MODERN INTERFERENCES IN TRADITIONAL WATER RESOURCES IN BALUCHISTAN

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1. The problem

Baluchistan, a province of Pakistan, is a mountainous region with little rainfall and no other major sources of water. Nevertheless, the small amounts of rainfall, surface runoff, and groundwater are used to produce crops and to supply drinking water to man and beast. Traditionally, a (more or less) balanced water-use system has evolved, but modern developments are tending to upset this balance by redistributing the water resources.

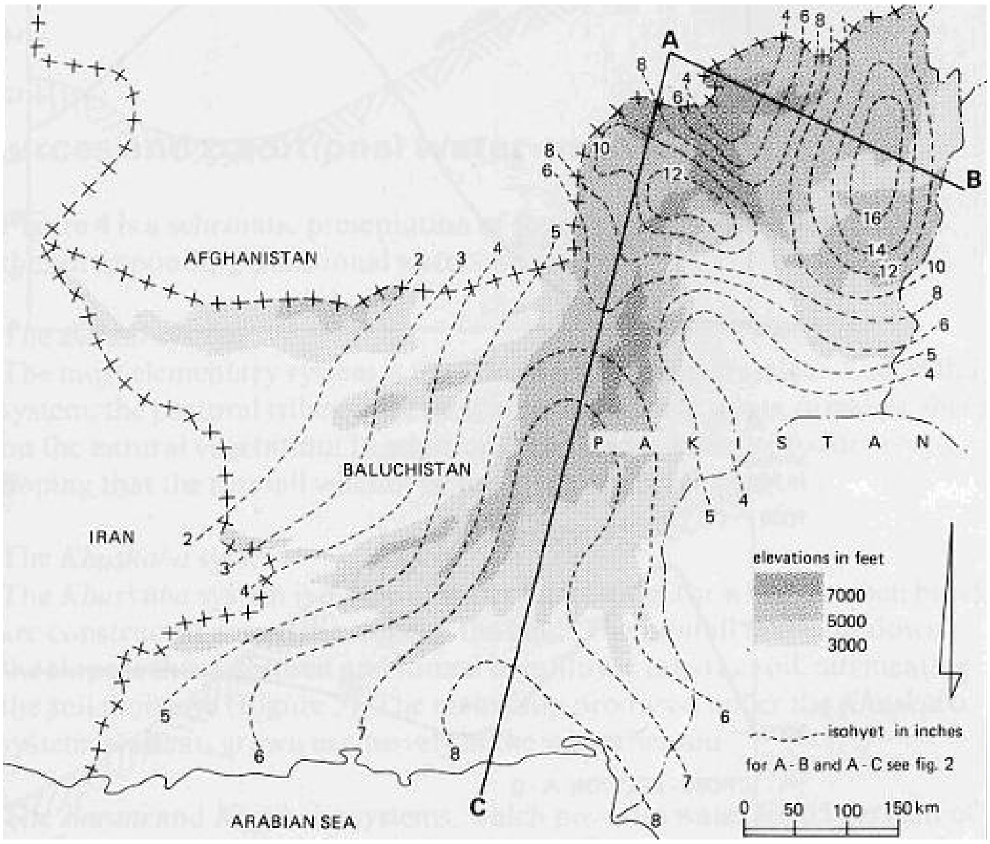

Figure 1. Annual rainfall and physical relief, Baluchistan

2. Climate and topography

Figure 1 shows the average annual rainfall distribution in Baluchistan. In the northern and north-eastern parts of the province, rainfall is higher than in the south and west. Orographic effects on rainfall are only moderate (Figure 2).

Figure 3 shows the average monthly day-temperature and a typical annual rainfall distribution. The winter-rainfalls are more significant than the summer-rainfalls. A comparison of monthly rainfall and temperature distributions over the year shows that rainfall-dependent agriculture can be practiced only in winter.

