Socio-Economic Benefits of the Vetiver System Technology in Mining Areas in Developing Countries

By
Paul Truong

Office of the Royal Development Projects Board
Bangkok, Thailand
November 2014
The Pacific Rim Vetiver Network (PRVN)

**Objective:** To serve the countries of the Pacific Rim as the center to collect, compile and disseminate information on the use of vetiver in the forms of newsletter, occasional publications, and homepage of the internet.

**Member Countries:** The following 20 countries, geographically situated in the Pacific Rim, are members of the PRVN: Australia, Brunei, Cambodia, China, Cook Islands, Fiji, Indonesia, Japan, Lao PDR, Malaysia, New Caledonia, New Zealand, Papua New Guinea, Philippines, Samoa, Taiwan, Thailand, Tonga, Vanuatu, and Vietnam.

**Scientist Members:** Scientists of the member countries of the PRVN who had made prior contact with the RDPB are automatically registered as the PRVN members, which at present amount to about 800. Others who want to join the Network can apply directly to its Secretariat Office. No application form in necessary. Those who are interested to apply just identify themselves with name, current position, place of work, and mailing address, e-mail address, and other information which they deem necessary.

**Activities:**

- **Newsletter:** An 8 to 16-page quarterly English-language newsletter under the name of VETIVERIM has been issued, starting first number in July 1997. Its circulation is 500 copies for each number. It has been sent in bulk to the Country Representatives of the member countries for further distribution to scientists and institutes within the country in order to save postage and other difficulties in international mailing. Starting from No. 63, an e-mail edition has been issued.

- **Internet Homepage:** The PRVN has established its internet homepage which can be seen through: http://prvn.rdpb.go.th. Scientists of the member countries, or from other regions for that matter, are invited to submit information on new research and technologies on vetiver, especially those appropriate to the Pacific Rim countries. Information and pictures are most welcome and can be sent to the PRVN Secretariat by mail, fax, or e-mail (see addresses below).

- **Publications:** It has been the intention of the Secretariat to publish technical bulletins and other documents, as and when opportunity arises. A series of technical bulletins (from one to three bulletins per year) have been launched since April 1998. So far, 20 bulletins have been issued.

**The Secretariat**

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By

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November 2014
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Foreword

One of the immediate activities of the Pacific Rim Vetiver Network (PRVN) is to disseminate information on the Vetiver System (VS), especially those techniques that are adaptive to local conditions of developing countries in the Pacific Rim. In this connection, the PRVN Secretariat is publishing a series of technical bulletins (TBs) that provide useful information about the VS to readers who are active members of the PRVN.

Since 1998, one to three TBs have been published annually. Altogether, 20 TBs have been published. These are:

