Vetiver System for Sand Dune Stabilization

A Vietnamese Experience

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Abstract

Sand dunes occupy more than 70,000 ha along the coast of Central Vietnam, being the sources of such natural disasters as sand storm, sand flow/flash flood etc., that eat either slowly or catastrophically villages and fields. This has been surveyed by a team of geologists from the Research Institute of Geology and Mineral Resources (RIGMR), who also looked for remedial measures. Having compared several traditional, both hard and other bio-engineering, using local vegetative species, measures, the authors came to a decision to promote the use of Vetiver grass, which could withstand very harsh climatic and soil conditions. With financial support from the Dutch Embassy Small Program, the authors had a real opportunity to try to fix a sand dune which was eroded away by strong water flow during rainy season. Despite the sub-optimal planting time, the grass withstood the hot and dry season thanks to the additional watering scheme, becoming very dense after 4 months. In so being, it was able to fix the sand dune and at the same time, allowing other local species to grow. Several types of seedlings (bare root and pots) and fertilization schemes were also tried but subsequent mass planting proved that with subsequent water supply, the grass can still survive an exceptionally cold winter and can establish well thereafter even without initial fertilization.

I. Introduction

From 2000 to 2002, the first author of this paper headed a team of geologists from the Research Institute of Geology and Mineral Resources (RIGMR) to conduct a State-funded project on the assessment and mitigation of geohazards in the 8 coastal provinces/cities of Central Vietnam. Their field survey and assessment has helped conclude that sand storm is one of the most frequent hazards in the area comes from the extensive sand dunes.

Sand dunes occupy more than 70,000 ha along the coast of Central Vietnam, most notably in Quang Binh, Quang Tri, Thua Thien-Hue, Da Nang, Quang Nam and Quang Ngai provinces. They have been and are being the cause of such natural disasters as sand storm, sand flow/flash flood etc., that erodee either slowly or catastrophically villages and agricultural fields.

Confronted with such disasters, local farmers have to spend much of their time and money on mitigation measures. But one traditional and very popular measure they use - building sand dykes/embankments - is in most cases, not effective. The sand dykes/embankments are easily washed away by floods, which equally easily uproot the local grass planted by farmers to stabilize their structures.

Sometimes the Government or some NGOs have come in to help farmers with some technical support, which, however, has its own problems. Local engineers are used to more expensive

solutions using rocks and cement and in many cases they very soon see their concrete/rock embankments built directly on sand either buried or collapsed.

Afforestration seems probably most appropriate for sand dunes and already for several decades, there have been continuous projects for planting Casuarinas, local grasses, wild pineapple. trees etc. to prevent sand storm and sand flow. However, perhaps Casuarinas are the only trees that can survive in such hostile conditions and to some extent reduce sand storm. But they can not help reduce sand flow and flash flood. It can be said that so far no effective measures have been found to minimize these hazards.

On the other hand, when Casuarinas are planted, the young seedlings are subject very often to strong winds and rains, which prevent them from growing up straight. Moreover, the sand is very poor in nutrition and because of this Casuarinas grow very slowly. Fertilizing the trees has never been a practice in the area as without that the farmers are already very poor. Thus how to ensure a good growth of Casuarinas remains unanswered.

In another attempt to reduce poverty, a new idea of raising on-sand shrimp has been introduced recently and many shrimp ponds have been and are being set up directly on sand (many ponds are built up where there is no natural water and water circulation in and out of the ponds has to rely on pumping system) along the coast of Central Vietnam. However, the initial investment is quite big, at the order of 30-50,000 US$ for a 100 m x 100 m pond. A major portion of the expenses is for the pond embankment, which is usually about 5 m bottom x 2 m crest x 1.5-2.0 m high, requiring about 2,000-3,000 m^3 of sand i.e. about 70,000-100,000 sand bags (25-30 kg each), costing about 10-15,000 US$. The bags are, however, very quickly worn out under sun light and to temporarily avoid this problem, they have to be protected by thick, paint-coated nylon sheets, which last also only for 2-3 years. So after 2-3 years, these ponds require substantial maintenance and upgrade.

Having learned that Vetiver grass can survive very harsh climatic and soil conditions, the authors saw in it a way that might help ease the problems encountered in sand dune areas. That is if Vetiver hedgerows can be established along the contour lines of sand dunes then they can help minimize sand storm and flow/flash flood, and facilitate the growth of other local varieties that can, eventually entirely cover the dunes.

In early 2002, the authors of this paper received a Dutch Embassy Small Program funding for trial application of Vetiver grass for sand dune stabilization and river bank erosion control. The one year project has been implemented with success, which consequently lead to the much wider use of the grass in North and Central Vietnam. A number of lessons have been learned and they will be in details elaborated in the following sections.

II. Location

The pilot site is located in Le Thuy district, Quang Binh province, along the No. 1A National Highway. To the West is the narrow belt of lagoonal plain which is about 10-15 km wide. A few hundred meters to the East starts a range of elongated sand dunes which, about 4-5 km to 10-12 km in width, 10-15 m in height, separates the above mentioned plain from the coastal line. Unlike the few large rivers that flow east-ward from the Truong Son Mountain Range to the East Sea, every few hundred meters there are small rivers flowing west-ward with fresh

water from these dunes. In dry season these small rivers almost disappear but on contrary, they are very fast flowing in the rainy season, transporting a huge volume of sand to deposit west-ward onto the irrigated farmers' fields downstream. Furthermore, these rivers are also quickly filled up with sand, aggravating the flood hazard in the area and threatening both bridges and the National Highway. In the past these rivers could change course, but now the whole area is under cultivation, any such a change would cause damage to the poor farmers who don't have anywhere else to go. With support from an NGO project using heavy equipment some sand-dikes have been built, but they are very unstable. They remain mostly barren except some sea-pine and wild pineapple species surviving here and there. Some experiments with turf-like organic matter are on-going, but it looks as if they too would not result in a good vegetation cover.

