CLIMATE PROOFING, ADAPTING TO CLIMATE CHANGE
&
REDUCING RISK
Through
Positive Interventions in HP (India)

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Eternal University: Presentation on May 28, 2014

Presentation Purpose

- To introduce a system that would not only mitigate Climate Change effects, but would take care of, and adapt to the climate change but also plug the risk of future disasters.
- The following slides will tell us how The Vetiver System is one such system, that would, on the one hand speed up the ongoing projects, and prevent future tragedies due to landslides and other calamities, on the other. In doing so, it would conserve the soil & water within the hills.
- Civil engineering interventions are not only expensive, but have other negativities wrt CDM projects.
- The Vetiver System is largely a bio-engineering intervention.
- We have the fullest support of the The Vetiver Network International.
- Most of the technical examples in this presentation are from the techinical experiences in India and in over fifty countries in the world.
- Vetiver is an Indian Plant and it is a particular sterile and non-invasive South Indian Variety,***(Vetiveria Zizanioides)*** that is being used all over the world.

Previous Background

- Vetiver was introduced by Richard Grimshaw and John Greenfield who re-introduced the Vetiver grass to its mother country, India, as part of an effort initiated by The World Bank here in India, in the 1980s.
- Today, the rest of the world is way ahead of us in understanding our own plant.
- The entire world uses the Vetiver System, we have just about begun.
- In the last 8-10 years we have started believing in our own past and have adopted this system.
- Most of the technical examples in this presentation are from a manual authored by John Greenfield, but is backed up by experience all over the world, including India
- I have pooled in a little experience of my own, in certain works, where Dick Grimshaw, Paul Truong and other colleagues from TVNI have helped with their respective experiences, over the last 7 years.

CURRENT SCENARIO

- Himachal Mid Himalayan Watershed Development Project is on going.
- Himachal Pradesh Reforestation Project – Improving Livelihoods and Watersheds : An A/R CDM project : *Registered on* 04/03/2011
- The first monitoring report of the Project released on15/03/2013
- Duration of 1st monitoring period: 01/07/2006 - 31/12/ 2012)
- Estimated GHG emission reductions for this period : 1,70,746 tCO2e
- Actual GHG emission reductions achieved in this time : 61,194 tCO2e
- A climate proofing project is now to be implemented with the help of GIZ & KfW.

"The main focus is to be on rejuvenation of the ever-depleting natural water resources by making watersheds resilient to current and future climatic changes through forestry activities".

IDENTIFICATION OF RISKS ARISING OUT OF CLIMATE VARIABILITY AND CHANGE

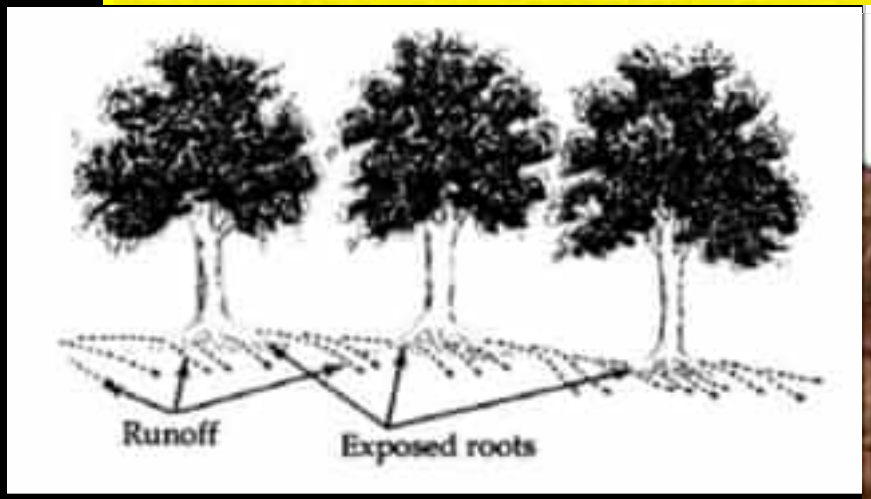
Risks and Calamities typical to the Mid Himalayan region are:

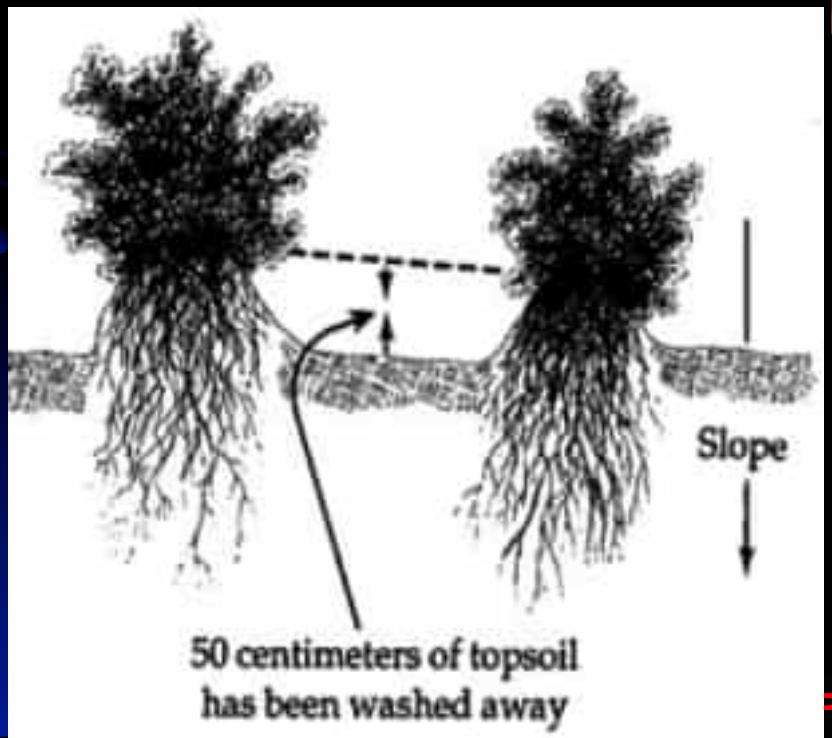
1. **Land Slides: due to gradual Soil Erosion & Human activities**
   - Further resulting in destruction of shallow rooted vegetation
   - Further into baring of tree-roots and eventual destruction of trees.
   - All this results depletion of sub surface water in the hill.
   - There is a cascading effect after this, rainwater flows straight down with ever increasing velocities and further erosion.
2. **Forest Fires, again resulting in all the things mentioned above**
   - Dried Pine needles are a major source of fire in the area.

SHEET EROSION

- Under normal conditions, sheet erosion is not recognized and therefore is seldom treated.
- However, triggered by torrential rainfall, sheet erosion accounts for the loss of thousands of lives through mud slides and landslides, and the loss of billions of tons of soil every year.
- This runoff further strips unprotected areas of their valuable topsoil.
- Major Erosion problems, including landslides, destruction of infrastructure, uprooting o plants and trees follow after this

Results of sheet erosion





THE VETIVER SYSTEM

The Vetiver System Can

- Stop Soil Erosion
- Slow down Water runoff
- In so doing, recharges water into the ground
- Stop fertile Top Soil from running off
- Hasten the Growth of trees & vegetation
- Hence, initiate the process of Reforestation and revegitation
- Protect Infrastructure like roads, dams, aquaducts, bridges
- Protect canal channel and river slopes
- Repair rain cuts, gullies and canyons
- Over a period, enables the terrain to survive long spells of drought
- After doing all this , its Carbon Sequestering capabilities are much more and more permanent than most other species, giving speed & impetus to the AR CDM Projects.

THE VETIVER SYSTEM
The Plant
(Vetiveria Zizanioides)

THE ROOT

Excavated root.
Average tensile root strength 75 Mpa

Longitudinal section through hedge profile
This type of root mass will improve soil shear strength by up to 39%

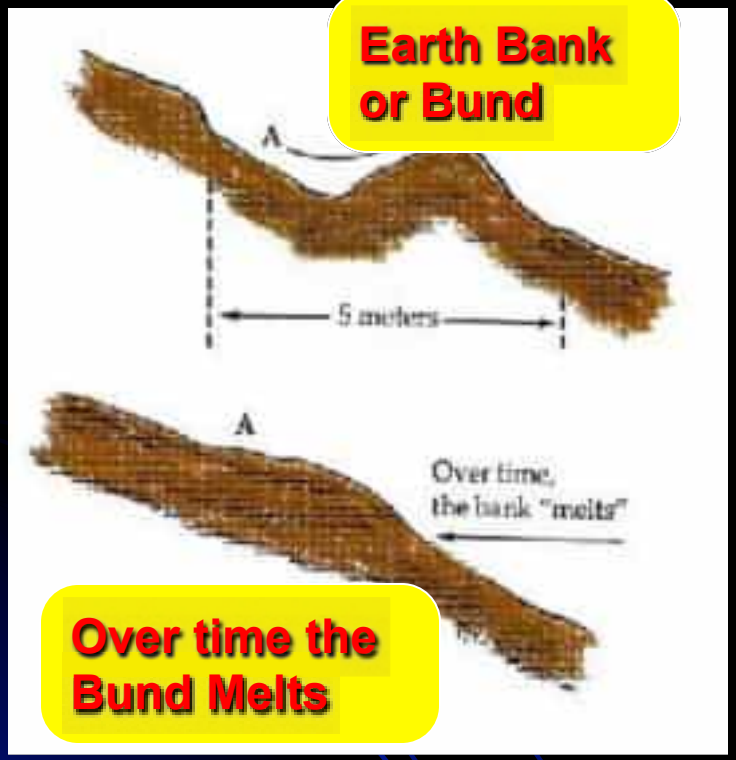
Can go upto 3 meters deep

The Vetiver Grass Special Characteristics

- Grows under extreme and wide range of conditions
- Is native to India (South Indian Genotypes used globally)
- Long Living Perennial Grass
- Air temperatures: -15 ° C to >55° C
- Soil pH from <3 to >10
- Annual Rainfall <300 mm to > 5,000 mm
- Tolerant to all heavy metals
- Saline tolerant (salinity threshold ECse = 8 dSm-1)
- Tolerant to long and total submergence in water (3months)
- Fire tolerant
- Resistant to most pests and diseases
- Powerful (75 Mpa root strength) and deep root system
- Non competitive and non invasive. According to the PIER level of invasiveness criteria, non fertile vetiver cultivars are rated – 8.
- An acceptable level for plant importation by the most strict countries is +1

