

Khadin system of runoff farming for crop production

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Khadin is a low lying area surrounded by rocky catchment and is therefore site specific technique of runoff farming in hyper arid zone (rainfall < 250 mm) of India. Traditionally khadin system of runoff farming was designed and developed by the Paliwal Brahmins of Jaisalmer (Rajasthan) in 15th century. Meagre runoff generated by low rainfall from a larger catchment (usually rocky) is concentrated in a low lying smaller area to the height of 60 to 90 cm during monsoon and crops (i.e wheat, mustard and gram) are grown in rabi season on conserve moisture. Since runoff from a very large catchment belonging to many farmers is get collected in a smaller area, therefore production from khadin is shared on the basis of size of catchment of the contributing farmer. Khadins occupy about 28,400 ha area of Jaisalmer districts with more than 500 nos. of khadins. Research, was conducted to optimise the ratio of khadin to catchment area for maximising the crop production and design package-cum-guidelines, was developed for the construction of khadins. In extremely low rainfall area (e.g. Jaisalmer), khadin system of runoff farming was found very useful and promising technology for crop production on sustainable basis.

Key words: Arid, Jaisalmer, *Khadin* system, Runoff farming

IN hyper arid zone, particularly in the extreme western part of Rajasthan, rainfall is very low (< 250 mm) in amount and its occurrences is highly erratic (CV 40 to 70%). Scarcity of water coupled with other adverse edaphic-climatic factors like intense solar regime, high temperature (40 to 45°C), high wind velocity and sandy soils in most part of this region, limit production potential in the zone. Weather conditions, for most parts of a year even during normal years remain inhospitable for crops growth. Under such hyper aridity conditions crops production can be pursued by locally developed techniques of runoff farming known as *khadin*. In this technique, rainwater falling on large tracts of rocky catchments travels a long distance through a natural surface drainage system and accumulates in low lying areas where a topographical barrier or a constructed bund is encountered.

These bunds are called *khadin* bunds, and the carried soils alluviated in the area of water accumulates become heavy in texture. With passage of time, the entire alluviated soils form a *khadin*. During winter when water recedes, following *rabi* crops like wheat, mustard and chickpea can be cultivated on conserved moisture in the *khadins*. The *khadin* soils hold moisture that lasts up to the crop growing season, and salt contents in the soils are low owing to leaching. Thus, a *khadin* is an unique practice of water-harvesting, moisture conservation, and utilization in hyper arid region of Rajasthan (Fig. 1)

Traditionally, *khadin* system was designed and developed by the Paliwal Brahmins of Jaisalmer (Rajasthan) in 15th century. This system has a great similarity with the irrigation methods found sometime back in 4,500 BC in Iraq, and in Nabateans of the Middle-East. CAZRI played an important role in

an improved version of *khadin* for western region of the Indian *Thar* desert. *Khadins* occupy about 28,400 ha of total area of 38,40,100 ha of Jaisalmer. More than 500 *khadins* are found there in different depressions surrounded by low hills (Fig. 2). Besides, 24,448 ha land was identified as a potential catchment for developing *khadins* having 412 ha bed area assuming average annual rainfall of 118.5 mm at 60% probability. The district has maximum potential of rainwater harvesting as it has its nearly 34% geographical areas under rocky and gravelly terrain, and highly undulating topography.

Main features of *khadin*

The main feature of *khadin* is a very long (100 to 300 m) earthen embankment built across the lower hill slopes lying below gravelly uplands. Sluices and spillways allow excess water to drain off. The *khadin*