- 1998: (1) "Vetiver Grass Technology for Environmental Protection" by Paul Truong and Dennis Baker; and (2) "Vetiver Grass for Slope Stabilization and Erosion Control" by Diti Hengchaovanich.
- 1999: (1) "Vetiver Handicrafts in Thailand" by the (Thai) Department of Industrial Promotion; (2) "Vetiver Grass Technology for Mine Rehabilitation" by Paul Truong; and (3) "The Use of Vetiver Grass System for Erosion Control and Slope Stabilization Along the Yadana Gas Pipeline Right-of-Way" by the Petroleum Authority of Thailand.
- 2000: (1) "Techniques of Vetiver Propagation with Special Reference to Thailand" by Narong Chomchalow.
- 2001: (1) "The Utilization of Vetiver as Medicinal and Aromatic Plants with Special Reference to Thailand" by Narong Chomchalow; (2) "Vetiver System for Wastewater Treatment" by Paul Truong and Barbara Hart; and (3) "The Development of the Vetiver System in Guangdong, China" by Hanping Xia.
- 2002: (1) "The Role of the Private Sector in Disseminating the Vetiver System with Special Reference to China" by Hanping Xia; and (2) "The Use of Vetiver for Soil Erosion Prevention in Cassava Fields in Thailand" by Somsak Suriyo and Wilawan Vongkasem.
- 2003: (1) "Vetiver Root - Oil and Its Utilization" by U.C. Lavania; (2) "Vetiver Victorious: The Systematic Use of Vetiver to Save Madagascar’s FCE Railway" by Diti Hengchaovanich and Karen Schoonmaker Freudenberger; and (3) "Research, Development and Implementation of the Vetiver System for Wastewater Treatment" by Paul Truong and Cameron Smaal.
- 2004: (1) "Utilization of Vetiver as a Construction Material for Paddy Storage Silo" by Pichai Nimityongskul and Thammanoon Hengsadeekul.
- 2006: (1) "Rehabilitation of Ravine on the Congolese Floodplain" by Alain Ndona, Paul Truong and Dale Rachmeler.
- 2009: (1) "Vetiver Phytoremediation for Heavy Metal Decontamination" by Nualchavee Roongtanakiat and (2) Application and Development of the Vetiver System in China: 20 Year Experience Retrospection" by Liyu Xu.
- 2013: (1) Application of the Vetiver System for Wastewater Treatment: An Innovative Nutrient Removal Technology for Sewage Water Treatment in Southern Guam" by Mohammad H. Golabi and Manuel Duguies.
- 2014: (1) Extreme Slope Stabilisation Using Vetiver System" by Paul Truong.

The present publication is TB 2014/2, “Socio-Economic Benefits of the Vetiver System Technology in Mining Areas in Developing Countries” by Paul Truong.

On behalf of the PRVN, we wish to express sincere thanks to the author, Dr. Paul Truong, a Board Director and Asia and Oceania Representative of TVNI for his great contribution. It is hoped that this publication will be of value to vetiver scientists and others who would like to know more about the Vetiver System applications in mine rehabilitation.

Narong Chomchalow
Coordinator, Pacific Rim Vetiver Network
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SOCIO - ECONOMIC BENEFITS OF THE VETIVER SYSTEM TECHNOLOGY IN MINING AREAS IN DEVELOPING COUNTRIES

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1. The Vetiver Grass

**Morphological Attributes:** Stiff and erect stems up to 2m tall and over 2.5m with flower head

- Forming a thick hedge when planted in row
- Young plant stiff enough to trap large gravel

**EXTENSIVE AND DEEP ROOT**

- **China:** One year old with 3.3m deep root system
- **Australia:** One year old, 1.3m and root bound

(These roots have a tensile strength equivalent to 1/6 mild steel reinforcement)

**Physiological Attributes**

- Vetiver grass is both a xerophyte and a hydrophyte and, once established, is not affected by droughts or floods.

- Adaptability to a wide range of soil and climatic conditions,
  - Can be established in sodic, acidic, alkaline and saline soils,
  - Tolerant to drought due to deep and extensive root system,
  - Mature plants are tolerant to extreme heat (50°C) and frost (-14°C).

- Vetiver can withstand burning, slashing and moderate tractor traffic.
- Vetiver is resistant to infestation from most pests, diseases and nematodes.
- Vetiver grass is extremely long-lived and has been observed to persist for over 50 years.
## Adaptable Range of Vetiver Grass in Australia and Other Countries

