THE VETIVER NETWORK INTERNATIONAL FUTURE DIRECTION

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INTRODUCTION TO THE VETIVER SYSTEM TECHNOLOGY

Historically, VST develops in the following order:

1. **Soil and Water Conservation in Agricultural Land**
   Contour hedges
2. **Stabilisation of Infrastructures**
   Bioengineering
3. **Environmental Protection**
   Phytoremediation of wastewater
   Phytoremediation contaminated lands
4. **Socio-economic impact on rural community**
   Poverty alleviation
   Rural employment
5. **Positive impacts on climate change**
   Disaster mitigation
   Carbon sequestration
   Bio-fuel

SUMMARY AND HIGHLIGHTS OF PAPERS SUBMITTED TO ICV6, DANANG, VIETNAM, May 2015

There were altogether 69 papers and 4 Posters from 26 countries and all 5 continents:

- **Asia:** Bangladesh, China, India, Indonesia, Iran, Malaysia, Nepal, Philippines, Thailand and Vietnam
- **Africa:** DR Congo, Ethiopia, Ghana, Nigeria and South Africa
- **America North**: USA
- **America South:** Brazil, Chile, Colombia, Guatemala and Peru
- **Europe**: Italy
- **Oceania**: Australia, New Zealand and Papua New Guinea

Distribution of Submissions to ICV6

Category	Applications	Research	Applications	Total
1	Infrastructure Protection Bioengineering	3	9	12
2	Environmental Protection Phytoremediation	7	7	14
3	Sustainable Agriculture Soil and Water Conservation	4	8	12
4	Socio-economic Impact Poverty Alleviation and Rural Employment	1	9	10
5	Research and Innovation Agricultural, industrials and Climate change	2	10	12
6	Other Applications Handicraft, Landscaping, Fodder and Medicinal		9	9
	Total	17	52	69

1. Infrastructure Protection

Bioengineering Research (3 out of 12)

The three papers in this group used new and more sophisticated methods to determine the effect of root biomass to enhance slope stability by reinforcing the soil in mechanical and hydrological effects.

This group has one Winner of The King of Thailand Award for Outstanding Application of the Vetiver System and two Certificates of Excellence for The King of Thailand Award for Non Agricultural Application

Bioengineering Applications (9 out of 12)

The nine papers in this group come from wide range of countries: Asia (China. Thailand and Vietnam); North America (Hawaii) and Latin America (Brazil, Costa Rica and Guatemala), and cover a very wide range of topics for applications in very hostile environment, in combination with geotextiles and hard structures

2. Environmental Protection

Phytoremediation Research (7 out of 14)

This group has 7 submissions covering a wide range of topics from wastewater and contaminated land, including sea water tolerance

This group has one Winner of The King of Thailand Award for Outstanding Application of the Vetiver System in Non-agricultural Application

Phytoremediation Applications(7 out of 14)

This group has 8 submissions covering a wide range of topics from wastewater and contaminated land, including Dioxin and other organic pollutants, heavy metals and industrial wastes

3- Sustainable Agriculture

Soil and Water Conservation Research (4 out of 12)

This group has 4 submissions covering topics from assessing the effect of Vetiver Grass planting on nutrient losses from soil erosion under soil rubber plantation to of Paddy soil properties. But most importantly, for the first time farmers' perception on the role of vetiver grass in soil and water conservation.

Soil and Water Conservation Applications (8 out of 12)

This group has 4 submissions covering topics from assessing the effect of Vetiver Grass planting on sediment control, crop yield and habitat restoration. As expected to be fully benefited from vetiver intervention, the planting has to be designed and the grass has to be mature enough.

4. Socio-economic Impact

Socio-economic Research (1 out of 10)

This group has 1 submission presents a research project on the application of the Vetiver System, combining the integration and binding force of vetiver grass, alongside other vegetation methods, in conjunction with engineering applications, to prevent and rehabilitate shallow landslides on a road embankment.

