VETIVER SYSTEM FOR NATURAL DISASTER MITIGATION AND ENVIRONMENTAL PROTECTION IN VIETNAM - AN OVERVIEW

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Keywords: Natural disaster, environmental protection, erosion, slope stabilization, pollution control.

ABSTRACT

The use of Vetiver grass for natural disaster mitigation in Vietnam has become very popular despite the fact it has been introduced into Vietnam for such purpose only 5-6 years ago and it was met with considerable skepticism at the beginning. However, thanks to the faith and efforts of some Vietnamese enthusiasts and believers, the grass is now known throughout the country and is in use practically in nearly 40 provinces (out of the total 64). It is planted in a very wide range of soil types and climatic conditions, from very cold winter in the North, very hot summer-cold winter, pure sand in Central Vietnam to acid sulfate soil, saline soil in the Mekong Delta.

The widest application of the VS is for river bank, irrigation canal, river and sea dyke erosion control, cut slope stabilization along highways. But it is also used for sand dune stabilization, reduction of soil erosion on sloping farm land due to surface runoff, reduction of flood damages etc. And very recently, several trials have been made in using VS for wastewater and pollution control, for reclamation of contaminated and toxic soils etc. Many lessons have been drawn out on the use of Vetiver grass, including its advantages and disadvantages as well as comparison with other, either rigid, ineffective, expensive, environmental-unfriendly structural measures or traditional bio-engineering approach. A plan to compile a manual on the use of Vetiver grass for natural disaster mitigation is now being implemented and it is expected to be complete by the end of 2006.

1.0 INTRODUCTION

The use of vegetation as a bio-engineering tool for land reclamation, erosion control and slope stabilization have been implemented for centuries and its popularity has increased remarkably in the last decades. This is partly due to the fact that more knowledge and information on vegetation are now available for application in engineering designs, but also partly due to the cost-effectiveness and environment-friendliness of this "soft", bio-engineering approach.

Although Vetiver grass (*Vetiveria zizanioides*) has been used first by Indian farmers for various purposes more than 200 years ago, its real impact on land stabilization/reclamation, soil erosion and sediment control only started in the late 1980's following its promotion by the World Bank. While it still plays a vital role in agriculture, the unique morphological, physiological and ecological characteristics of the grass including its tolerance to highly adverse growing conditions and tolerance to high levels of toxicities provide an unique bio-engineering tool for other, non-agricultural applications such as land stabilization/reclamation, soil erosion and sediment control.

Although the concept of using Vetiver grass for various applications has only been introduced into Vietnam in 1999 by The International Vetiver Network (TVN) and since actively promoted by the Vietnam Vetiver Network (VNVN), Vetiver has become widely known throughout the country with numerous successful applications for natural disaster mitigation and environmental protection. Typical examples include road batter stability enhancement, erosion/flood control of embankments, dykes, riverbanks, sand dune fixation.

2.0 NATURAL DISASTERS IN VIETNAM

Vietnam is a natural disaster-prone country, where many types of natural disasters take place annually, causing a lot of losses of life, economic and environmental damages. Located in the tropical monsoon zone the country features a marked seasonal rhythm of rainfall of roughly 2,000 mm/year. However, about 75-80% of the rainfall takes place usually only during the 3 months of summer (starting from May in the North but becoming later in the South). And although there are about 200 rainy days a year, the major portion of the rain intensity falls in just about 10 days with more than 100 mm/day records. Coupled with the very diverse geological conditions, including many rock/soil types, active tectonic regime and the fast economic and demographic growth with its uncontrolled negative environmental degradation during the last two decades, such climatic extremes cause severe natural disasters, most frequent and destructive being floods, landslides and debris flows, flash floods, river bank and coastal erosion, sand storm/flow etc.

Total loss of life and properties by natural disasters has rapidly increased in 1990s. According to the "Second National Strategy and Action Plan for Disaster Mitigation and Management in Vietnam-2001 to 2020", about eight thousand people were killed, 2.3 million tons of foods were destroyed, and 6 million houses collapsed and washed away in the decade of 1991 to 2000. The total estimated economic loss was about USD2.8 billion, i.e. 1.8-2.3% of the national GDP or nearly USD 300 million yearly.

