# WATER HARVESTING FOR AFFORESTATION IN DRY AREAS

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## ABSTRACT

Water harvesting for **afforestation** is applied in arid and semi-arid regions where rainfall is not sufficient to sustain a good seedling / tree growth . Water harvesting can significantly increase the rate of tree establishment in drought prone areas by concentrating the rainfall/runoff .

Various water harvesting techniques of **Rainwater Harvesting and Floodwater Harvesting**, ('Spate Irrigation') are employed worldwide for tree establishment. Rainfall amount and distribution, topographical conditions, soil type, crop species and the preferences of the cultivators determine the choice of the technique applied. Details are given, under what environmental conditions what technique can be applied.

## INTRODUCTION

In arid and semi-arid regions, where rainfall is not sufficient to sustain a good seedling / tree growth, water harvesting for **afforestation** is applied . Water harvesting can significantly increase the rate of tree establishment in drought prone areas by concentrating the rainfall/runoff ('Run-off Irrigation').

These advantages are countered by the problem of unreliability of rainfall, which can be partly overcome by interim storage (cisterns, small reservoirs etc.). Modern hydrological tools (e.g. calculation of rainfall probability) allow a more precise determination of the necessary size of the catchment area (Prinz et al., 1998).

There are two major groups of water harvesting techniques: (1) **Rainwater Harvesting,** which is the collection of runoff and its use for the irrigation of crops, pastures and trees and (2) **Floodwater Harvesting**, also called 'Spate Irrigation', which uses the floodwater of ephemeral streams and rivers.

**PARAMETERS:** The most important parameters to be taken into consideration in selecting a water harvesting technique for afforestation are: (1) rainfall distribution and rainfall intensity, (2) topographical condition, (3) runoff / infiltration characteristics of the location, (4) water storage capacity of soils, cisterns and reservoirs, (5) the type of fruit, nut, or forest tree, (5) available technologies and socio-economic conditions and preferences of the cultivator.

## RAINWATER HARVESTING TECHNIQUES

### ***MICROCATCHMENT SYSTEMS***

**Contour bunds** (Contour ridges) are used in areas of 300-600 mm annual rainfall on slopes of 1-25 % inclination. The earthen bund might be enforced by stone material. The size of the catchment area is about 50 – 100 m²; the size of the cropping area about 10 - 20 $m^2$ (Fig.1). The resulting catchment : cropping area ratio (CCR) is about 5 : 1. Contour bunds are used e.g. in the Lake Baringo area in **Kenya** as a water harvesting technique for forest tree establishment.

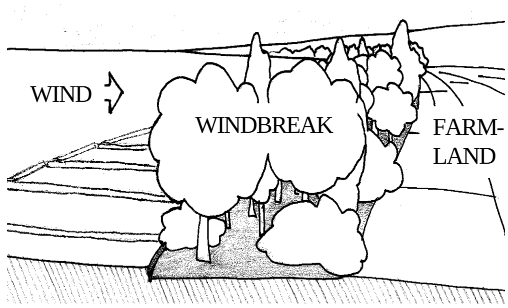


Fig 1: Microcatchments of the 'contour bund' type supply a windbreak with runoff water Source: Boers, 1994, redrawn

Fig. 2: Semi-circular microcatchments with fodder bushes in NW - Syria (Photo: Prinz)

**Semi-circular and triangular bunds** are widely used for tree establishment. They are useful on sloping land of 0.5-5 % inclination in areas with more than 300 mm annual rainfall. Earthen bunds about 0.5 m in height enclose a slight depression, where the water is stored until it infiltrates into the soil. The structures might be 1-7 m wide and they are mostly lined in staggered rows. The tips of the basins have to be on the contour.

These basins have been **used for** almonds, apricots, peaches, pistachio, olives, pomegranates and fodder bushes (Fig. 2).

**Eyebrow terraces** are microbasins to supply single trees or bushes with sufficient water. They are also called ‘Platform Terraces’ as their ‘run-on’-area is kept level.. The catchment size is 5-50 m² and the cropping area 1-5 m². This technique can be applied on slopes of 1-50% inclination; the steeper the inclination, the more the bunds have to be strengthened by stone material. Eyebrow terraces can be applied in areas of 200-600 mm annual rainfall (Fig. 3).

