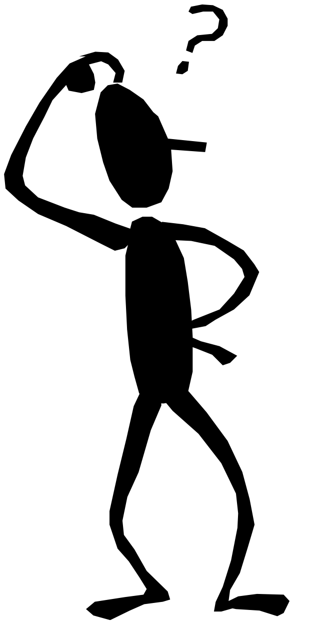
MECHANISMS OF SOIL CONSERVATION IN DESERT REGIONS

Why is soil conservation important?

"A nation that destroys its soil destroys itself."

- President Franklin D. Roosevelt, 1937

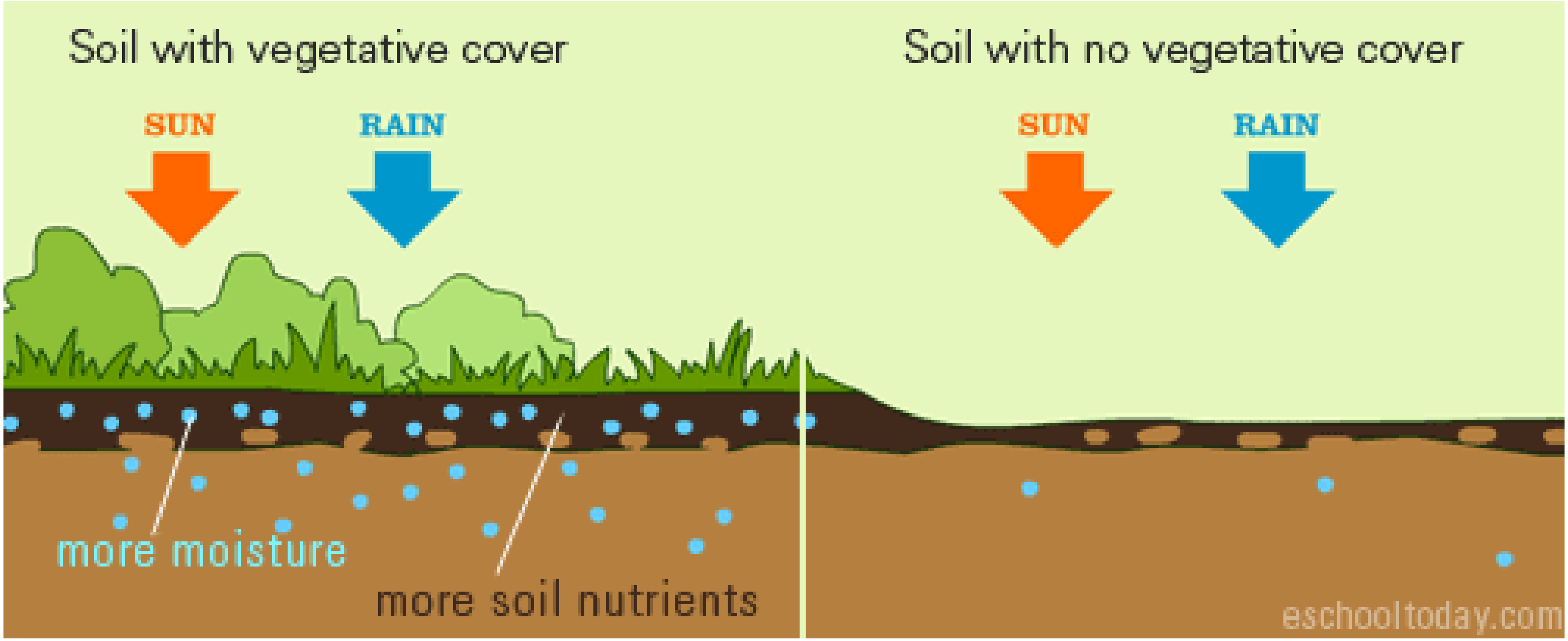


WHAT IS SOIL CONSERVATION?

- Soil conservation is the prevention of soil loss from erosion or prevention of reduced fertility caused by over usage, acidification, salinization or other chemical soil contamination.
- Soil conservation is one such step that protects the soil from being washed away.

- The value of soil is reduced when soil loses its fertility and when topsoil is lost due to erosion.
- Soil can be damaged when it loses it fertility.
- Soil that has lost its fertility is said to be exhausted. (**soils** are no longer able to support crops or other plant life.)
- Soil in which only cotton was grown became exhausted.

Whenever topsoil is exposed, water and wind can quickly erode it.



SOIL CONSERVATION IN DESERTS?

IMPACT OF SOIL EROSION CAUSED IN DESERTS:

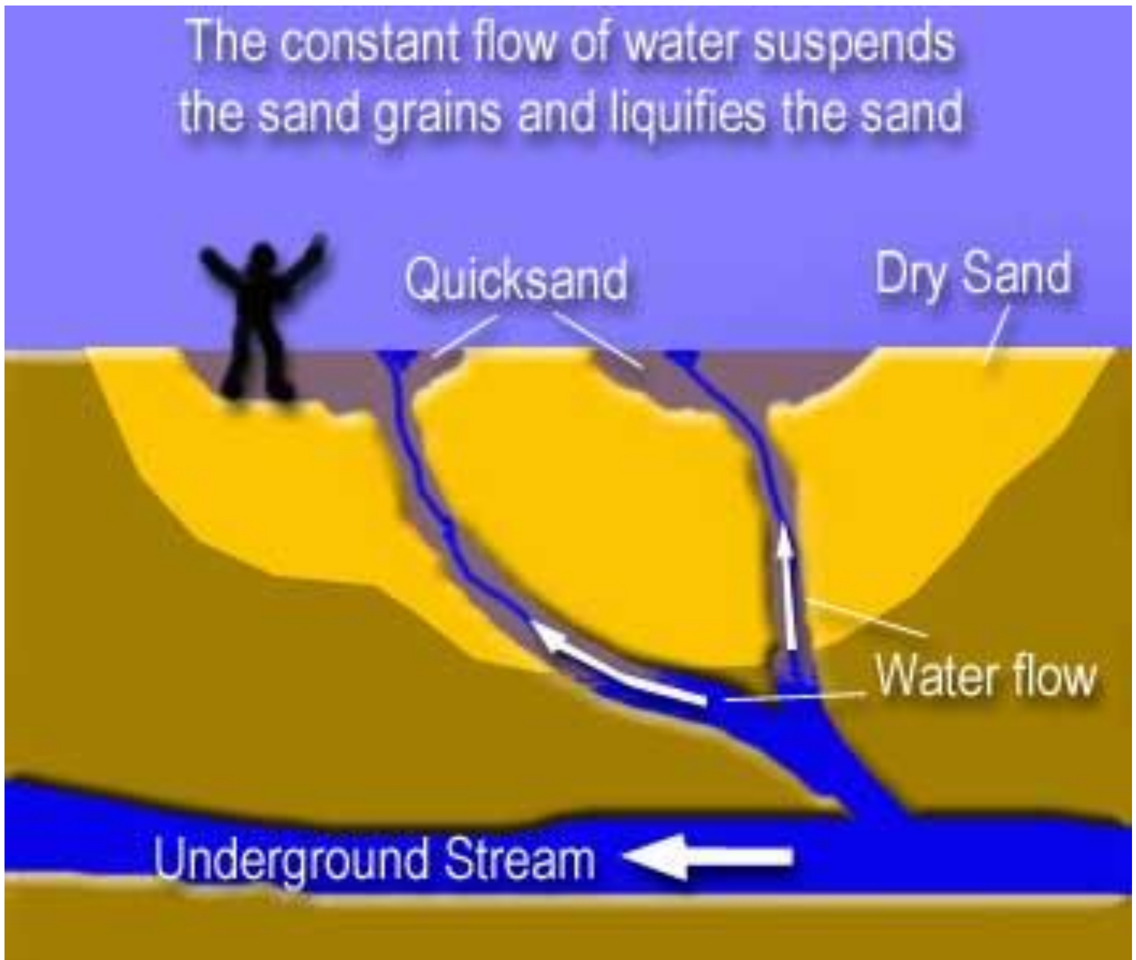
- Dust storms in Cities
- "aeolian desertification," which is caused by wind erosion after vegetation is destroyed;
- Formation of Loess
- Sand dunes diverting to settlements
- Sand dunes affecting transportation