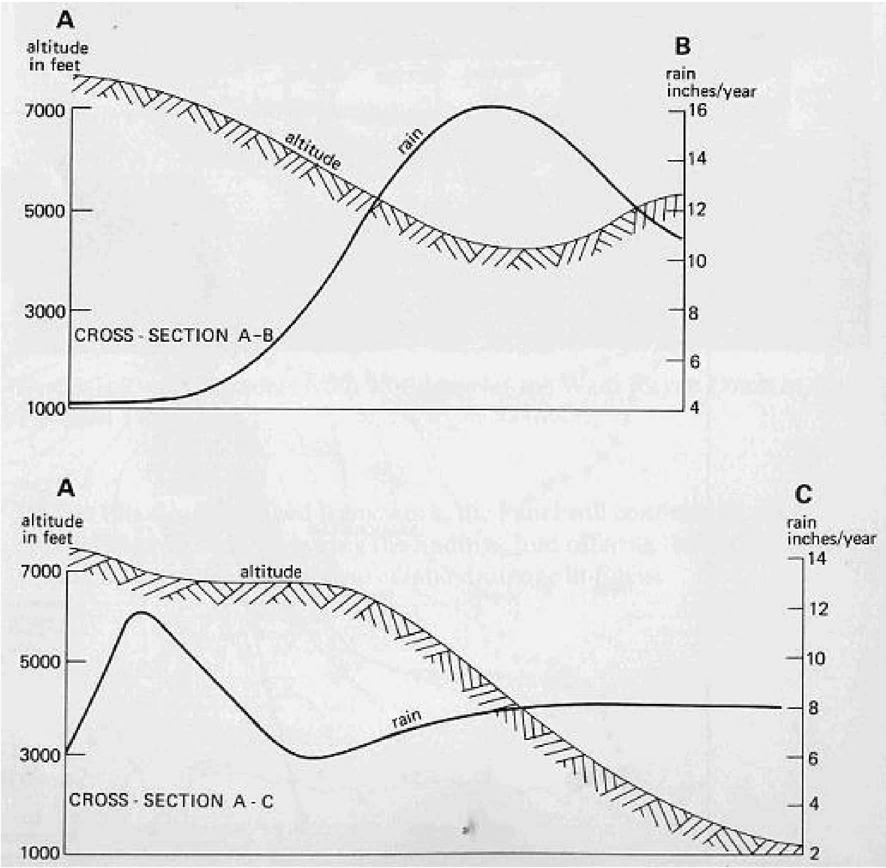

Figure 2. Cross-section over Figure 1.

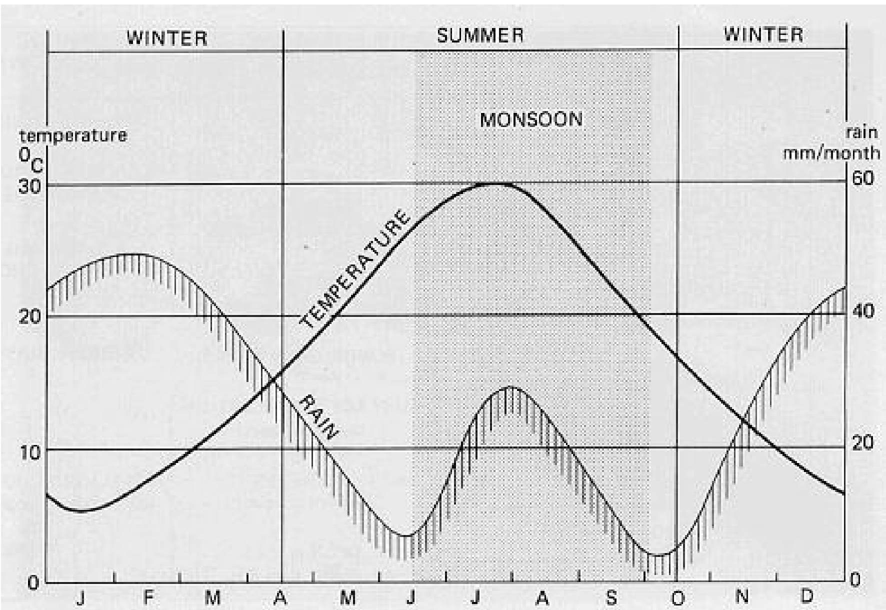

Figure 3. Distribution of average day and-temperature and rainfall over the year

The summer rains are the result of a minor monsoon influence. Baluchistan, in fact, marks the boundary of the monsoon climate to the east and the arid climate to the west. To the west of its central mountains the monsoon effects have completely vanished. There, only winter rains occur. More to the east the importance of the winter rains decreases and that of the summer (monsoon) rains increases. The rainfall distribution in Figure 3 with its double peak is indicative of the climatic transition zone.

3. Water resources and traditional water-use systems

Figure 4 is a schematic presentation of the available water resources and the corresponding traditional water-use systems.

3.1 The Barani *system*

The most elementary system is the Barani (or rain-land) system. Under this system, the pastoral tribes graze their animals (camels, goats, donkeys, sheep) on the natural vegetation. In addition, people sow wheat or fodder crops, hoping that the rainfall will not be too erratic to produce a crop.