Fig. 3: Olive trees on Eyebrow WH -Terraces in Central Tunisia (Photo: Wolfer)

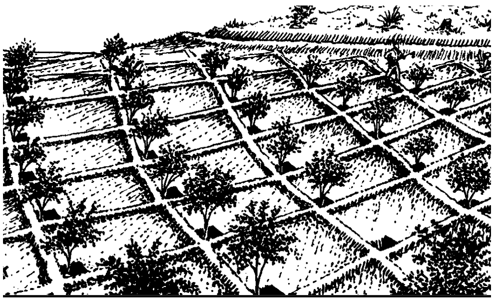

Fig. 4: Negarim system with trees planted at the lowest corner of the bunded area
Source: Rocheleau et al., 1988

**Negarim microcatchments** are small diamond-shaped basins, surrounded by low earth bunds. The runoff infiltrates at the lowest point, where the trees are planted (Fig. 4). Most negarim microcatchments are found on slopes of 1-5% inclination in areas of 100-400 mm annual rainfall. Reported sizes of negarim microcatchments are 100-250 m² in Israel and up to 400 m² in India. As 15-90% of the rain might be harvested and used for the tree crop, the catchment to cropping area ratio is often only 1:1 or 10:1, in larger and flatter catchments up to 25:1.
In the Middle East, negarim microcatchments are used for fruit trees like apricots, olives, almonds, wine, pomegranates, and pistachios, but they are also used for the establishment of fodder bushes and forest trees.

**Meskat systems** are suitable for areas with 200-400mm annual rainfall and slopes between 2-15 % . The system consists of a catchment area called " meskat", of about 500 m² in size, and a cropping area called "manka" of about 250 m² . The entire meskat system is surrounded by a 20 cm high bund, equipped with a spillway to let the runoff flow into the manka plots and surplus water to leave the manka (Fig. 5).
The meskat system is a microcatchment technique which is only used for tree cropping, covering around 300.000 ha in Tunisia, where mainly olive trees are cultivated in the manka plots.

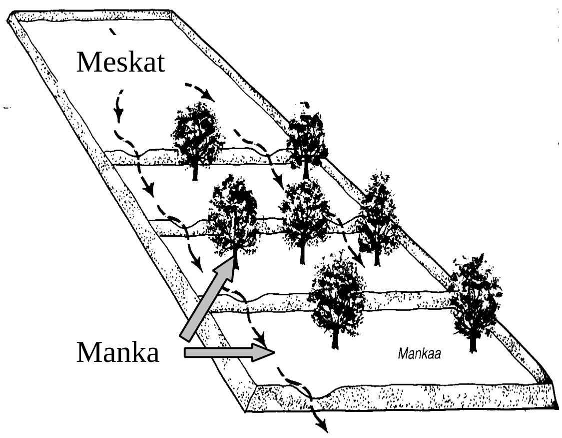


Fig. 5: Meskat microcatchment in Tunisia
Source: El Amami 1983, altered

Fig. 6: Trees on contour bench terraces in Southern Tunisia (Photo: Prinz)

**Contour bench terraces** are constructed on sloping land of 20-60% inclination in areas of 200-600 mm/a rainfall. The natural slope of the terrain is converted into a series of steps.
Contour bench terraces have level cropping areas which are supplied with additional water from steeper, uncropped areas between the terraces.
These terraces very often show drains and 'lips'. The catchment to cropping areas ratio is in the range of 1:-10. This technique has been applied in Tunisia, Cameroon, Sudan, Ethiopia, Nigeria and other countries of Sub-Saharan Africa for tree cropping (Fig. 6).

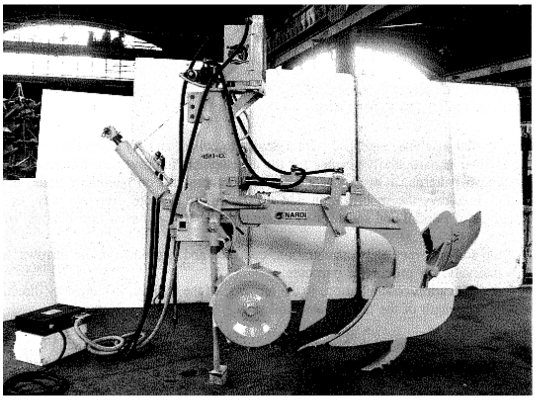

Fig. 7: The 'Wavy Dolphin Plough' for construction of Vallerani-type micro-catchments for afforestations
Source: Antinori and Vallerani, 1994

**Vallerani-type microcatchments:** A fully mechanized system of preparation of small (micro-)catchments for afforestation was developed by the Italian engineer Vallerani. This system can be applied in areas of 200-600 mm annual precipitation and on slopes of 2-10% inclination. The microbasins are constructed by a special plough, called the "dolphin plough", which constructs 400 microcatchments per hour. (Fig. 7). Each microbasin has a water-holding capacity of about 600 l. The reported rates of tree establishment are very high. The use of this special plough can be economic if large areas have to be treated and if quick action in thinly populated regions is required, e.g. to avoid further deserti-fication. The plough has been used for afforestation purposes in Mediterranean and African countries (e.g. in Niger).