<table>
<thead>
<tr>
<th>Adverse Soil Conditions</th>
<th>Australia</th>
<th>Other Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidity</td>
<td>pH 3.3</td>
<td>pH 4.2 (with high level soluble aluminium)</td>
</tr>
<tr>
<td>Aluminium level (Al Sat. %)</td>
<td>Between 68% - 87%</td>
<td>80%-87%</td>
</tr>
<tr>
<td>Manganese level</td>
<td>&gt; 578 mgkg⁻¹</td>
<td></td>
</tr>
<tr>
<td>Alkalinity (highly sodic)</td>
<td>pH 9.5</td>
<td>pH 12.5</td>
</tr>
<tr>
<td>Salinity (50% yield reduction)</td>
<td>17.5 mScm⁻¹</td>
<td></td>
</tr>
<tr>
<td>Salinity (survived)</td>
<td>47.5 mScm⁻¹</td>
<td></td>
</tr>
<tr>
<td>Sodicity</td>
<td>33% (exchange Na)</td>
<td></td>
</tr>
<tr>
<td>Magnesicity</td>
<td>2 400 mgkg⁻¹ (Mg)</td>
<td></td>
</tr>
</tbody>
</table>

### Heavy Metals

<table>
<thead>
<tr>
<th>Element</th>
<th>Threshold levels in soil (mgKg⁻¹)</th>
<th>Threshold levels in plant (mgKg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>100-250</td>
<td>21-72</td>
</tr>
<tr>
<td>Cadmium</td>
<td>20-60</td>
<td>45-48</td>
</tr>
<tr>
<td>Copper</td>
<td>50-10</td>
<td>13-15</td>
</tr>
<tr>
<td>Chromium</td>
<td>&gt;1 500</td>
<td>&gt;78</td>
</tr>
<tr>
<td>Lead</td>
<td>200-600</td>
<td>5-18</td>
</tr>
<tr>
<td>Mercury</td>
<td>&gt; 6</td>
<td>0.02-0.20</td>
</tr>
<tr>
<td>Nickel</td>
<td>100</td>
<td>347</td>
</tr>
<tr>
<td>Selenium</td>
<td>&gt;74</td>
<td>&gt;11</td>
</tr>
<tr>
<td>Zinc</td>
<td>&gt;750</td>
<td>880</td>
</tr>
</tbody>
</table>
2. Vetiver System Technology and Applications

The VST is based on the application of vetiver grass and its unique and extraordinary attributes.

The major applications of VST are:

1. Soils and water conservation in farm land
2. Infrastructure protection by bioengineering
3. Environmental protection by phytoremediation
   - Wastewater treatment: Sewage effluent, landfill leachate and industrial wastewater
   - Mine rehabilitation and industrial contaminated land
4. Poverty alleviation

*Globally over 100 countries are using VST for at least one of these applications (www.vetiver.org)*

**VST Application: Soils and Water Conservation in Farm Land**

- Flood erosion and sedimentation control on the Darling Downs flood plain, Queensland
- Soil erosion and sedimentation control on sugar cane field in North Queensland
VST Application: Infrastructure Protection by Bioengineering

Vetiver
Other grass

Mackay, Central QLD
Road Batters
El Salvador, Central America
Cooktown, Nth Qld

Dam wall Guangzhou, China

HCM Hiway, Vietnam

VST Application: Wastewater treatment - Sewage and Leachate

Sewage effluent, Ephemeral Wetland, Qld
Teys Abattoir, Beenleigh, Qld

Landfill leachate, Tweeds, NSW
Sewage effluent, Boonah, Qld
VST Application: Mine Rehabilitation - Overburden

Vetiver

Other grasses

Coal mine overburden, Ipswich, Qld

Bentonite mine overburden, Miles, Qld

VST Application: Mine Rehabilitation – Tailings

Coal Tailings, Emerald, Qld

Vetiver had the best growth among the 5 species used in central Qld.

pH 3.7
SiO₂ 8500ppm
S 3.77%
As 970ppm
Ba 710 ppm
Cu 230 ppm
Pb 290 ppm
Se 350 ppm
Zn 5600ppm

Redmud, Alcoa, Gove, NT

Bermuda grass grows on higher ground which is less caustic.

Good establishment and growth with some lime and fertilisers

Old gold Tailings, Kidston, Qld
Fresh Gold Tailings, Kidston, Qld.

The Flexible Vetiver Hedges Provided a LowCost Wind Barrier, Provided Excellent Protection for Crop Establishment.