3.2 The Khuskaba *system*

The *Khuskaba* system is a type of water-harvesting, for which earthen bunds are constructed across the slope of the land. The rainfall that runs down the slope is thus captured and forced to infiltrate into the soil, augmenting the soil moisture (Figure 5). The main crop produced under the *Khuskaba* system is wheat, grown exclusively in the winter season.

The *Barani* and *Khuskaba* systems, which occupy 65% of the arable land, are relatively independent of the natural systems of watercourses and groundwater flows.

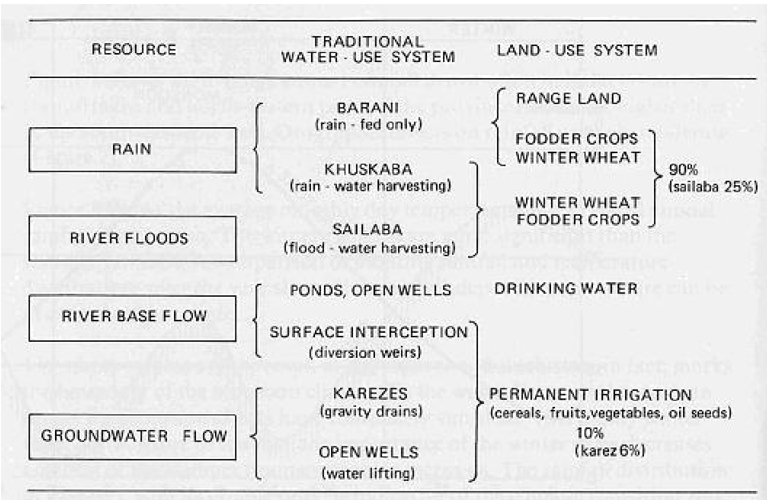

Figure 4. Traditional water resource systems

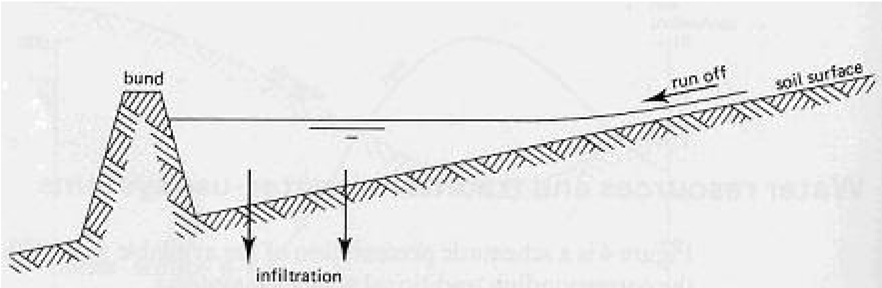

Figure 5. Principle of an infiltration bund

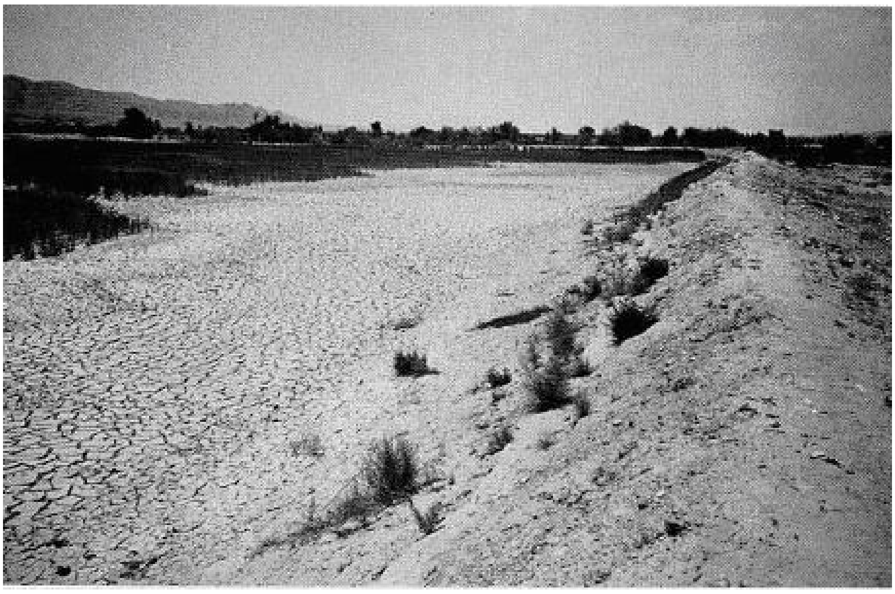

Photo 1. Earthen bund for water harvesting

3.3 The Sailaba *system*

The *Sailaba* system depends on the floods occurring in the natural watercourses. These floods are captured by earthen bunds, built across the slopes and intercepting the floods. Flood lands are found at the foot of the mountains and alluvial fans, where watercourses emerge from the hills (Figure 6).

