</li> <li>* During the Sassanids, agriculture was the main source of the country's income; goods were even exported to Italy</li> <li>* Seeds, equipment and draft animals were distributed to farmers</li> <li>* Silk worm raising was common practice</li> <li>* For the first time in history, specialized officials controlled the management of the natural resources</li> </ul>
Arabic rule (from ca 650 AD)	Slowing agriculture	<ul style="list-style-type: none"> <li>* Saudi were mainly business- oriented, giving less importance to agricultural activities</li> <li>* Later on, the same people transferred their acquired agricultural knowledge to other places in North- Africa and Spain</li> </ul>
Tahirids, Saffarids, Samanids, Ghaznavids, Saljuqs and Khwarazmians (7th - 12th century)	Resurgence of irrigation	<ul style="list-style-type: none"> <li>* Although this period is better known for its literature and poetry, relics of irrigation systems and dams are found in many places</li> </ul>
Mongols and Ilkhanids (13th century)	Agriculture went down	<ul style="list-style-type: none"> <li>* People were prohibited to have a fixed place to live. Farming was only practised by the poor who were slaved be feudal lords</li> <li>* Villagers were constantly attacked, people and cattle were deported, and farmers were forced to pay high taxes</li> <li>* Irrigation systems were destroyed; ruins exist in Bahar, north of Hamadan</li> </ul>
Safavids (16th century)	Renaissance	<ul style="list-style-type: none"> <li>* Safavids amended the damages from the Mongol invasion</li> <li>* Date, pomegranate, orange, onion were cultivated. Products such as pickles, jams, fruit juice and syrup were exported. Silk production was better than ever before</li> <li>* The skilled rice growers from northern Shazand and the Sharra district were encouraged by Shah Abbas to move to the capital city of Esfahan to train other farmers in rice cultivation practices</li> </ul>
Afshars and Zands (18th century)	Localized development	<ul style="list-style-type: none"> <li>* Activities at local level, for example in the Moghan, Shiraz, etc.</li> </ul>
Ghajars and Pahlavis (19th and 20th centuries)	Loss of territory but modernization	<ul style="list-style-type: none"> <li>* Loss of fertile lands due to the peace treaties with Russia</li> <li>* Introduction of a western- style economy changed agricultural traditions and put self-sufficiency at risk</li> <li>* The development of large irrigation schemes caused considerable drop in groundwater resources</li> <li>* Emphasis on industrialization damaged agricultural development</li> </ul>

Iran's social structure was built around the rule of an absolute monarch supported by feudal lords, who as early as the Achaemenids period were named governors in control of vast areas. The loyalty of the feudal lords was always somewhat precarious and the monarch was often faced with the task of retaining their military support while keeping them from growing too powerful. The situation of the common people was much the same over time. Bound to the soil and cultivating the land the same way for centuries, their condition was fairly secure when the monarchy was strong enough to spread the benefits of irrigation and of public safety, but very unfavourable when political weakness led to economic chaos. Invasions by Mongols, Timurs, Afghans and others frequently interrupted the course of life. The isolation of thousands of villages was probably the reason for the preservation and continuity of Iranian civilization. Many remote villages were spared from destructive invasions.

Iranians have always been deeply concerned with the aim and purpose of life. The principle of "good thoughts, good words and good deeds" (Mazdaism and later Manichism and Mazdakizm) was always respected. This principle materialized in cultural norms, and even in doing business based only on promises and thrust, such as lending money versus a hair of the borrower's beard. The prestigious value of the beard hair brought the borrower back to pay his debt.

The typical character of Iranians is reflected in their agricultural activities and particularly the traditional irrigation, based on ghanats, wells or streams, which require collective action, close cooperation and a certain amount of capital. Boneh, the traditional production unit, is a good expression of such a cooperative life-style. Each village was divided into several bonehs. Normally six farmers formed a boneh. The number and extent of bonehs depended on the quantity of irrigation water and the area of arable land in the village, as all bonehs had to be equal in size and received equal shares of water. Each boneh was controlled by a sarboneh, who was selected by the landlord or his representative (mobasher). Each sarboneh had two assistants, usually people very close to him. Boneh members who worked together divided the production according to conventional rules. The main boss was the landlord who was regularly in contact with his mobashers.

Irrigation has a special meaning to people whose agricultural production depends on it. In contrast to the climatic conditions in the semi-arid parts of the country (e.g., Hamadan, Kermanshah) which permit dry-farming and animal husbandry, places like Kashan and Yazd with very low annual rainfall sums have always been depended on irrigated farming and small scale rural industries.