This group has one Winner of The King of Thailand Award for Outstanding Environmental Protection

Socio-economic Applications (9 out of 10)

This group has 9 submissions covering a wide range of topics from Thailand, India, Peru and south Africa promoting the planting of Vetiver with People Participation

This group has one Winner of The King of Thailand Award for Outstanding On-farm Applications and Socio-economic Impacts

5. Research and Innovation

Research (2 out of 12)

This group has 10 submissions covering a wide range of topics from the impact of vetiver planting on crop, soil, CO2 emission, salt tolerance

This group has one Winner of The King of Thailand Award for Outstanding Research

Innovation

This group has 2 submissions on some topics on desert rehabilitation and feed supplement

6. Other Applications

This group has 9 submissions covering a wide range of topics from DR Congo, Thailand, India, China, Madagascar, Indonesia, USA and Vietnam, including anti snake Venom, bioengineering and research

This group has one Winner one Certificates of Excellence for The King of Thailand Award for Outstanding Dissemination and Technology Transfer

HIGHLIGHT OF SOME PROJECTS

The following three papers was selected to highlight the role of VST research and applications that can have global effects and will lead the Vetiver movement in the future.

1. The first to illustrate the unique role of Vetiver Phytoremediation Technology in remediating a major future problem. In the project *<Effectiveness of vetiver grass in phytostabilization and/or phytoremediation of dioxin-contaminated soil at Bien Hoa airbase, Vietnam – An overview and preliminary result>* Dr Ngo Thi Thuy Huong from the Vietnam Institute of Geosciences and Mineral Resources, Hanoi, investigated the VPT for bioremediation of soils contaminated with dioxin at low and moderate levels. The two main objectives of this project are to investigate:

i) The capability of vetiver grass in phytostabilization of dioxin-contaminated sites, preventing its offsite contamination; and

ii) Its effectiveness in the bioremediation of the dioxin-contaminated soils.

The experimental site is on a soil of about 1000 – 1800 ppt (part per trillion) TEQ.

Initial concentration of toxic dioxins

Level of PCDD/Fs (ppt TEQ-WHO$_{2005}$) of soil samples (taken from 0-60 cm soil depth) from Bien Hoa Airbase

Samples	Latitude	Longitude	2378-TCDD	TEQ$_{who}$	%TCDD
MT1	10°58'23.4"	106°48'21.7"	1,221.2	1,235.0	98.9
MT2	10°58'23.8"	106°48'21.6"	1,142.9	1,169.4	97.7
MT3	10°58'23.8"	106°48'21.5"	686.1	694.8	98.8
Average of lot 1 (G1)			**1,017 ± 167**	**1,033 ± 170**	**98.5 ± 0.4**
MT4	10°58'23.9"	106°48'21.5"	1,058.9	1,071.6	98.8
MT5	10°58'24.1"	106°48'21.5"	2,781.9	2,795.6	99.5
MT6	10°58'24.3"	106°48'21.4"	1,617.8	1,626.1	99.5
Average of lot 2 (G2)			**1,819 ± 507**	**1,831 ± 508**	**99.3 ± 0.2**
MT7	10°58'24.5"	106°48'21.4"	4,413.5	4,425.2	99.7
MT8	10°58'24.6"	106°48'21.3"	2,815.2	2,831.9	99.4
MT9	10°58'24.7"	106°48'21.4"	1,623.7	1,631.6	99.5
Average of lot 3 (Blank)			**2,950 ± 808**	**2,961 ± 809**	**99.6 ± 0.1**

Initial concentration of other toxic chemicals

Soil samples (taken from 0-60 cm soil depth) from Bien Hoa airbase

- ***Arsenic concentrations***: ranged from 16.2 to 39.5 mg/kg dry weight ➔ higher than Vietnamese allowable limits (12 mg/kg dry wt.) and the US EPA limit (1.6 mg/kg, for industrial soil).

