Global Review of Contribution of VST in Alleviating Climate Change Disasters

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Abstract

It has been well established that temperatures will increase, climatic events are likely to be more intense and extreme, and further stress will be added to our soil and water resources. Now it is a good time to assess how responsive the Vetiver System might be to climate change at this International Conference in Vetiver. VS is most effective in the tropics and semi tropics, but as global temperatures increase its area of application can be expanded into the more temperate areas of the world.

The Vetiver System has been tested and used widely around the world in:

- Reducing the potential damage from disasters and extreme events – land slide prevention, storm levee stabilization, erosion and flood control.
- Reducing soil erosion and conserve soil moisture that will result in improved crop yields.
- Protecting the environment from pollution in water and land
- Sequestering high amounts of atmospheric carbon.
- Providing a potential inexpensive fuel and energy source

However, the most obvious contribution of Vetiver System (VS) to the impact of climate changes is its prevention and mitigation of natural disasters such as landslides, floods and extreme erosion.

This paper reviews the contribution of the VS in alleviating the disastrous consequences of climate changes in Australia, Brazil, Congo, India, Madagascar, Thailand, Vietnam and Venezuela.

1. INTRODUCTION

The Vetiver System Technology (VS) was first developed for soil and water conservation in farm lands by the World Bank in the 1980s. While this application still plays a vital role in agricultural lands, vetiver grass unique morphological, physiological and ecological characteristics including its tolerance to highly adverse growing conditions and tolerance to high levels of heavy metal provide an unique solution for environmental protection and climate change alleviation.

1.1 Brief History on the Development of VS:

Phase 1: Soil and water conservation in farm land:

- Soil erosion control on sloping land
- Water conservation by retarding runoff and increase in filtration

- *International Vetiver Workshop, Kuala Lumpur, 1999*

Phase 2: Land stabilisation

- Road and railway embankment stabilisation
- River and canal bank stabilisation
- *International Conference on Vetiver 2:* ***Vetiver and the Environment*** *(Jan 2000, Thailand)*

Phase 3: Environmental Protection

- Wastewater
- Contaminated land and mine rehabilitation
- *International Conference on Vetiver 3:* ***Vetiver and Water*** *(Oct 2003, Thailand)*

Phase 4: Socio-economic

- Poverty alleviation
- Rural employment
- *International Conference on Vetiver 4:* ***Vetiver and People*** *(Oct 2006, Venezuela)*

Current phase: Combination of all above to combat Climate change

- *International Conference on Vetiver 5:* ***Vetiver and Climate Change*** *(Nov 2011, India)*

1.2 VS as a Bio-engineering Tool

The use of vegetation as a bio-engineering tool for erosion control and slope stabilisation have been implemented for centuries but its popularity has increased in the last decades. This is partly due to the low costs of bio-engineering techniques, partly to the 'soft' vegetative approach instead of the 'hard' conventional engineering structures which have been the concern over the visual degradation of the environment caused by infrastructure development and partly due to the fact that more knowledge and information on vegetation are now available for application in engineering designs.

1.3 Some Special Characteristics of Vetiver Grass Suitable for Bio-Engineering.

- Extremely deep and massive finely structured root system, capable of reaching down to two to three metres in the first year. This extensive and thick root system binds, reinforces and pinning the soil and at the same time makes it very difficult to be dislodged
  - Roots having high tensile (6-10 kPa/kg of root per cubic metre of soil) compared to 3.2-3.7 kPa/kg for tree roots.
- Roots having high shear strength
- Deep and massive roots provide pore pressure reduction, and extremely tolerant to drought.
- Stiff and erect stems which can stand up to relatively deep water flow (0.6-0.8m).
- Tolerance to extreme climatic variation such as prolonged drought, flood, submergence and extreme temperature from -14^{o}C to 55^{o}C.
- Ability to regrow very quickly after being affected by drought, frost, salt and other adverse soil conditions when the adverse effects are removed.