### **3.2 Land Tenure**

Iran's large area and climatic variability, the close relationship between rural societies and tribes, and the influence of cultural disturbances caused by Mongols, Afghans, Turks and Arabs, have all played a role in the complexity of land ownership. The ambitious program of land reforms, which started in 1962, created new problems. Before the establishment of Islam, kings owned everything. The king donated inalienable rights on land to anyone he liked. Under Islamic rules, land was controlled for a great part by the calif. It was given partly to those who worked it and partly to the officers who had won the war against Iran. Land donated by kings to holy places was considered as governmental property. The governmental land and the tax paid by the people who were given land formed the government's revenues. Tax was either according to the land surface area or the output, or fixed pay on a contract basis. During the Abbasids reign, a kind of landlordship (tiyouлдаuri) came into being, by means of which the proceeds of the land use rights was given to the landlord but not the full private ownership. This included lands donated to heads of tribes

and governmental representatives in various states. In this period, religious places were also given lands (called *waghfi*), that were exempted from tax.

The ownership changed every time a new reign began to rule the country, especially under the Mongols, Safavids, Ghadjars, and finally the Pahlavis. Before the land reform, landlords could own a whole village or even several villages in different parts of the country. The royal family, for instance, owned over 2100 villages. Absentee owners practiced often the system of share cropping. In this system, the five essential shares were land, water supply, seeds, land preparation costs and human labour. The production was divided according to the number of shares covered by the two partners: the landlord and the farmer. Very often, land and water were supplied by the landlord, in which case he had a right on 2/5 of the production. The distribution of shares depended very much on how honest the land lord and/or how experienced the farmer was. The relationship was formalized by a contract, usually not to the benefit of the farmer. No matter how strong the relationship between the partners was, farmers were often slaved by the landlord (Farshad, 1990).

Through the land reform, all lands belonging to absentee landlords were sold to those working the land. The traditional division of land according to *nasagh* was conceived as an effective and inexpensive means of redistributing land and wealth. *Nasagh* is the customary form of allocating land amongst share-croppers, each cultivator having *nasagh* rights in more than one area, both in poor and good land. This procedure was short-lived. Unhappy landlords abandoned agriculture and invested in other productive sectors. The inter-farm managerial role of the landlords was not properly substituted. Farmers were not prepared to cope with the newly developed situation. As a result, maintenance of agricultural infrastructure was neglected so that, for instance, the *ghanats* were not cleaned in time and soon collapsed.

The second phase of the land reform was a modified Russian centralist approach. In this phase, the distributed lands were brought back together in the form of corporations, that employed a small proportion of the total rural labour force (Afshar, 1985). In the third phase, an assumedly closing phase to an unsuccessful program, the lands had to be either divided between the landowners and tenants or sold to the tenants. This took place in a time when farmers, in great numbers, were migrating to larger towns where full industrialization was in progress. In 1977, some 27000 villages were reported to be empty. In the following 10 years, this number increased to 39000. At present, over 60% of the country's total population live in urbanized areas.

## **4. Examples of Traditional Wisdom and Knowledge**

### **4.1 The Sialk Tappeh, Kashan**

The Sialk culture spanning 3000 years, from 7000 to 4000 BP was discovered in the Sialk Tappeh, on which the original town of Kashan was built. Today's Sialk consists of two mounds, a few hundred meters apart, in the territory of the village of Nadji-abad, about 3 km southwest of the present town of Kashan. An extensive residential complex recently developed in the area. The agricultural lands surrounding the mounds are now encircled by fast growing settlements.

#### **Geology**

The geological formations around Kashan dominantly belong to the Cenozoic. These consist mainly of pyroclastic and volcanic rocks with intercalations of tuffous limestone and doloritic dykes, and stretch from south to northwest. In the west and southwest of the

Kashan basin, reddish coarse-textured sediments (conglomerates, sandstone, etc.) occur. The Karkas mountain range (3588 m) in the south comprises older rocks (Mesozoic), mainly shale, dolomite, limestone and sandstone. This also includes the fractured Cretaceous limestones, in which the well-known springs of the Fin and Niasar villages originate. The thickest part of the sediments (210 m) is in the south. The depth to groundwater varies from 150 m in the south to 1-5 m in the north ( the Sombak area in the territory of Aran-Bidgol). The groundwater depth becomes shallower towards the salt lake located south of the town of Ghom.