Vetiver System Technology

The technology comprises a hedgerow of vetiver grass planted on the contour

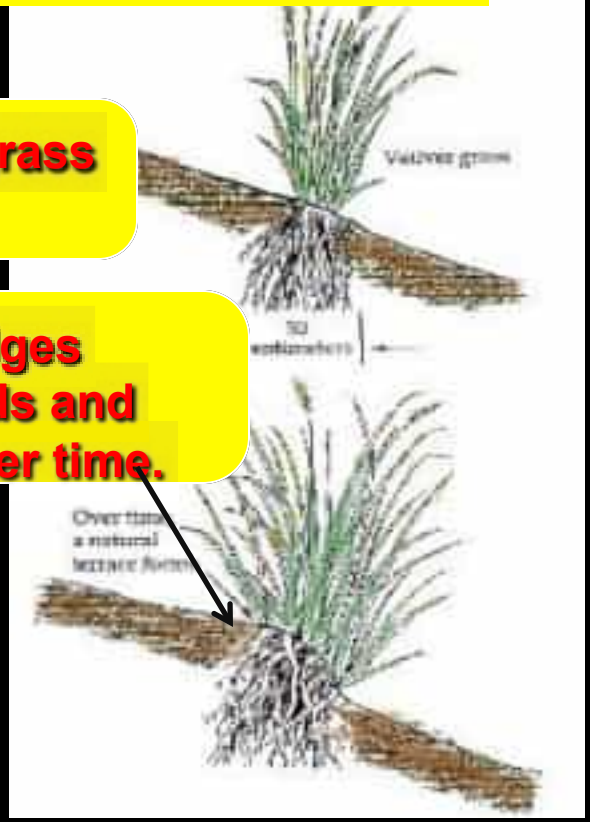


Earth Bank or Bund

Over time the Bund Melts

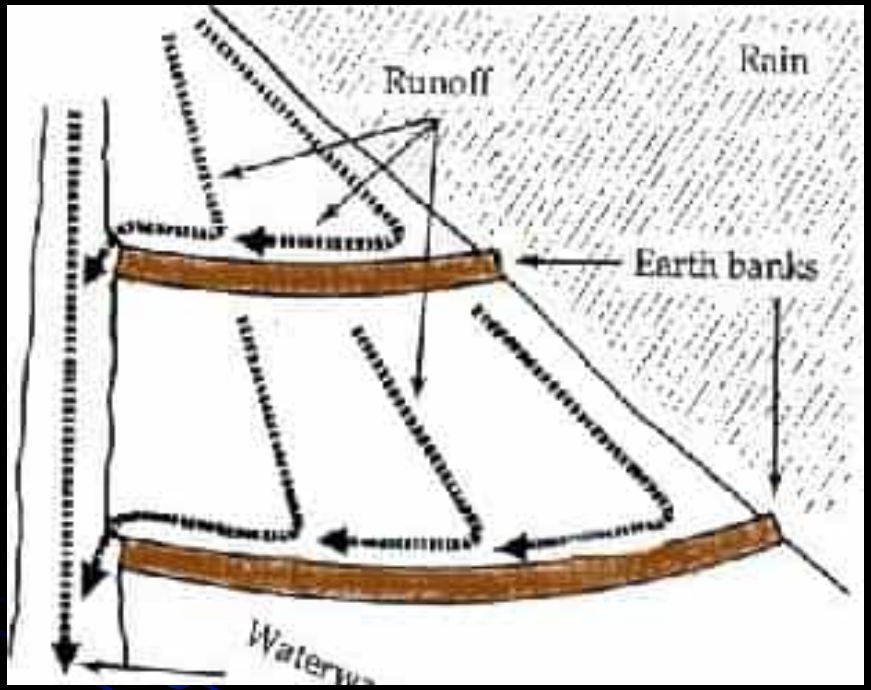
Vetiver grass

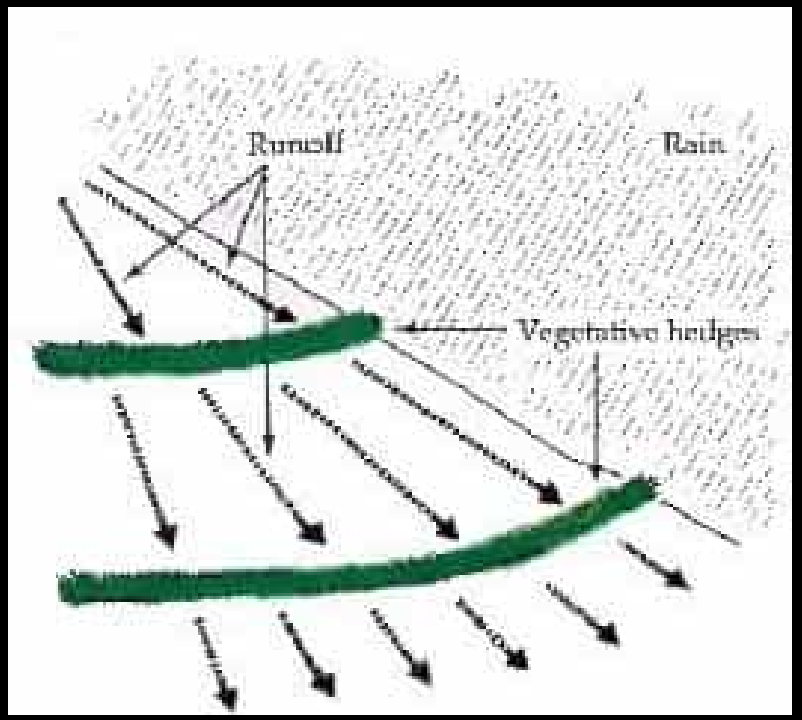
Vetiver Hedges create bunds and terraces over time.



Note that the width of a hedgerow is just 30cm, whereas space required for an earthen bund is in meters

VS Technology Contd…





Banks divert the entire water

Vetiver hedges slow the runoff to increase infiltration, and some water remains behind and slowly percolates *(Greenfield 1989)*

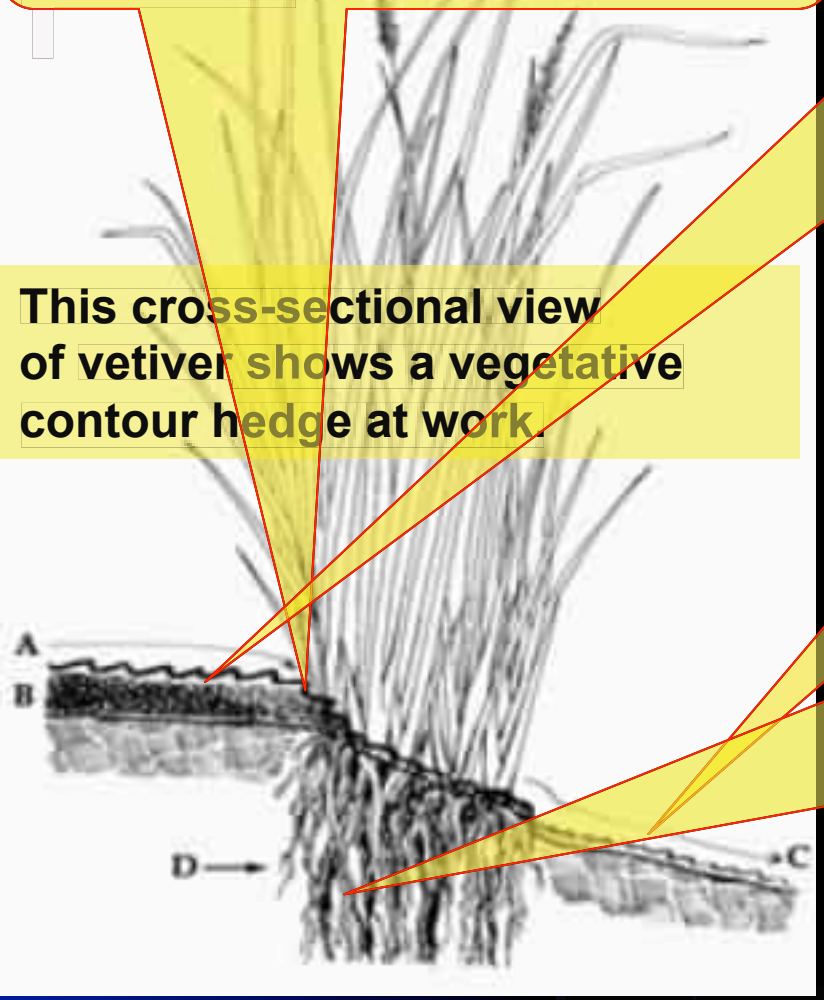
VS Technology Contd…

The leaves and stems of the vetiver plant slow the silt-loaded runoff at A

Reduced Velocity causes it to deposit the silt behind the plant at B

while the water continues down the slope at C at a much slower pace.

