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Floodwater Spreading for Spate Irrigation, the Artificial Recharge of Groundwater, and Flood-Damage Mitigation in I.R. Iran

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Floodwater Harvesting Concepts

- 1. Water is the most precious commodity in drylands and rainfall is its only supplier in areas lacking trans-boundary rivers.

- While the mean annual rainfall in drylands is very low, its variability is extremely high (erratic in distribution and frequency). Thus, the chance of receiving the desired rainfall at the expected time is meager, indeed.

- Fortunately, meteorological and geomorphological features of most drylands lead to flood generation.

- Floodwater harvesting is a **must** if one decides to 'ride the variability curve' in drylands. Although floodwater is a renewable capital, its use must be optimized.

Table 1. Shiraz annual rainfall for the 1963-1973 period.

Year	Rainfall,mm
1963	223.0
1964	251.0
1965	397.0
1966	96.3
1967	395.1
1968	294.8
1969	388.6
1970	143.2
1971	207.0
1972	499.3
1973	183.4

Floodwater Harvesting Concepts

- 2. Available water capacity is the most important direct driver of ecological sustainability in drylands.

  - Soil *texture* and *depth* are the two major determinants of available water capacity.

Floodwater Harvesting Concepts

- 3. Harvested floodwater is a land renovator and soil builder as it transports to and deposits nutritious sediment on the slightly-sloping, drastically disturbed lands by:

  - Improving their texture and increasing their depth; *therefore, enhancing their available water capacity*;
  - Modifying the topography, stabilizing the moving sands and depriving the wind of the erodible material at its source.

Floodwater Harvesting Concepts

- 4. Large dams offer the most *hydro-illogical technology* in drylands where potential aquifers exist. The main reasons are:

  - High evaporation rate from surface waters;
  - Rapid siltation;
  - Inundation of productive lands and dwellings; thus, forced migration of the inhabitants of the inundated area and construction sites;

Floodwater Harvesting Concepts

- Threat to biodiversity;
- Reservoir leakage, earthquakes and other related environmental hazards;
- Very high costs and time needed for their construction;
- Deprivation of the inhabitants of the runoff-producing headwater catchments of the accrued benefits, and infringing on the riparian rights of the downstream communities; therefore,

Floodwater Harvesting Concepts

- 5. Turbid floodwater should be harnessed to:
  - Build soil;
  - Produce virtual water through spate irrigation;
  - Be stored in aquifers by employing the artificial recharge of groundwater methods and used commensurate with needs (*the Genesis Strategy*);
  - Mitigate flooding hazards;

Floodwater Harvesting Concepts

- 6. The floodwater consumed by spate-irrigated crops replaces some of the water extracted from underground resources.

  Moreover, depending on the amount, some water is drained through the soil profile to the water table; this represents a right move in aquifer stabilization. This saves on nonrenewable energy used in pumping water too.

- ***Caution**: Equity dictates that a fair share of floodwater should be released for the owners of the riparian rights and as "ecological water".*

Fig. 1. ***Bandsãr***, a spate irrigation system in Khorãsãn, NE Iran.

Fig. 2. ***Bandsãr***, a spate irrigation system in Khorãsãn, NE Iran.

Fig. 3. ***Pal***, a spate irrigation system in Khorãsãn, NE Iran.

Fig. 4. ***Pal***, a spate irrigation system in Khorãsãn, NE Iran.

Fig. 5. ***Hootak***, a small water reservoir in Baluchestãn, SE Iran.

Fig. 6. ***Degãr***, a spate irrigation system in Baluchestãn, SE Iran.

Fig. 7. ***Darband***, a spate irrigation system in Baluchestãn, SE Iran.

Fig. 8. ***Khooshãb***, a spate irrigation system in Baluchestãn, SE Iran.