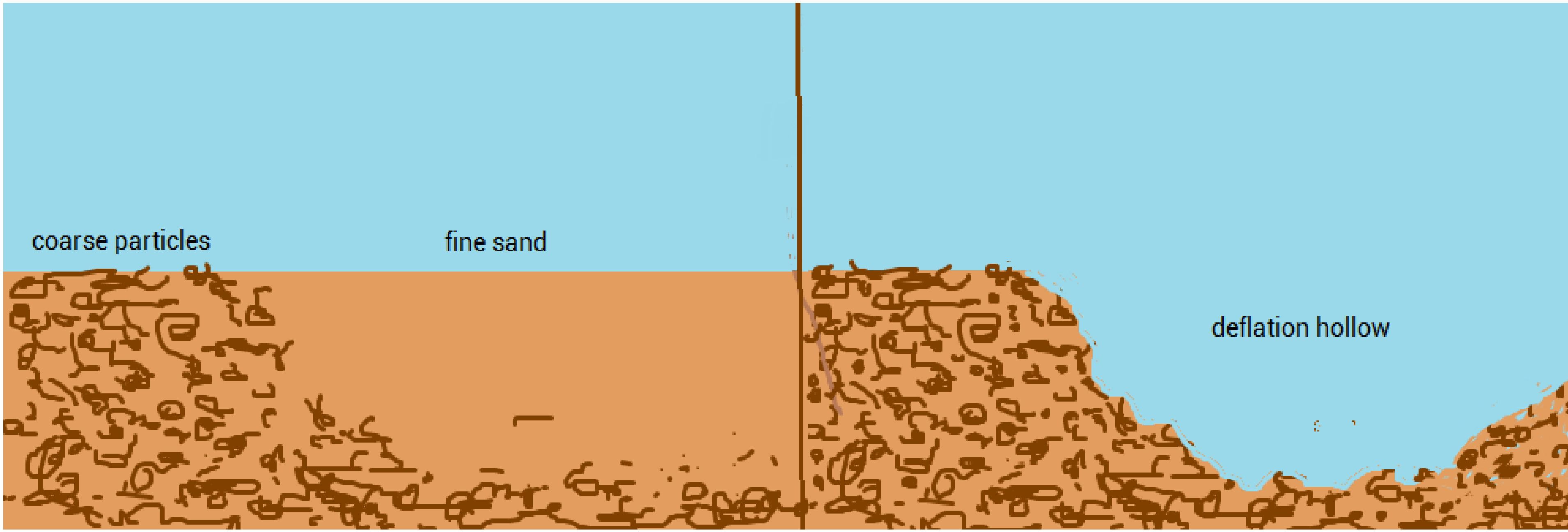
Roads covered by
sand dunes in Dubai

Saudi Arabia

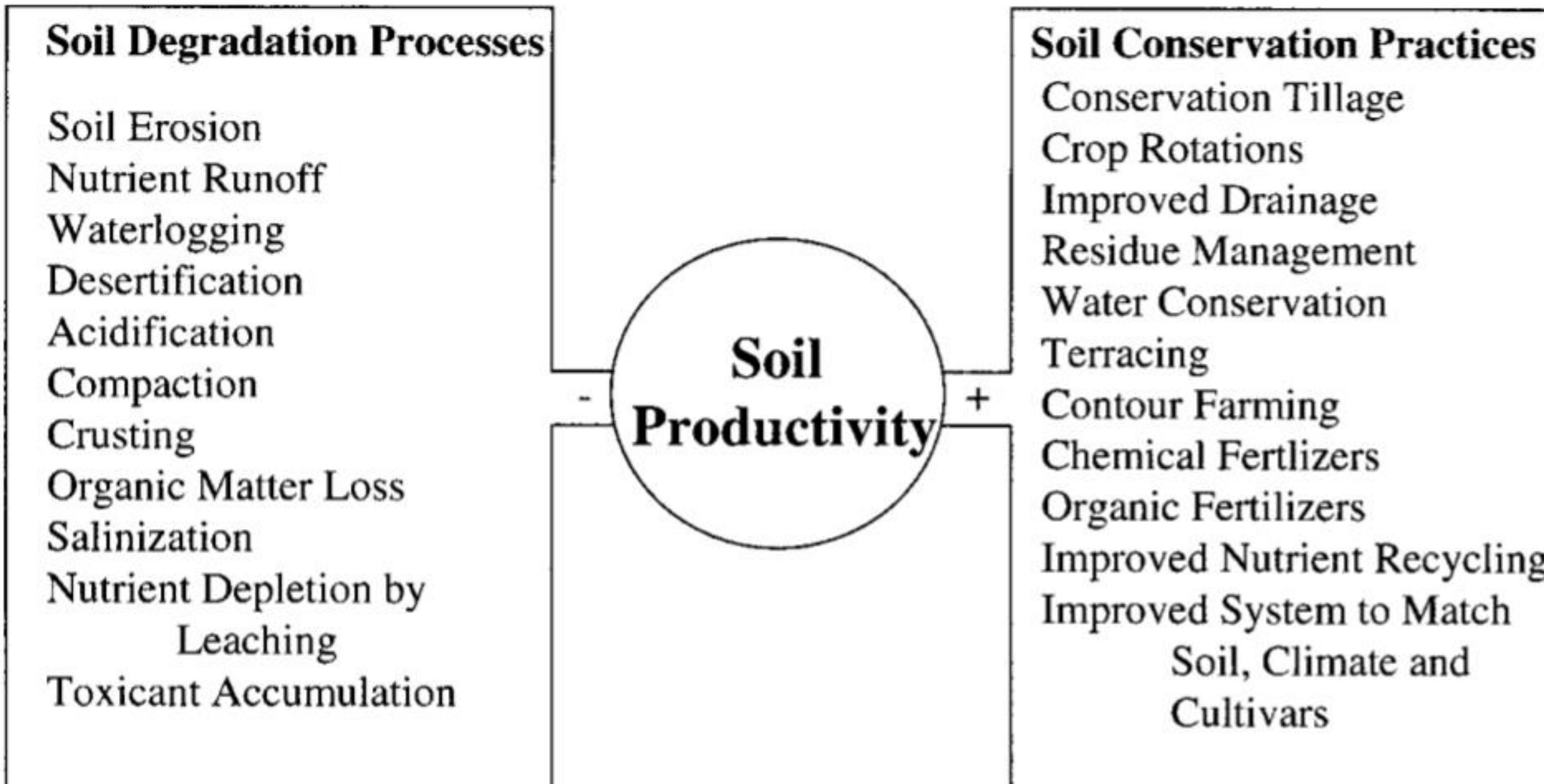
Green wall china

BORDER OF GOBI DESERT


The constant flow of water suspends
the sand grains and liquifies the sand
Quicksand
Dry Sand
Water flow
Underground Stream


coarse particles
fine sand
deflation hollow

DESERT SOIL CONSERVATION METHODS



Sand Dune Stabilization

- Temporary Sand Control Systems
  - Sand Shielding
  - Sand Fences
- Permanent Sand Control Systems
  - Afforestation

Sand Shielding

- Stone Mulch
- Water or Brines Wetting
- Chemical Stabilizers
- Biological Crusting

Stone Mulch

- Gravel, stone or crushed rock blankets are used as mulches.
- Blankets formed of gravel smaller than ½ in. in diameter can withstand wind velocities up to 137 km/hr.
- A 1-in. layer of aggregate or gravel is normally adequate for areas not subject to traffic.
- Suggested grading:
  - Passing 1 ½ in. sieve 100%
  - Passing 1 in. sieve 60-90%
  - Passing ¼ in. sieve 0-20%

Water, Wastewater or Brine Wetting

- Increases cohesion between grains.
- Increases in the percentage of the fines (silt and clay) particles between the sand grains.
- Grow vegetations existing in the area.
- Reduce the harmful salt content in the soil.
- Brines rich in carbonates or sulfates precipitate salts that tend to cement the sand grains and resist wind erosion.