Sometimes, the distinction between *Khuskaba* and *Sailaba* systems is blurred. There appear to be intermediate systems, especially in areas where the floods are not pronounced.

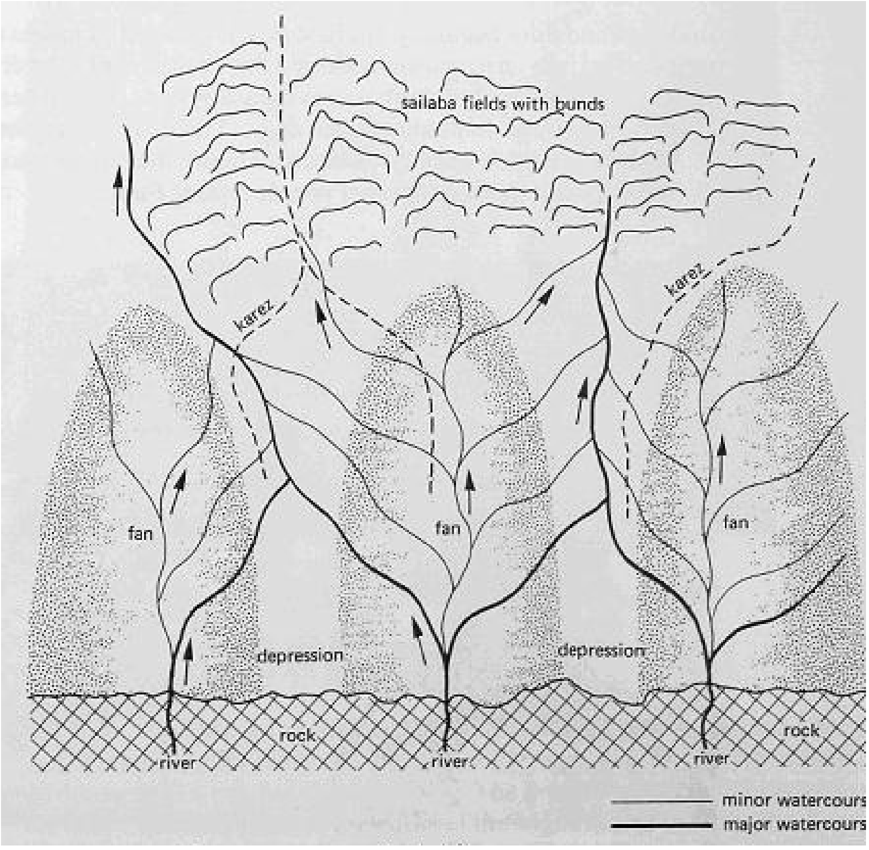

Figure 6. Sailaba systems near alluvial fans

3.4 River base-flow

River base-flow is used in two ways.

Firstly it serves as drinking and household water, especially for pastoral tribes and their animals. When the river flow has ceased, ponds or open wells are dug in the riverbeds to take advantage of the underground flow.

Secondly the base-flow is diverted by means of a diversion weir into an irrigation canal system. Traditionally, the diversion weirs are stone or cobble dams built across the stony riverbeds. When a flashflood occurs, these dams may be partially washed away. This provides a safety system in the same way as fuses do in an electrical circuit. The farmers reconstruct the dams almost as easily as other people replace fuses.