A research project on natural hazards of geologic origin (geohazards) in 8 coastal provinces of Central Vietnam was carried out recently (RIGMR, 2000-2002) which shows that river bank and coastal erosion, landslide, sand storm and sand flow are mainly caused by short but catastrophic storm/floods. A survey has been conducted for more than 850 km of banks of 25 main rivers and more than 900 km of the coastline in the region. It has identified in each province tens of km of river bank or coastline that are currently severely eroding. At the same time, a landslide inventory survey has also been conducted for mountainous regions. More than 1600 landslides have been mapped including nearly 100 large-sized landslides. Among them, quite a few landslides occurred along important national and provincial routes. An example was the large landslide on the Hai Van Pass in 1999 that totally disrupted the North-South traffic for more than half a month and cost more than one million US dollars for remedial work.

3.0 TRADITIONAL REMEDIAL MEASURES AND THE NEED FOR NEW APPROACHES

The Ministry of Agriculture and Rural Development (MARD) and its provincial departments (DARD) are responsible for dyke management and "naturally" they undertake measures to protect river banks. Similarly, the Ministry of Transport (MOT) and its provincial departments (DOT) are in charge of road construction and road-related slope protection. Their concept is mostly to use structural, rigid protection measures e.g. concrete or rock riprap bank revetment, groins, retaining walls etc.

These measures are, however, very expensive and the State budget for such works can never be sufficient. For example, river bank revetment costs usually 200,000-300,000 USD/km, sometimes up to 0.7-1.0 million USD/km. An extreme case is the Tan Chau embankment in the Me Kong Delta which costs nearly 7 million USD/km. And it has been estimated that river bank protection in Quang Binh province alone would already require more than 20 million USD, while the annual budget for that is only 300,000 USD. Construction of sea dyke costs usually 0.7-1.0 million USD/km but more expensive sections costing up to 2.0-2.5 million USD/km are not rare. After the recent storm No. 7 in September 2005 that washed away many dyke sections, some dyke managers believe that even such rigorous dyke system is not rigid and strong enough (capable to withstand storms of up to 9th level only) and they begin to talk about constructing stronger sea dykes (capable to withstand storms of up to 12th level) that would cost about 7-10 million USD /km. In the mean time, budget constraint is always there and as a result, structural, rigid protection measures can only be very much localized, for the most acute sections, and can never be extended to the full length of the river bank/coastline that needs protection. The problem thus becomes much severe than the means to solve it, and one could conclude that this has seriously challenged the present concept of river bank and/or coastal protection using only localized, structural, rigid measures.

From the technical and environmental perspectives, one may notice the following concerns:

- Rock/concrete is mined/produced elsewhere, where it can cause environmental problems;
- Localized structural, rigid measures do not absorb flow/wave energy and tend to displace erosion to another place, opposite or downstream. In so doing, they even aggravate the disaster, rather than really reduce it for the river as a whole. Typical examples of these can be found in several provinces in central Vietnam;
- Structural, rigid measures bring in considerable amount of stone, sand, cement into the river system, disposing considerable volume of bank soil into the river, all eventually causing the river to become full, changing, raising the river floor, thus worsening flood and bank erosion problems;
- Rigid structures are not compatible with the soft ground particularly on erodible soils. As the later is consolidated and/or eroded and washed away and undercut the upper rigid layer. This occurred in many places such as the right bank immediately downstream of the Thach Nham Weir (Quang Ngai province), where it cracked down and collapsed. Engineers try to replace concrete plates with rock rip-rap with or without concrete frame which, however, leaves the problem of subsurface erosion unsolved. A very typical example can be seen along the Hai Hau sea dyke, where the whole section of rock rip-rap collapsed as the foundation soil underneath was washed away;

- Rigid structures can only temporarily reduce erosion but they can not help stabilize the bank in case of big landslides with deep failure surface;
- Concrete or rock retaining wall is probably the most common engineering method applied for road slope stabilization in Vietnam. Most of these walls are, however, passive, waiting for the slopes to fail. When they do fail, they also cause the walls to fail as seen in many cases along the Ho Chi Minh Highway;
- Rigid structures like rock embankments are unsuitable for certain applications such as sand dune stabilization. They are, however, in some cases, still being built, as can be observed along the new road in central Vietnam.