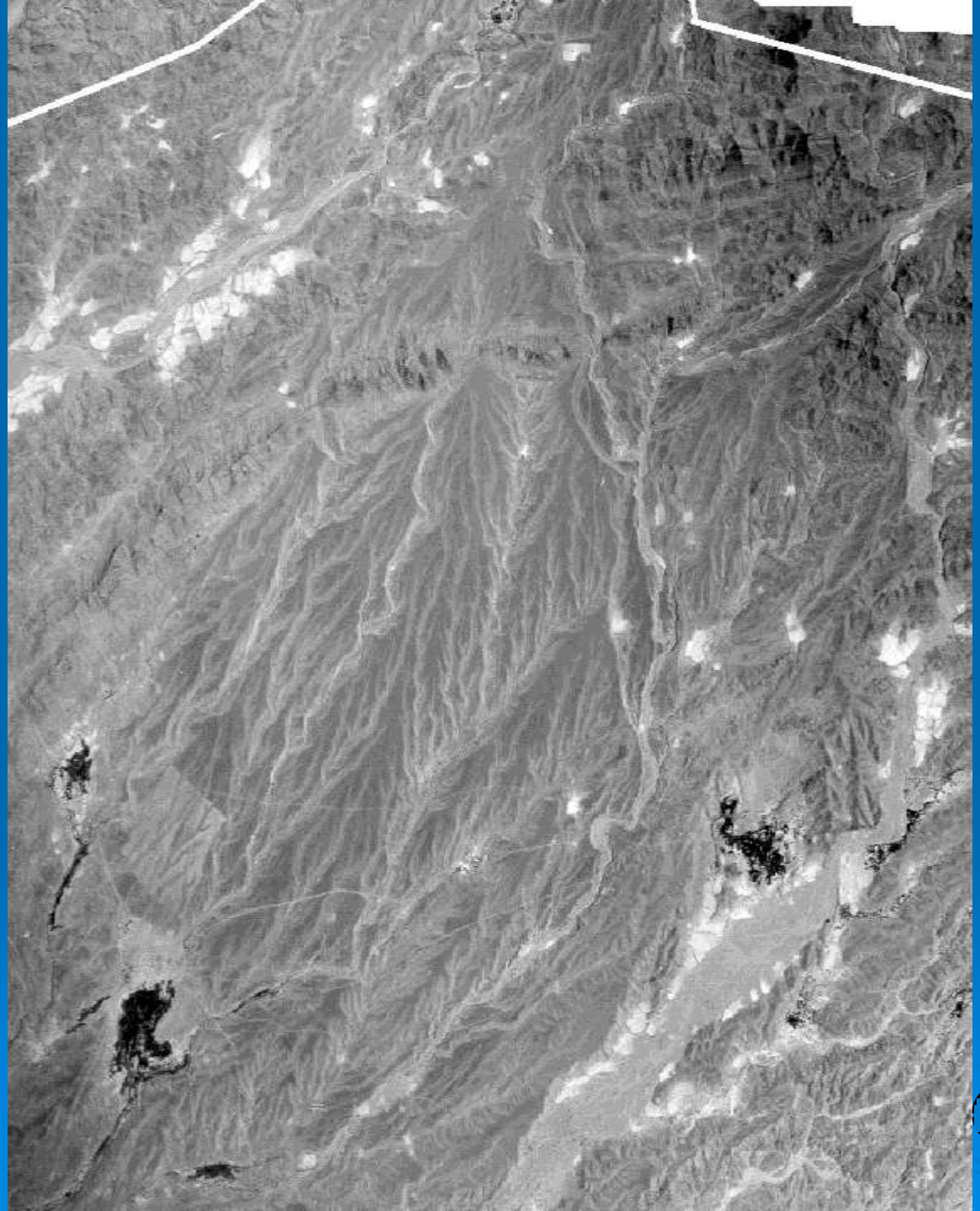

Fig. 9. Distribution of *darband*s and *khooshãb*s in northern Baluchestãn, SE Iran

Fig. 10. An ancient stone-walled terrace system in near Dogonbadãn in Fars province.

Fig. 11. A spate-irrigated barley field at the Kowsar Station in the Gareh Bygone Plain.

Fig. 12. Floodwater spreading for the artificial recharge of groundwater,Kowsar Station, Gareh Bygone Plain, SE Iran.

Fig. 13. Water collection and transport from the Kowsar Station, Gareh Bygone Plain, SE Iran.

Fig. 14. A downstream view of a gabion apron with a triangular cross section. This apron is functioning well since its construction in 1984. The crest of this apron was raised 30 cm in 2002 after sedimentation raised the level of a sedimentation basin by about 20 cm.

Fig. 15. The late Haj Mohammad Pashali is pointing to the water mark of the flood peak. This structure diverts floodwater for a 25 ha artificial recharge of groundwater system in the Gareh Bygone Plain.

Fig. 16. A gabion apron with a triangular cross section in operation. A ski jump dissipates most of the kinetic energy of the flowing water.

Fig. 17. A gabion mattress connected to a gabion apron protects the lower bank of an inundation canal in the Gareh Bygone Plain.