  - No correlation between As and dioxin TEQ was found.

- ***2,4-D and 2,4,5-T concentrations:*** are quite low, i.e.

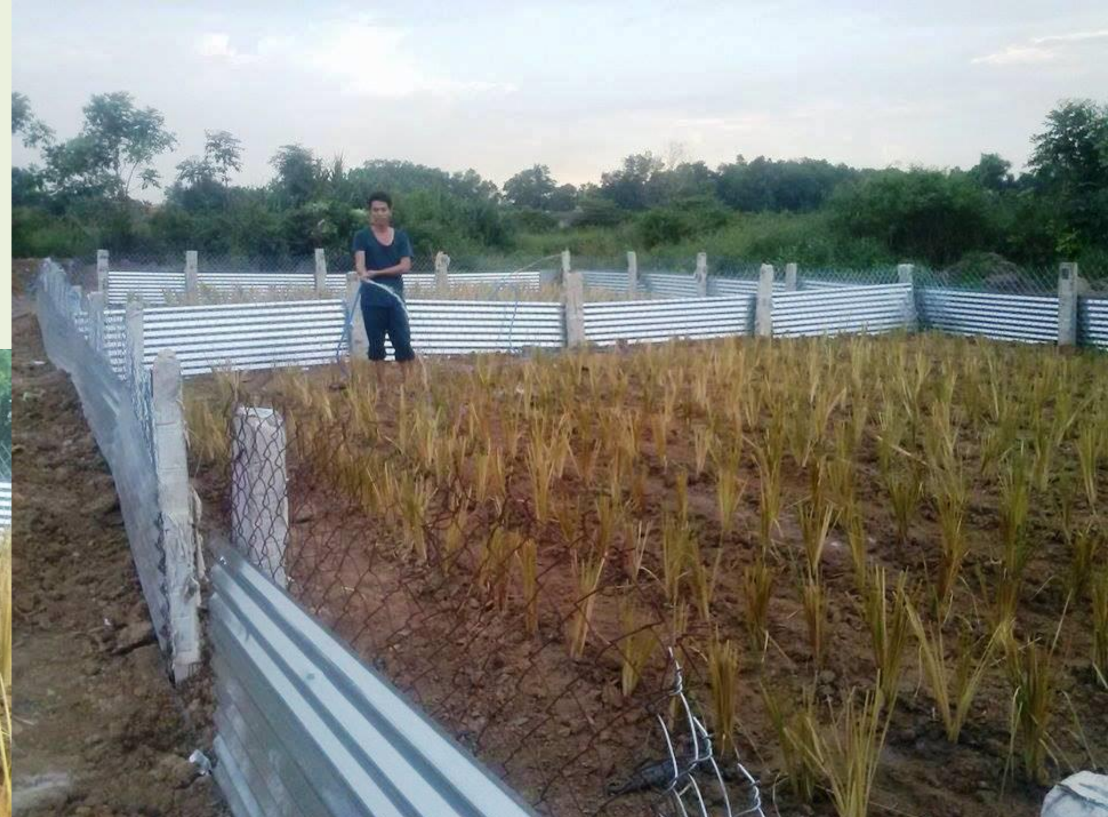
  0.012 – 0.067 mg/kg d.wt. (2,4-D);

  0.017 – 0.274 mg/kg d.wt. (2,4,5-T)

- Due to short half-lives: 7-10d (2,4-D) and 21-24d (2,4,5-T).
- 2,4-D and 2,4,5 T were tightly correlated to dioxins TEQ,

  r = 0.97 and 0.99, respectively ($p<0.0001$).