Along with rigid structural measures, softer solutions, using vegetation have also been tried, though to a much less extent. For river bank erosion, the most popular bio-engineering method is probably the planting of bamboo, while for coastal erosion, mangrove, casuarinas, wild pineapple, nipa palm etc. are also being used. However, applications of these plants have shown some essential weak points, for example:

- Growing in clumps, bamboo can not provide closed hedgerows. The flood water tends to concentrate at gaps in-between clumps, where the water destructive power increases, thus causing more erosion to occur;
- Bamboo has only a shallow (1-1.5 m deep) bunch root system, not in balance with the high, heavy canopy, therefore clumps of bamboo put an additional heavy surcharge on a river bank, without contributing to the bank stability;
- With the bunch root system of bamboo, site surveys show that in many cases erosion undermines the soil below, creating conditions for larger landslides to take place. Examples of bank failure with extensive bamboo strips can be seen in several provinces in central Vietnam;
- Mangrove trees, where they can grow, form a very good protection buffer zone for reducing wave power, thus reducing coastal erosion. However, establishment of mangrove is difficult and slow as its seedling is eaten by mice, and thus, of the hundreds of hectares planted, only a small part can develop to become forest. This has been reported recently in Ha Tinh province;
- Casuarinas trees have long been planted on thousands of hectares of sand dunes in Central Vietnam. Similarly, wild pineapple is also planted along banks of rivers, streams and other channels as well as along the contour lines of dune slopes. But they are good mainly for reducing wind power and respectively, sand storm but not sand flow as they do not form closed hedgerows and do not have deep root systems. Examples of building sand dykes along flow channels in Quang Binh province, with casuarinas and wild pineapple trees on top ended with obvious failure as the sand fingers continues to invade arable land. Moreover, experiences also show that casuarinas seedlings can hardly survive sporadic but extreme cold winter (less than 15^{o}C) while wild pineapple dies from extremely hot summer in North Vietnam;

It seems, thus, that no appropriate engineering solutions for natural disaster reduction have been found yet in Vietnam. It is for this reason that the RIGMR research project recommends to fundamentally reconsider the present concept, economically and technically as well as environmentally.

4.0 INTRODUCTION OF THE VETIVER SYSTEM TO VIETNAM: INITIAL DIFFICULTIES AND SUBSEQUENT WIDE SPREAD

In 1999 at the request of the Ministry of Agriculture and Rural Development (MARD), Ken Crismier of The International Vetiver Network (TVN) invited two VS experts, Paul Truong and Diti Hengchaovanich, to visit Vietnam. A series of workshops were organized in Hanoi, Ho Chi Minh City and Nghe An province, which received great interests at all levels, from Ministries to farming communities. Several trial sites were set up following 3 truck loads of Vetiver grass donated by the Department of Land Development, Thailand. Some results were achieved by the National Institute for Soil and Fertilizer for erosion control in slope farming but it was not bold enough to move forward. On the other hand, due to the lack of good design, experience and care, some trials did not give good results in Central and North Vietnam when applied for river dyke protection and river bank erosion control. The grass was met with skepticism while the few first followers could not agree to cooperate in promoting the grass nation-wide.

4.1 The First Bold Results and Juridical Basis for Wider VS Application

Fortunately, almost at the same time in the South, with support from Paul Truong, Pham Hong Duc Phuoc from The Ho Chi Minh City University of Agro-Forestry carried out some trials in Central Highland for land slips control and slope stabilization. A private company, THIEN SINH, in Ho Chi Minh City was interested in using VS for land stabilization and environmental protection purposes. It requested Paul Truong and Pham Hong Duc Phuoc to advise and develop specifications for land slip control and slope stabilization on the HCM highway. Their good results convinced MARD and consequently in October 2001, MARD issued a Decree to allow for mass application of Vetiver grass for natural disaster reduction in Vietnam.

