CHAPTER 3

DISASTER MANAGEMENT

VETIVER SYSTEM FOR NATURAL DISASTER MITIGATION IN VIETNAM

Tran Tan Van[1], Paul Truong[2] and Elise Pinners[3]
[1] Coordinator Vietnam Vetiver Network
Email: van@rigmr.org.vn; trantv@gmail.com
[2]TVNI Director Responsible for Asia and South Pacific,
Brisbane, Australia
Email: truong@uqconnect.net
[3] TVNI Associate Director, Nairobi, Kenya
Email: epinners@africaonline.co.ke

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 less than a decade ago and met with considerable skepticism at the beginning. However, the grass is now known throughout the country and is in use practically in nearly 40 out of 64 provinces. 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 and 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 etc. Research results, successes and failures of numerous applications indicate that VS, having many advantages and very few disadvantages, is a very effective, low cost, community-based and environment-friendly bio-engineering tool for natural disaster mitigation and infrastructure protection. However, to ensure successes and avoid failures, it is important that the VS be used with proper care, in which the two most important points are good quality of the planting material and the all-important appropriate design and correct planting techniques.

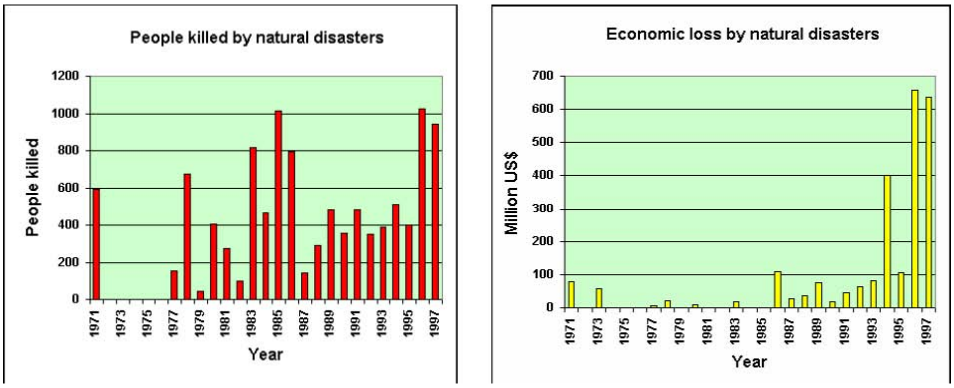
Keywords: Disaster mitigation, cut slope stabilization, river bank, irrigation canal and sea dyke erosion control,

1.0 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 as shown in Figure 1 below. 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.

Fig.1. People killed and economic loss by natural disasters in Vietnam during 1974-1997 period (Source: UNDP Project VIE/97/002 - Disaster Management Unit).



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.

2.0 TRADITIONAL REMEDIAL MEASURES AND THE NEED FOR NEW APPROACHES

The Ministry of Agriculture and Rural Development and its provincial departments are responsible for dyke management and "naturally" they undertake measures to protect river banks.

Similarly, the Ministry of Transport and its provincial departments 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 US$/km. An extreme case is the Tan Chau embankment in the Mekong delta cost 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 9^{th} level only) and they begin to talk about constructing stronger sea dykes (capable to withstand storms of up to 12^{th} 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 also 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.

3.0 VETIVER GRASS AS A BIO-ENGINEERING TOOL

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 (*Chrysopogon 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 following 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.

- Extremely deep and massive finely structured root system, capable of reaching down to 2 to 3m in the first year. This extensive and thick root system binds the soil and at the same time makes it very difficult to be dislodged and extremely tolerant to drought.
- The tensile strength of vetiver roots varies between 40-180 Mpa. The mean design tensile strength is about 75 Mpa - **equivalent to approximately one sixth of mild steel**. This indicates that vetiver roots are as strong as, or even stronger than that of many hardwood species, which have been proven positive for root reinforcement in steep slopes.
- New roots are developed from nodes when buried by trapped sediment. Vetiver will continue to grow with the new ground level eventually forming terraces, if trapped sediment is not removed
- Stiff and erect stems which can stand up to relatively deep water flow (0.6-0.8m).
- Dense hedges when planted close together, reducing flow velocity, diverting runoff water and forming a very effective filter.
- Tolerance to extreme climatic variation such as prolonged drought, flood, submergence and extreme temperature from $-14^{o}C$ to $55^{o}C$.
- Ability to re-grow very quickly after being affected by drought, frost, salt and other adverse soil conditions when the adverse effects are removed.
- High level of tolerance to soil acidity, salinity, sodicity and acid sulfate conditions.

Although the concept of using vetiver grass for various applications has only been introduced into Vietnam in 1999 by The Vetiver Network International (TVNI) 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.