Chemical Stabilizers

- **The nature of the bonding by chemical stabilizers in sand is adhesive.**
- **Some other chemicals form a film on the sand grains that increases its specific gravity and consequently decrease the rate of erosion.**

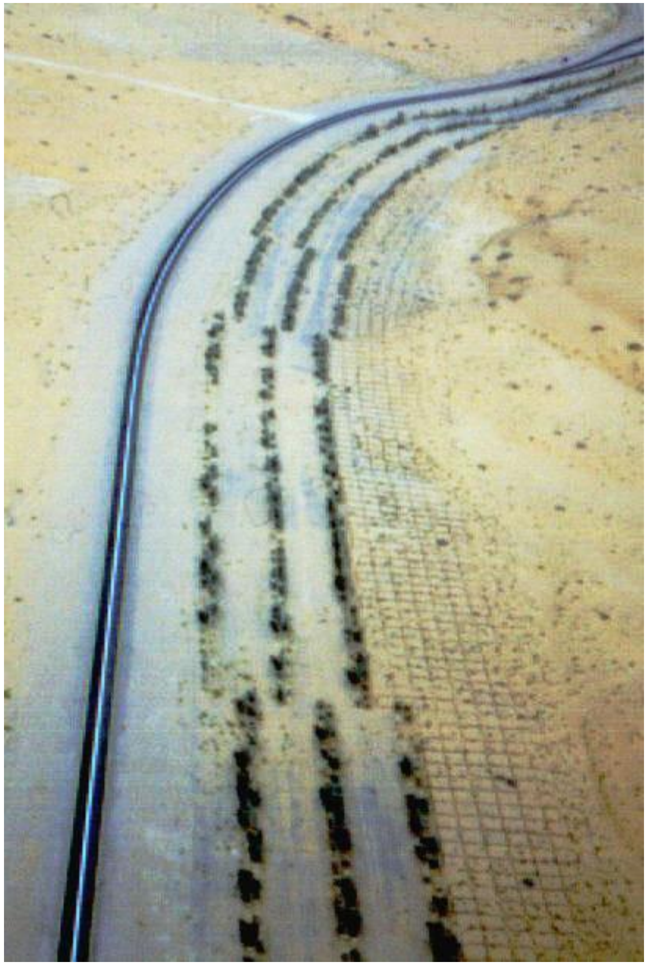
Biological Crusting

- **Biological soil crusts are communities of living organisms on the soil surface in arid and semi-arid ecosystems**
- **Dewfall is a process whereby moisture from the atmosphere condenses on the earth's surface**
- **The frequent occurrence of dew can serve as an important source of moisture for biological crusts**
- **The crust is formed by biological activity of blue-algea.**
- **This idea is worth further investigations under the Saudi Arabian climatic conditions.**

Sand Fences

- Checkerboard fences
- Fore dune fences
  - Impounding sand fences
  - Diversion sand fences

Checkerboard Fences

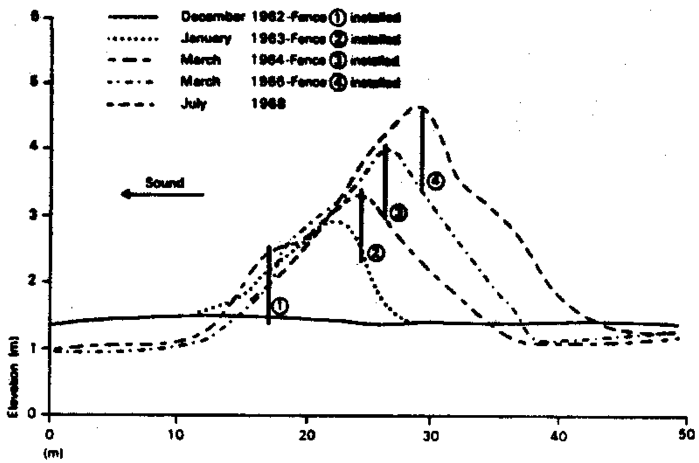


- Constructed of plant remains or plastic nets
- 50-70 cm high forming 3 x 3 m rectangles
- Can withstand weather conditions for few years, which is long enough to implement the permanent solution

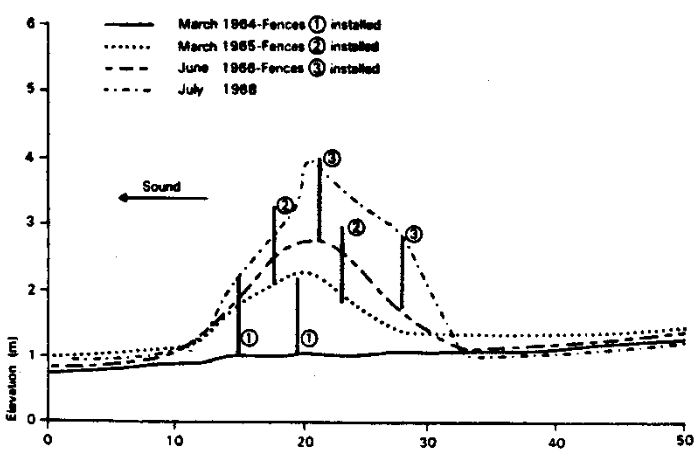
Impounding Sand Fences

- Fence heights should range between 0.5 m to 1.2 m
- Fences should be erected around 50 m down-wind the erosional area or 30-60 times the fence height from the area to be protected
- Multiple rows of fences can trap more than 80% of wind-borne sand
- Gaps should be left between long fences to lessen the load caused by wind and accumulated sand
- The porosity of the fence should range between 30 and 40%
- A fence should extend 10-20 times its height beyond the area to be protected

Impounding Sand Fences (continued)



(A) Using single fences



(B) Using double fences

- Since the fences will eventually be buried by trapped sand, new fences must be erected on the accumulating mound
- Fences should be located in areas where the creation of a large artificial dune will not pose any problems

Impounding Sand Fences (continued)

- **Fences will require regular maintenance and renewal to avoid deterioration or constructed from better material**

Diversion Sand Fences

- **They are erected either as single fences slanted at about 45^o from the wind direction or in the form of a V-shaped fences pointing up-wind**
- **They not only trap the sand but also deflects it away from the area that needs to be protected**
- **The effectiveness and life span of the diversion fences depends on the material of construction, height and porosity**

Permanent Sand Control System (Afforestation)

- Decrease the wind speed
- Protect the ground from scouring
- Change the microclimate in the area
- Enhance the soil condition for further plant growth
- Create recreational areas
- An appealing way to mitigate the dune migration hazard

Afforestation Application

- Water
- Plants
- Site maintenance

Plants

- Quantity and quality of the available water
- Soil moisture content
- Percentage of salts in the soil
- Speed and direction of wind
- Rate of sand movement
- Rate of plant growth
- Capability of the plant to multiply
- Capability of the plant to enhance the soil condition
- The root system of the plant

Site Maintenance

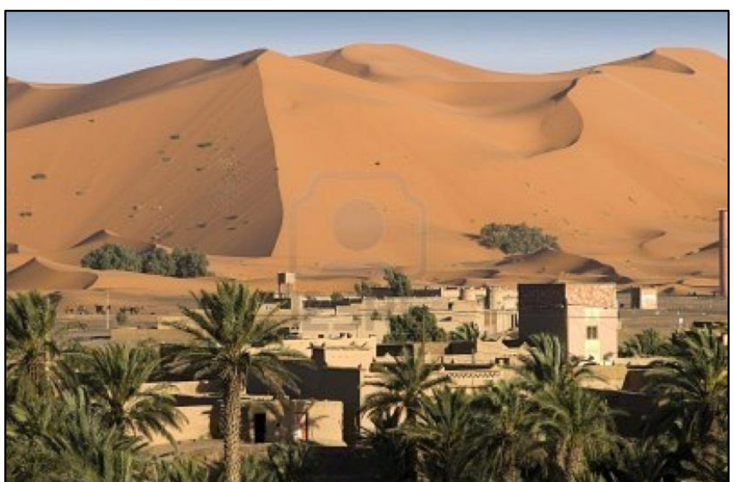
- **The site should be protected against possible unlawful grazing activities**
- **The site should be protected against possible trespassing and firewood cutting**

Sand dunes stabilization

why is it important?