A significant importance is the change in attitude of the Dyke Department with respect to Vetiver grass. Being one of the few pioneers in Vietnam to try the grass (in 1999) for protecting its extensive dyke system, but due to bad design of their earlier trial, the Department unfortunately did not see encouraging results and since then was quite skeptical about this measure. Quite a few doubtful questions were raised with regards to the use of the grass on dyke, e.g. would it strengthen the soil or be rather harmful to the dyke body by increasing soil porosity and permeability, or would the grass root become harmful when dead etc. However, numerous successes at other sites, coupled with continuous failures of traditional “hard” measures gradually pushed the Dyke Department to accept the new solution. Although not entirely enthusiastic about it, the Dyke Department has silently issued Decrees No. 436 and 438/PCLB dated 12/09/2003 on the use of Vetiver hedgerows for river bank and coastline protection. Very recently the Dyke Department announced that it has approved the technology for protection of embankment on several rivers in North, Central and South Vietnam.

4.2 VS Application and Promotion in North Vietnam

In 2004, at the recommendation of Elise Pinners and Tran Tan Van, the Danish Red Cross funded a pilot project using Vetiver grass for sea dyke protection in Hai Hau district, Nam Dinh province. The project implementers came in and to their biggest surprise, they found out that Vetiver grass had already been planted 1-2 years earlier to protect several km of the inner side of the local sea dyke system. Although the planting design was not up to the standard recommended for such application, this planting has helped protecting the dyke system from erosion and the local people were already convinced of the effectiveness of the grass, asking for more mass planting. The effectiveness of Vetiver grass in reducing erosion of the sea dyke was even more remarkable after typhoon No. 7 in September 2005, which broke even rigorously rock rip-rapped sections.

Concerned with the wellbeing of the people living on the path of these typhoons in the Ha Long area, where their livelihood depends on the stability of this protective sea dike system, HRH ***Princess Maha Chakri Sirindhorn*** of Thailand, Patron of The Vetiver Network, has just approved a project for Chaipattana Foundation, a private foundation set up by the HM The King of Thailand, to assist VNVN both technically and financially to improve the stability of a sea dike at Hai Hau District, Nam Dinh Province, where the sea dike system was devastated by typhoons number 6 and 7 in September 2005. A group of Thai engineers and Vetiver experts will come to Hai Hau in July 2006 to finalize the project details with VNVN.

4.3 VS Application and Promotion in the Mekong Delta

In 2001 with financial and technical supports from the Donner Foundation and Paul Truong respectively, Le Van Du from the same university worked on Acid Sulfate Soil to stabilize canal and irrigation channels and sea dyke system in Go Cong province. Despite the poor embankment soil the grass grew rigorously in just a few months, helping to protect the sea dyke, preventing surface erosion and facilitating endemic species to establish.

Later on, during the period of 2003-2005, Le Van Du went on to try VS on the sodic-saline “desert” provinces of Binh Thuan and Ninh Thuan, where the annual rainfall intensity averages just 200-300 mm. In the topsoil a thin gypsum layer develops to effectively prevent the root system of many other species to penetrate to the more humid layer underneath. Du and his staffs developed a good technique to help Vetiver grass survive the initial stage. Once established, their trial showed that the grass root system reached 70 cm after 3 months, penetrating the gypsum layer. The grass grew 2-3 times faster than any other crops, yielding a fresh biomass of 25-30 tons during the first two months and up to 50 tons after 3 months.