- Millet cover crop to control wind erosion
- The dust is highly contaminated with heavy metals such as Arsenic, Copper etc.
- Rhodes Grass
- 10 years later and grazed by stock
VST Application: Poverty Alleviation

3. Benefits of VST in Mining Areas in Developing Countries

Rural employment: Plant production in Madagascar and Vietnam
4. Case Studies of Benefits of VST in Africa, Latin America and Asia

1. MADAGASCAR: Local employment, professional training and income

2. VENEZUELA: Local employment, professional training and income

3. VIETNAM: Local employment and income

4. WEST AFRICA: Local employment, professional training and income
CASE STUDY 1: Madagascar  Demographics

- 4th biggest Island in the world with a population around 20 Million
- 80% of population live below the poverty line.
- Only 54% of population in urban areas & 4% in rural areas have access to potable water.
- Life expectancy is 52 years with 46% literacy.
- Infant Mortality is 89 per 1,000
- Economic isolation for many communities resulted from the collapse of the regional & national road network system with 80% of roads impassable for up to 10 months per year
- Massive environmental degradation (biodiversity)

The Project: Erosion and sediment control of highly erodible sand dunes on service road at Rio Tinto Ilminite mine at Fort Dauphin

Before

After
**The Project**

- Started in 2006 with 15 communities and expanded to 32 communities by 2008.
- Involved 133 families over the project period.
- 4,000,000 Vetiver plants were propagated & supplied.
- 40 hectares were stabilised and revegetated with commercial and locally harvested native grass seed species used in mixture.
- Vetiver was inter-planted with native dune vegetation.
- *This community based “Vetiver propagation program” has generated approximately US$250,000 collectively to the respective communities within the construction period.*

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**Nursery Establishment Training**

- Nursery establishment training
- Family nursery
- Project implementation

**Obtaining Vetiver for home nurseries**

- Well established nurseries and new houses built from nursery production and employment income
CASE STUDY 2: VENEZUELA – Poverty Alleviation and Rural Employment
The Project: Open Cut Bauxite Mine at Los Pijiguaos

Employment and Technical Training

Indigenous people at Fort Dauphin

Project implementation
VENEZUELA: Poverty Alleviation and Rural Employment by Handicraft Production

- **Introduction**
- **Training**
- **Growing Vetiver**
- **Harvesting**
- **Handicraft Production**
- **Marketing**

**VST for erosion and sedimentation control at Los Pijiguaos Bauxite mine**

- **Fill slope**
- **Cut slope**
- **Drainage channel**
- **Dam wall**
Number of family and people involved from 2002-2006
(3,673 families and 11,019 local people)

Number of direct and indirect people employed from 2002-2006
(3,673 direct people employed and 367 indirect people employed)
CASE STUDY 3: VIETNAM - Infrastructure Protection

The Project: The Ho Chi Minh Highway

Before and after VST application on the 3,000-km Highway from the Chinese border to the gulf of Thailand

Community nurseries along the Highway
Local employment during implementation phase

CASE STUDY 4: VIETNAM - Infrastructure Protection

The Project: Flood mitigation in the Mekong Delta

Flood water causing severe erosion on dikes

Vetiver planting on outer wall of the dikes

Effectiveness of vetiver planting in protecting dikes from flood erosion
CASE STUDY 5: Some Major Mining Projects in Africa

Rio Tinto Bauxite mine at Simandou, Guinea, West Africa
Excessive Erosion Caused by Surface Water Runoff

Before & After VST Application for Slope Stabilisation – Reasonable cover attained on slopes PC
540 ha of tropical jungle situated on the Equator removed in one operation, resulting in a civil and environmental disaster
Phase 1: 20 ha side slopes rehabilitated with VST

