The Fifth International Conference on Vetiver (ICV-5) "Vetiver and Climate Change", Lucknow, India, 28-30 October 2011

Vetiver System for Natural Disaster Mitigation in Vietnam: Some Lessons Learned After a Decade of Application

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Content

1. VS application for sand dune protection
2. VS application for river bank erosion control (skip)
3. VS application for coastal erosion control (skip)
4. VS application for road batter stabilization
   a) The Ho Chi Minh Highway (HCMHW) - a brief introduction
   b) Some lessons learned after the first few years
   c) A few more lessons learned after a recent field check
5. Conclusions

VS application for sand dune protection

Sand dunes in Central Vietnam - the problem

- A vast area of more than 70,000 ha along the coastline of Central Vietnam, having severe climatic and soil conditions
- The sand dunes migrate westward to invade the inner, narrow coastal plain under the action of wind and water
- The government tries for years to mitigate this hazard by implementing forestation programs using such varieties as Casuarinas, wild pineapple, eucalyptus, acacia etc. without positive result

The trial

- The trial was carried out in February 2002 with Dutch Embassy financial support
- VS was planted in 3 rows along the contour lines on the slope of the sand dune, starting from the edge of the stream
- VS was subject to different soil treatments:
  - In polybags
  - Bare root
  - With green manure
  - With good soil
  - W/o anything

1 month after planting

The trial

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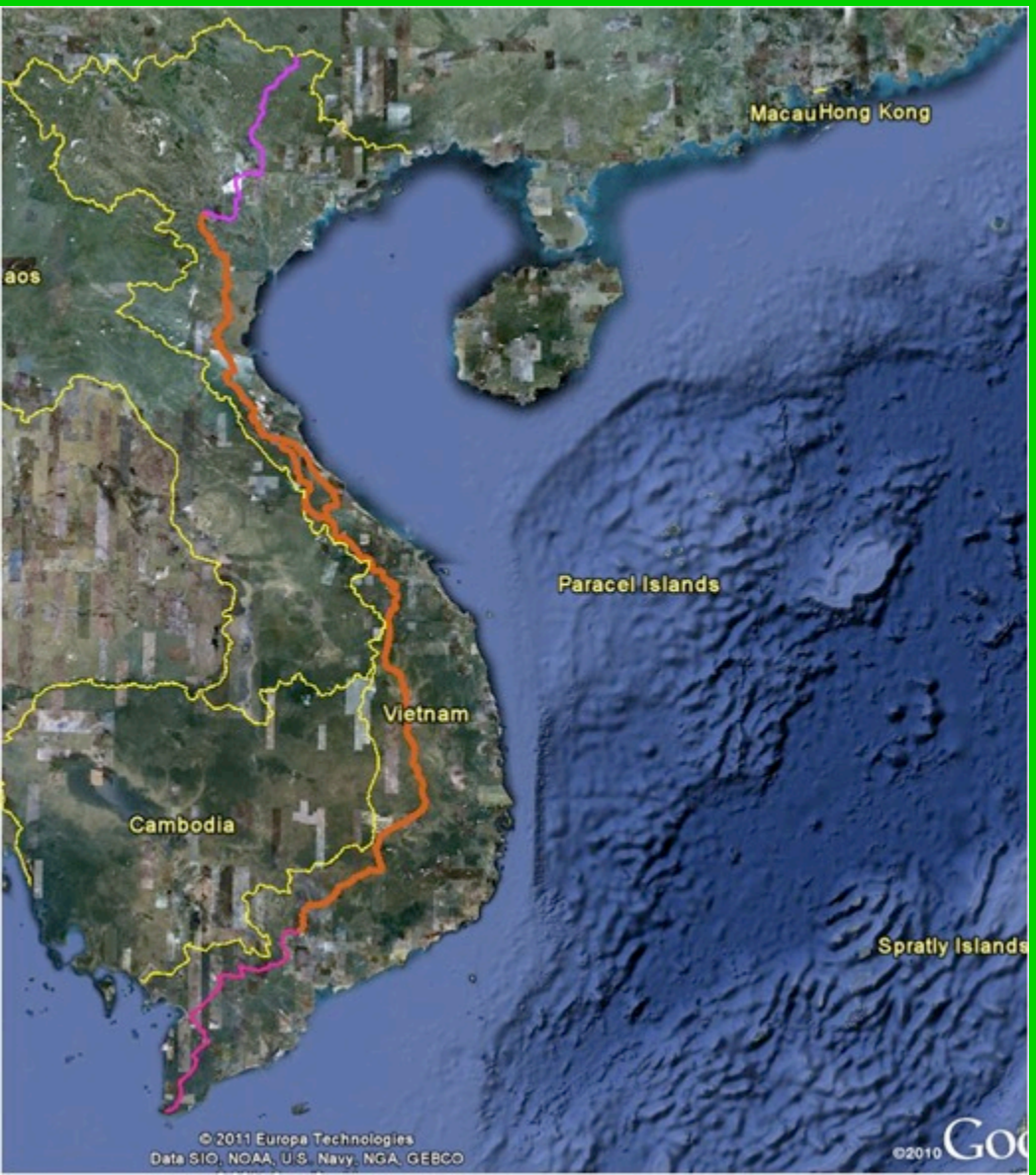
Some lessons learned