active

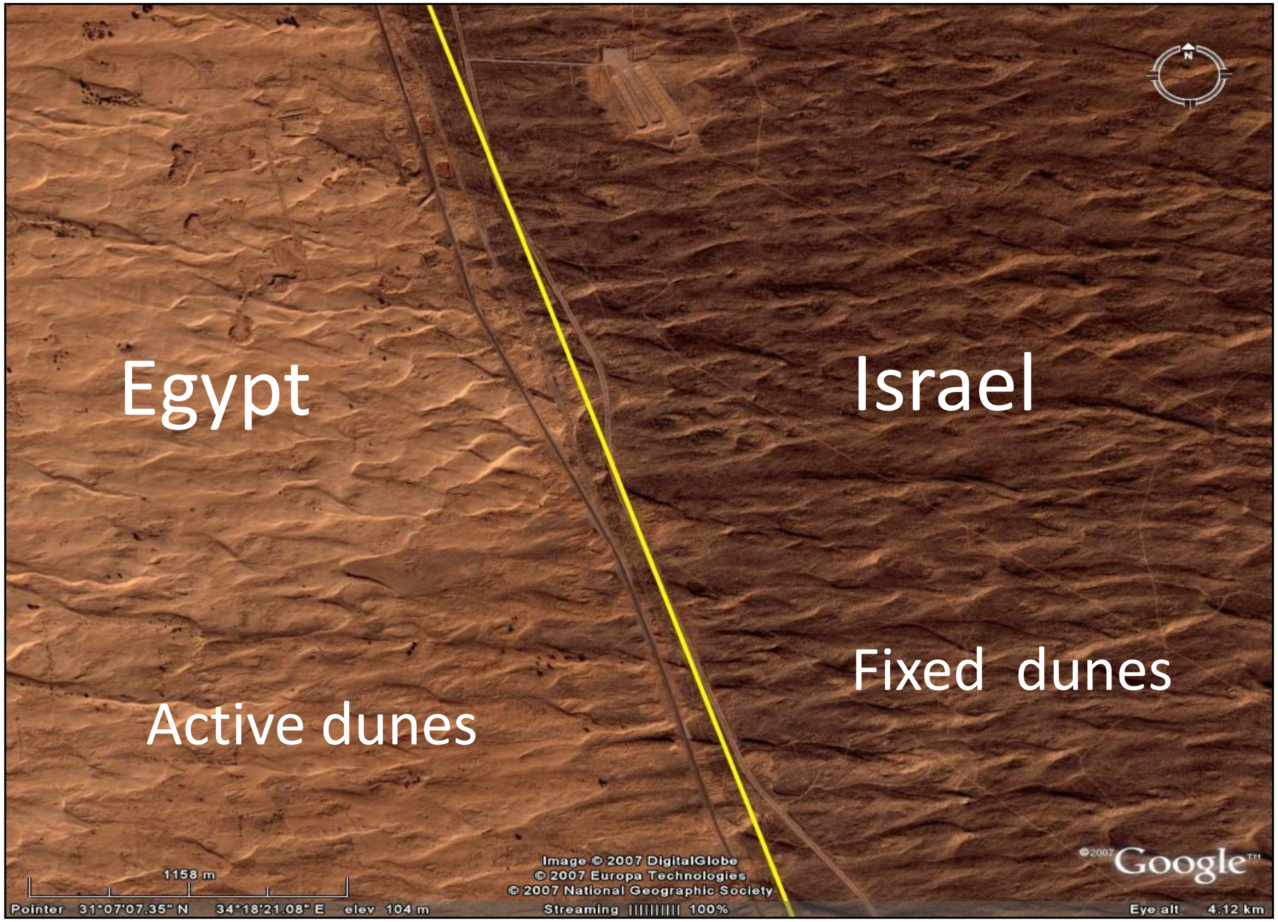
stabilized



Sand dunes stabilization

Change in dune mobility
➔ change in biodiversity

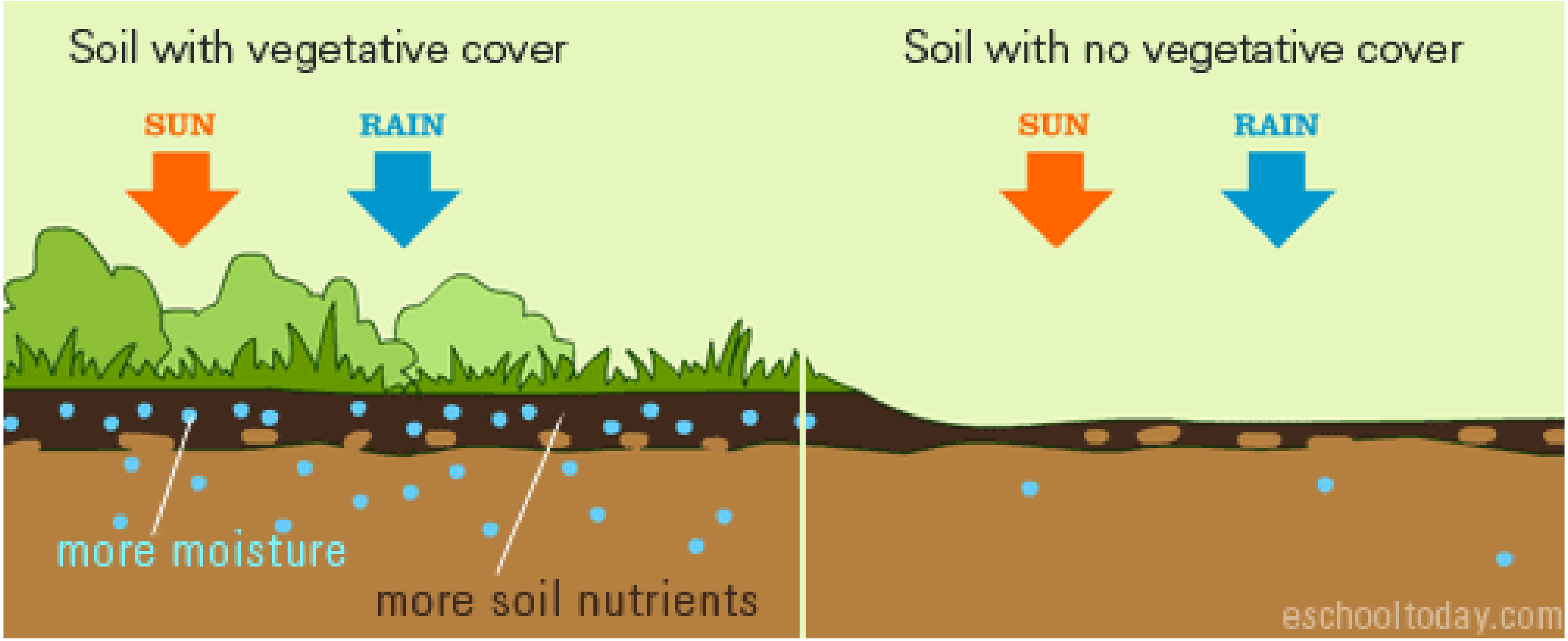
Stabilization by **biogenic crust**

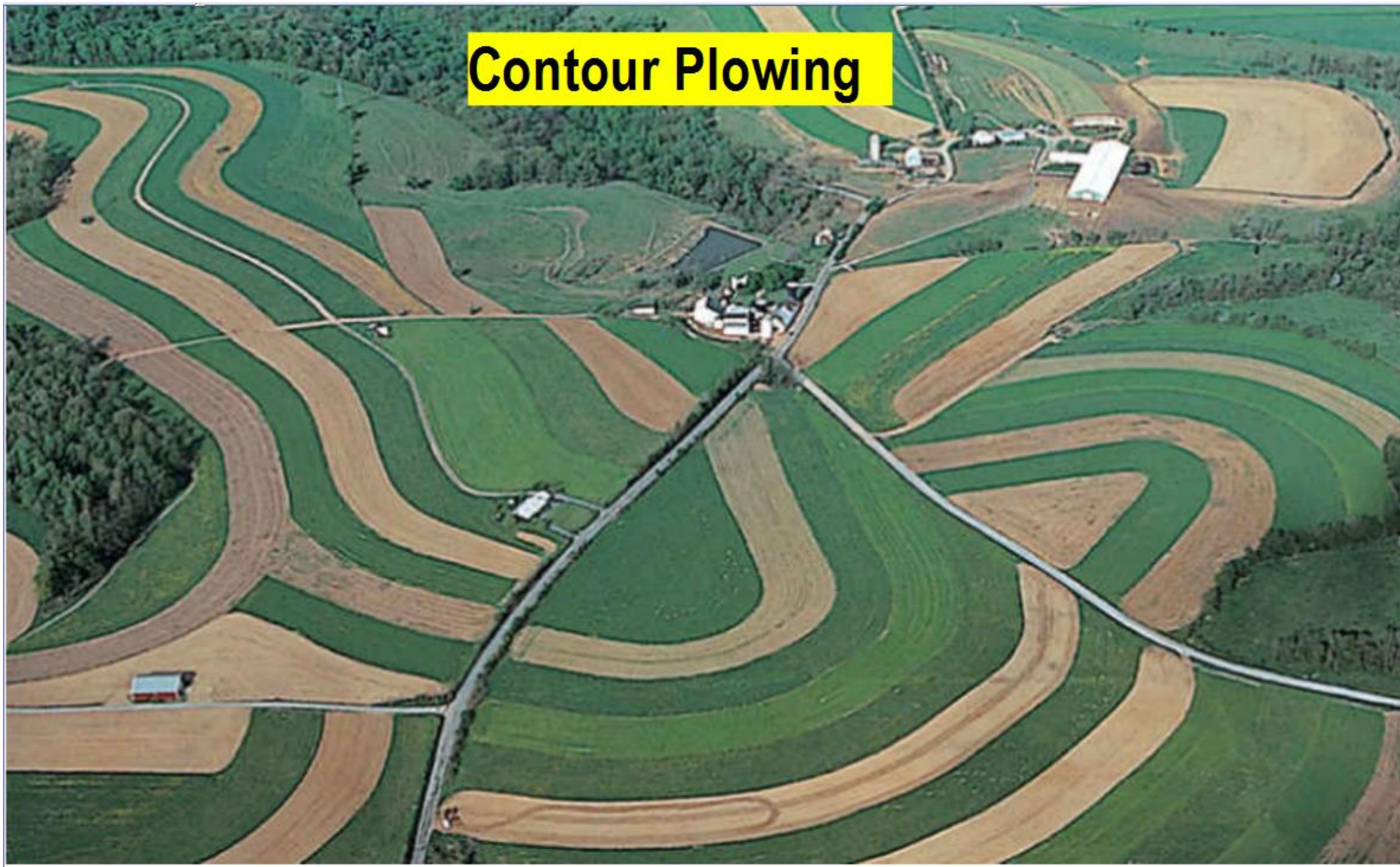


Israel-Egypt Border (NW Negev)
annual precipitation ~ 100mm/year

MOST EFFECTIVE METHOD

- Plant cover can protect soil from erosion.
- Plants break the force of falling rain, and plant roots hold the soil together.





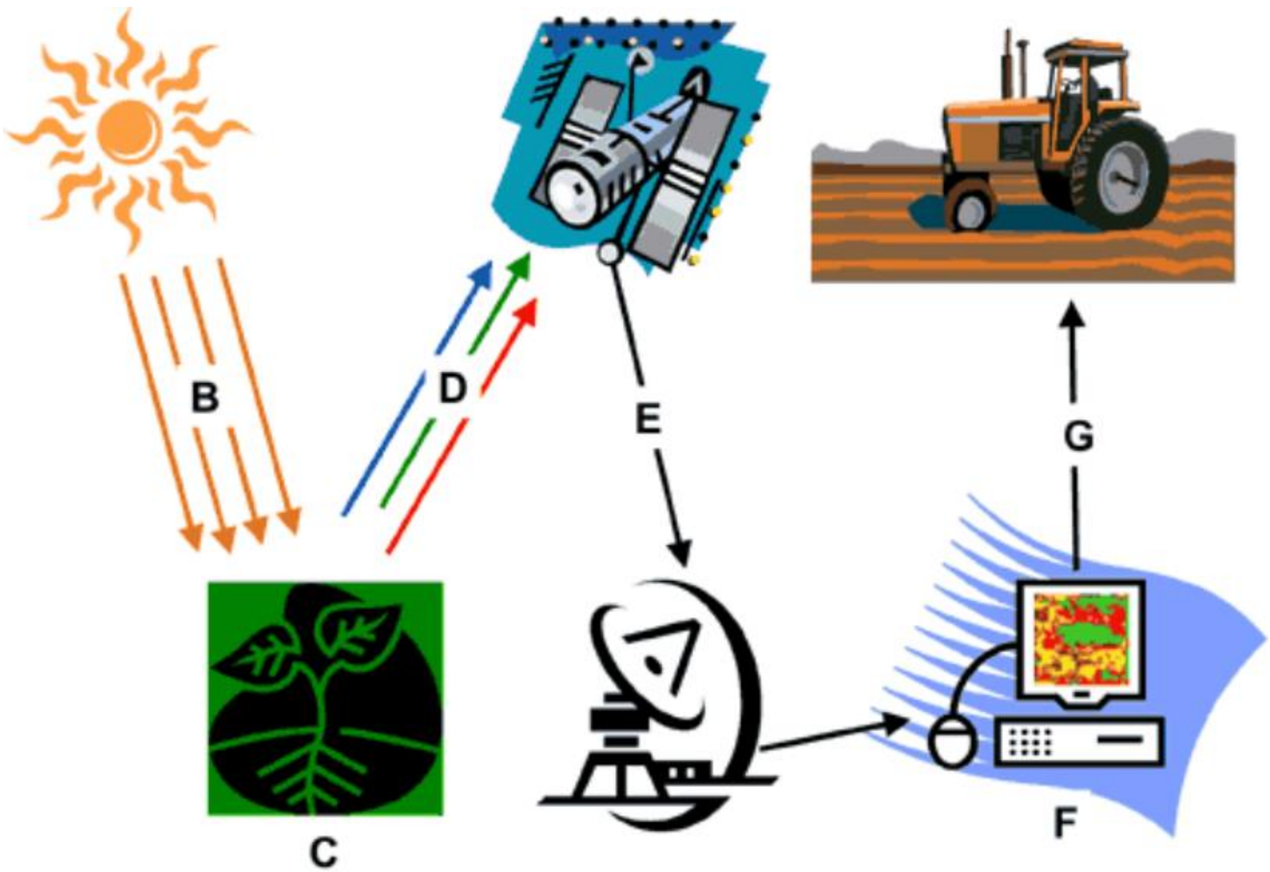
Contour Plowing is used on sloping terrain in order to prevent gullying. Furrows are plowed along the contour (at the same elevation) of the land. When rain occurs, it fills the furrow rather than flowing downhill.

Terracing is another method used to control the runoff of water in areas with steep slopes. The land is leveled in order to prevent downhill runoff.

A windbreak causes the wind to swirl and it therefore does not cause as much damage.

Wind blowing in the same direction for a long time is able to gain speed and therefore evaporate more water from the soil and move more topsoil.

Information from remotely sensed images allows farmers to treat only affected areas of a field. Problems within a field may be identified remotely before they can be visually identified.
farmers use remote sensing to identify prime grazing areas, overgrazed areas or areas of weed infestations.