With financial support from Donner Foundation and technical support from Paul Truong, Le Viet Dung and colleagues from Can Tho University worked on river bank erosion control in the Me Kong Delta. The area features long lasting (up to 3-5 months) high water (flood) season, high (up to 4-5 m) difference in the water levels between high and low water seasons, and strong water flow during the high water (flood) season. In addition, river banks are mostly made up from alluvial, silt to loam soils, extremely erodible when wet. Due to the fast economic development in recent years, most boats traveling on rivers and canals now are motorized, in many cases with very powerful car engines. They even more aggravate the problem of river bank erosion by generating strong waves. However, inspite of these negative factors, Vetiver grass withstands well, protecting lots of precious land from erosion.

A very comprehensive and massive Vetiver planting program has been carried out in An Giang Province, where annual flood can reach up to 6 m depth. The province 4932 km long canal system needs maintenance and repair every year. In addition, a network of dikes, 4600 km long, was built to protect 209957 ha of prime farm land from flood. The erosion on these dikes is about 3.75 Mm^3/year and required USD 1.3 M to repair. There are also 181 resettlement clusters built on dredged materials for people to live. These clusters also need erosion control measure from flood. Depending on the locations and flood depth Vetiver has been successfully used by itself or in combination with other vegetation. ***The total length of Vetiver planting for dyke protection from 2002-05 is 61 km using 1.8 M polybags.*** It is anticipated that for the next 5 years, 2006-2010, the 11 districts of An Giang province will plant ***2025 km of Vetiver hedges on 3100 ha of dike surface***. If unprotected by Vetiver, it is expected that 3750 Mm^3 of soil will be eroded and 5 Mm^3 will have to be dredged from the canals. Based on the current cost, the total maintenance cost over this period would exceed ***USD 15.5 M*** for this province alone. In addition, application of VS in this rural region will provide extra income to the local people: men to plant and women and children to prepare Vetiver polybags.

As a result, extensive use of Vetiver grass is now seen along the rigorous sea and river dyke systems as well as along river bank, canals etc. in the Me Kong Delta.

4.4 VS Application and Promotion in Central Vietnam

In February 2002, with financial support from the Dutch Embassy Small Program and technical support from Elise Pinners and Pham Hong Duc Phuoc, Tran Tan Van from RIGMR tried to stabilize sand dunes and river banks in Central Vietnam. A sand dune was badly eroded by a stream that served as a natural boundary between farmers and a Forestry Enterprise. The erosion took place for several years, resulting in a mounting conflict between the two groups. Vetiver grass was planted in rows along the contour lines of the sand dune. After 4 months it formed closed hedgerows and the sand dune was stabilized. The Forestry Enterprise was so happy that it decided to mass plant the grass in other sand dunes nearby and even for the protection of a bridge abutment. The grass further surprised local people by surviving the coldest winter in tens of years, when the air temperature lowered down well below 10^oC, forcing the local farmers to replant twice their paddy rice and Casuarinas. After 2 years, the grass has helped local species such as Casuarinas, wild pineapple etc. to re-establish. The grass itself is fading away under the shade of these trees but by then it has accomplished its mission. The project once more proved that with proper care Vetiver grass could survive very hostile conditions (very poor nutrition, hot summer and cold winter).

At the same time, Vetiver grass was planted in several rows to fix erosion of a river bank, bank of a shrimp pond and a road embankment in Da Nang City. After several months of trial, in October 2002 the local Dyke Department also decided to mass plant the grass on more bank sections of several rivers. Furthermore, the city authority decided to fund a project on cut slope stabilization using Vetiver grass along the mountainous road leading to the Ba Na resort.

Following the success of this pilot project, a workshop was organized in early 2003 for more than 40 participants from local DARDs, DOSTEs, different NGOs and Universities of Central Vietnam’s coastal provinces. The workshop helped both the authors of this paper and other participants draw useful lessons, especially on planting time, watering, fertilizing etc. After the event, also in 2003 World Vision Vietnam decided to fund another project for introducing Vetiver grass for sand dune fixation in the two Vinh Linh and Trieu Phong districts in Quang Tri province.