- Wide range of soil pH (3.0 to 10.5)
- High level of tolerance to soil salinity, sodicity, heavy metals and acid sulphate soil

2.0 RECENT RESEARCH ON STEEP SLOPE STABILISATION

The Institute of Road Engineering (IRE), Ministry of Public Works, Indonesia, has conducted extensive research on steep slope stabilisation and has concluded that:

- VS can be used effectively to control surface erosion and shallow failure of road slope
- VS can be used effectively at slope 30^o – 60^o
- VS could be applied by road authority to cope with erosion and shallow failure of road slope
- At road slope > $60^{o,}$ vetiver technology is not recommended to applied solely (must combined with mechanical method)

Slope gradient 80^o

Slope gradient 60^o

Slope gradient 45^o

Slope Gradient 30^o

3.0 3.0 CONTRIBUTION OF VS IN ALLEVIATING THE DISASTROUS CONSEQUENCES OF CLIMATE CHANGES IN AUSTRALIA,

3.1 Flood erosion control at Laidley

A major drainage channel that runs across the town of Laidley in Queensland. In summer this channel often flows at full capacity due high runoff (up to 400 cumecs) from the hills east of the town. This often results in flash flooding. At the head of the channel, runoff water is first concentrated in an area of approximately one hectare. This area received very

high velocity flows during summer storms and in times of flash flooding severe erosion occurred after every major flooding event.

Following a severe erosion occurred during the last flood the Laidley Shire decided to use the Vetiver System instead of conventional engineering structures to control flood erosion damage as these structures are not only too expensive but also not very effective in the past. Site construction started in 2000 and since the vetiver planting has successfully protected this area from several major and flash floods, especially the flood erosion during the January 2011 massive flood, with water level over topping the banks by several meters.

Layout of vetiver rows at the head of the drain and flood flow at 5m/sec

Eight year old Vetiver hedges before the big flood

Eight year old Vetiver hedges after the big flood

Strong current lifted this concrete fence post (left) and move this shipping container 23km from upstream (right, while the undamaged vetiver rows fully protected the drain

3.2 Flood erosion control at Logan

A major waterway draining a large catchment along the Logan Motorway was severely eroded due to erodible soil, large volume and high velocity flows during the wet season. Several attempts in the past using conventional engineering methods have failed, so a combined hard structures and bioengineering using vetiver was installed. The results was outstanding, while vetiver was very effective in controlling erosion both on the bank and floor of the drain, the hard structures, including gabions failed during normal high flows resulted from flash floods and record rainfall \ in the past three years. But more impressively, VST has provided excellent protection against flood erosion during the January 2011 massive flood, with water level almost topping the banks. (Fig. 4,5).

The badly eroded drain before and after vetiver planting. Vetiver conditions before the flood

Vetiver planting after the flood and no damages to the banks during flood (left) when flood level almost topping the banks. Flood washed away rock on the groyne while vetiver stayed put (right)

3.3 Landslide prevention at Samford Valley

A heavy down pour in 2008 caused this landslide on a house block on a very steep hill, vetiver was planted after site reparation. Due to the steep gradient of the slope it was first protected by jutemesh during vetiver establishment phase. Vetiver planting has successfully stabilised this very steep and difficult site and protected it from further erosion in the next two years despite periods of record rainfall. The slope remained stable during the very high and intense rains in January 2011.

Landslide threatened the foundation of this house on a very steep hill. The slope was repaired and vetiver planting provided full protection two years after planting

The house was fully protected during the record breaking rain fall in January 2011

4.0 CONTRIBUTION OF VS IN ALLEVIATING THE DISASTROUS CONSEQUENCES OF CLIMATE CHANGES IN ASIA

4.1 China

Initially, the Vetiver System was introduced to China in 1988 for soil and water conservation in agricultural lands. But later it was s adopted for bioengineering as people found it could be used in civil engineering construction such as slope stabilization. In some provinces, the application of VS has become an official policy and a regular activity adopted for highway and railway embankment protection. These structures have remained stable despite highly adverse weather conditions including several typhoons in the last 10 years.