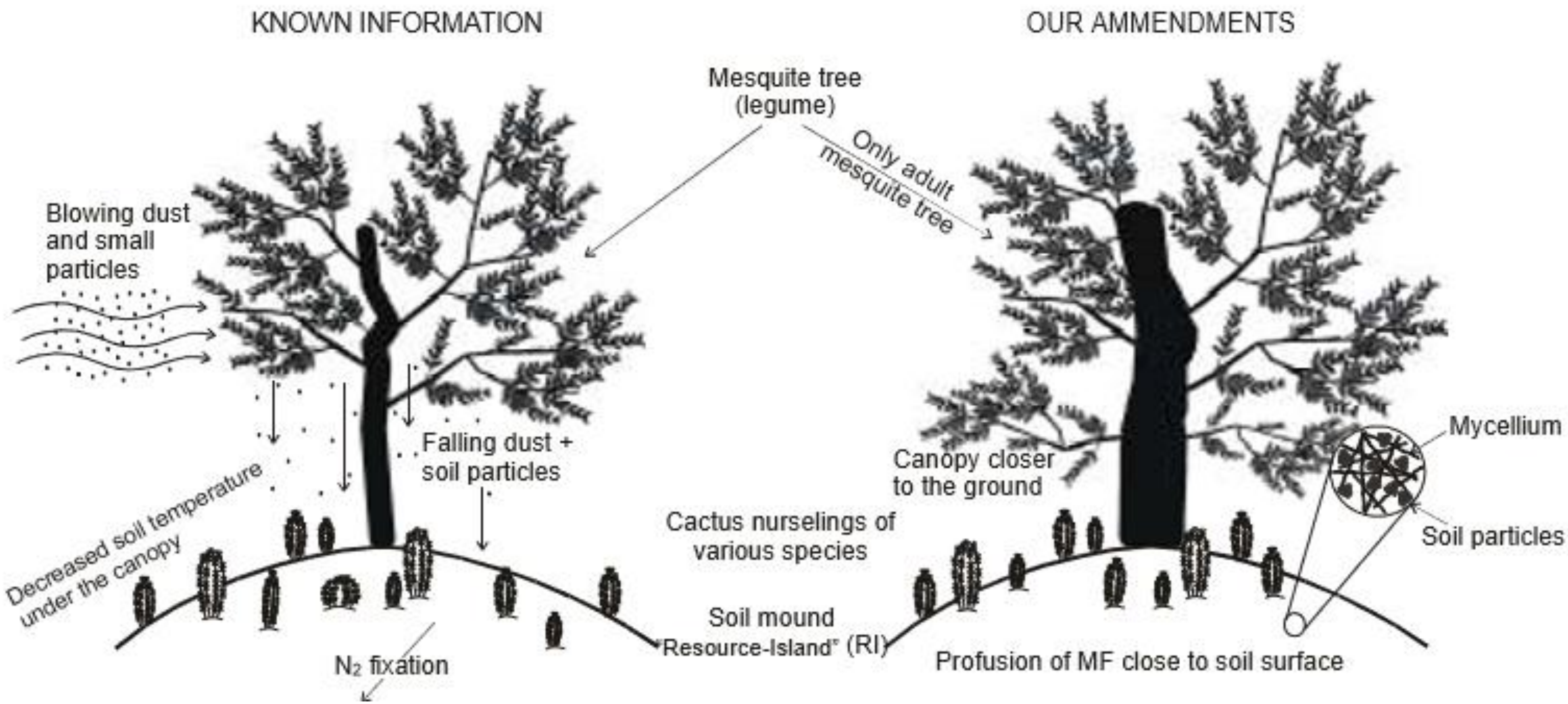
CASE STUDY 1

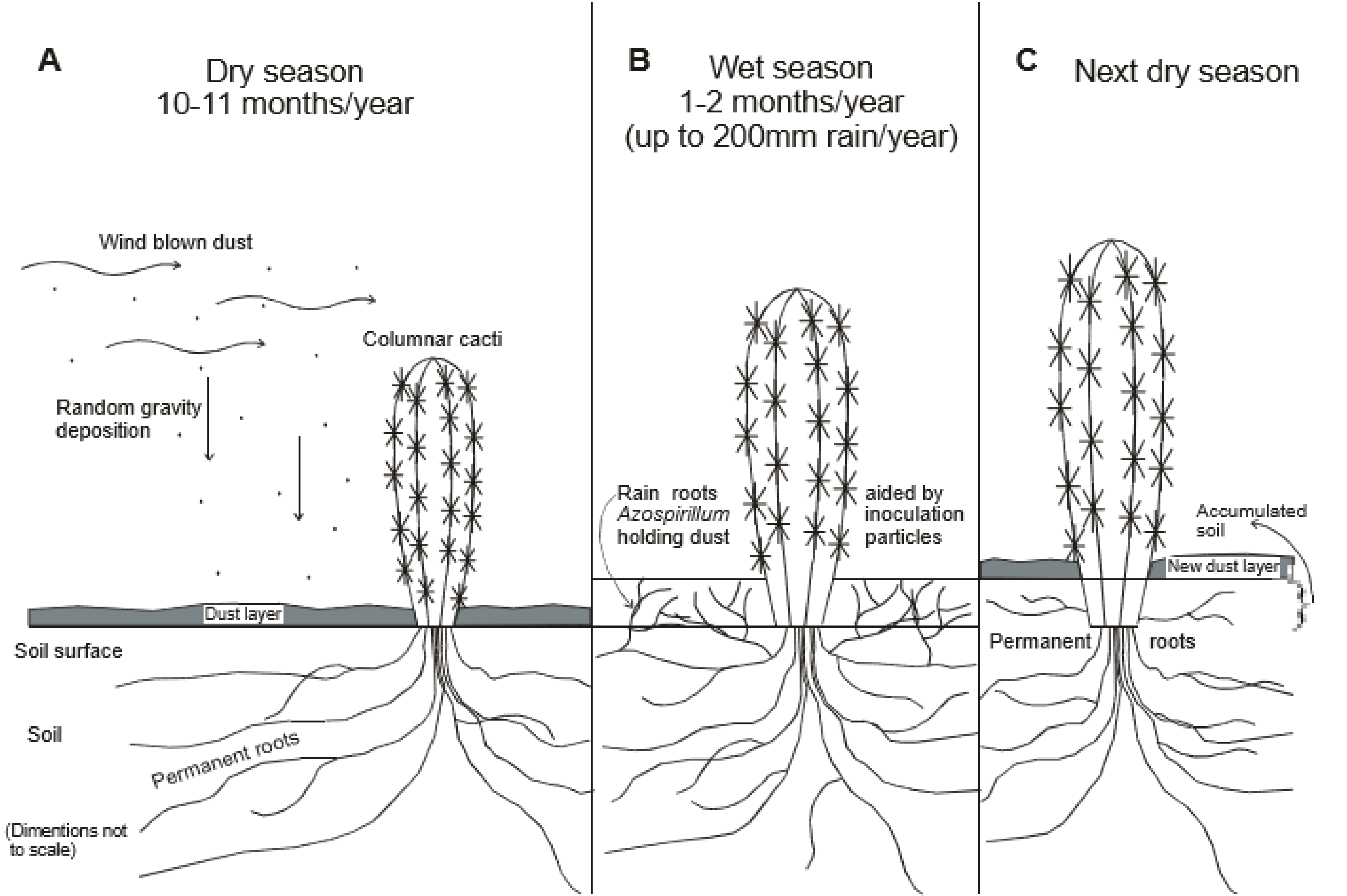
TITLE:PREVENTION OF DESERT SOIL EROSION AND ENHANCING SOIL STABILIZATION BY MYCORRHIZAL FUNGI AND BY CACTUS PLANTS INOCULATED WITH AZOSPIRILLUM BRASILENSE

ABSTRACT: In North America, it predominates in the semiarid region of the Mexican Northwest, where abandoned fields quickly become barren ("desertify"). Many desert plants, especially cacti, are excellent top-soil stabilizers.

These plants may be used to prevent soil erosion and reduce dust pollution in urban areas, but their low rate of establishment and slow development when transferred from natural habitats or from nurseries to eroded urban soil limit their use. Cacti (as all plants), however, not only benefit from, but actually depend on, the presence of soil microbes for early establishment and subsequent growth.

Inoculation with soil organisms is therefore common practice of agriculture and forestry in developed countries. We contend that microorganisms, such as **plant-growth-promoting bacteria (PGPB) and mycorrhizal fungi (MF),** are integral parts of the revegetation process and can be used as a biotechnological tool to reduce soil erosion and dust pollution.


KNOWN INFORMATION
OUR AMMENDMENTS
Mesquite tree
(legume)
Only adult
mesquite tree
Blowing dust
and small
particles
Falling dust +
soil particles
Decreased soil temperature
under the canopy
Canopy closer
to the ground
Mycellium
Soil particles
Cactus nurselings of
various species
Soil mound
"Resource-Island" (RI)
N2 fixation
Profusion of MF close to soil surface


A
Dry season
10-11 months/year
Wind blown dust
Columnar cacti
Random gravity deposition
Dust layer
Soil surface
Soil
Permanent roots
(Dimentions not to scale)
B
Wet season
1-2 months/year
(up to 200mm rain/year)
Rain roots
Azospirillum
holding dust
aided by inoculation particles
C
Next dry season
Accumulated soil
New dust layer
Permanent
roots