Also as a result of this pilot project, Vetiver grass was recommended for use in another natural disaster reduction project in Quang Ngai province, which was funded by AusAID. With technical support from Tran Tan Van, Vo Thanh Thuy and his co-workers from the provincial Agricultural Extension Center planted the grass at 4 locations, for sea water intrusion protection dyke and irrigation canal in several districts. The grass grew well in all locations, and although at its young age, survived the flood in the same year. Following these successful trials, the project has decided to mass plant the grass on other dyke sections at 3 more districts, in combination with rock rip-rap measure.

4.5 VS Application and Promotion for Road Batter Stabilization

A particular bold move was made by the Ministry of Transport, following successful trials by Pham Hong Duc Phuoc and Thien Sinh Co. in using Vetiver grass for cut slope stabilization in Central Vietnam. In 2003, the Ministry of Transport allowed the wide use of Vetiver grass for slope stabilization in a series of National Highways, most notably along hundreds of km of the newly constructed Ho Chi Minh Highway.

On a survey in January 2005 trip, a stretch of 500 km in the northern section of the Ho Chi Minh Highway was inspected to see that Vetiver planting was very extensive. In total more than half of this 500 km stretch has now been protected by Vetiver and more planting is in progress on the rest of the northern section as well as the southern section, and eventually most of this highway will be protected by Vetiver. This project is probably one of the largest VS applications in infrastructure protection in the world. The entire Ho Chi Minh Highway, over 3000 km long, is being and will be protected by Vetiver, planted on a variety of soils and climate: from skeletal mountainous soils and cold winter in the North to extremely acidic Acid Sulfate Soil and hot and humid in the South.

Pham Hong Duc Phuoc demonstrated clearly how VS should be used and its effectiveness and sustainability on a road leading to the Ho Chi Minh Highway. He carefully monitored the development of the VS in term of establishment (65-100%), top growth (95-160 cm after 6 months), tillering rate (18-30/plant) and root depth on the batter (Table 1).

Table 1. Vetiver root depth on Hon Ba road batters.

	Position on the batter	**Root depth (cm)**			
		6 month	**12 month**	**1.5 year**	**2 years**
	Cut Batter				
1.	Bottom	70	120	120	120
2.	Middle	72	110	100	145
3.	Top	72	105	105	187
	Fill Batter				
4.	Bottom	82	95	95	180
5.	Middle	85	115	115	180
6.	Top	68	70	75	130

Failures and successes with Vetiver grass protecting cut slopes along the Ho Chi Minh Highway show some further lessons:

– The slopes should first be internally stable as the effect of Vetiver grass does not come immediately and the slopes may fail before it really takes place. Stabilization may take place only after 3-4 months at the earliest; hence timing is also very important if slope failure during the forthcoming rainy season is to be avoided;

- Appropriate slope angle should not exceed 45-50^{o}; and
- Regular trimming is also important to ensure further growth of the grass to achieve good, dense hedgerows etc.

4.6 Application for Pollution Control

With financial support from the Wallace Genetic Foundation and technical input from Paul Truong the **Water Quality Improvement Project** was launched in all three regions of Vietnam, with the following project sites:

1. A seafood processing factory, CAFATEX, in Can Tho, Me Kong Delta
2. A small paper mill at Bac Ninh, north Vietnam
3. A small nitrogen fertilizer factory at Bac Giang, north Vietnam
4. A municipal landfill leachate disposal at A Luoi, Central Vietnam
5. A rural site contaminated with herbicides, pesticides and other toxic chemicals at A Luoi.

4.6.1 A seafood processing factory, CAFATEX, in Can Tho, Me Kong Delta

Due to the effectiveness of VS in treating wastewater and the current trend in water recycling around the world, the seafood processing factory, CAFATEX, was interested in testing VS as a method of phytoremediation to reduce the contaminant levels in the factory effluent. The emphasis is on the low cost and simple VS alternative instead of more costly chemical and engineering solutions. Can Tho City is the capital of the Mekong Delta, which is also the centre of several food processing industries. These seafood processing factories are the major sources of pollution to the region watercourses and farmlands nearby.