Before and after vetiver planting on a highway in Fujian province

4.2 India

Tremendous advances have been made in the application of VS for erosion control and disaster mitigation since the national conference organised by the Indian Vetiver Network in Kochi in February 2008. In the north, MP Singh has successfully promoted and applied VS on several sites in Punjab. All these works have provided sustainable protection to these structures in spite of several heavy and intense storms in the last few years.

Before and after result of MP Singh rehabilitation work in Punjab

Before and after result of MP Singh erosion control work in Punjab

The Vetiver system was introduced to Assam in the beginning of the year, 2009 with the formation of Eastern Vetiver Network, India and Shantanoo Bhattacharyya has used VS for two major bioengineering projects- one to stabilize a big bridge approach and the other to protect against the severe erosion of the Brahmaputra and steep slope stabilisation in Sikkim

Before and after result of Shantanoo Bhattacharyya to protect a big bridge approach against the severe erosion on the Brahmaputra

4.3 Thailand

Under the guidance of the King of Thailand and Princess Maha Chakri Sirindhorn, TVNI Patron, R&D of the VS Thailand is leading the world in its applications. But the most outstanding effort is the works achieved by the Department of Highway in developing a sustainable program for construction and maintain the numerous roads and highways in Thailand. More details will be presented separately by Mr Surapol Sanguankaeo et al. at his conference.

Before and after Vetiver planting on a very steep fill batter of a road in Thailand

4.4 Vietnam

The Ho Chi Minh Highway is more than 3 000km long, stretching over the whole length of Vietnam, from the Chinese border in the north to the gulf of Thailand in the south. It runs over skeletal mountainous soils and cold winter in the North and central Vietnam to alluvial and extremely acidic sulfate soil and hot and humid climate in the South. All of which are highly erodible and unstable in the monsoon and cyclone seasons. Vetiver planting is the main method of stabilization of deep cut and high fill slope, and landslip mitigation. This is probably the largest application of Vetiver System for infrastructure protection in the world. Update of the stability of this project will be presented by Van Tran at this conference.

Before and after Vetiver planting on a very steep cut batter of the HCM Highway

In addition to the HCM Highway project, VS has been also used successfully to protect sea dikes against typhoons devastating destruction.

Before and after Vetiver planting on a sea dike in Hai Hau, north Vietnam

5.0 CONTRIBUTION OF VS IN ALLEVIATING THE DISASTROUS CONSEQUENCES OF CLIMATE CHANGES IN AFRICA

5.1 Congo

Drought, flooding and erosion are a few of the convincing signs of climate change in sub-Saharan Africa. In Brazzaville, the capital of the Republic of Congo, there has been for over a decade, high intensity rainfall. This high level of rainfall has caused and continues to cause more erosion and massive property damage, including destruction of roads, homes, etc.

During the same period, conventional engineering efforts to halt erosion damage have remained ineffective. Given these difficulties, the idea of integrating bio-engineering technology, including the VS into the conventional technology. The followings photos clearly demonstrated its effectiveness not only in erosion control, but will also ensure the protection and sustainability of conventional structures to be built in the future.

The results so has have been an outstanding success. The ravines remained stable and fully protected from tropical torrential rains on the last few years. Here is proof:

Initial status at the Boukeni ravine, before placing sandbags and planting vetiver

Placing bags containing topsoil and vetiver planting on the Boukeni site (February 2009)

The Boukeni site 2 months after planting vetiver directly into the bags of topsoil (April 2009)

Status of the vetiver cover at Boukeni 10 months after planting (November 2009)