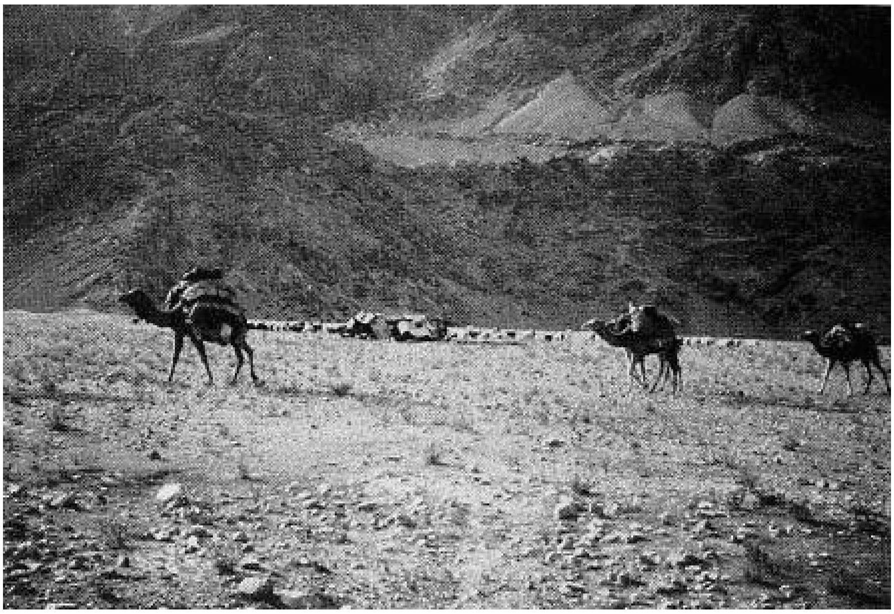

Photo 2. Nomadic pastoralists at large

Photo 3. Reconstructing a traditional diversion weir

3.5 The karez *system*

The *karez* system is an ancient and ingenious way of recovering groundwater in sloping areas. A *karez* (also known as *qanat*) is an underground tunnel, dug in a gentle upslope direction until it the water table. The groundwater then flows into the *karez* and through it to the outlet at the beginning of the tunnel, where the water is captured and used for irrigation (Figure 7).