Two demonstration trials were set up at the factory. The first one was on an area of about 800 m^2, aiming at identifying which of the following methods would give the best result in the reduction of nitrate and phosphate in the wastewater:

- Subsurface flow; or
- Surface flow (flooding) over the Vetiver field

The second trial was 12 m long x 5 m wide, aiming at testing the ability of Vetiver grass in absorbing Nitrate and phosphate in wastewater.

Preliminary results have shown that both methods of irrigation are very effective in reducing nutrient load in the effluent.

4.6.2 A small paper mill at Bac Ninh, North Vietnam

This trial was established in July, 2005, at a small paper factory. The waste water from this factory is heavily polluted with acids and lime, as bad as landfill leachate, and is being discharged directly to a small river. As shown below, Vetiver could establish and grow well under these extremely polluted conditions.

4.6.3 A small nitrogen fertilizer factory at Bac Giang, North Vietnam

This trial was established in July, 2005 at a small nitrogen fertilizer factory. The waste water from this factory is highly polluted and is discharged to a small river after going through a chain of 3 environmental ponds which can't filter suspended and soluble wastes. The treatments consist of some rows on the banks of the holding ponds, where the soil is highly polluted from the ponds and on an adjacent wetland. Despite the highly polluted conditions, Vetiver established and grew well as shown below.

4.6.4 A municipal landfill leachate disposal at A Luoi, Central Vietnam

A Luoi is a district in Central Vietnam mountainous region near the Laotian border and like most cities and towns in Vietnam it does not have any means to treat leachate from landfill depots. As a result the discharged leachate either drains into local streams and river or infiltrates to the underground water storage.

The leachate of A Luoi municipal landfill drains into a mountain stream, the water source for both domestic supply and agriculture use of several villages living along its course. Planting was carried out in February 2005, good establishment was achieved but due to the cold and wet weather growth has not been as good as in the low land.

4.6.5 A contaminated site with herbicides, pesticides and other toxic chemicals at A Luoi

A Luoi district was also the centre of some very big battles during the Vietnam War. A So air base, in A Luoi district, was the main base of an Agent Orange (AO) spraying unit of the US Air Force in the northern section of South Vietnam. The billboard erected on the edge of the airfield warns local people to keep out of the airfield as it is heavily contaminated with Agent Orange and also has high level of Dioxin. ***Hatfield Consultant,*** a Canadian consulting group, carried out a site survey about 10 years ago and it has identified several "hot spots", which had very high level of herbicides and dioxin. A trial was set up in February 2005. The grass survives but the growth rate is slow which may require additional care. There is a plan to come back to the site, replant the grass and test its ability to adsorb/absorb the toxic chemicals.

5.0 VS APPLICATION AND PROMOTION

VS applications for natural disaster mitigation and environmental protection are now well known in Vietnam. In fact nearly 40 out of 64 provinces of Vietnam are now using Vetiver grass for various purposes. However, to further promote and convince any doubters, with the support of the Royal Netherlands Embassy and TVN, the Vietnam Vetiver Network organized a Regional International Conference entitled **"Vetiver System: Disaster Mitigation and Environmental Protection in Vietnam"** from 19-21 January, 2006 at Can Tho University, Can Tho city. 75 Vietnamese delegates from various governmental departments and private sectors in the Mekong Delta and Ho Chi Minh City participated in the conference and field trip. In addition, 18 international speakers from Australia, China, Indonesia, South Africa and Thailand presented papers on various topics covering Disaster Mitigation, Environmental Protection, and On-farm Applications and its Socioeconomic Impacts on local communities. Also as part of the Royal Netherlands Embassy Small Program, a manual on the use of VS for natural disaster mitigation and environmental protection is now being compiled and it is expected to be complete by the end of 2006.