4. VETIVER SYSTEM FOR NATURAL DISASTER MITIGATION

4.1 VS Application for Road Batter Stabilization and landslip control

A particular bold move was made by the Ministry of Transport, following successful trials 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 along hundreds of km of the newly constructed Ho Chi Minh Highway and other national, provincial roads several provinces in Central

Vietnam.

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 climate in the South. The extensive use of Vetiver grass for cut slope stabilization brings in very good results e.g.

- Applied primarily for slope surface protection it greatly reduces surface erosion, which otherwise would cause hazards downstream.
- By preventing shallow failures, it greatly stabilizes cut slopes and consequently greatly reducing the number of deep slope failures;
- By preventing shallow failures, it greatly stabilizes cut slopes and consequently greatly reducing the number of deep slope failures;
- By preventing shallow failures, it greatly stabilizes cut slopes and consequently greatly reducing the number of deep slope failures;
- In some cases where deep slope failures do occur, it still does a very good job in slowing down the failures and reducing the failed mass and
- It helps increase the environmental friendliness of the road etc.

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

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

	Position on the batter	**Root depth (cm)**			
		6 months	**12 months**	**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

Success and failure along the Ho Chi Minh Highway show further lessons:

- The slopes should first be internally stable, as the Vetiver grass is not immediately effective (slopes can fail before roots have established). Stabilization may take place earliest 3-4 months after planting; hence timing is also very important to avoid slope failure in the first rainy season;

- 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.

4.2 VS Application for River Bank Erosion Control

- ***In Central Vietnam***

In a large pilot project, Vetiver grass was planted to fix erosion of a river bank, bank of a shrimp pond and a road embankment in Da Nang City. Following the success of this pilot project, in October 2002 the local Dike Department also decided to mass plant the grass on more bank sections of several rivers and subsequently, Vetiver grass was recommended for use in another natural disaster mitigation project in Quang Ngai province, which was funded by AusAid for protection of dikes and irrigation canals in several districts against flash flood and sea water intrusion. 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 natural disaster mitigation project was expanded to mass planting on several dikes at 3 more districts, in combination with rock rip-rap measure. Some design modifications have been introduced to better adapt Vetiver grass to the local conditions. For example, mangrove fern and more salt tolerant grasses are planted on the lowest row to better withstand the high level of saline water and effectively protect the embankment toe. The grass is further introduced to local communities so that they themselves can protect their own land.

- ***In the Mekong Delta***

In An Giang and Tien Giang Provinces of the Mekong Delta of southern Vietnam major floods occur every year. These floods are usually up to 6-8m deep and can last up to 3-4 months. As a result unless houses are built inside the land protected by major dike systems, they are flooded every year. Therefore people cannot build their permanent homes, they have to rebuild every year causing extreme hardship to subsistent farmers. In addition, river banks in the Delta are mostly made up of soils ranging from alluvial silt to loam, which are 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. These boats aggravate the problem of river bank erosion further by generating strong waves. However, despite these negative factors, Vetiver grass withstands well, protecting large areas of invaluable farm land from erosion.

To over come this problem, local government select a relative high area and further top it up with soil dredged from the surrounding land, high enough to escape the annual prolonged flood. These are called Flood-Escaping Communities or People Clusters. But the banks of these clusters are themselves highly erodible. They need to be protected from the strong current and waves during the flood season. Vetiver planting has been highly effective in protecting these clusters against flood erosion with the added benefit of treating the community effluent and waste water during the dry season.

A comprehensive Vetiver program has been carried out in An Giang Province, where annual flood can reach up to 6 m depth. The province 4 932 km long canal system needs maintenance and repair every year. In addition, a network of dikes, 4 600 km long, was built to protect 209 957 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. In addition there are also 181 resettlement clusters need erosion control measures 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 dike 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 2 025 km of Vetiver hedges on 3 100 ha of dike surface. If unprotected by Vetiver, it is expected that 3 750 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 dike systems as well as along river bank, canals etc. in the Mekong Delta.

4.3 VS Application for Coastal Erosion Control

In 2004, at the recommendation of Tran Tan Van, the Danish Red Cross funded a pilot project using Vetiver grass for sea dike 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 dike system. Although the planting design was not up to the standard recommended for such application, this planting has helped protecting the dike 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 dike was even more remarkable after typhoon No. 7 in September 2005, which even broke the sections rigorously protected by rock rip-rap.

In 2001 with financial and technical supports from the Donner Foundation and Paul Truong respectively, Le Van Du from Ho Chi Minh City Agro-Forestry University initiated works on Acid Sulfate Soil to stabilize canal and irrigation channels and sea dike system in Go Cong province. Despite the poor embankment soil Vetiver grew rigorously in just a few months, helping to protect the sea dike, preventing surface erosion and facilitating endemic species to establish.