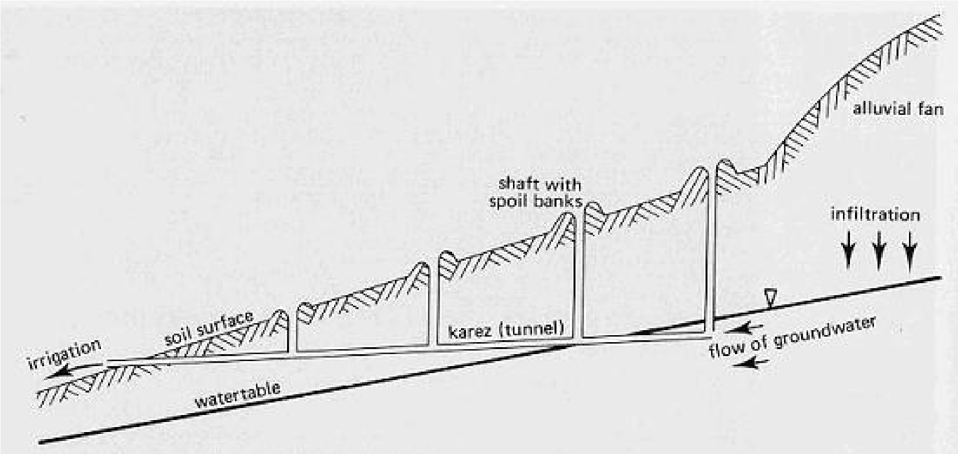

Figure 7. Principle of a karez system

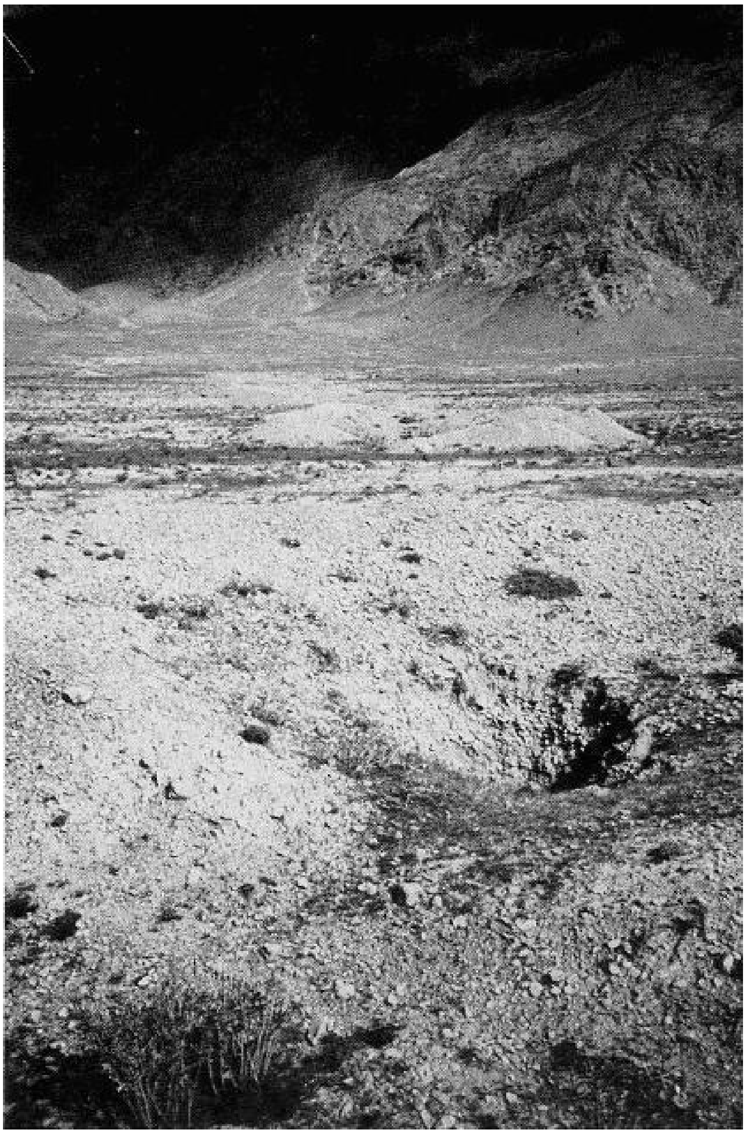

Photo 4. A karez shaft

While the *karez* is being dug, vertical shafts are sunk at regular spacings along it to provide ventilation to the diggers and to allow the removal of the spoil. At the surface, one can follow the alignment of the *karez* by the spoil banks around the shafts.

The most appropriate site for a *karez* is in an alluvial fan at the foot of a mountain range (Figure 6). There, large amounts of water infiltrate into the soil, thus replenishing the groundwater and feeding the *karez*.

Although the *karez* system provides water to only 6% of the arable land, it is of great importance to the rural population. With its relatively stable discharge throughout the year, it allows fruits and vegetables to be grown – crops that otherwise would not be possible under the rainfall-dependent *khuskaba* and *saliaba* systems.

Other water uses

As well as being used for agriculture, the permanent water resources in Baluchistan are used to generate energy for small mills.

4. Modern developments and their effects

As continuation to Figure 4, Figure 8 adds the modern water resources developments.

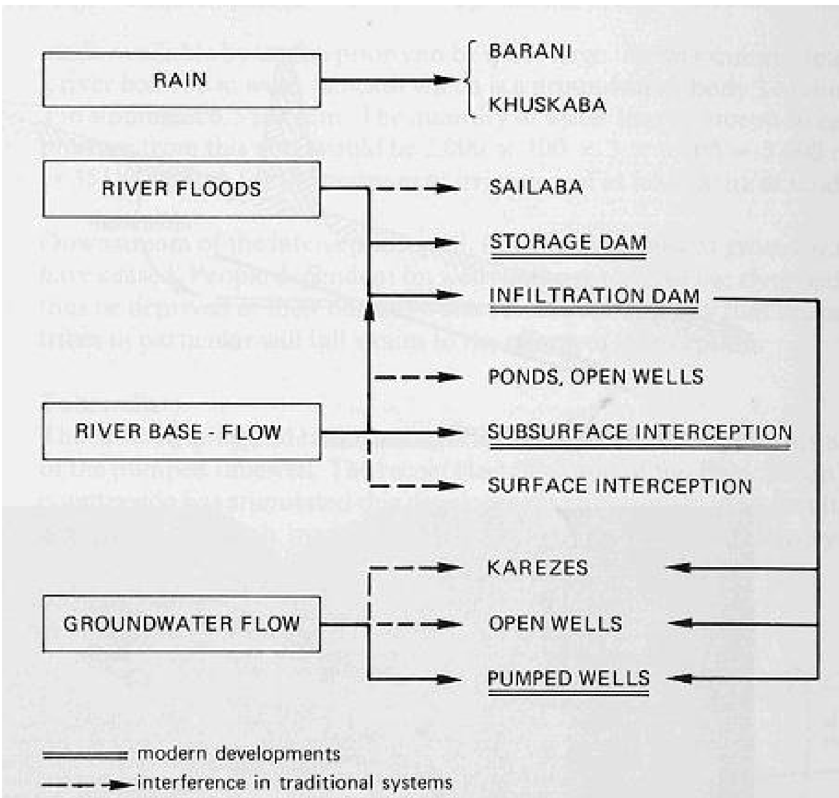

Figure 8. Modern and traditional water resource systems

4.1 Storage dams

Of modern techniques of water resources development, storage dams play only a minor role, because of their high costs, so that not many of these are being made.