- By trying several planting options it can be concluded VS can establish on poor sand dunes as long as its root can penetrate deeply enough into the sand to get water
- Even though still young, the grass could survive both the harsh winter (<10^{o}C) and the hot summer (>40-45^{o}C)
- Under the latter condition, it is necessary to supply the grass with enough water, especially when the grass is still young (sometimes the farmers had to water the grass twice a day)
- Placing dry mulching on-top and along the rows was very useful: first to help prevent the grass from being buried by hot sliding sand; and second to help distribute the supplied water evenly and gradually).

VS application for road batter stabilization

The Ho Chi Minh Highway (HCMHW) - a brief introduction



- Master plan approved by Government in 1997;
- Construction started in 2000;
- 40-100m wide (2-8 lanes), composed of sections:
  - Section 1 (Hanoi-Quang Binh): 500km;
  - Section 2 (Quang Binh-Quang Nam): 2 branches i.e. East HCMHW, 364km; and West HCMHW, 514km;
  - Section 3 (Quang Nam-HCM City): 825km;
- Connects Cao Bang in the North with Ca Mau Cape in the South, totaling in length 3,200km. Connects with National Route No.1 by 20 traverses totaling 1,700km

The Ho Chi Minh Highway (HCMHW) - a brief introduction

At many locations the road alignment never existed before and had to go through rugged

Many cut slopes designed and constructed not to the standard, tens of m in height, very steep, often >60-75° with rare benches etc.

The Ho Chi Minh Highway (HCMHW) - a brief introduction

Ready to slide down during the rainy season

Under time pressure, at many locations the primary aim was to get the road operate first, leaving behind many other aspects e.g. safety of cut slopes, waste disposal, environmental impacts, nature conservation etc.

VS application for cut slope stabilization

In early 2002, Pham Hong Duc Phuoc (Ho Chi Minh City Agro-Forestry University) and Thien Sinh Co. tried for the first time the use of VS for a cut slope on the newly constructed HCMHW

Visited by then Vietnam's President Tran Duc Luong

In 2003, the Ministry of Transport allowed the wide use of VS for slope stabilization.

VS application for cut slope stabilization

Trial site at planting and one year later

VS application for cut slope stabilization

Trial site at planting and one year later

Some lessons learned after the first few years

The use of Vetiver helps increase the environmental friendliness of the road

Applied primarily for slope surface protection it greatly reduces surface erosion, which otherwise causes downstream hazards