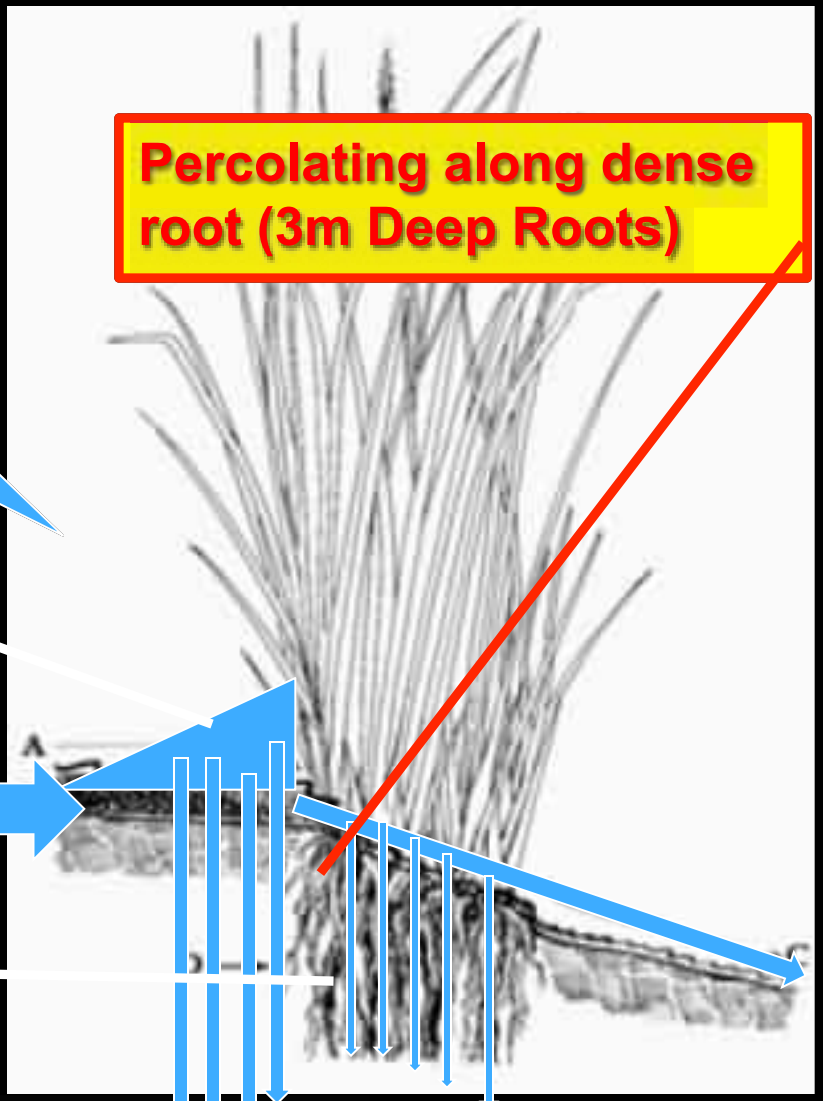
This cross-sectional view of vetiver shows a vegetative contour hedge at work.



The Plant's spongy root system, pictured at D, binds the soil beneath the plant to a ***depth of up to 3 meters***. forming a dense underground curtain that follows the contour of the land, the roots prevent rilling, gullying, and tunneling.

VS Technology Contd…

Water Conservation and natural water harvesting, without physical intervention



Back water retained

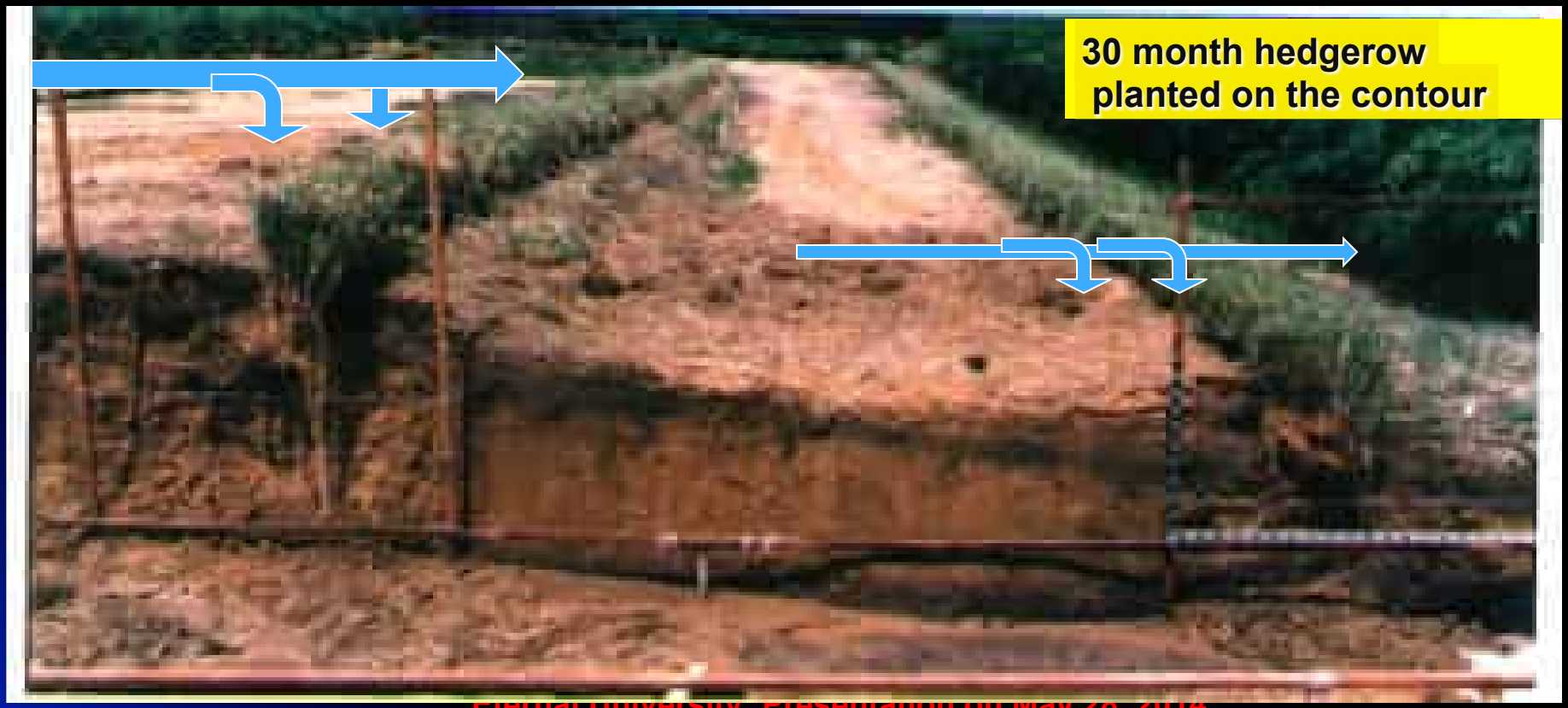
Run off water

Percolating water, recharging the ground

VS Technology Contd…

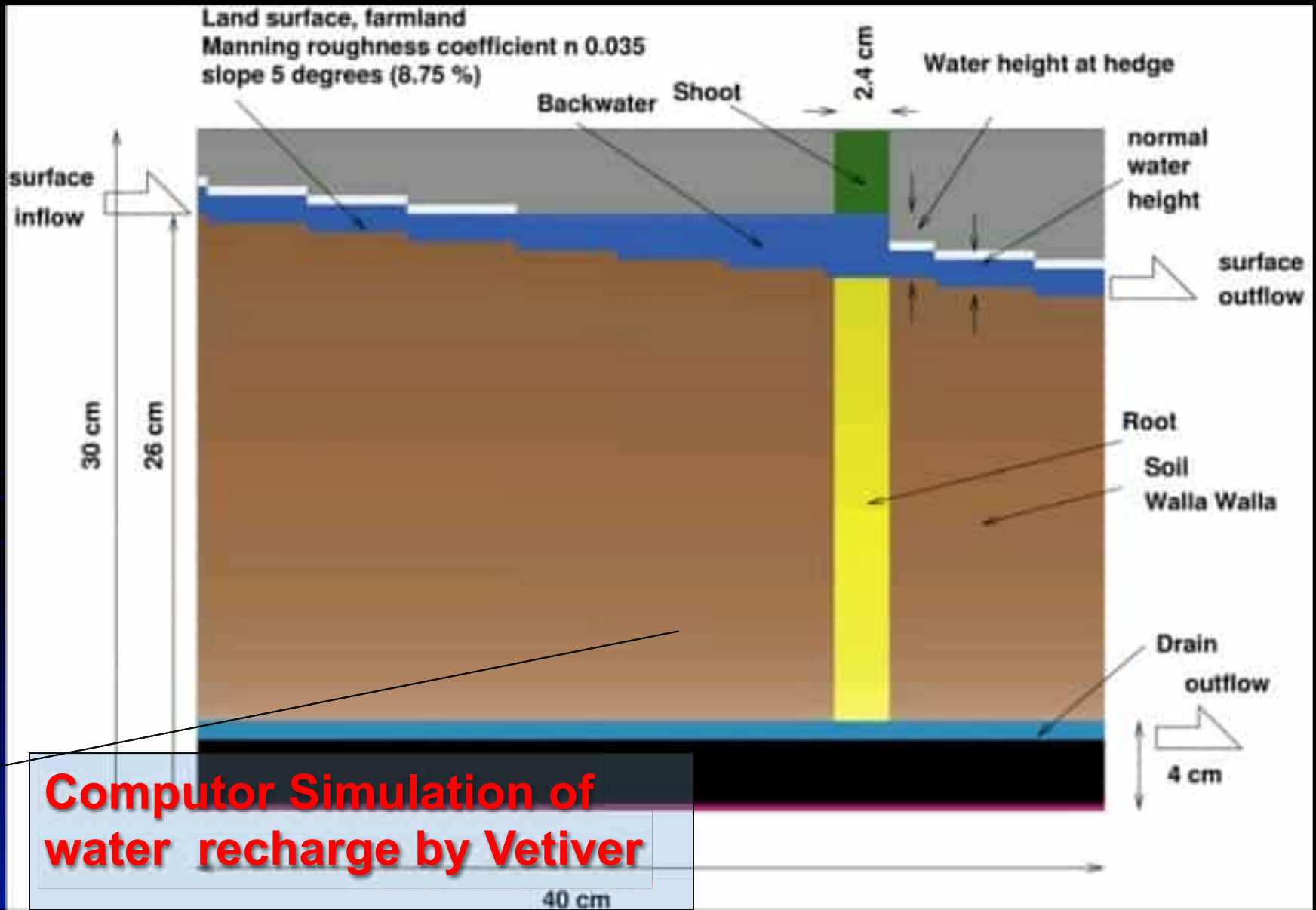
Four things happen

1. Velocity of water reduces
2. Soil is deposited on the upstream side as the down arrow shows.
3. Some water stays back as backwater to percolate down along the vertical roots of the VS Hedgerow, as the down arrows show.
4. Balance water, with reduced velocity flows through