Fig. 18. The late Haj Mohammad Pashali contemplates the Gareh Bygone Plain artificial recharge of groundwater system in operation on 8 March 1985.

Fig. 19. Spate-irrigated wheat in Joonegãn, Mamassani, SW Iran (March 1981).

Fig. 20. Spate-irrigated wheat in Imãmzãdeh Jaafar, SW Iran (March 1984).

Fig. 21. A 3-row gabion weir at the Gooyom spate irrigation system. This weir diverted floodwater for irrigating 250 ha of wheat.

Fig. 22. Sheep and goats are grazing in a fallowed wheat field in Joonegan, Mamassani in the spring of 1981, seven days after the latest flood.

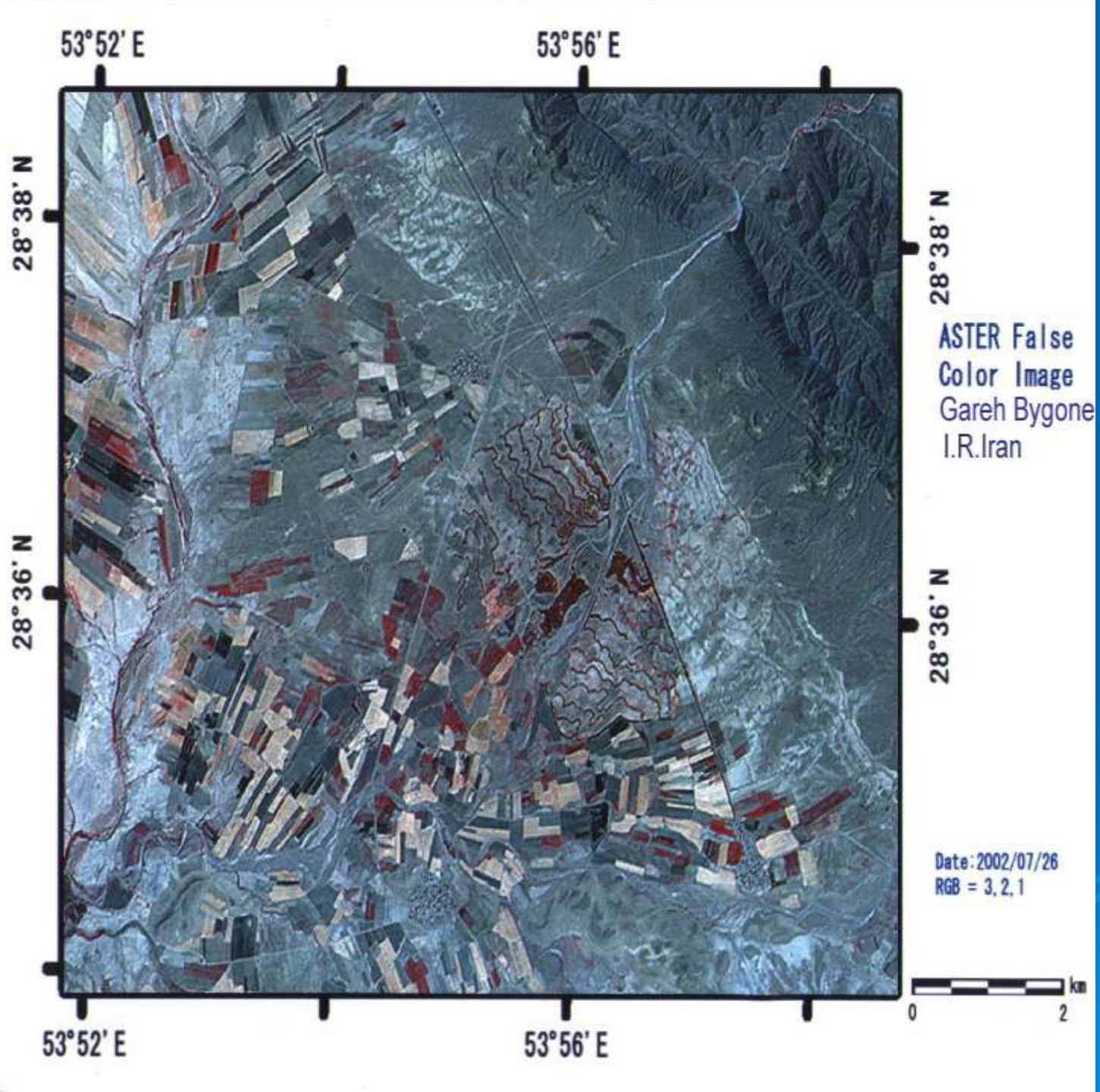

Fig. 23. Water is the best adhesive that glues the dryland farmers to their fields. The area of the irrigated fields has grown to 1193-ha, 8 times the expanse prior to the initiation of the artificial recharge of groundwater (photo credit, ERSDAC, Japan, and JICA).