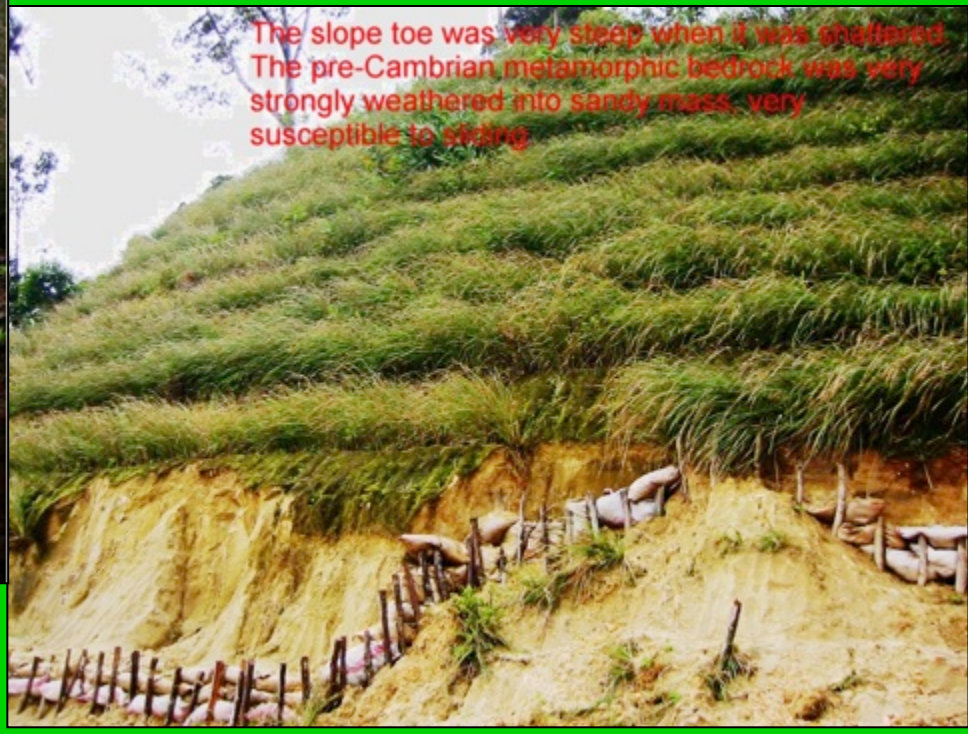
Some lessons learned after the first few years

The slopes should first be internally stable as the VS is not immediately effective (slopes can fail before roots have established)

Timing is very important as stabilization may take place earliest 3-4 months after planting

Some lessons learned after the first few years

Appropriate slope angle should not exceed 45° (H:V = 1:1) to allow for successful establishment and visible effect of VS on slope stability



Good protection of slope toe is a must even with VS, be it alone or in combination with other structural measures

Some lessons learned after the first few years

Regular trimming is important to ensure further growth of the grass to achieve good, dense hedgerows

This, unfortunately was done not on the HCMHW but downstream, on anti-salinity dyke

A few more lessons learned after a recent field check in April 2011

Deep-seated failure:

A slope instability problem can exhibit itself in the following forms:

1. Slow, gradual, either continuous or seasonal slope surface erosion;
2. Shallow, small slide, having failure surface within 1-2 m below the slope surface; and
3. Large, deep-seated slide, having failure surface sometimes exceeding a few m or even tens of m below the slope surface.

- Slope instability is usually progressive, starting from (1) via (2) to (3)
- (3) can also happen suddenly but rarely, during extremely heavy meteorological events
- VS can help prevent (1) and (2) but it can hardly, even if well designed, established and maintained, prevent (3)

A few more lessons learned after a recent field check in April 2011

Slope surface erosion, developing into gullies…

… and small, shallow landslides

A few more lessons learned after a recent field check in April 2011

… before large, deep-seated ones take place and Vetiver grass can't help

So try to stay within the capacity of the grass if it is not to be blamed in case of deep-seated failures

A few more lessons learned after a recent field check in April 2011

***Retarding failure*:**
Nevertheless, even in cases of large, deep-seated failures, VS, when established, can play a very useful role in retarding failure

Slopes constructed on strongly crushed rock/soil along a fault zone continuously fails even though it has been very gently flattened down

A few more lessons learned after a recent field check in April 2011

***Retarding failure*:**
Nevertheless, even in cases of large, deep-seated failures, VS, when established, can play a very useful role in retarding failure

A combination of VS and rock groins did a better job even though at the other end still couldn't prevent a massive failure to occur

A few more lessons learned after a recent field check in April 2011

***Retarding failure*:**
Nevertheless, even in cases of large, deep-seated failures, VS, when established, can play a very useful role in retarding failure

Planted in June 2004, visited in August 2004 … and … January 2005

A few more lessons learned after a recent field check in April 2011

***Retarding failure*:**

Nevertheless, even in cases of large, deep-seated failures, VS, when established, can play a very useful role in retarding failure

The grass couldn't help prevent a deep failure in Sept. 2004 during the rainy season (photos taken Jan 2005)