**Hillslope microcatchments** are microbasins of rectangular shape to supply single trees or bushes with sufficient water. The catchment size is 5-50 m² and the cropping area 1-5 m². This technique can be applied on slopes of 1-50% inclination; normally there are no bunds around the plot.
Regular hoeing of the infiltration basin is a prerequisite for the functioning of the system.
Hillslope microcatchments can be applied in areas of 200-600 mm annual rainfall (Fig. 8).

Fig. 8: Afforestation in the Israelian Negev Desert using 'Hillslope Microcatchments'

Fig. 9: Hillside conduit water harvesting in the Israelian Negev Desert (Photo: Prinz)

***<u>MACROCATCHMENT SYSTEMS</u>***

**Hillside Conduit System**:
In hillside conduit systems small conveyance channels direct the water from long slopes to cropped areas at the foot of the hill (Fig. 9). This technique is applied in areas of 200-600 mm/a rainfall; the slope should exceed 10% inclination. There is a need for the disposal of surplus water; the structures have to be strong and they require proper design.

**The jessour system** consists of small dams, made from soil, rock, or gabions, which are either built at the foot of slopes or across seasonal stream channels. Fertile sediments accumulate behind the dams which allow the cropping of trees and annual crops (Fig.10). The jessour system is used for the cultivation of a number of trees like olives, almonds, palms, etc.
The cropping area is in the range of 0.2 - 5 ha and the CCR varies from 100:1 to 10,000:1.

Fig. 10: Jessour with masonry wall (‚tabia') in Southern Tunisia (Photo Prinz)

## FLOODWATER HARVESTING SYSTEMS

Floodwater is used in many parts of the dry world for afforestation. Floodwater harvesting comprises systems with catchments being many square kilometers in size, from which runoff water flows through a major wadi (bed of an ephemeral stream), necessitating more complex structures of dams and distribution networks.

Floodwater harvesting techniques have already been applied for several thousand years, and systems exist in NW Mexico, Pakistan, Tunisia (Fig. 11), Kenya, China, etc. (Khouri et al., 1995; Reij et al., 1988).

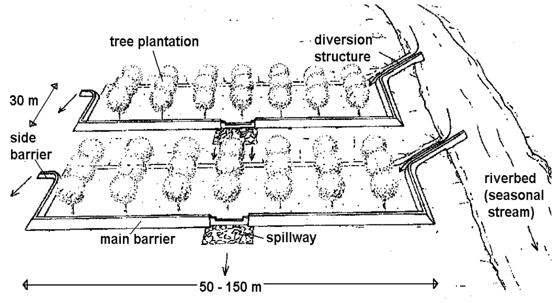


Fig.11: Floodwater diversion in Tunisia using diversion stone or concrete structures and dykes with spillways, Source : GTZ/DGF, 1993

## SUSTAINABILITY CONCERNS OF WATER HARVESTING

Numerous water harvesting projects have failed because the technology used proved to be unsuitable for the specific conditions of the site (Siegert, 1994). Each of the water harvesting methods has its advantages and limitations which have to be evaluated.

The sustainability of water harvesting systems has, in the past, been based on the 'fitting together' of the basic needs of the users, the local natural conditions and the prevailing economic and political conditions of the region. The preconditions for a positive future development of water harvesting will be the very same (Agarwal and Narain, 1997; Prinz, 1994).

## CONCLUSIONS

Water harvesting has proved to be a valuable tool, especially in dry marginal areas, to establish tree crops and to allow afforestation. It makes best use of available water resources and supplements the other sources.

However, there are also some problems associated with water harvesting for afforestation:

- A higher risk than by a supply with pumped water or water transported (by lorries) to the planting spot.
- The tree species used have to withstand drought **and** flooding.

Nevertheless, the positive elements of water harvesting remain valid and they can be utilized for the well-being of people and nature in the dry areas of the world (Prinz, 1996).

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