### **Geomorphic setting**

The heights south and southwest of Kashan belong to a volcanic belt, forming the Iranian central heights, which stretches to Iranian Azarbuydjan (Tabriz). Further to the north, the Latif and Yakhaub mountain complex runs parallel to the southern heights. The lowland between these two ranges is a graben known as the Ghom-Ardakan depression. The Sialk Tappeh is located in the middle of an extensive accumulation glacia sloping from the southern heights towards the salt lake. The spring of Fin is exposed in the upper part of this glacia and visible from the Sialk Tappeh.

### **Soils**

The soils are stratified, with layers of sand and gravel alternating with sandy loam to clay loam and, in places, with lenses of clay. These soils are members of the coarse loamy, mixed, thermic Typic Torrifluvents. One of the traditional management practices is to add sand mixed with manure to the clayey topsoil while preparing it for cultivation, particularly in areas where vegetables are grown.

### **Land use and cultural setting**

The Sialk Tappeh shows a long-abandoned civilization in several superimposed layers, the oldest of which, in the northern mound, comprises an urban settlement with wooden buildings. The northern tappeh, with a surface area of about 300 x 100 m and a relative elevation of 6 m, consists of 12 m of man-made materials. Ghirshman (1938) found two cultural eras (A and B) with the oldest sub-era (A1) dating back to the late sixth or beginning of the fifth millennium BC. The excavations in the southern mound revealed that the Sialk inhabitants abandoned the northern mound around the B3 sub-era and moved to the southern mound, where they lived to about the first millennium BC. The excavations in the Sialk mounds unearthed relics and remains of elementary agricultural societies on the Iranian plateau. Later excavations in Ghazwin, some 150 km north of Tehran, uncovered other ancient sites which indicate that human societies existed before the Sialk culture.

At the beginning, people living in Sialk did not know about constructing houses (Ghirshman, 1938). In the upper two layers, however, not only relics of bricks and houses are found on top of the remnants of the first wooden huts, also other objects such as clay and, in later periods, copper bowls and some tools used to cultivate the land were discovered. In the oldest period, agricultural activities are believed to have been practiced alongside hunting. Bones of tamed cows and sheep were found, indicating food storage. Inhabitants used to bury the dead bodies under the place where they lived, a custom surviving throughout the cultural eras in both the northern and the southern mounds.

## **4.2 The Sombak and Chartaghi Areas, Kashan**

About twenty years ago, the villages of Aran and Bidgol were administratively pooled together to form the Aran-Bidgol township, located 10 km north of Kashan, at the margin of the desert (Kawir-e- Markazi). Other villages around the township include Madjd-abad, Nezam-abad and Taghi-abad to the east and northeast and Nasr-abad, Akbar-abad and Mohammad-abad to the north. The Centre for Dune Stabilization, established some thirty years ago as a division of the Ministry of Agriculture and Fisheries, is situated north of

Mohammad-abad. The Sombak district is located 7 km east of the township, whereas the Chartaghi (also known as ghool-abad) region begins at some 15 km to its north. Both areas are renowned for their quality watermelon.

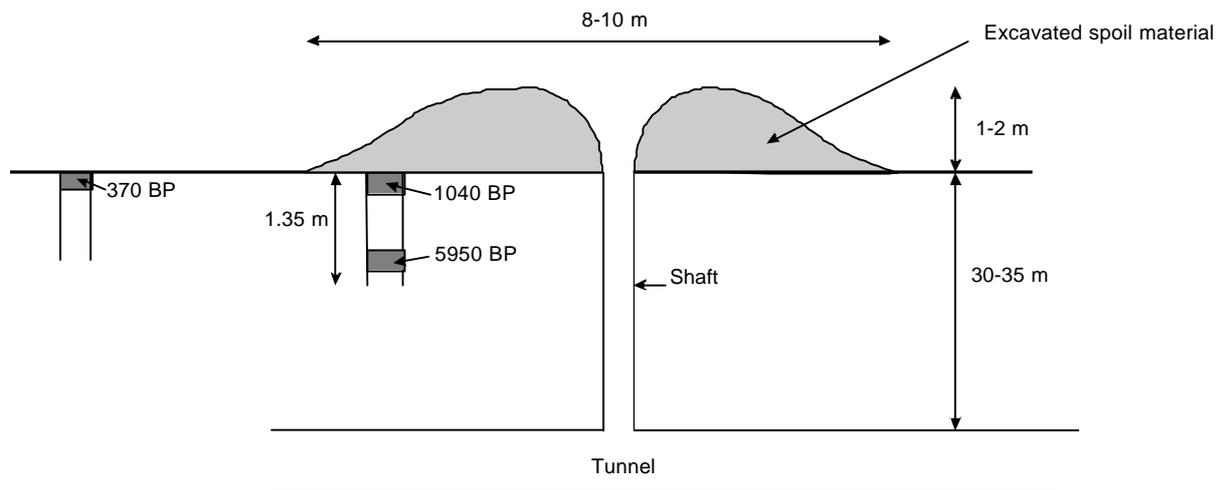
Geomorphologically, there are four glacial levels starting from the southern mountains ( 2000 m asl) to the salt lake ( 800 m asl) located north of the catchment. Three kinds of sand deposits have been distinguished on the basis of mineralogical and granulometric studies (Motamed, 1988). Hydrologically, this area is the lowest part of an extensive piedmont; the salt lake controls a relatively high groundwater table. Sand dune soils 1 to 5 m thick lie on loamy sand to sandy loam layers and classify as Quartzipsamments. In the Chartaghi area, soils are often saline, with a higher gypsum content than the soils of the Sombak area.