At planting



One month later

Four months after planting

RESULTS TO DATE

Due to the extremely eroded and poor soil an soil admentment was added in on treatment to ensure good establishment and initial growth. Results to date shows:

- **One month after planting there was no difference in growth (plant height) and tiller number per clump between two groups.**
- **From 6 to 12 weeks, the number of tillers increased very fast,**
- **At week 16, the circumference of G1 and G2 were 25 and 24 cm, respectively, indicating that vetiver can be established and thrive under the harsh and dioxin contaminated soil without soil supplement**
- **This investigation is in progress**
- **Results to date showed that *only 4 months after planting vetiver grass can be used for phyto-stabilization of dioxin contaminated sites, preventing its offsite contamination***

Four months after planting No significant in growth between vetiver grown in soil with and without amendment

SIGNIFICANCE OF THIS PROJECT

The significance of this project is that dioxin contamination is not limited to herbicides, such as 245T in Agent Orange, but it is a by-product of numerous industrial chemical processes, such as fertiliser and plastic manufacturing. But due to its extremely low level (part per trillion) and very expensive to analyse, the presence of dioxin in our food chain and environment is not known generally.

Analyses of plant samples taken seven months after planting indicated that Vetiver has taken up a substantial amount of Dioxin in both roots and shoots. This may lead to the next important step of breaking down Dioxin as in the case with Atrazine.

Further analyses are needed and if this result is proven, that Vetiver can absorb and break down dioxin in the plant, then its role in environmental protection is immeasurable.

HIGHLIGHT OF SOME PROJECTS

The second one conducted by Dr Tanapon Phenrat et al at Naresuan University in Thailand showed how VST was used to remediate water and soil contaminated with Phenol and other hazardous substances from illegal dumping in Thailand

The community of a district in Thailand has suffered from illegal dumping of industrial wastewater containing highly carcinogenic Phenol, far exceeds the limit in drinking water (1 µg/L) by more than 250 times.

Two strategies for using vetiver systems to treat the contaminated water:

1) Vetiver grass on a floating platform

2) Planting vetiver hedgerows along the creek to decrease the exposure of villagers to residual phenol migrating along the creek.

To implement this program, both laboratory scale and field scale application were carried out.

Laboratory Experimentation

Laboratory-scale experimental results suggested that phenol degradation by vetiver involves two phases:

Phase I, phytopolymerization and phytooxidation assisted by root-produced H_2O_2 and peroxidase (POD) and

Phase II, a combination of Phase I with enhanced rhizomicrobial degradation.

The first phase reduced phenol level from 500 mg/L to around 145 mg/L.

In the second phase rhizomicrobial growth was ~100 times greater on the roots of the vetiver grass than in the wastewater, increasing the phenol degradation rate by more than 4-fold. This combination of phytopolymerization, phytooxidation, and rhizomicrobial ompletely eliminated phenol in the wastewater in less than 700 hours.

Field Application

Based on the laboratory results:

1- In December 2015, a field-scale treatment of illegally dumped wastewater was implemented on a 768-cubic meter pond using 45 vetiver floating bamboo platforms

2- Similarly in August 2014, the first field-scale vetiver system was implemented with 120 000 bare roots vetiver to create 1.2-kilometer vetiver hedgerows along the Creek.

This is the first time that vetiver systems have been used for field-scale phenol degradation. Such environmental restoration projects can be a model for the more than 50 communities recently affected by illegal dumping.

Illegal dumping and contaminated creek

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Reported strange miscarriages in pigs believed to be caused by phenol contamination of shallow groundwater.

Laboratory-scale vetiver grass research

Field-scale implementation of Vetiver System

Planting on canal banks

Field-scale implementation of Vetiver System

Vetiver floats in village pond

HIGHLIGHT OF SOME PROJECTS

This very innovative work shows how VST applications can be monitored globally. In a project entitled *< Management and monitoring of vetiver grass plantation in Thailand by using vetiver grass tracking system>* Kittima Sivaarthitkul and her team from Thailand Land Development Department (LDD) have developed the Vetiver Grass Tracking System (VGT) since 2011 to manage and monitor the database of vetiver grass plantations in various parts of Thailand

Currently there are totally 418 million tillers planted from 2011-2014 and the number continually increases from 39 million tillers in 2011 to 133 million tillers in 2014.