CASE STUDY 2

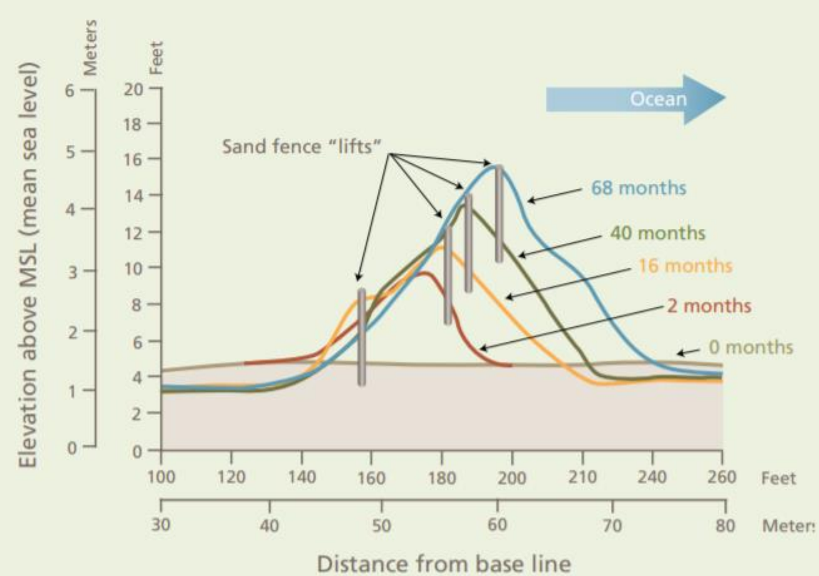
TITLE:Coastal Dune Protection & Restoration Using 'Cape' American Beachgrass & Fencing in Maine to North Carolina

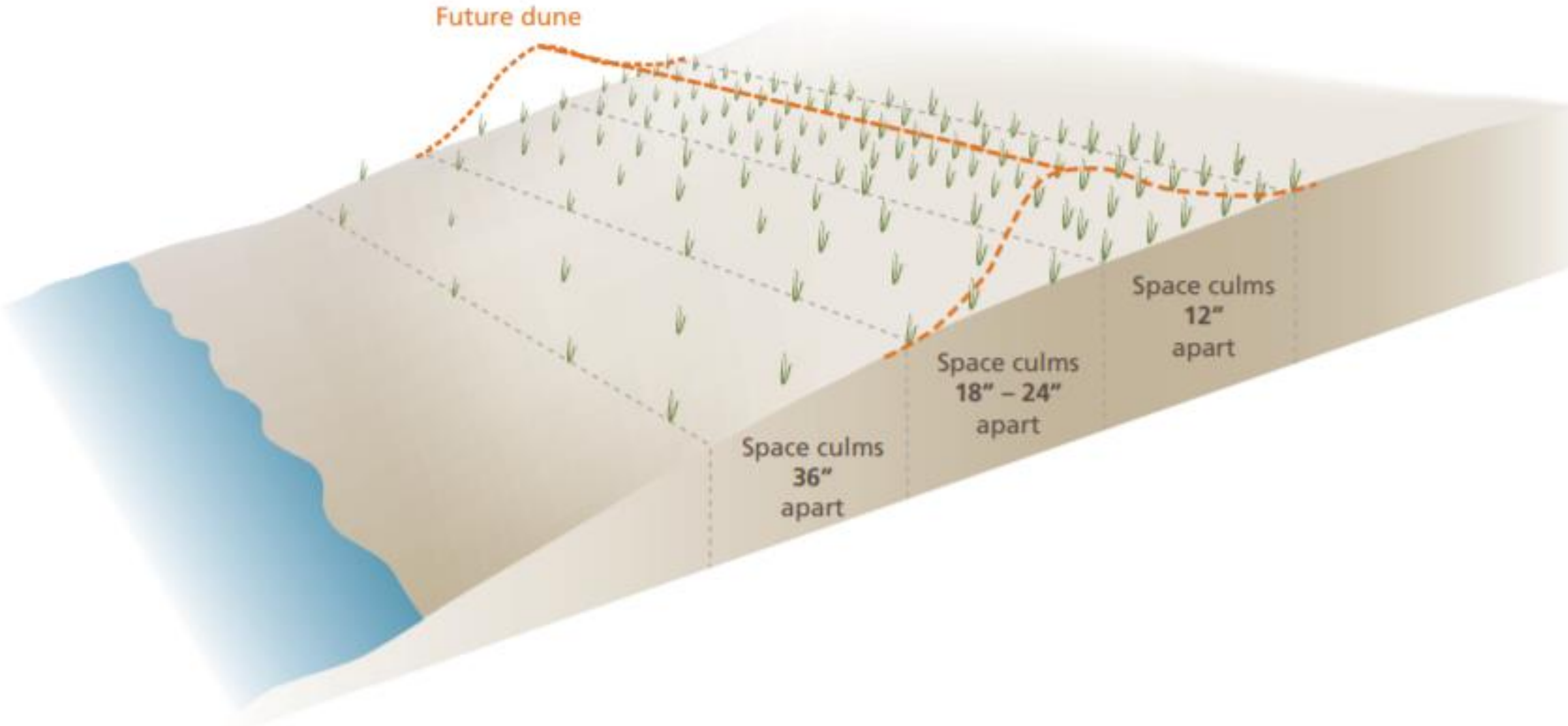
Abstract:This bulletin addresses restoration of the dynamic frontal coastal sand dune system with sand fencing and 'Cape' American beachgrass. Other typical Northeast area dune plants, such as Rosa Rugosa, Bayberry, and Beach Plum occupy more stable secondary and backdune areas (Clark and Clark, 2008)

Figure 3. Covering quarry sand with natural dune sand.

Figure 5. Artificially built dune naturally revegetating.

Figure 12. Fence is attached to 6” diameter posts.




Future dune
Space culms
12"
apart
Space culms
18" – 24"
apart
Space culms
36"
apart

WATER CONSERVATION

In India around 83% of available fresh water is used for agriculture. Rainfall being the primary source of fresh water, the concept behind conserving water is to harvest it when it falls and wherever it falls. The importance of storing rainwater through different techniques can be understood by an example of the desert state Rajasthan which is water self-sufficient despite experiencing meager rainfall as against Cherrapunji, which is blessed with the highest rainfall in the world, but still faces water shortage due to lack of water conservation methods. Water harvesting is deeply rooted in the social fabric of Rajasthan. Since Rajasthan is a region where there are no perennial rivers, most water-related problems are related to the fluctuating weather and river systems. Water is so scarce in Rajasthan that sources of natural water have become places of pilgrimage. There are hundreds of small and medium water conservation techniques in the state that have been adapted and used over centuries to protect against water insecurity. These ancient water conservation techniques, that helped the state survive its climate for centuries, and even today. Some of traditional ways of water conservation are:

Sr. No.	Ecological Region	Traditional Water Management System
1.	Trans - Himalayan Region	Zing
2.	Western Himalaya	Kul, Naula, Kuhl, Khatri
3.	Eastern Himalaya	Apatani
4.	North Eastern Hill Ranges	Zabo
5.	Brahmaputra Valley	Dongs / Dungs/ Jampois
6.	Indo-Gangetic Plains	Ahars – Pynes, Bengal's Inundation Channels, Dighis, Baolis
7.	The Thar Desert	Kunds, Kuis/beris, Baoris / Ber/ Jhalaras, Nadi, Tobas, Tankas, Khandins, Vav/Bavadi, Virdas, Paar
8.	Central Highlands	Talab, Bandhis, Saza Kuva, Johads, Naada/Bandh, Pat, Rapat, Chandela Tank, Bundela Tank
9.	Eastern Highlands	Katas / Mundas / Bandhas
10.	Deccan Plateau	Cheruvu, Kohli Tanks, Bhandaras, Phad, Kere, The Ramtek Model
11.	Western Ghats	Surangam
12.	West Coastal Plains	Virdas
13.	Eastern Ghats	Korambu
14.	Eastern Coastal Plains	Eri / Ooranis
15.	The Islands	Jack Wells

Jhalaras are typically rectangular-shaped stepwells that have tiered steps on three or four sides. These stepwells collect the subterranean seepage of an upstream reservoir or a lake. Jhalaras were built to ensure easy and regular supply of water for religious rites, royal ceremonies and community use. The city of Jodhpur has eight jhalaras, the oldest being the Mahamandir Jhalara that dates back to 1660 AD.

Talabs are reservoirs that store water for household consumption and drinking purposes. They may be natural, such as the *pokhariyan* ponds at Tikamgarh in the Bundelkhand region or man made, such as the lakes of Udaipur. A reservoir with an area less than five *bighas* is called a *talai*, a medium sized lake is called a *bandhi* and bigger lakes are called *sagar* or *samand*.

Bawaris are unique stepwells that were once a part of the ancient networks of water storage in the cities of Rajasthan. The little rain that the region received would be diverted to man-made tanks through canals built on the hilly outskirts of cities. The water would then percolate into the ground, raising the water table and recharging a deep and intricate network of aquifers. To minimise water loss through evaporation, a series of layered steps were built around the reservoirs to narrow and deepen the wells.