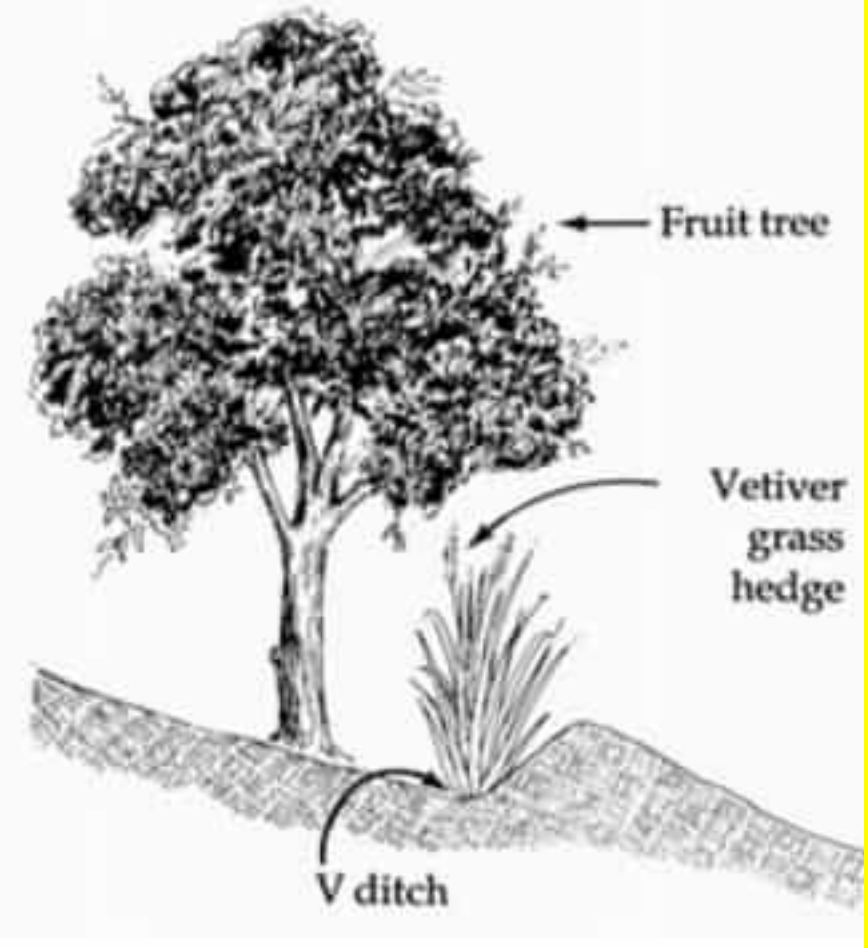
THE VETIVER GRASS TECHNOLOGY CONTD…

Whole paper can be viewed at:
https://drive.google.com/file/d/0B3E8MMCy36wZNmMxYzZkZWItZGM4YS00MzM0LWE3MDQtOTBiZmE2Yjc4NmFl/edit?usp=sharing



Computor Simulation of water recharge by Vetiver

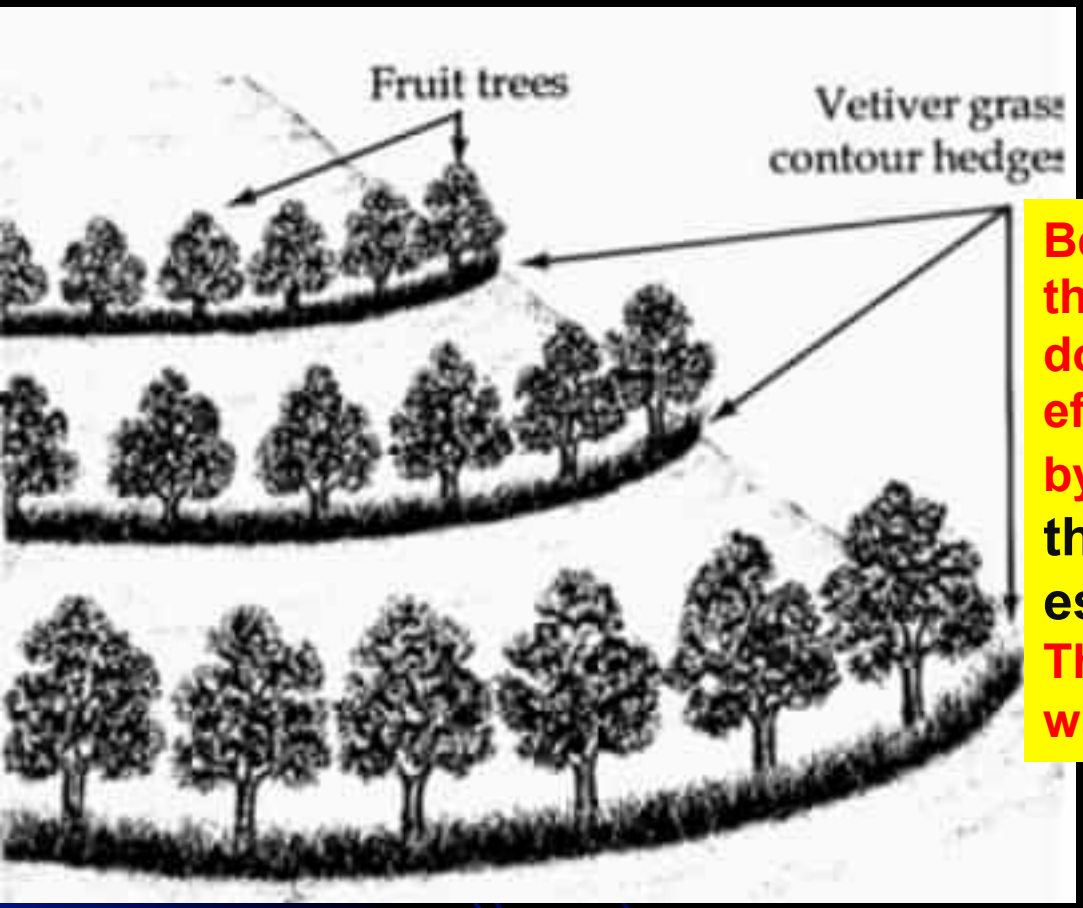
Vetiver System: tree growth promotor



- Under this arrangement of planting, the runoff between one row of trees and the next one down the slope. collects in the vetiver-lined ditches.

- Thanks to the effects of such water harvesting, the rows of trees do not have to be planted as close together as the trees within a row. Initially, the V ditch will provide a measure of runoff control, thereby increasing the soil's moisture content,

- Vetiver hedges stabilize tree crops. and both the vetiver and the planted trees will benefit.



Because the collection of runoff in the contour ditches has the effect of doubling or tripling the amount of effective rainfall, fruit trees planted by this method need no irrigation in the first three years of establishment.

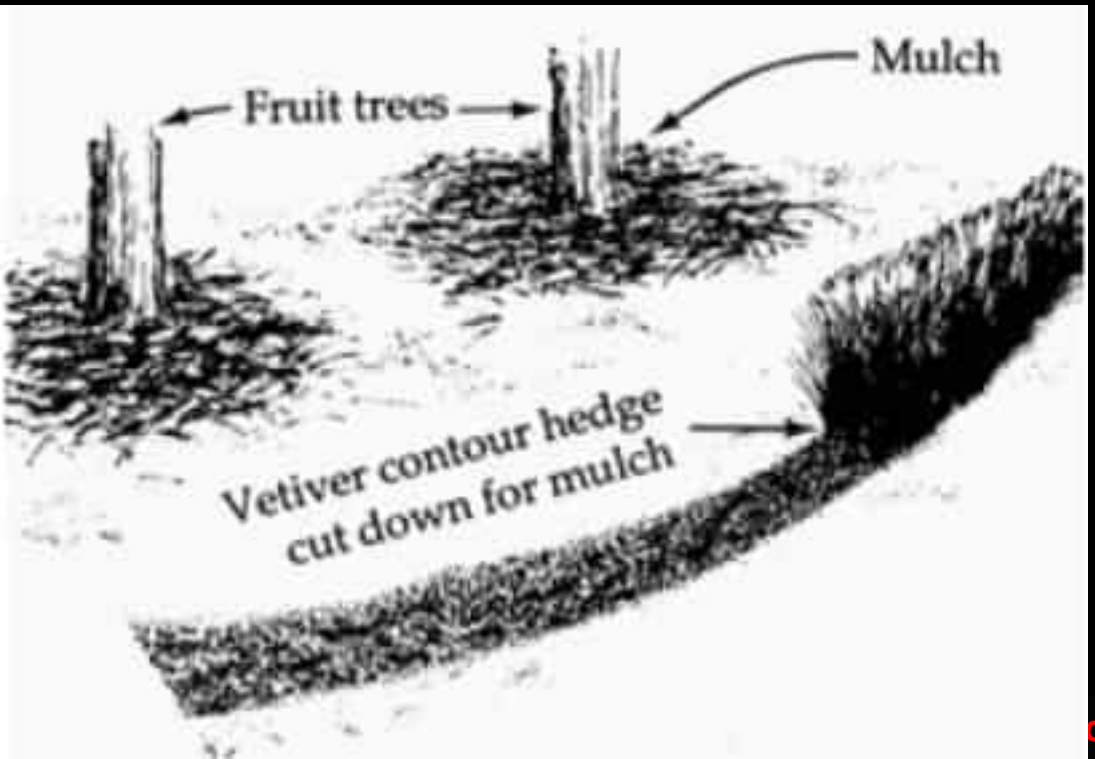
The vetiver grass lines stabilize the whole system.