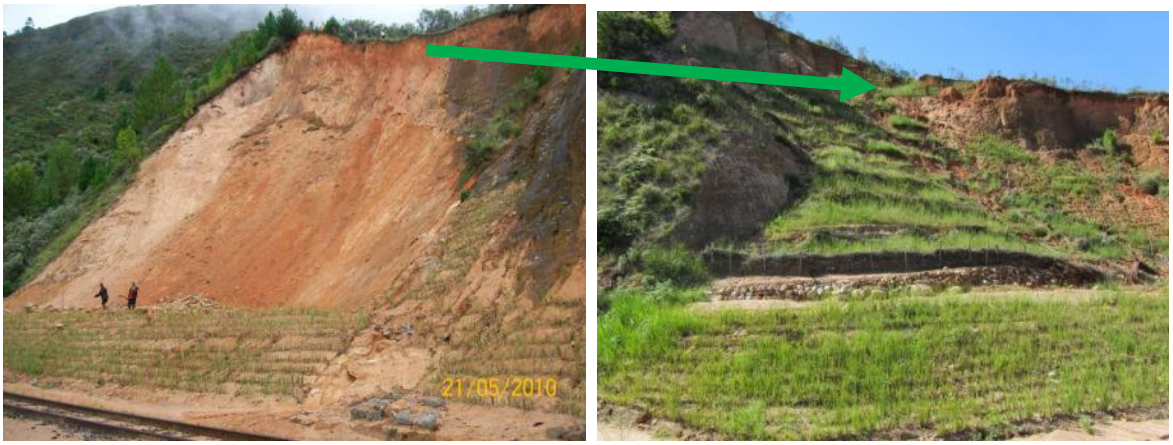
The Pylôn site two months after planting vetiver on parts of the site (June 2009)

The Pylône site 23 months after planting vetiver (May 2011)

5.2 Madagascar

Lavaka is a massive form of landslide very common in Madagascar due to the deep and highly erodible volcanic soil and high torrential rainfall. This erosion problem occurs on big steep slope, disrupted traffic and sometimes forces the railway lines to be relocated. Up to now there has been no effective and low cost solution. But Vetiver System Technology has provided the needed solution.

In addition VST has also provided an effective and low cost solution to another major problem in Madagascar - Wind erosion on coastal sand dunes - where VST has been used successfully to alleviate sand dunes erosion.



Before and after result of Yoann Coppin's work on Lavaka rehabilitation

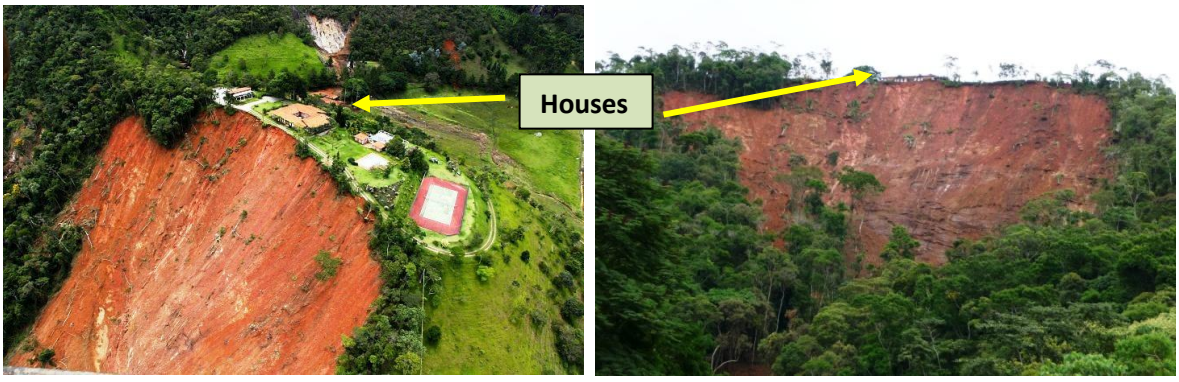
Before and after result of Roley Noffke's work on coastal dune stabilisation

6.0 CONTRIBUTION OF VS IN ALLEVIATING THE DISASTROUS CONSEQUENCES OF CLIMATE CHANGES IN THE AMERICAS

Extensive applications of the Vetiver System for road and railway batter stabilisation projects in North America, Central America and South America.