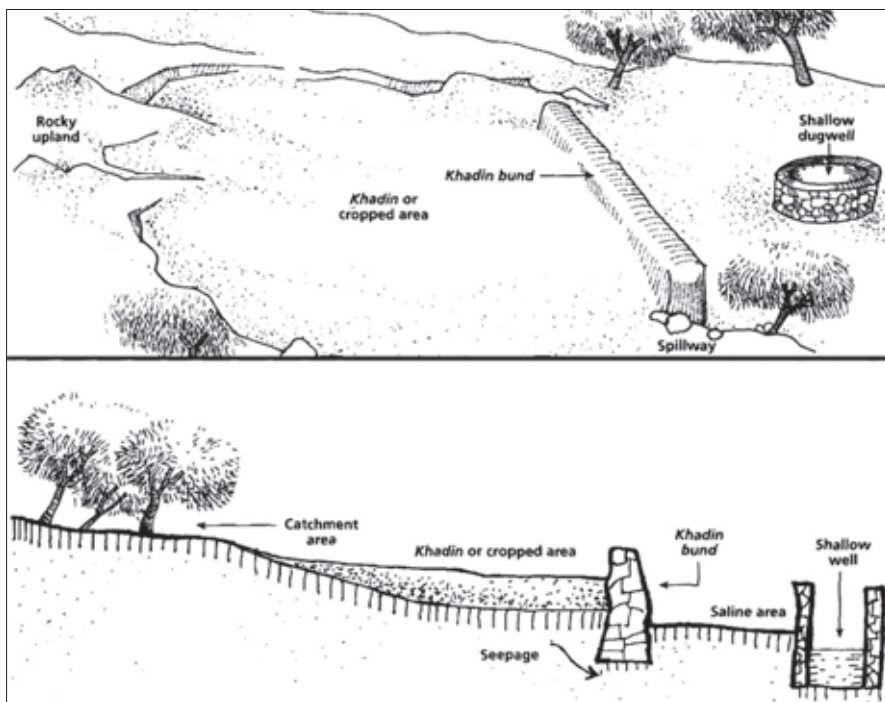


Fig. 1. *Khadin* plays an important role in water harvesting, moisture conservation and utilization in hyper arid region of Rajasthan

system is based on the principle of harvesting rainwater on farmland, and use residual moisture for crops production. The ratio of the catchment area to the storage area for a *khadin* depends on both catchment characteristics and rainfall patterns. The ratio between cultivated and catchment areas varies from 1:15 to 1:56. The relationship between rainfall-runoff for *khadin* was developed, which can be used for prediction of runoff and crop planning in the *khadin*.

The total energy input of rainwater, sand-silt-clay accumulation and cultivators' own activities are inter-woven into a complete production system of temperate crops. There is progressive increase in crop yields every year as more and more fresh silt and clay accumulate in the *khadin* bed. The ratio of farmland and catchment areas is maintained so that a suitable moisture supply is uniformly maintained. The water holding capacity and water infiltration rate are balanced by the shallow depth of soils in the beds. The basement of *khadin* is invariably a hard surface upon which sand-silt-clay is made to accumulate just to a depth of few meters. This maintains a convenient supply of natural moisture and nutrients within the crop's root zone. Few wells are generally kept on

down side of earthen bund; they are recharged from water in *khadin* and the water is used during summer when *khadin* bed dries.

Research on *khadin* soils indicated that these are more fertile than other desert soils. The organic carbon contents in surface and sub-surface soils varies from 0.39 to 0.76% and from 0.12 to 0.40%, respectively. As crops are grown on conserved moisture in *khadins*, application of fertilizer is generally not practised. The available P_2O_5 and K in the soils varied between 26–120 and 300–1000 kg ha⁻¹, respectively. The total nitrogen (N) content in different *khadin* ranges 0.018–0.035%, and pH of the surface is usually below 8.5. The water holding capacity of *khadin* soils range from 200 to 250 mm/m depth. The *khadin* has great promise for enhancing crop production in hyper-arid region like Jaisalmer.

Design package and guidelines for *khadin* construction

The Central Arid Zone Research Institute, Jodhpur has prepared the design package and guidelines for construction of *khadin* by users agencies as follows;

1. The catchment may be classified on the basis of infiltration rate. In the areas where infiltration rate is less than 5 cm hr⁻¹ may be



Fig. 2. Traditional Roopsi *khadin* (District Jaisalmer, Rajasthan)

considered as good catchment. The delineation of catchment should be done on cadastral/village map or G.T. sheet through reconnaissance survey.

2. The average rainfall of over 30 years available at the nearest rain gauging stations should be considered for working out the catchment yield. Log Pearson III method or strange table should be used.
3. For calculation of flood discharge up to 480 ha area Rational Formula and above 480 ha Dicken's Formula may be used.
4. *Khadin* may be constructed in a area where soil is fine textured, medium to deep with high soil moisture retention capacity. Soil should be free from salinity.
5. To have economic design the ponding depth over sill level at the *khadin* bund may vary from 0.65 to 1.10 m with overall average of 0.60 m.
6. The flood lift may be adopted as 0.3 m.
7. During the ponding period from July to October there will be wave action therefore, a free board of 0.5 m may be considered.
8. The side slopes of the bunds may be generally kept 2.5:1 (D/S) and 2:1 (U/S). However, these would be governed by the type of soil, angle of repose, bund cross section and its safety factor.
9. The top width of *khadin* bund may be calculated by appropriate formula and not for constructing inspection road.
10. A *murrum* capping of 7.5 cm thick layer be provided over the bund section for protection against wind and rain erosion.
11. The head outlet sluice of appropriate size may be provided in the *khadin* bund for the release of the standing water, if any before the *rabi* sowing.