RECOMMENDATIONS

a) **A paradigm shift in water management policies**. As long as the engineers, who are illiterate in ecology-related fields, decide on the fate of floodwater in our country, nothing substantial would happen in applying this technically practicable, environmentally friendly, economically feasible and socially acceptable traditional art and science. It is my dictum that ***the rulers of a fragile land should be ecologists or at least seek their advice*** (Fig.23)***!***

RECOMMENDATIONS

b) **Public education in conservation of natural resources**. The majority of our population assumes that soil and water are easily renewable resources; therefore, they waste both of them. We annually waste upwards of 61 km3 of floodwater, while suffering 200 deaths and billion of dollars in flooding-related damages. Floodwater harvesting, particularly for the artificial recharge of groundwater, and the prudent utilization of soil and water resources are our only choice for survival; nothing short of miracles can insure the continuation of life in drylands if the current over-exploitation of natural resources, particularly soil and water, continues unchanged.

RECOMMENDATIONS

c) **Capacity building and deployment of masses in water-short areas.** Cityward migration, mostly due to water shortage in agricultural communities and nomadic pastureland, is beginning to wreak havoc on our society. Provision of livelihood is the first step in turning back the migration tide. Employing farmers and nomads to construct the spate-irrigated systems, particularly for the artificial recharge of groundwater, is a logical way to remedy many social ills. Training the engineers and technicians is very easy; one week to one month, depending on their background. A side benefit of this revolutionary move is the mitigation of flooding casualties and damages, and the rejuvenation of thousands of *qanãts*, our most precious water collection and conveyance systems.Over-pumping has lowered the watertable below the galleries that used to drain the aquifer.

RECOMMENDATIONS

d) **Collection of carbon sequestration rent from industrial countries.** At the Kowsar Station in the Gareh Bygone Plain, the above ground carbon sequestration potential of an 18-year old, spate-irrigated *Eucalyptus camaldulensis* Dehnh. was 2.221 tons ha-1yr-1; this for *Acacia salicina* Lindl. was 1.304 tons ha-1 yr-1. As windbreaks mitigate wind erosion, we have to plant adopted trees in our ARG systems. Moreover, the root channels formed after decomposition of fine roots increase the hydraulic conductivity of the vadose zone in sedimentation basins and recharge ponds. Collecting carbon rent from polluters and paying it to farmers is an incentive for growing trees in the vast ARG systems and protecting them from graziers and wood-cutters.

RECOMMENDATIONS

e) **Selection of the most suitable crop species and improved cultivars**. Modern plant breeders have never tried to select species and cultivars of food and industrial crops for planting under spate irrigation. Spate irrigation is an intermediate between rain-fed farming and irrigation agriculture. Therefore, research on selection and development of the most suitable species and cultivars is badly needed. Genetic engineering offers a tool for materialization of this concept. A case in point is the spate-irrigated *Oroji* durum wheat in Mamassani in southern I.R.Iran that grew taller than 2m in 1981. Imparting short stature to this indigenous cultivar may prevent its lodging in rainstorms.

RECOMMENDATIONS

f) **Offering conditional land tenure.** Land preparation and spate irrigation require a heavy investment of funds and labor; therefore, the operator must be sure of permanent rewards. On the other hand, the shortage of arable land dictates that the field should be under cultivation. Therefore, the occupier of the spate-irrigated land must not leave the land idle. This and other pertinent points should be clearly understood by the concerned parties.

RECOMMENDATIONS

g) **Strict enforcement of groundwater utilization.** The vicious cycle of over-exploitation of groundwater and its artificial recharge is going on for the past 25 years in the Gareh Bygone Plain and Dorz and Sãyehbãn in southeastern I.R. Iran. The main reason for an impending disaster in these 2 agricultural communities is a disregard for regulations, and the laxity of law-enforcers. As supplementary irrigation of crops, even in the spate-irrigated fields, is advantageous, utilization of groundwater must be regulated and enforced. Installment of water meter on the pump head should become mandatory.