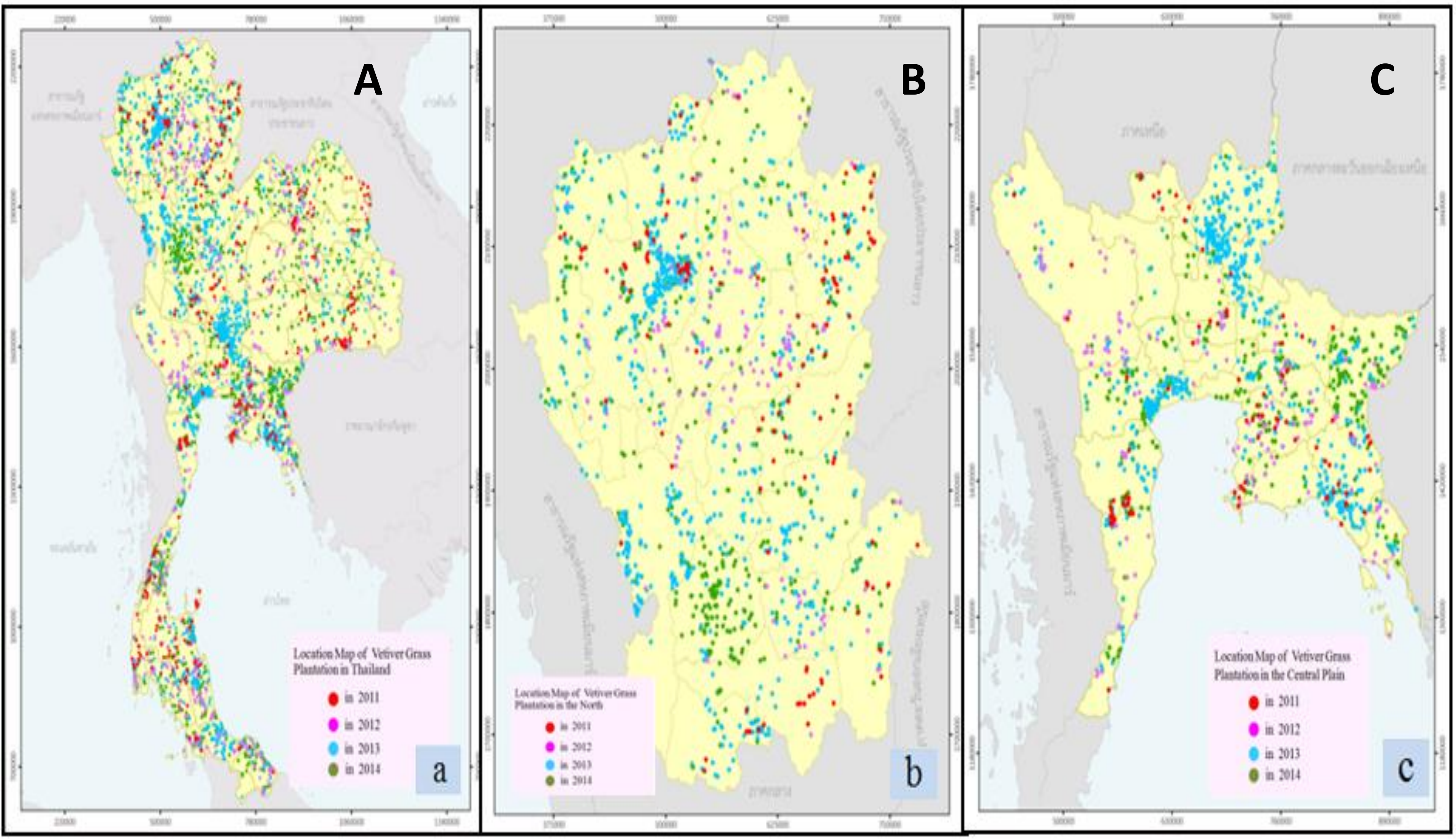
The VGT database shows that *Chrysopogon zizanioides* is the predominant species with 4,092 records (97.45%) planted in Thailand

Most importantly, policy makers can use the VGT database as a tool to monitor and manage implementation activities and plans, to promote future vetiver use and continually advocate for the utilization of vetiver for soil and water conservation, soil improvement and environment preservation.