Although the areas are no longer used as intensively as in the past, some traditional owners still use the land to grow watermelon. The cultivation is based on the practice of "bringing the crop in contact with water". The local geomorphic setting and hydrological conditions must have been known to local people for long. In order to cultivate the area, huge amounts of sand must be removed until the loamy sand to sandy loam substratum is reached wherein seeds are sown. Very large pool-like holes, about one tenth of a hectare (= two djeribs) in size, are excavated in the sand dunes by removing the sand and piling it up all around the pit. The walls of the depression are planted with plant residues acting as windbreak. Usually, sof is used for this purpose, although it is prohibited by law to cut this plant which resists the dry conditions and strong winds of the region. Once the pit is ready, its floor is parceled and sown. The watermelon is fed by groundwater at about 70 cm depth. If it is not harmed by sand attacks, yield can easily reach 100 kharwars ( one kharwar = 120 kg) per hectare. The Centre for Dune Stabilization has been successful in fixing a large part of the desert dunes by planting *Haloxylon salicornicum* ( tagh ), *Calligonum crinitum* (eskanbil) and *Atriplex* sp., and by means of chemical mulching.

Two reasons may explain why the Sombak area is used more intensively than the Chartaghi area: (1) the shorter distance and easier accessibility of the Sombak area from the township and (2) the salinity problem in the Chartaghi area causing lower yields. In the past, farmers used to move in groups to the area on their donkeys and settle there for a few months until the watermelon was harvested. Obviously, after such a long period away from home, they had grown long hair and beards, looking like "monsters". This is said to be the origin of the name ghool-abad, meaning a place developed by monsters, a kind of nickname for the Chartaghi region.

### **Underground Tunnels (Ghanat)**

A ghanat is an underground tunnel dug into alluvial deposits on the mountain skirt, which taps the aquifer and brings the water to the surface by gravity flow (Fig. 1). The construction of a ghanat system is time demanding, costly and risky for builders (Safinegad, 1979; Ghobadian, 1982; Kardawani,1990). An experienced senior ghanat builder (moghamni) surveys the area where a ghanat is planned to be excavated. A long rope, a water level, a large triangle with a plumb are the only tools that a surveyor uses. Local criteria, such as type, slope and setting of the alluvial fan in relation to groundwater recharge, are decisive. Other factors including precipitation, vegetation cover, number and distribution of existing ghanats and wells, which might influence the recharge of the ghanat, are also taken into account in such a survey. Usually, several trial wells are dug to examine the thickness and capacity of the aquifer. If the evaluation of the aquifer is satisfactory, the course, gradient, and outlet point of the underground tunnel are determined. Several guide shafts, with relatively large intervals, are dug in the established direction.



**Figure. 1 A schematic presentation of a ghanat mound (Farshad, 1997).**

After the distance and the position of all access wells (shafts) of a ghanat chain are determined by the surveyor, the excavators (moghanni) start their work from ghanat mouth (maz'har). This is the point where water should appear on the land surface, after the construction of the ghanat is finished. Usually, the distance between consecutive wells varies from 20 to 50 m. The wells are the access ways to the underground tunnel and also secure ventilation for the underground workers. When constructing, excavated spoils are hauled to the surface through the shafts by means of a windlass operated by one or two surface workers, the windlass operator (charkh-kesh ) and the bucket operator (dalw-guir). The moghanni team consists of three members working in the tunnel; the kolangdaur, the most experienced one who executes the digging job, the guel-band who fills up leather buckets (dalw), and the lausheh-kesh who carries the filled- up buckets through the tunnel to the nearest shaft opening for hauling to the surface by the two members operating the windlass.