Vetiver System: mulch for the trees

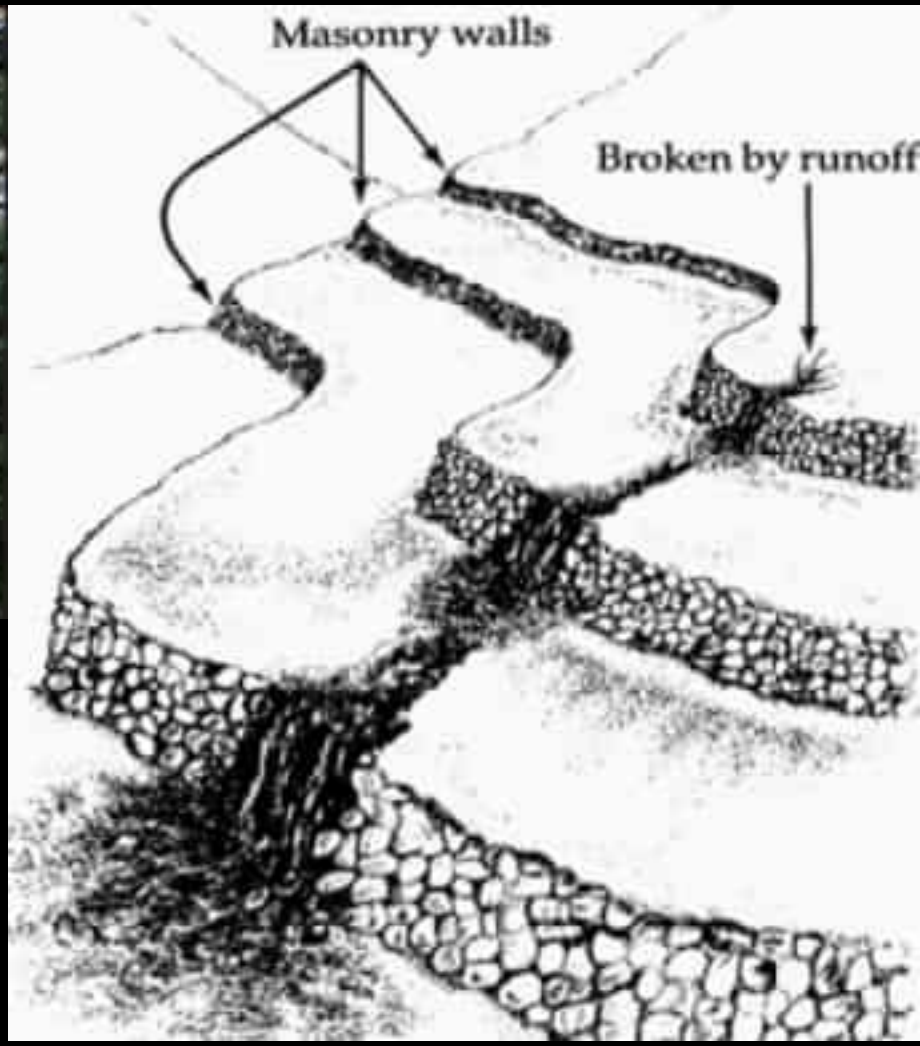
After the vetiver hedges are properly established, the farmer can cut down the vetiver grass to ground level when the dry season sets in and use its leaves as mulch at the base of the fruit trees to help retain stored moisture.

The advantage of using vetiver for this purpose is that its leaves harbor few insects and last well as a mulch. Vetiver hedges also protect the young plants in the hot summer months by providing some indirect shade;

in the colder winter months the hedges act as windbreaks.



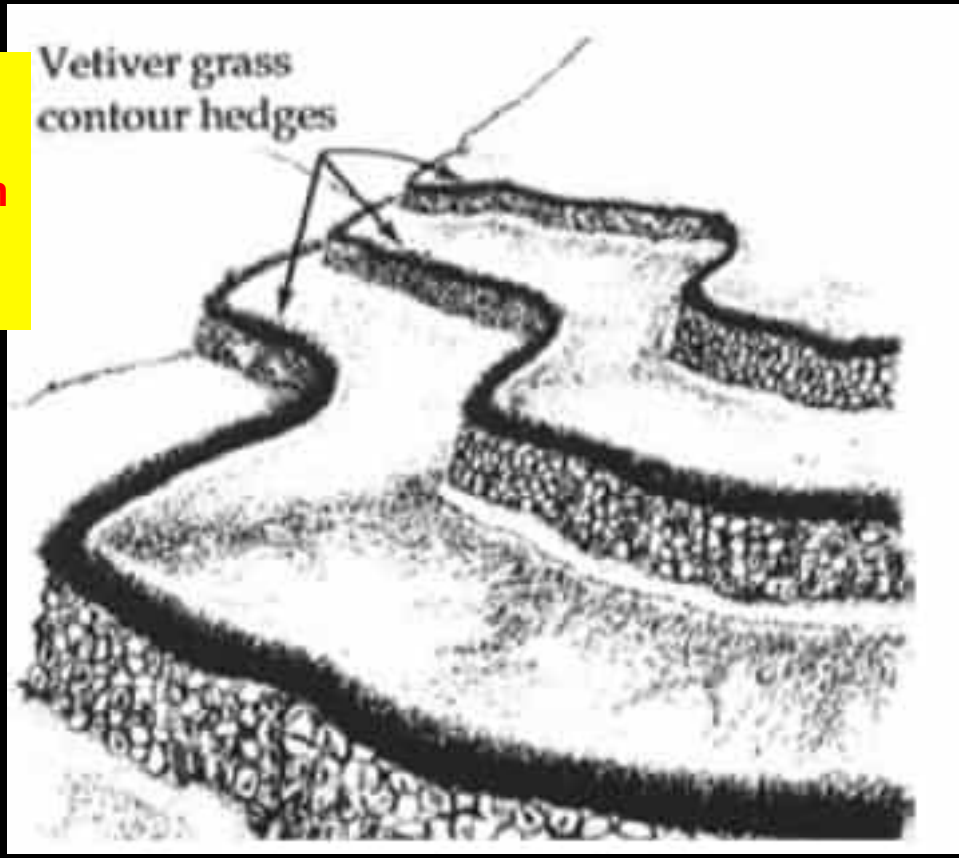
Vetiver System: failure of civil structures



In the Himalayan highlands terraces are frequently washed out by concentrated flows of run-off water.

Vetiver System: Guardingcivil structures

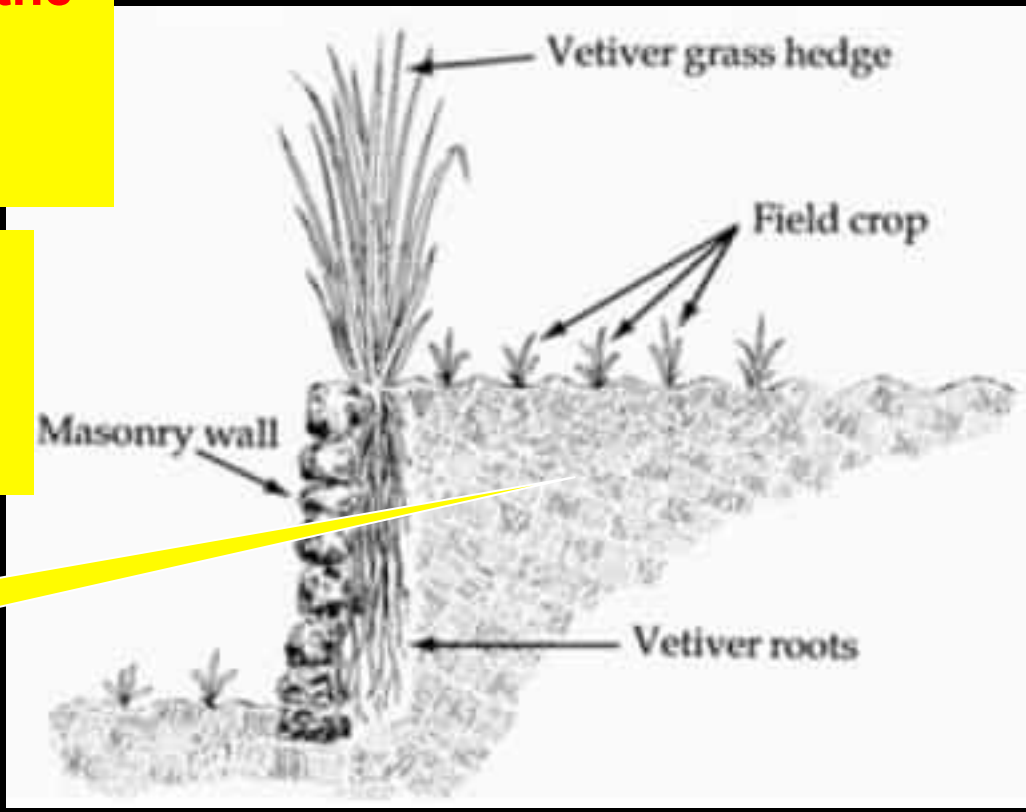
Vetiver grass, planted on the extreme edge of each terrace, stabilizes the terraces without interfering with the essential drainage between the stones.



Vetiver System: Guarding civil structures

The vetiver root system stabilizes the entire rock face of the vulnerable masonry risers.

The vetiver root system stabilizes the entire rock face of the vulnerable masonry risers.