PROJECT OBJECTIVES

1. **Number of Vetiver Grass Tillers Planted in Thailand**
2. **Utilization Patterns of Vetiver Grass in the Agricultural Areas in Thailand**
3. **Ecotypes of Vetiver Grass Planted in Thailand**
4. **Recommendation and Benefits**

Location map of vetiver grass plantation during 2011-2014 (a) national level (b) regional level in the North and (c) regional level in the Central Plain



1. Number of vetiver grass tillers planted in each region of Thailand during 2011 – 2014

Region		Year				Total tillers	
		2011	2012	2013	2014	Number	%
North		7,608,124	39,925,034	55,742,600	42,047,870	145,323,628	34.75
Northeast		14,769,000	21,896,508	20,034,070	35,648,640	92,348,218	22.08
Central Plain		9,806,900	26,923,015	37,208,767	33,897,740	107,836,422	25.79
South		7,022,134	26,177,500	17,542,500	21,914,400	72,656,534	17.38
Total		39,206,158	114,922,057	130,527,937	133,508,650	418,164,802	100.00

2. Number of records of utilization patterns of vetiver grass in the agricultural areas in Thailand during 2011-2014

Utilization patterns of vetiver grass	Year				Total	
	2011	2012	2013	2014	Records	%
prevention of soil erosion	212	166	432	389	1,199	29.04
prevention of sediment into reservoirs	252	411	1,040	778	2,481	60.09
improvement of soil fertility and preserve of soil moisture	4	62	26	3	95	2.3
others	38	91	80	145	354	8.57
Total	506	730	1,578	1,315	4,129	100

3. Records of ecotype of vetiver grass planted in Thailand during 2011-2014

Type	Year				Total	
	2011	2012	2013	2014	Records	%
zizanioides	480	771	1,648	1,193	4,092	97.45
nemoralis	22	40	7	38	107	2.55
Total	502	811	1,655	1,231	4,199	100.00

Recommendation and Benefits

General public people can access and search for information on vetiver grass plantation easily, conveniently and effectively in the form of spatial and attribute data pass through LDD websites. They can choose the suitable utilization patterns of vetiver grass in their agricultural area. Moreover, the database of vetiver grass plantation in VGT are processed for supporting the implementation plans and activities to continually campaign and promote of utilization of vetiver grass in the concept of sustainable development.

Most importantly, policy makers can use the VGT database as a tool to monitor and manage implementation activities and plans, to promote future vetiver use and continually advocate for the utilization of vetiver for soil and water conservation, soil improvement and environment preservation.

THE VETIVER INSTITUTE

TVI

Problem:

The online Vetiver information is not structured

Web information is not very well structured for an easy learning and access.

Problems to evaluate and certify the quality of the knowledge

There is no entity that is responsible for conducting evaluations worldwide with standardized process, fulfilling academic requirements and providing a high quality control of Vetiver System techniques.

The lack of confidence on VS for not standardized methods

Providing a standard and well structured certification process will increase the credibility of VS by Governments, private companies and professionals.