**Table 2 : Excavation work of a 6 km long ghanat**

Tunnel sections	Length (m)	Number of shafts	Depth (m)	Total excavation length (m)
Khoshgueh- kar	1000	50	6	1300
Tar-o- khoshgue	1000	44	15	1660
Kam aub- bedeh	2000	66	25	3650
Ziaud aub- bedeh	2000	50	35	3750
Total	6000	210	81	10360

The tunnel gradient is usually 1 m in 1000 m distance, sometimes 5 to 10 m in 1000 m, depending on the type of bedrock. If the tunnel is dug into loose collapsable material, it has to be lined with the right construction materials, normally pre-fabricated lining hoops (kawal). In some cases, arc-like roofs lining the tunnel have to be constructed using bricks and lime mortar. The opening to the underground tunnel (maz'har) is placed at a relatively short distance from the first shaft and somewhat above the level of the surrounding land. This is mainly for the purpose of controlling the water pressure, but also to secure performance continuity of the ghanat when the tunnel floor will be gradually lowered through repeated cleanings (lairoobi). Maintenance operations take place regularly, using the shafts for access and spoil evacuation. In the past, before the land reform, owners used to have permanently employed moghannis for the maintenance of their ghanats.

According to Safinegad (1979), it requires 14500 mandays of work to establish a ghanat chain of 6 km length (Tables 2 and 3). This includes the excavation of some 8000 m<sup>3</sup> of alluvial material and additional work to fix the loose sediment with pre-fabricated hoops (seft-kari).

**Table 3. Mandays work of a 6 km long ghanat**

Tunnel sections	Tunnel (mandays)	Shafts (mandays)	Seft-kari (mandays)	Total (mandays)
Khoshguez- kar	850	150	-	1000
Tar-o- khoshgue	1000	330	-	1330
Kam aub- bedeh	3200	1650	-	4850
Ziaud aub- bedeh	5000	1750	300	7050
Total ghanat length	10050	3880	300	14230

Ghanats are distinctive features of the agrarian landscape in (semi) arid regions. Their spatial distribution can be easily traced on the field through the alignment of rounded mounds around the excavation shafts and their location is often recorded on large-scale topographic maps. Even very old crumbled ghanats are never totally erased from the landscape and can still be recognized on aerial photographs. A typical excavation mound has a conic shape, and is one to two meters high and some ten meters in diameter. Although the spoil material settles down with time, the elevation of the mounds remains nearly constant because of the piling up of the sediments periodically extracted for tunnel maintenance. Even when no longer functional, mounds survive for long times; the scarcity of rainfall contributes to their preservation.

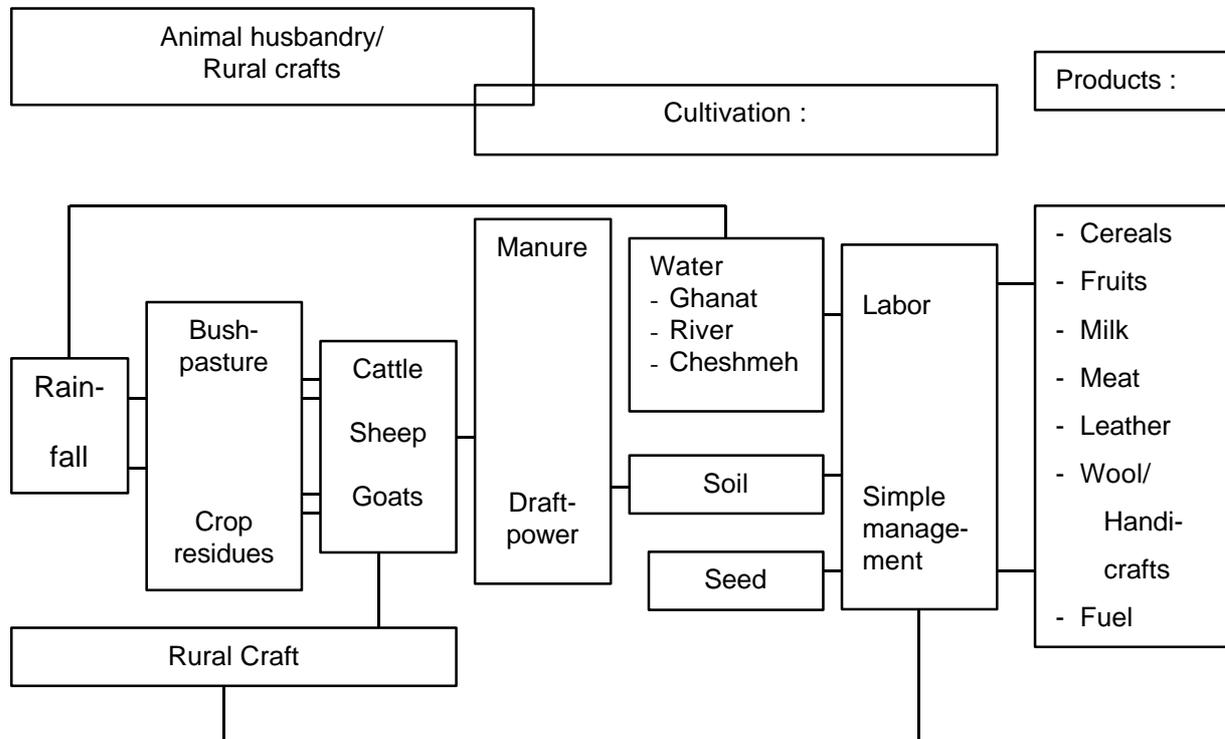
## 5. Traditional Farming; an Integrated System