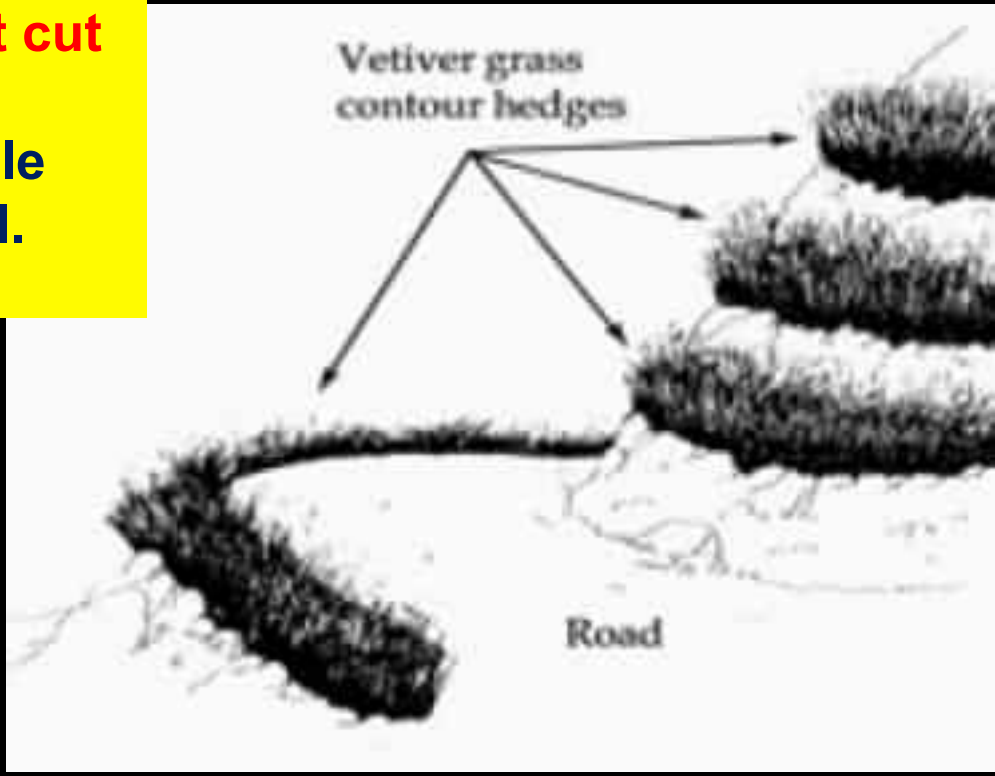


Water recharge into the hill.
More effective and enduring.
Lasts the whole year

Vetiver System: Protecting Roads & Road Batters

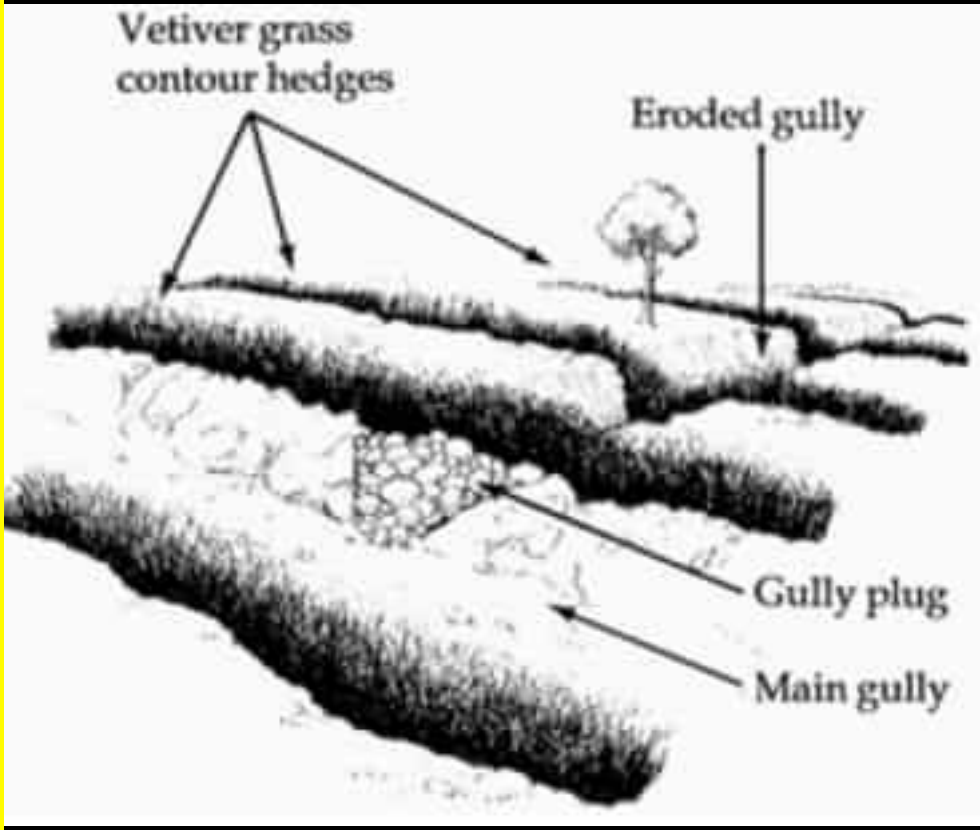
Vetiver grass is also used to protect cut and fill batters

The grass has exhibited a remarkable ability to grow in practically any soil.



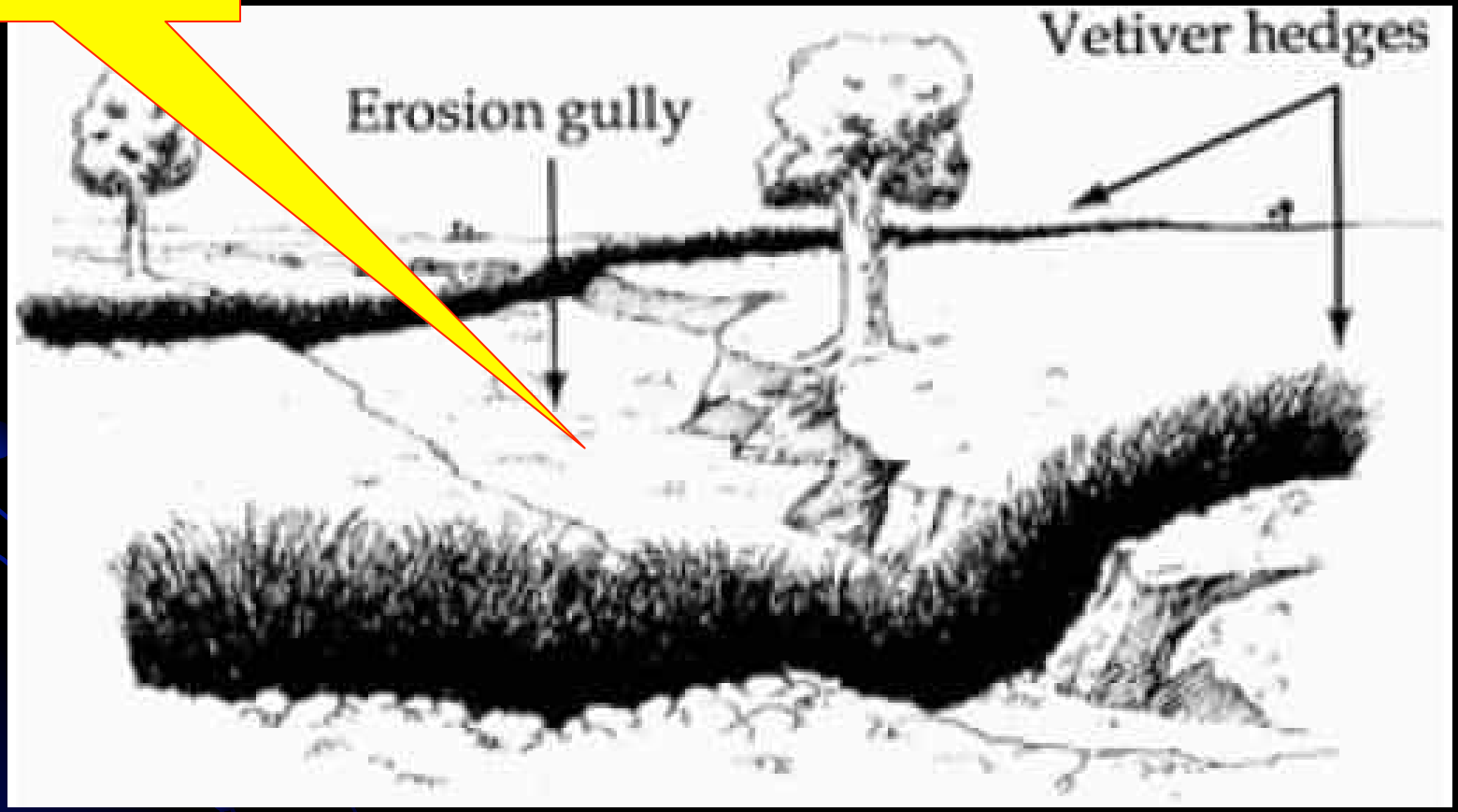
Vetiver hedges can stabilize multi-gullied wasteland areas

The use of vetiver grass in wasteland development has proven effective as the initial stabilizing plant.
When planted as contour hedges across wasteland areas - the first stage in stabilization - *C. zizanioides* reaps the benefits of surplus runoff and harvests organic matter as it filters the runoff water through its hedges.
The improved micro-environment of improved soil moisture allows for the natural generation of native species between the vetiver hedgerows. As an example, the use of vetiver grass is in most instances an excellent alternative to an engineered structure as a measure to control complex multi-gullied land areas.
The addition of a masonry plug at the end of the system allows silt to build up and gives the grass a basis of establishment.