GSEZ Nkok, Gabon, West Africa

Work Undertaken
- 30,000m vetiver grass hedge rows
- Bio-Jute – 10,000 m²
- Silt fences - 3,600 m¹
- Sand Bags – 2,500 m¹
- Hydroseeding -200,000 m²

Climatic Conditions
Annual rainfall + 3700mm
2 Rainy seasons – September to December & May to July

Ambatovy Access Road Project, Moramanga, Madagascar

PC: R Noffke
Installing Erosion Control Structures, VST & Hydoseeding

All Vetiver Plants and Labor are Sourced from Local Communities

Malomanye Village On-Site Training in Soil Conservation Techniques
The Office of the Royal Development Projects Board and the Establishment of PRVN

His Majesty King Bhumibol Adulyadej of Thailand has been dedicated to development work ever since the beginning of his reign in 1946. His Majesty has become familiar with the problems and real conditions of the people through constant visits to every region of the country, often accompanied by Her Majesty Queen Sirikit and other members of the Royal Family. It is during these many Royal visits to the rural areas that His Majesty has realized the need to initiate development projects that would directly benefit the people at the grassroots. Thus, the first Royal Development Project was launched in 1952 followed by numerous projects, which currently reach the total of 4,447.

However, the implementation of the Royal Development Projects in the past lacked cohesiveness because each agency carried out the work on its own without coordinating with other concerned agencies. Therefore, in order to serve and implement the Royal initiatives through a consistently integrated system which allows the Royal Development Projects to run efficiently, the Thai government issued a “Regulation of the Office of the Prime Minister” which became effective on 9 September 1981. The Regulation led to the establishment of the Coordinating Committee for Royal Development Projects which later became the Royal Development Projects Board in 1993. The Board has the major task of directing, monitoring and coordinating the operation of government agencies and state enterprises concerning the Royal Development Projects. Moreover, it considers and approves projects, plans and activities as well as expenditures to be used in the operation of the projects. All of these tasks are supported by the Office of the Royal Development Projects Board (ORDPB), the secretariat of the Board.

With agriculture being the backbone occupation in the Thai society, His Majesty the King understood the vital need in preserving natural resources and therefore, initiated the vetiver grass project in Thailand. The project principally aimed to mitigate soil erosion, a distinct aspect of environmental deterioration in Thailand which needs to be managed properly. His Majesty recognized the potential of vetiver grass as a practical and inexpensive yet effective management and conservation tool to address the soil erosion problem. As a result, the Committee on the Development and Promotion of the Utilization of Vetiver (CODPUV) under His Majesty’s Initiative was set up under the administration of the ORDPB in 1992 to look after all the Royally-initiated vetiver projects implemented in various parts of the country. The First International Conference on Vetiver (ICV-1) was co-organized by the Chaipattana Foundation and the Mae Fah Luang Foundation with the collaboration of the World Bank and the FAO. The main purpose was to commemorate the 50th Anniversary Celebrations of His Majesty the King’s Accession the Throne.

Immediately after ICV-1, a proposal was made by Mr. Richard Grimshaw, who was then the President of the Vetiver Network, to establish the Pacific Rim Vetiver Network (PRVN) in Thailand with the principal objective of serving as the center to collect and disseminate information on the use of vetiver grass in the form of newsletters, occasional publications as well as a homepage on the internet. His Majesty the King agreed with the proposal and commissioned the setting up of the PRVN under the supervision of the CODPUV, to be administered by the ORDPB. The PRVN then became active with the establishment of a working team on 6 May 1997.
The Author

Dr. Paul Truong is a Board Director and Asia and Oceania Representative of The Vetiver Network International (TVNI), and CEO and Principal Consultant of Veticon Consulting. His pioneering research on vetiver grass tolerance to adverse conditions, heavy metal tolerance and pollution control has established the benchmark for Vetiver System applications in toxic wastes and mine rehabilitation, and wastewater treatment, which he has won several World Bank and the King of Thailand Awards. 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, Mediterranean Europe, Latin America and the USA.