6.0 SOME LESSONS, RECOMMENDATIONS AND CONCLUSIONS

Natural disasters are very diverse in origin, very wide-spread, affecting many communities. Some natural disasters have their causes originated from very far upstream. Therefore:

- Macro-scale, non-structural, basin-wide disaster management should be introduced. Rigid, localized, difficult to apply, expensive, environmental unfriendly structures should be avoided, minimized and replaced by cost-effective, soft and flexible, easy to apply, community-based and environmental friendly bio-engineering methods, such as using Vetiver grass;
- Vetiver grass doesn't compete with rigid, traditional structural measures but rather supplement them. For example, the later may be applied in combination with VS at critical sites, by the Government agencies, while the grass can be planted at other, less critical sites, by local communities. Successful examples of combining Vetiver grass with rigid rock riprap can be found around Da Nang city for river bank protection, in Hai Hau for sea dyke protection, or along the Ho Chi Minh Highway for cut slope stabilization etc.;
- Vetiver grass can also be used in combination with other local vegetation, such as Casuarinas or wild pineapple for sand dune stabilization in Quang Binh province, Nipa palm, mangrove and mangrove fern for river bank protection in brackish to saline water near the sea in Quang Ngai province;
- Experience with sand dune protection in Quang Binh province show that planting time is very important as watering is crucial for the grass to withstand the hostile climatic and nutrition conditions in sand dune areas. Planting at the end of the rainy season, i.e. about September, may ensure sufficient water. Likewise, planting during spring, i.e. January, with little but frequent rains would also be appropriate. However, planting right in the dry season, e.g. April-May would require a lot of watering work. But planting right in the rainy season may result in too much water to wash away the seedlings etc.

Regarding the problem of pore water pressure inside the slope, there can be some good arguments as follows:

- Increase in water infiltration is one of the major effects of vegetation cover on sloping lands and there is concern that extra water will increase the pore water pressure in the soil which could lead to slope instability;
- However, field observations show much better counter-effects. First, planted on contour lines which would trap and spread runoff water on the slope, the extensive root system of Vetiver grass helps prevent localized accumulation of surplus water and distribute it more evenly and gradually;
- Second, increased infiltration is also balanced by a higher, and again, gradually rate of soil water depletion by the grass;
- Research in soil moisture competition in crops in Australia (Dalton *et al*, 1996) indicated that under low rainfall condition this depletion would reduce soil moisture up to 1.5 m from the hedges, thus increasing water infiltration in that zone, leading to the reduction of runoff water and erosion rate;
- Geotechnically, these conditions have beneficial effects on slope stability. On steep (30-60^o) slopes the space between rows at 1 m VI (Vertical Interval) is very close, this moisture depletion would be greater therefore further improve the slope stability.

- In high rainfall areas, to reduce this potentially negative effect of Vetiver grass on slopes, Vetiver hedges could be planted on a gradient of about 0.5% to divert extra water to stable drainage outlets (Hengchaovanich, 1998).

7.0 ACKNOWLEDGEMENTS

VNVN is grateful to The Vetiver Network (TVN), the Royal Netherlands Embassy in Vietnam Small Program, AusAid, Wallace Genetic Foundation, Donner Foundation, World Vision Vietnam, Danish Red Cross and many others for their kind supports. VNVN's steady growth would not also be possible without the continuous supports, inputs and advises of many individuals, in particular: Dr. Paul Truong, Director and Asia Pacific Representative, The International Vetiver Network, Ken Crismier, the first VNVN's coordinator, and Elise Pinners, Senior TVN Associate and other colleagues in Vietnam and overseas.

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A Brief Introduction to the First Author

Dr Tran Tan Van is a geologist and geo-technical engineer and he is currently Deputy Director of the Research Institute of Geology and Mineral Resources, Ministry of Natural Resources and Environment in Hanoi, Vietnam. He is the current Coordinator of the Vietnam Vetiver Network and responsible for introducing VS to various regions of Vietnam and later proved its effectiveness in various applications especially in disaster mitigation, which produced a great impact to the country in a period of only 4-5 years. At the end of 2005 at least 40 provinces out of 64 provinces in Vietnam have adopted some VS applications, this is an extraordinary effort as it spreads over the whole length of Vietnam, over 3 000km.