6.1 Brazil,

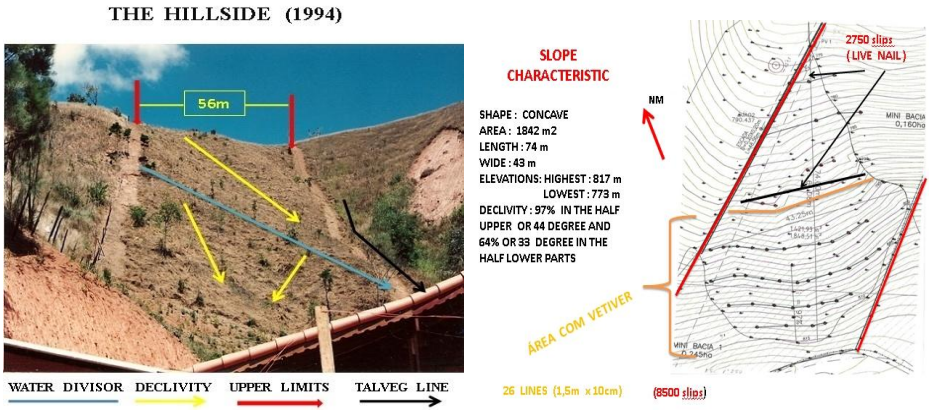
Brazil has suffered massive world-news landslides in recent years due to torrential rains. For example this is one of the many sites in Rio de Janeiro State.



On February 02, 2008 heavy rains and intense lightning occurred for about 3.5 hours, causing landslide on the ranch of João Eboli in Itaipava, district of Petrópolis. Before the landslide, the hill was covered with natural grass and native bushes (Fig.1). The landslide had the shape of a concave basin of 1840 m^2, with a length of 74m and a width of 43m, funnel shaped towards the lower side, and vertical height of 47m (elevation of the highest point:817m and lowest point: 770m). Right after the owner read about Vetiver grass, which is available in Brazil and appropriate for use in slope stabilization. He studied the plant characteristics and decided immediately to try and use it on his landslide area with the aim to provide long term slope stability. He planned, designed and implemented the stabilisation and rehabilitation of the slope with four employees.

The results are outstanding and have clearly demonstrated the real potential of the VST in mitigating the effects of the climate changes that currently provokes the natural disasters on the environment around the world, as it happened here. João Eboli concluded that:

- VS is a cheap, effective and safe solution for the rehabilitation of landslides and reduction of landslips incidence in high rainfall region
- The VS will fail when not properly applied or not well maintained. The VS when installed and following the correct technical guidelines is a guaranteed success.
- Perhaps the only real defect of the Vetiver solution is: ***Too cheap to be true, too cheap to believe when compared to heavy stone structures.***
- Here is the final living proof



April 2008 **January 2011**

More details of this work will be presented separately at this conference by Joao Eboli

6.2 Other Latin American countries.

The following is an example from Venezuela, more details of this work will be presented separately at this conference by Eng. Raphael Luque.

Before and after result of Raphael Luque's work landslide stabilisation in Venezuela

Before and after result of Jorge Lodono's work on landslide stabilisation in Colombia

7.0 CONCLUSION

From the successes of numerous applications presented above, it is clear that we now have enough evidence that VST is a very effective and low cost bio-engineering tool for the protection and rehabilitation of lands devastated by climate changes.

However it must be emphasised that to provide an effective and sustainable protection and rehabilitation program, the all-important point is ***appropriate design and correct planting techniques must be applied***.

A Brief Introduction to the author.

Dr. Paul Truong, a Board Director and Asia and Oceania Representative of The Vetiver Network International, and recently Principal Consultant of Veticon Consulting. In the last 20 years he has conducted extensive R&D and Application of the Vetiver System in erosion and sediment control, land rehabilitation and environmental protection in tropical and subtropical Australia, Asia, Africa and Latin America.

His pioneering research on vetiver grass tolerance to adverse conditions, heavy metal tolerance and pollution control has established the benchmark for VS applications in wastewater treatment, toxic wastes and mine rehabilitation which he has won several World Bank and the King of Thailand Awards.