There are few people certified

With the big potential of VS world wide is not enough people with the right technical knowledge

Revenue for TVNI

Solution:

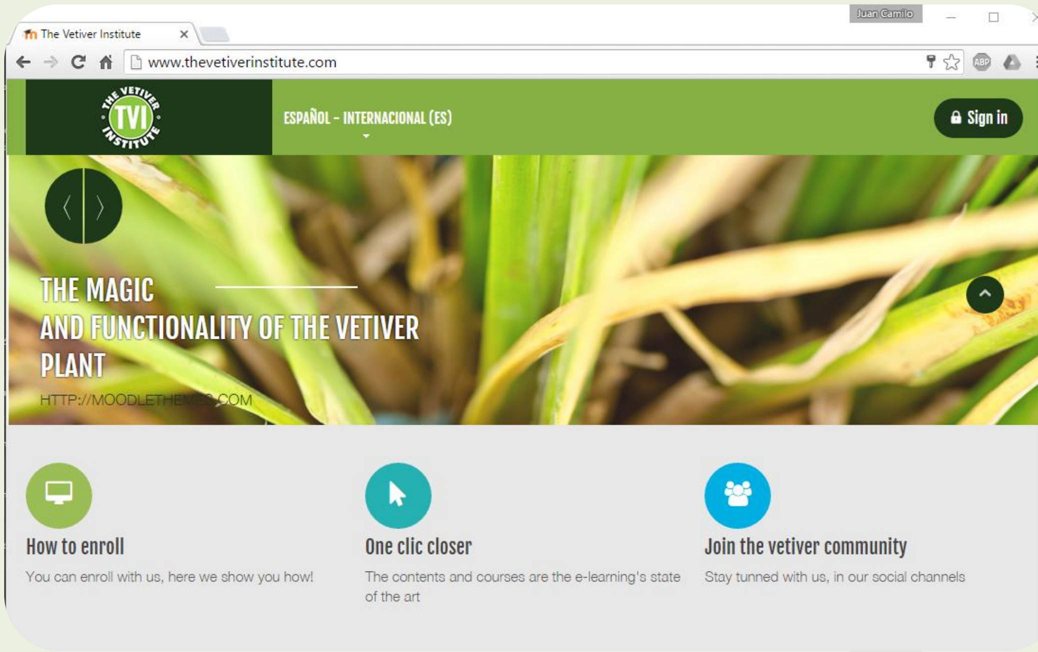
The creation of an Online Education Institute

TVi Objectives

- To create an Online Educational Institute – that transcends barriers of language and geo-political limits – for purposes and of offering technical courses and certificates recognizing successful course completion in all aspects and applications of the Vetiver System. Creating Credibility and assuring high quality application of VS Worldwide

- To create a clear structure of Vetiver System and its application with all the information Researched and proven in the las 40 years for TVNI Directors.

- To collect Funds for the promotion of the VS worldwide supporting TVNI operations and ensuring long-term sustainability



Our target

CONECTED COSTUMERS

NGO NETWORK

GOVERNMENT

UNIVERSITIES

Companies

ENVIROMENTAL

MINING

CONSTRUCTION

Outcomes

WorldWide Education

SOCIAL
MEDIA

STUDENT PARTICIPATION

Creation of e-learning platform

Organized and standardized

TVNI Certifications
New Online Application

CONCLUSION AND RECOMMENDATIONS

Chrysopogon zizanioides, **is the most researched non-food and non-industrial plant to date. While it has become well established and proven in bioengineering and agriculture, its role in environmental protection needs further research and development to meet increasing demands created by expanding climate change, population, and pollution challenges.**

The following topics should have high priority in future research.

Applications of the Vetiver Phytoremediation Technology to purify polluted water from hazardous chemicals, particularly organic compounds such as human hormones, antibiotics, drugs and food additives

The following areas also need special attention:

- **The original application of VS was for on farm soil and water conservation, progress has been slow, and great focus and effort should be given for this use.**

- **Development and identification of special vetiver characteristics that may help to distinguish between species and cultivars, including genotypes that can adapt to colder climates, should be important and would help accelerate a wider and faster application of the technology.**

- **Expansion of monitoring and evaluation of vetiver applications would strengthen the credibility of the technology and would provide potential users with a greater degree of confidence in its adoption.**

Paula Leao Pereira
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THANK YOU ALL

Jason Fox
Hawaii