Taanka is a traditional rainwater harvesting technique indigenous to the Thar desert region of Rajasthan. A Taanka is a cylindrical paved underground pit into which rainwater from rooftops, courtyards or artificially prepared catchments flows. Once completely filled, the water stored in a taanka can last throughout the dry season and is sufficient for a family of 5-6 members. An important element of water security in these arid regions, taankas can save families from the everyday drudgery of fetching water from distant sources.

Johads, one of the oldest systems used to conserve and recharge ground water, are small earthen check dams that capture and store rainwater. Constructed in an area with naturally high elevation on three sides, a storage pit is made by excavating the area, and excavated soil is used to create a wall on the fourth side. Sometimes, several johads are interconnected through deep channels, with a single outlet opening into a river or stream nearby. This prevents structural damage to the water pits that are also called madakas in Karnataka and pemghara in Odisha.

Khadins are ingenious constructions designed to harvest surface runoff water for agriculture. The main feature of a khadin, also called dhora, is a long earthen embankment that is built across the hill slopes of gravelly uplands. Sluices and spillways allow the excess water to drain off and the water-saturated land is then used for crop production. First designed by the Paliwal Brahmins of Jaisalmer in the 15th century, this system is very similar to the irrigation methods of the people of ancient Ur (present Iraq).

A kund is a saucer-shaped catchment area that gently slope towards the central circular underground well. Its main purpose is to harvest rainwater for drinking. Kunds dot the sandier tracts of western Rajasthan and Gujarat. Traditionally, these well-pits were covered in disinfectant lime and ash, though many modern kunds have been constructed simply with cement. Raja Sur Singh is said to have built the earliest known kunds in the village of Vadi Ka Melan in the year 1607 AD.

Built by the nobility for civic, strategic reasons, **baolis** were secular structures from which everyone could draw water. These beautiful stepwells typically have beautiful arches, carved motifs and sometimes, rooms on their sides. The locations of baolis often suggest the way in which they were used. Baolis within villages were mainly used for utilitarian purposes and social gatherings. Baolis on trade routes were often frequented as resting places. Stepwells used exclusively for agriculture had drainage systems that channelled water into the fields.

Found near Jodhpur in Rajasthan, **nadis** are village ponds that store rainwater collected from adjoining natural catchment areas. The location of a nadi has a strong bearing on its storage capacity and hence the site of a nadi is chosen after careful deliberation of its catchment and runoff characteristics. Since nadis received their water supply from erratic, torrential rainfall, large amounts of sandy sediments were regularly deposited in them, resulting in quick siltation. .

Phad, a community-managed irrigation system, probably came into existence a few centuries ago. The system starts with a bhandhara (check dam) built across a river, from which kalvas (canals) branch out to carry water into the fields in the phad (agricultural block). Sandams (escapes outlets) ensure that the excess water is removed from the canals by charis (distributaries) and sarangs (field channels). The Phad system is operated on three rivers in the Tapi basin – Panjhra, Mosam and Aram – in the Dhule and Nasik districts of Maharashtra.

Khadeen

It was first developed in the 15th century in the Jaisalmer district, Khadeen is a most multi-purpose method of water conservation. The run-off from upland and rocky surfaces is collected in a khadeen from the adjoining valley against an embankment having a masonry water barrier for outflow of runoff excess. The standing water in a khadeen assists continuous groundwater recharge. On the Khadeen bed at least one crop is cultivated even in the arid region as it retains moisture and contains fine and fertile soil. In the immediate vicinity downstream the sub-surface water is extracted through bore wells.

Kui

To minimize the wastage of water, small well known as Kui or Beri is constructed near a water leaking and oozing tank. At Bikaner, Jaisalmer and Jodhpur 'Kui' are found in a large number. Its opening is covered by strips of wood and mostly they remain kaccha. Kuis or beris are normally 5 metres (m) to 12 m deep. Six or ten of kui's when constructed together constitute a ***PAAR System***. Rainwater harvested through PAAR technique is known as Patali paani.

Jhalras

The water of Jhalras was used in religious ceremonies, community bath and such other functions. Jhalras in Man Mandir at Jodhpur are well known. They do not have their own catchment area rather, the water reservoirs receive water from soakage of tanks or lakes situated at a higher level.

Johad

Johads are small earthen check dams that capture and conserve rainwater, improving percolation and groundwater recharge. Starting 1984, the last sixteen years have seen the revival of some 3000 *johads* spread across more than 650 villages in Alwar district, Rajasthan.

Traditional Roof-Water Harvesting

The houses in western Rajasthan during ancient times were constructed with stone and lime and the roof water was diverted to Tankas. The housing complexes and institutional buildings in urban areas have large roofs and the roof-top rainwater can be conserved and used for recharge of groundwater. Here an outlet pipe from the roof top to divert the water to the existing wells or special recharge wells in urban areas.

Modern Methods of Rain-Water Harvesting in Rajasthan

RajRAS   February 10, 2018   0

Rajasthan has a tradition of building, and maintaining rainwater harvesting (RWH) structures such as johad, kuis, and kunds. Traditionally, these structures supported life in this water stressed region, and were well supported in turn by a system of community ownership. Excessive reliance on government run systems has led to the gradual neglect of these structures and disintegration of the entire support mechanism. The relevance of RWH in addressing today's water crisis is unquestionable; however implementation models, design norms, and funding vary. The lack of financial models and capital limitations at the user end pose challenges in the rural individual context. In the urban setting, enforcement of RWH norms for large buildings has been a challenge. With the advancement of technology and increasing need for water new methods are adopted to conserve water using scientific techniques.

Water Harvesting Dams or Nalla bunds:

In ravine lands, a series of small barriers are constructed across selected Nalla sections of second order streams so as to obstruct the flow of surface water in the stream channel and water is retained on the surface for a longer period. These check dams act as a mini percolation tank which helps retention of the silt load, supplement irrigation, contributes groundwater recharge and enhances the overall biomass production of the system. These Water harvesting dams are promoted under the Watershed Management Program in Rajasthan.

Ditch and Furrow Method

In areas with irregular topography, flat bottomed, shallow and closely-spaced ditches or furrows there is maximum water contact area to recharge water from source stream or canal. This technique is less sensitive to silting.

Anicuts

A small water harvesting masonry dam constructed across a stream to hold sufficient water and submerge the upstream area during the rainy season is known as an Anicut. The stored water is used for drinking and recharging groundwater in adjacent wells. Lift irrigation is also practiced. Like in a khadin, if the submerged area is large then bed cultivation is practiced using the stored soil profile moisture.

Percolation Tanks

Percolation tanks are recharge structures for impounding surface runoff constructed on small streams with adequate catchment. These tanks are more feasible in hard rock regions which are highly fractured and weathered to quickly recharge the groundwater due to low evaporation losses. They can be dug in alluvial rock formations as well.

Sub-Surface Barriers

In the sandy bed of an ephemeral desert streams the sub-surface barrier is a suitable artificial recharge structure. It is constructed below the river bed on impermeable sub-surface strata and so the structure is secure from flooding and does not require periodic de-silting and has limited evaporation.

Harvesting and Conservation of Flash Floods:

Flash floods occur in response to very high rainfall or a cloudburst of short duration. Over-topping of defined courses of streams and spreading into flood plains causing immense damage are their characteristic features. These waters can be allowed to percolate inside the already existing aquifers of the water is diverted towards the run- off storage tanks. The water can be later put to agricultural or domestic purposes after basic purification.

In-situ water harvesting and moisture conservation is very useful in drought mitigation and in enhancing land productivity, which are field based, cost effective, location-specific soil and water conservation technology. Under this technique, Contour furrowing is practiced on mild slopes. Also, a large numbers of mini-storages are created across the slope which alleviate drought.

Contour bunding is recommended in the semiarid region of the state for soil and water conservation in rain-fed farming regions. Locally adapted, native, fast-growing perennial grasses with extensive root systems are planted against the slopes to act as Contour vegetative barrier. These grasses and shrubs form a dense hedge and conserve soil and water. This cheap and environmental friendly measure improves land productivity.

Recharge Shaft

In the areas where source of water is only seasonally available the recharge shaft allows water to stand in it for longer time and allowing it to percolate to recharge a nearby well or other water body. The recharge shaft is efficient and cost effective structure to recharge the aquifers directly