Storage dams retain the river flows and floods. A storage dam would remove almost all river water that provided livelihood to downstream water users.

4.2 Infiltration dams

Infiltration dams are becoming quite popular. An infiltration dam is a large-scale version of the bunds used in the *sailaba* land. It is, however, not used to store water in the soil, but it forces the water to infiltrate into the stony and permeable riverbeds, where it replenishes the groundwater (Figure 9). The dams enhance groundwater supplies to the *karez* systems and thus enhance permanent irrigation.

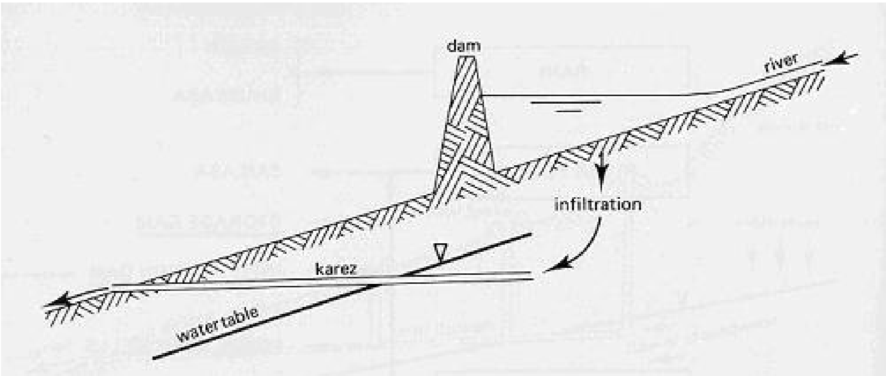

Figure 9. Principle of an infiltration dam

Photo 5. Permanently irrigated land

Infiltration dams interfere with *sailaba* agriculture, because they reduce river floods. They also reduce river base-flows, which endanger the livelihood of those who depend on these flows downstream of the dams.

4.3 Subsurface interception walls

Another interference to traditional systems is the modern subsurface interception wall. Figure 10 illustrates its principle. The wall is built across a riverbed on the hard rock base underlying it. This wall forms a barrier to the groundwater flowing through the sediments beneath the riverbed and forces the flow sideways, where it is captured and led to an irrigation system. The hydraulic conductivity of the sediments below the stony riverbed is extremely high, of the order of a few thousand meters a day, so the quantity of water made available by the interception can be quite large.

As an example, imagine a riverbed 100 m wide, beneath which is a groundwater body 3m thick and sloping at 0.5 percent. With a hydraulic conductivity of 2000 m/day, the quantity of water that interception could produce from this area would be 2000 x 100 x 3 x 0.5 = 3000 m^3/day, or 35 l/s, enough for the permanent irrigation of at least 30 ha.

Downstream of the interception wall, however, the flow of groundwater will have ceased. People dependent on dug-wells in those parts of the riverbed will thus be deprived of their natural water resource. It is likely that the pastoral tribes in particular will fall victim to the effects of the interception.