A few more lessons learned after a recent field check in April 2011

***Retarding failure*:**
Nevertheless, even in cases of large, deep-seated failures, VS, when established, can play a very useful role in retarding failure

But when established it helped restore the local vegetative cover and strongly retard the failure even though eventually a by-pass had to be made a few meters down (photos taken 4/2011)

A few more lessons learned after a recent field check in April 2011

***Slope drainage and dissipation of excessive pore pressure*:**

- Water is number one enemy of the slope

Improper drainage is an important cause of slope failure. Left photo taken Aug. 2004; Right photo taken Apr. 2011

A few more lessons learned after a recent field check in April 2011

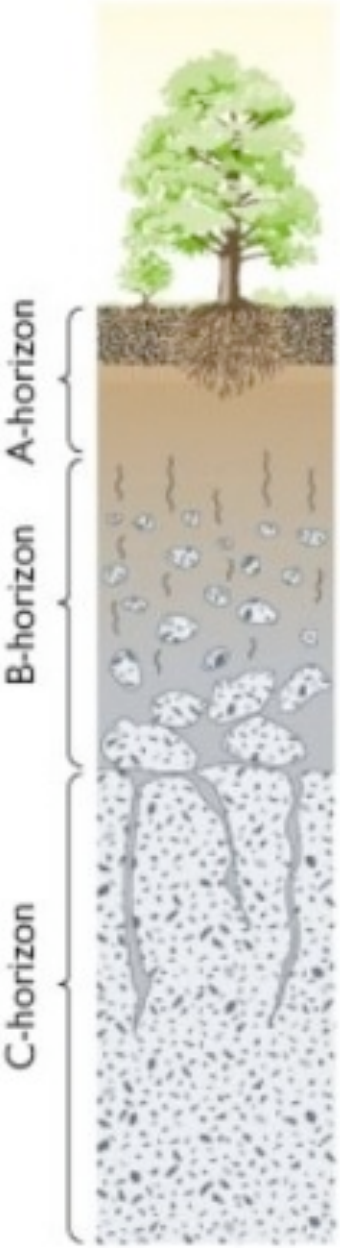
***Slope drainage and dissipation of excessive pore pressure*:**

With its unique characteristics and coupled with proper design, VS does a very good job in draining away surface run-off, dissipating excessive pore pressure and reducing infiltration

A few more lessons learned after a recent field check in April 2011

***Understanding the geology, especially the weathering profile of cut slopes*:**

- Different parts of a cut slope may differ greatly in composition, due either to the weathering process or to the original bedrock lithology and structure.
- Understanding the regional and the slope geology and particularly its weathering profile is, therefore, a must if proper design and construction is desired
- For a completely weathered cut slope, or at least it's completely weathered part, it is advisable not to exceed 45o (H:V = 1:1).
- Moreover, although VS appears versatile enough to grow on different soil types, this difference may also influence its growth and may need to be taken into account



A typical weathering profile

A few more lessons learned after a recent field check in April 2011

Vetiver grass vs. local species, or do we need long-term maintenance?

- As the VS is seasonal and no longer maintained, it cannot compete with the local, perennial (shallow-rooted) species
- it is better to provide long term and regular maintenance to ensure as deep root penetration, and together with that, slope stability, as possible.
- Another reason for doing so is to maintain the environmental friendliness of the measure.

As Vetiver is seasonal and no longer maintained, local, perennial species strongly compete, penetrating even the rock rip-rap and wire mesh

A few more lessons learned after a recent field check in April 2011

Vetiver grass and negative slope side/embankment protection:

- No VS is applied on the negative side of slopes along the HCMHW although it is very useful

Negative side failure and rigorous remedial measures

Conclusions

- From both successes and failures of numerous applications presented above, it is clear that VS, having many advantages and very few disadvantages, is a very cost-effective, community-based and environment-friendly bio-engineering tool for natural disaster mitigation and infrastructure protection.
- However it should be used with proper care, with lessons learned so as to achieve desirable results:
  - Keeping the measure within its capacity and using it in combination with other proven measures,
  - Understanding geological and geotechnical conditions; and
  - Providing long term maintenance etc.

  are probably the most important pre-requisite conditions.

THANK YOU FOR YOUR ATTENTION!