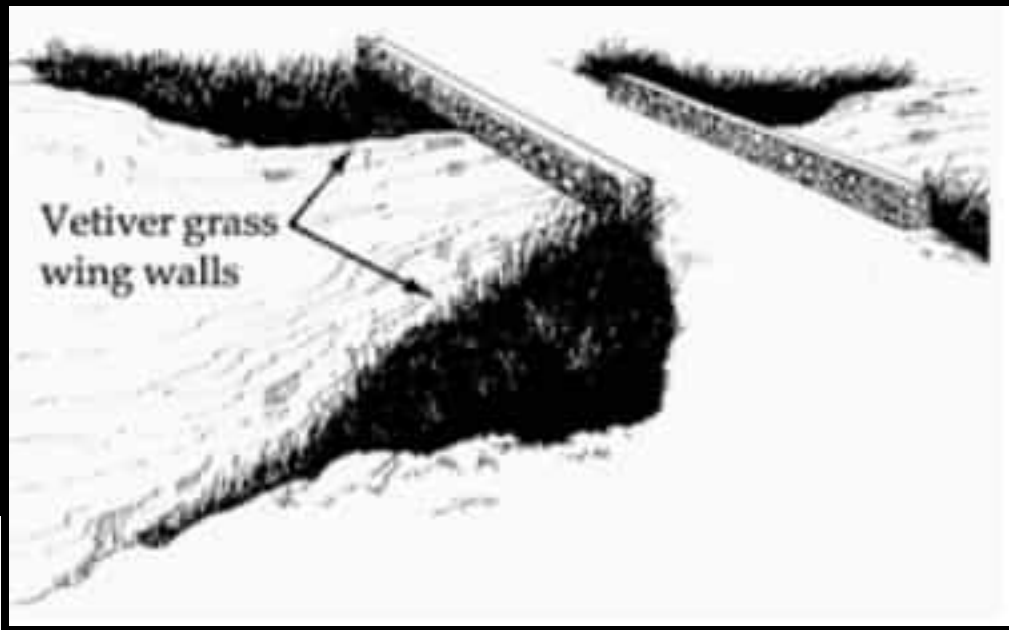


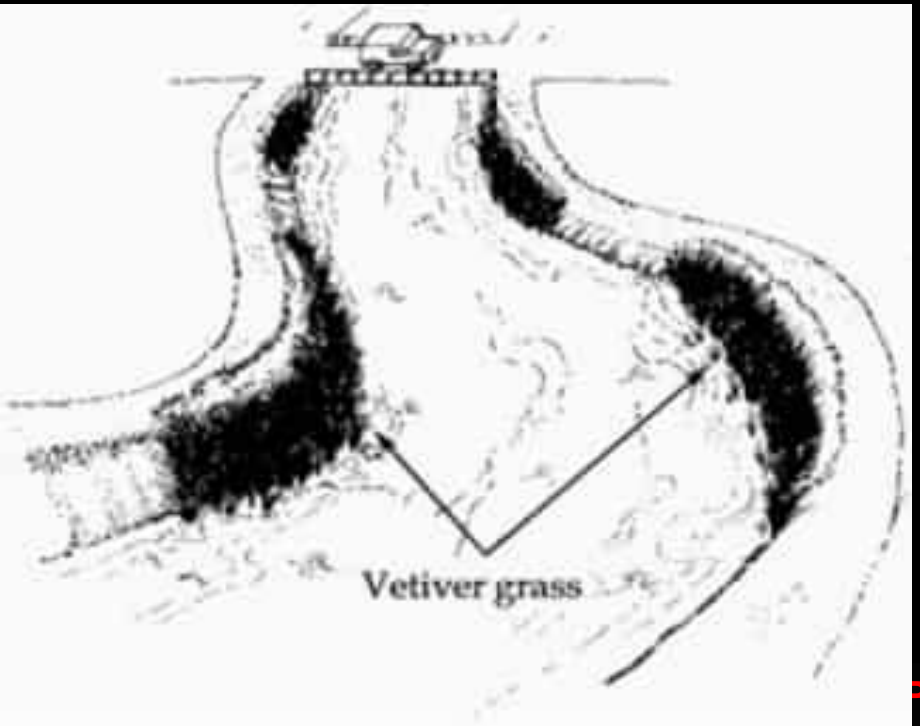
Vetiver System to stabilize gullies

This will ultimately be filled with silt

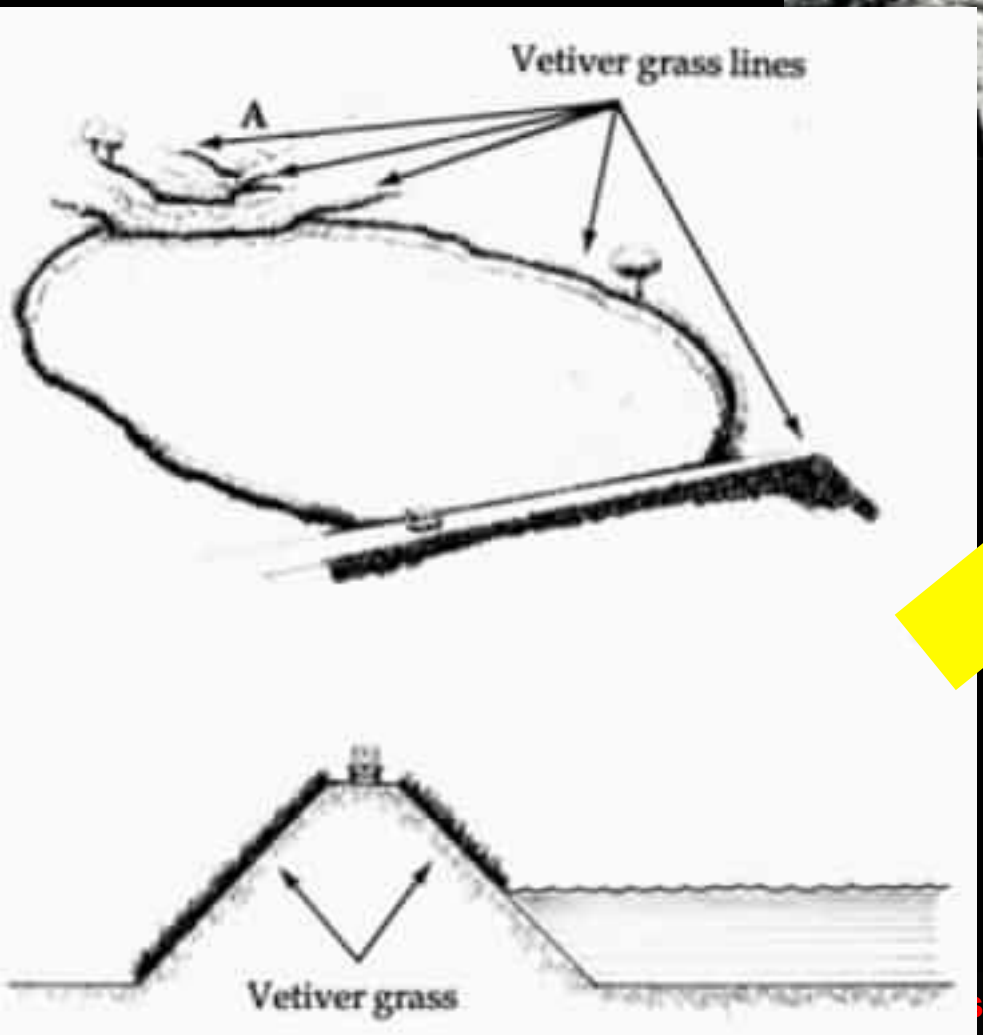


Vetiver System: Infrastructure Protection





Vetiver to harness the Brahmaputra



Protection of Bunds and Dams

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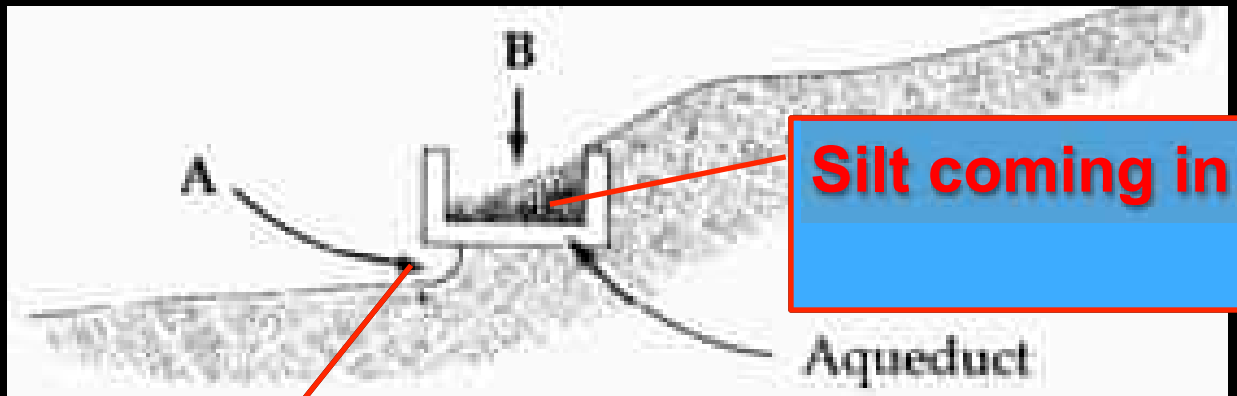
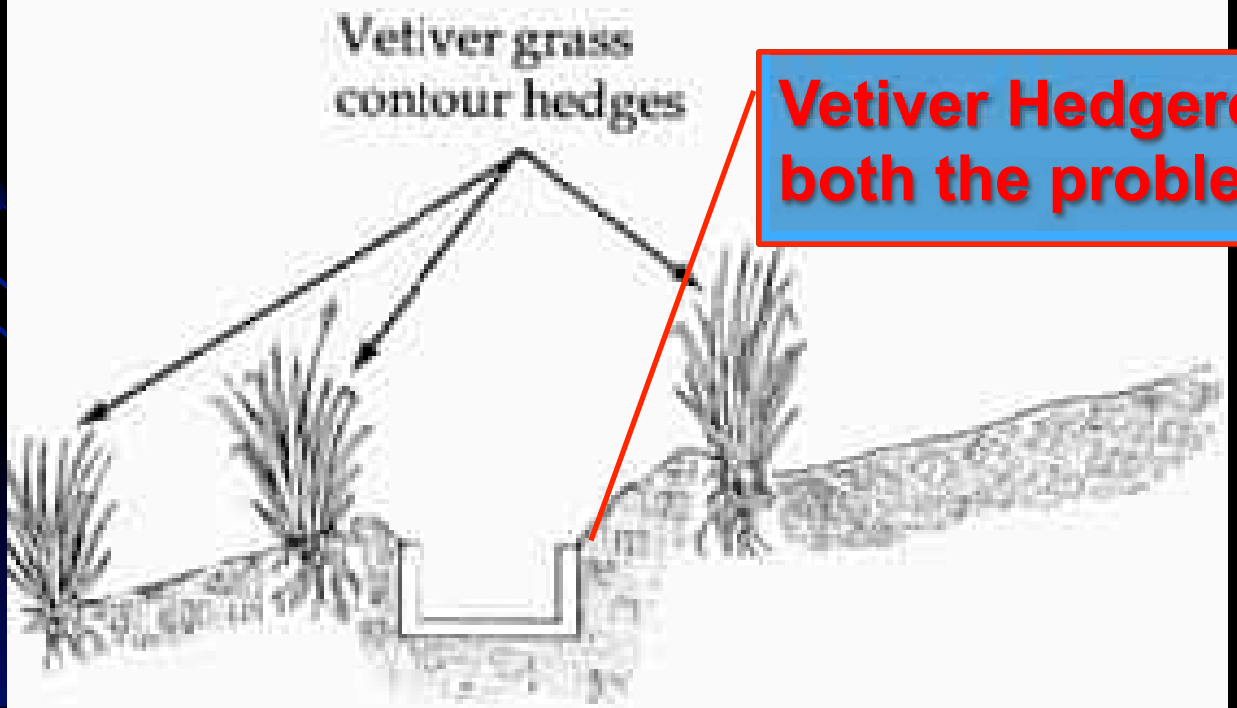