A traditional production unit is a complex system of interrelated activities carried out by a household. It includes three main components: crop farming, animal husbandry and handicraft production (Fig. 2). The output of one activity may be the input to another one, leading to an increasing transformation of the primary farm products (vegetal and animal) either for auto- consumption or for sale. Functional integration and temporal distribution of the activities make that all family members participate full-time all year around. The large variety of products generated helps mitigate all kinds of risk, from climatic (drought, late frost) to economic (market price fluctuations, product scarcity). Such integration is the result of a long co-evolution between ecosystem and sociosystems (Farshad and Zinck, 1993).

Animal husbandry was present in all households. Oxen, cows, sheep, goats, hens and pigeons were common. Eggs, milk products, meat, flour from wheat and barley, vegetables, fruits, leather and wool were produced by each household with the active participation of all family members. Large flocks of sheep and goats, belonging to mighty and often absentee landlords, were in the care of paid shepherds. Sheep and goats were slaughtered daily for meat production. Animal skins were either exported to larger market centres or bought at the farm gate by agents of small local factories. Many people were involved in leather making, from cleaning and skin processing to dyeing shoe- making and selling.

Wool from sheep and goats had to undergo a long process of beneficiation before it was ready for making carpets. This occupation, called farshbaufi, demanded the participation of many workers to make the wooden installations (dastgauh-e- ghauli), produce the cotton threads (nakh-ris), construct the basic thread-frames (chelleh-dewan), prepare the wool threads and dye them in different colours (rangraz), elaborate natural dyes from wallnut shells, pomegranate skins and other natural substances, make the carpet designs (nagh'sheh-kesh), and finally weave the carpets (ghaulibaf). Except for some really

specialized jobs requiring designers and carpenters, farmers were involved in almost all wool processing steps, on top of their farming activities. Women were mainly responsible for carpet weaving. The rural crafts were either marketed locally or otherwise exported to larger towns. Carpets and guelims, a kind of woven carpet, were mainly exported, ultimately to foreign countries.



**Figure 2. Model of a traditional agricultural system (Farshad and Zinck, 1995).**

## 6. Conclusion

The fate of agriculture in a great part of the (semi-) arid regions of Iran is uncertain in the medium and long run. The traditional agriculture is vanishing because its structural cohesion, inherited from a long co-evolution between eco- and sociosystems, is being disarticulated by fast changing economic and social conditions. Traditional systems were based on a sustainable management of surface and near-surface water resources, but are increasingly unable to satisfy the needs of a fast growing population. On the other hand, the large scale and high-external-input agriculture, developed over the last four decades, looks unsustainable because it degrades the land by extensive use of machinery and leads to groundwater depletion beyond the natural recharge capacity of the aquifers. In brief, while the traditional systems are disintegrating, the new systems have not yet proven their sustainability. What is the fate of agriculture in these regions: sustainability or casual survival? Is the present trend conducting to increasing desertification? It might be too early to answer these questions but not too early to face the alarming challenge they raise.

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