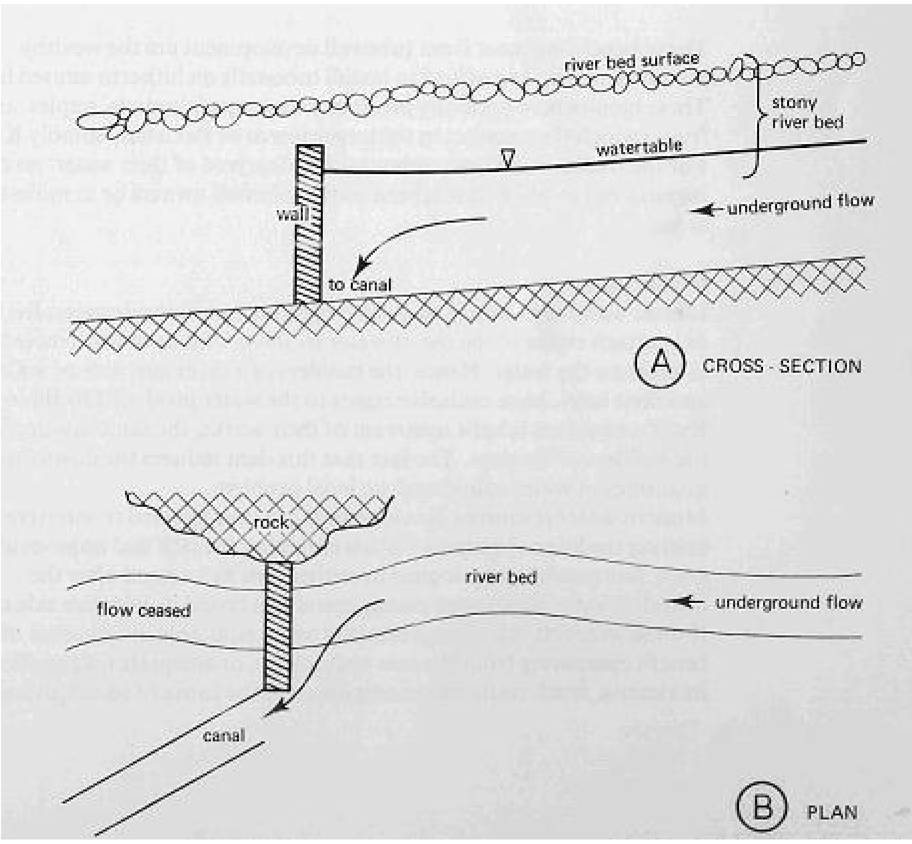

Figure 10. Principle of an underground interception wall in a riverbed

4.4 Tube-wells

The most striking and far-reaching effects of modern developments are those of the pumped tube-wells. The recent electrification of the Baluchistan countryside has stimulated this development enormously. As a result of tube-well installation, many *karezes* and watercourses have fallen dry (Figure 11).

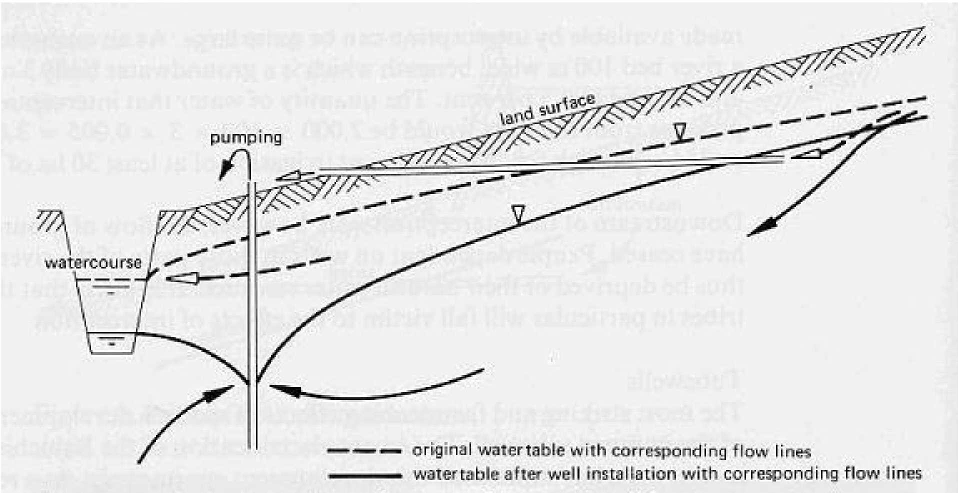

Figure 11. Hydrological interference of a pumped well with karez and watercourse: both fall dry

Those benefitting most from tube-well developments are the wealthy landowners who can afford to install tube-wells on hitherto unused land. These landowners normally produce cash crops (almonds, apples and other fruits), which they market in the larger towns of Pakistan, notably Karachi. For the traditional *karez* communities, deprived of their water, no option remains but to offer their labor to the tube-well owners or to migrate to urban centers.

5. Conclusion

Islamic water laws attach no property rights to water resources. The laws only attach rights to the use of water by those who have constructed works to produce the water. Hence, the builders of a diversion weir or a *karez,* and their heirs, have exclusive rights to the water produced by these works. But if a new dam is built upstream of their works, the same law applies to the builders of the dam. The fact that this dam reduces the downstream quantities of water and intercepts the water resources of downstream water users constitutes no legal problem.

Modern water resources developments are thus allowed to interfere with existing traditional systems – often enriching the rich and impoverishing the poor. But careful hydrological investigations before and after the introduction of new water management techniques can reveal its negative side effects. If these were followed by agreements on an equitable distribution of the benefit emanating from the new technology or on adequate indemnification for its victims, much could be accomplished in the cause of social justice.