Silt coming in from point B

Erosion under the Aqueduct



Vetiver Hedgerows solve both the problems

Accidents have stopped happening in the Konkan Raiways ever since, several Kilometers of Vetiver Hedgerows were planted, resulting in strengthening of the Ghats. The RDSO adopted the Vetiver System in 2007-8

Carbon Sequestriation

1 Megagram= 1 tonne

Table 1. C- sequestration by different species (normalized to 12 month crop cycle)

Tree/Crop/Cropping System	C- sequestration (megagrams ha^{-1} $year^{-1}$)
Albizzia lebbek[1]	1.04
Tectonia grandis[1]	1.33
Artocarpus integrifolia[1]	1.21
Shorea robusta[1]	0.87
Poplar[2]	8
Eucalyptus[2]	6
Teak[2]	2
Vetiveria zizanioides	15.24
Lemongrass	5.38
Palmarosa	6.14
Vetch(V)-maize(M)-oat(O)-soybean(S)-wheat(W)-soybean(S)[3]	7.26
O-M-W-S[3]	8.56
V-M-W-S[3]	7.58
Ryegrass(R)-M-R-S[3]	8.44
Alfalfa(A)-M[3]	7.52
Rice-rice[4]	1.54-2.48(residues)
Maize-rice[4]	2.1-3.51(residues)

[1]Jana *et al.*,(2009); [2]Kaul *et al.*,(2010); [3] Santos *et al.*,(2011); [4]Witt *et al.*,(2000)

Carbon Sequestration

Trees/crops/cropping systems	C- sequestration (Mg ha $^{-1}$ year $^{-1}$)	Ref.
V-M-O-S-W-S O-M-W-S V-M-W-S R-M-R-S A-M	0.12 0.16 0.28 0.32 0.44	Santos et al.,2011
Rice-maize Maize-rice	0.92-1.37 -0.11-0.23	Witt et al.,2000
Rice-wheat Maize-wheat	0.13-0.31 0.03-0.14	Kukal et al.,2009
Eucalyptus Poplar Teak	1.11 3.88 0.70	Kaul et al.,2010
Vetiver lemongrass	5.54 3.08	

Source: . A Strategy for Sustainable Carbon Sequestration using Vetiver *(Vetiveria zizanioides (L.)): A Quantitative* Assessment over India

A Project Document under the CSIR Network Project, Integrated Analysis for Impact, Mitigation and Sustainability (IAIMS), July 2011

Carbon Sequestration

Table 6: Estimates of sequestration CO_2 (carbon) Emission through vetiver

C-sequestered by Vetiver			
Vetiver System	C-sequestered(Tg $year^{-1}$) in India (10 m ha of degraded soils)	% of emissions (2009)	
		India	World
Biomass	150	34.6	1.8
Soil	50	11.5	0.6
Total	200	46.1	2.4

As a broad estimate, utilization of about 10 m ha of degraded soil in India could potentially sequester up to 46% of total carbon emission by India (in 2009). While the sequestration in practice is naturally likely to be much less, it is still expected to be significant.

Vetiver Leaves as Fodder

Cattle love soft leaves, which can be cut and and mixed with their feed. The photo is only meant to show that cattle do enjoy it. But young vetiver plants should be guarded and cattle should not be allowed for the first few months.

Nutritonal Value of Vetiver as Fodder

Analytes	Units	Vetiver grass	Vetiver grass	Vetiver grass	Rhodes	Kikuyu
		Young	*Mature*	*Old*	*Mature*	*Mature*
Energy (Ruminant)	kCal/kg	522	706	969	563	391
Digestibility	%	51	50	-	44	47
Protein	%	13.1	7.93	6.66	9.89	17.9
Fat	%	3.05	1.30	1.40	1.11	2.56
Calcium	%	0.33	0.24	0.31	0.35	0.33
Magnesium	%	0.19	0.13	0.16	0.13	0.19
Sodium	%	0.12	0.16	0.14	0.16	0.11
Potassium	%	1.51	1.36	1.48	1.61	2.84
Phosphorus	%	0.12	0.06	0.10	0.11	0.43
Iron	mg/kg	186	99	81.40	110	109
Copper	mg/kg	16.5	4.0	10.90	7.23	4.51
Manganese	mg/kg	637	532	348	326	52.4
Zinc	mg/kg	26.5	17.5	27.80	40.3	34.1

Vetiver Leaf Straw& Pine Needle Straw

If, after using soft leaves for forage, and using as mulch, there is a surplus, then the Communities can be given hand balers and rakes to bale the straw and the same can be used along with dried pine needles for Bio-Energy.

A 2007 Google Earth image of farmland in Fiji that John Greenfield planted with vetiver hedgerows in the 1950s'. The hedgerows are still there (red arrows) after 57 years.

Applications of VS in the Kandi Area to prove the claims, through Practical Intervention

Vetiver application for Revegitation & Reforestation at Anandpur Sahib, Punjab (Hillock Slopes)

Before & After


BEFORE
This hill has soil saver on it
Road Batter
This Swale receives silt
Freshly planted vetiver hedgerow
02 07 2009 14:46


AFTER
The hill with the soil saver
The swale is protected
Road Batter
07 10 2010 11:22


BEFORE
02 07 2009 14 40


AFTER
07.10.2010 11:24


BEFORE
Notice the bare hill. Various methods have been tried for several years
02 07 2009 14:41


Local Species have already started coming.
AFTER
07 10 2010 11 24


BEFORE
02.07.2009 15:27


Local Species have already started coming. Soon they will take over and the HERO would perish
AFTER
07 10 2010 11:57

Vetiver application for Prevention of Soil Erosion & its Migration

Before & After

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SOIL ERODED FROM THE CLIFFS SPREADS ON THE ROADS

ZERO SOIL MIGRATION DESPITE RECORD RAIN

Vetiver application for Steep Filled up Slope Stabilisation (Road Batter) Before & After

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BEFORE
The rains did this. Maybe the road drainage system collapsed


Total Washout


The earth has given way from under the geo-textile
The Geo-textile needs to be removed and the earth refilled, remoulded and compacted


The Vetiver that we grew on top has survived


AFTER


AFTER
Vetiver has retained moisture within the slope enabling other vegetation to grow.
07 10 2010 11:25

Vetiver application for Silt Control in water body

(Planting in the Catchment Area and handling gullies and rain cuts)

Silt Before and Silt After


Location 'V'
Rain Cuts & Gullies
This is a hillock of Debris


Location 'V'
(Behind Drop off)
Water Body
Gully/ Rain Cut
Area Z
29.04.2010 13:06

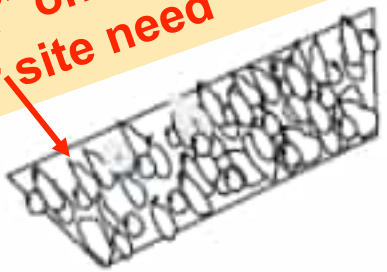
Average 5 rows running across reshaped slopes.

Total rows per raincut (average) =5+5=10

Total length of rows/raincut = 10X25=250m

Total length/ raincut in addition to the rows running across hill= 250+50= 300mtrs

Trapezoidal "porous wall" one or two as per site need



Vetiver rows running across hill, already accounted for

Assume 5 additional rows at the bottom of the cannel, total lenfth=5X10=50m/ raincut


Courtesy: Paul Truong
Note that the vertical interval is only one sand bag thick.
2009

SILT IN OCT 2009


Polythene liner is Visible
SILT IN 2010
Catchment Area Protected with Vetiver
07 10 2010 14:25


Polythene liner is Visible
SILT In 2010
07 10 2010 13 06


SILT IN 2010
First Cell:
Zero Silt
07.10.2010 12:14

Our Intervention: Clumps of Vetver strategically Planted in the rain to Prevent Silt Carried by the same rain to the Water Body.

The Silt was reduced by 99% at the end of the same monsoon as planting

Conclusion

- Vetiver System is the only System that can bring a totally wasted land back to life.
- Lands like vacated mine fields and other degraded lands
- After bringing the land back to life, it allows other local species to take over.
- Vetiver roots have gone deep inside and have enriched the hill with moisture. It has brought below ground carbon stocks.
- Vetiver will ultimately be overtaken by the local species.
- **The below ground carbon stock will stay there for ever.**

Thank You