Benefits of *khadin*

Collecting water in a khadin aids the continuous recharge of groundwater aquifers: Studies of groundwater recharge through *khadin* in different morphological settings suggested that 11 to 48% of the stored water contribute to groundwater annually. This replenishment of aquifers means that sub-surface water can be extracted through bore-wells dug downstream from *khadins*. The average water-level rise in wells bored into sandstone and deep alluvium was between 0.8 and 2.2 m, respectively. The electrical conductivity of *khadin* soils were 2- to 16-fold lower compared to outside farms due to leaching of salts through seepage water in *khadin*. Average pearl millet yield ranges from 3 to 5 q ha⁻¹ during poor rainfall (60-70 mm/year). The average yield of 20-30 q ha⁻¹ for wheat and 13 to 25 q ha⁻¹ for chickpea without any specific agronomical practices and fertilizers were also reported under *khadin* in Jaisalmer.

An improved *khadin* has been constructed by CAZRI near village Danta in Barmer district. The catchment area of the *khadin* is 137 ha with 6.88 ha submergence. Provision of 40 m bed bar in 450 m long earthen embankment was provided for spilling over excess water in the *khadin* bed. The total water storage capacity of *khadin* was 54.2×10^4 m³ and beneficiaries were four farm-families. CAZRI has developed another *khadin* of 20 ha in Baorali-Bambore watershed with surplussing arrangements (Fig. 3). Improved variety seeds of pearl millet (HHB-67), *Guar* (RGC-936), moong bean (K-851), moth bean (RMO-40) and chickpea (RSG-44) were given to the farmers in *khadin* area. Before construction of the *khadin*, uncontrolled runoff from upper catchment used to wash away seeds, fertilizers, and standing crops besides loss of valuable water. After construction of *khadin*, farmer could take excellent *kharif* and *rabi* crops. Cropping in the *khadin* has resulted 33-64 % increase in grain yield of various crops.

A study reveals that the



Fig. 3. *Khadin*, developed by CAZRI, at Baorali-Bambore watershed (Distt. Jodhpur)

productivity of the *khadin* can be further increased by diversifying cropping pattern in lower and middle reaches and integrated agri-horticulture system in upper reach of the *khadin*. Grafted ber (*Ziziphus mauritiana*) and Gonda (*Cordia dichotoma*) are suitable fruit species for the upper reach of the *khadin*. During drought years, moong bean (green gram) and *guar* (cluster bean) in middle reach and *bajra* (pearl millet) in lower reach may be grown successfully. Further, short duration variety of pearl millet can be grown in lowest reaches even if the rainfall received is 30-40 mm, and soil profile is charged with the water of about 200 mm/m in soil. The study further reveals that HHB-67 variety of pearl millet is suitable for late sowing and can yield grains even if sown up to 1st week of September. During normal monsoon year, the ideal cropping pattern would be agri-horti (*Ber*/*Gonda* + *Guar*) in upper reach, mustard in middle reach and wheat in lower reach of the *khadin* bed area.

Designing of *khadins* also play a vital role in optimum storage of runoff water during monsoon. *khadin* can be designed with contour bunding or vegetative barriers in upper reaches, graded bunds in middle reaches and level terraces in lower reaches. Local participatory approach is also important in designing, construction, and management of *khadins* considering the fact that they are owned by individuals or a group of farmers. The system also needs to identify new potential areas for *khadins* in the

region and their proper management through community participation for sustainable production.

Further, technological interventions like short duration high-yielding crop varieties, integrated nutrient management, soil moisture conservation practices and integration of multipurpose perennial woody component can further enhance the productivity of this traditional farming system.

SUMMARY

The constructions of *khadin* played a major role in developing agriculture and producing food grains for sustenance of desert dwellers in western region of Indian arid zone. Cropping pattern and crop productivity in *khadin* greatly depends on status of ponding of runoff water. Its productivity can be improved by adopting optimum design of bund based on local topography, rainfall and diversification in cropping system along with trees and grasses. Planning crops/trees/grasses for different parts of *khadin* further reduces the risk of complete failure due to drought and ensures life support system to the farmers. The *khadin* system also help in recharge of groundwater in downstream. Such system of runoff farming is highly recommended for extremely low rainfall areas.

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