4.4 VS application for sand dune stabilisation in Central Vietnam

A vast area of more than 70,000 ha along the coastline of Central Vietnam is covered by sand dunes where the climatic and soil conditions are very severe. Sand dunes often migrate as a result sand blown by strong wind. Sand flow also takes place frequently due to the action of numerous permanent and temporary streams. Sand fly and sand flow transport huge amounts of sand from dunes land inwards onto the narrow coastal plain. Traveling through Central Vietnam, one can easily notice giant sand “tongues” that are invading into the precious farm land on the coastal plain day by day. The government implements reforestation programs using plants such as Casuarinas, wild pineapple, eucalyptus, acacia. But at most, when fully and well established, this can help reduce sand fly; there was no way yet to reduce sand flow.

In February 2002, with financial support from the Dutch Embassy a project was initiated to stabilize sand dunes along the coastline. Vetiver grass was planted in 3 rows along the contour lines on the slope of the sand dune, starting from the edge of the stream. After 4 months it formed closed hedgerows and the sand dune toe was stabilized. The local Forestry Enterprise was so happy that it decided to mass plant the grass in other sand dunes and even for the protection of a bridge abutment. Vetiver grass further surprised local people by surviving the coldest winter in ten years, with temperatures below 10^{o}C, forcing the farmers to replant twice their paddy rice and Casuarinas. After 2 years, local species such as Casuarinas, wild pineapple etc. re-established between Vetiver hedges; the grass itself faded away under the shade of these trees but it has accomplished its mission: dune sand flow was considerably reduced. The project proved that with proper care Vetiver grass could survive very hostile soil and climatic conditions. According to Prof. Henk Jan Verhagen from Delft University of Technology (pers. comm.), it may be equally effective using Vetiver grass to reducing sand fly. For this purpose, the grass could be planted across the wind direction, especially at low places in-between sand dunes, where the wind velocity is expected to increase.

Following the success of this pilot project, a workshop was organized in early 2003 for more than 40 participants from local government departments, 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.

5. ADVANTAGES AND DISADVANTAGES OF VETIVER SYSTEM

5.1 Advantages

- The major advantage of VS over conventional engineering measures is its low cost. For slope stabilization in China for example, the saving is in the order of 85-90% (Xie, 1997 and Xia et al, 1999). In Australia the cost advantage of VS versus conventional engineering methods ranges from 64% to 72%, depending on the method used (Braken and Truong 2001). In short, the maximum cost is only 30% that of traditional measures;
- Secondly, as with other bio-engineering technologies, VS provides a natural and environment friendly method of erosion control and land stabilization which 'softens' the harsh look often associated with conventional engineering measures such as concrete and rock structures. This is particularly important in urban and semi rural areas where the visual degradation of the environment caused by infrastructure development is often a major concern of local population;
- Thirdly, VS's maintenance costs are low in the long term. In contrast with conventional engineering structures, the efficiency of bio-engineering technology improves with time as the vegetative cover matures. VS requires a good maintenance program in the first 1-2 years but once established it is virtually maintenance free in the long term. Therefore, the measure is particularly suitable for remote areas where maintenance is costly and difficult;
- Particularly effective in poor and highly erodible and dispersible soils;
- Particularly suitable for regions or countries with low cost labor forces.

5.2 Disadvantages

- The main disadvantage of VS is its intolerance to shading particularly in the establishment phase. Partial shading will reduce growth and severe shading can eliminate it in the long term by reducing its ability to compete with more shade tolerant species. However this weakness could be consider as a desirable characteristics in situations where a pioneer plant is needed to provide the initial stabilization, improve the micro environment for the introduction, either voluntarily or by planting of native endemic species;

- Vetiver contour system is only effective when the plants are well established. Therefore an initial establishment period of about 2-3 months in warm weather and 4-6 months in cooler time should be allowed for. This time lag can be overcome by planting early, in the dry season;
- Vetiver grass can be fully effective only when it forms closed hedgerows. Hence, the gaps in between clumps should be timely re-planted;
- Difficult to plant and water on very high slopes;
- Protection from livestock during establishment phase;

Based on the above, it is clear that the advantages of using the VS as a bio-engineering tool outweigh its disadvantages particularly when the Vetiver plant is used as a pioneer species.

6. CONCLUSIONS

From the results of research and the successes of numerous applications presented above, it is clear that we now have enough evidence that VS, having many advantages and very few disadvantages, is a very effective, low cost, community-based and environment-friendly bio-engineering tool for natural disaster mitigation and infrastructure protection. It has been used successfully in many countries in the world, e.g. Australia, Brazil, Central America, China, Ethiopia, India, Italy, Malaysia, Nepal, Philippines, South Africa, Sri Lanka, Thailand, Venezuela, Vietnam etc. ***However it must be emphasized that to provide an effective support for engineering structures, the two most important points are good quality of the planting material and the all-important appropriate design and correct planting techniques.***