This particular pilot site so selected was along a sand dune on the bank of a small river. The river in fact is a natural boundary between a Forestry Enterprise and a commune. During the dry season, the river bed is leveled off and used by the Enterprise's workers as a nursery, but it is full with both water and sand during the rainy season. As the river gradually undermines its sandy bank during rainy season, the sand dune was retreating several meters year by year, making the commune people very unhappy. They thought it was the Forestry Enterprise to blame for their nursery activities. Several attempts were made for fixing the dune but all failed while the conflict was mounting, requiring an immediate solution.

At the recommendation by the provincial and district People's Committees, the Department of Agriculture and Rural Development as well as the local Department for Dyke Management and Flood Control (DDMFC), the authors surveyed the site and decided to set up a trial there.

III. The trial

The pilot planting started in late February-Early March 2002, as soon as the funding was made available. In fact it was rather late as the dry season was approaching, so it was decided first to set up a small pilot site while the mass planting would come a few months later. More on the appropriate planting time would be addressed below.

Fig. 1. The site in early March, 2002 - a dry river at the foot of a bare sand dune.

Fig. 2. Early April - one month after planting. Note the mulching above the uppermost row.

As not much was known on the ability of Vetiver grass on almost pure sand, the following pattern was selected:

Establishment: The foot of the sand dune was prepared and 3 rows of Vetiver grass were planted, each 60 m in length. These rows were divided in two trials; on the left side (30 m) only bare root slips were used; on the right side (30 m) pots were used in the upper line, and 5m on-off in the 2nd and 3rd lines. Planting distance was adopted equally at 10 cm.

To anticipate the possible strong flow of the stream in the rainy season, a few perpendicular lines of Vetiver grass were later added in at 10 m interval.

Fertilization: Three fertilization treatment schemes were adopted for each 10 m interval in each row, i.e. per meter run: (a). 3 kg green manure; (b). 3 kg black soil + 3 kg green manure; and (c). 6 kg green manure. In the other half the order is (b), (a) and (c). This manuring was used to counter the problem of sub-optimal planting time, i.e. to ensure quick growth of the grass, for it to be able to withstand the forthcoming drought and possible heavy rains in August.

After half a month, as the grass established, a little NPK was applied at about 100 g/m run.

Watering: As the dry and hot season was approaching immediately, with very high air temperature during daytime (sometimes more than 40^{o}C, the surface sand even hotter), during the first month after the planting, the grass was watered twice daily. Thereafter, it was watered once per day in the 2 consecutive months.

Maintenance and monitoring: Also during the dry season, the dry sand on the slope easily moved down with the wind, sometimes half burying the young grass, sometimes even washing it away. The farmers taking care of the trial were very creative in making a long and narrow ditch right above each row and putting in there dry Casuarinas leaves and mulches. In so doing they reduced the flow of dry sand and at the same time ensure a better watering. The first author of this paper visited the site once a month to measure the growth of the grass and give further instructions on any incurred technical problem.

Nursery: A small nursery was set up at the same time nearby, on a flat sandy ground with better moisture condition. The spacing was selected at 0.5 m apart. The purpose of this nursery was to supply the mass planting phase a few months later.

IV. Results and discussion

The grass grew very well both in the nursery and at the pilot site. Initially plant from the pots grew better, but after a while there was almost no difference between bare roots and pots. The grass then flowered but did not spread wild while its leaves become dry, replaced by younger tillers from the crown.

Farmers found bare root planting a better option as it made the grass more resistant to the harsh climatic and nutrient conditions. For mass planting, they also argued that bare root would also be a more desirable and economic option.

All fertilization schemes also appeared to give similarly good growth results. After 4 months dense hedgerows established, which effectively stabilised the sand dune. The Forestry

Enterprise was so happy with the results that, apart from some sand dunes planned by the project, it decided to mass plant the grass itself on other sand dunes. The Forestry Enterprise director even order to uproot a few hundred mature clumps to replant at a bridge abutment along the National Highway. Although technically it was not properly designed, but as the 2002 flood season was not so severe, the bridge abutment was also stabilized.

Fig. 3. Early July - 4 months after planting - very good growth to form dense hedgerows.

Fig. 4. The nursery after 4 months. More than 1.7 m high grass.

Fig. 5. Mid-October 2002 - The pilot site. Note the flowering, the dry leaves and the growth of Casuarinas in between Vetiver rows.

Fig. 6. Mid-October 2002 - One month after mass planting at a similar site. The "river" is quite wet.

Farmers later also argued that for mass planting, no fertilization scheme adopted above would be realistic. For other species e.g. Casuarinas, they also uses no fertilizers. In the end, it was decided that for mass planting of Vetiver grass, except for some sporadic watering, nothing special in terms of fertilization would be adopted.

Mass planting with 2 km run was carried out in October 2002, at the end of the rainy season. This was to avoid some heavy rains that could wash away the seedlings and at the same time to ensure adequate moisture in the sand before the next winter comes in December-January.

The 2003 winter was exceptionally cold, with daily temperature often went down below 10^{o}C. So cold that the local farmers had to replant their paddy rice and Casuarinas twice before their

third replanting succeeded. Local grass also died because of the cold weather and the local farmers reported their Vetiver nurseries were cut by strangers for feeding cows. The mass planted Vetiver grass, however, survived and they looked quite green in February 2003, when a regional workshop was organized. After 2 years, at the first pilot site the grass has helped local varieties such as Casuarinas, wild pineapple etc. to re-establish. The vetiver grass growth was reduced under the shade of these trees but by then it has accomplished its mission.

Fig. 7. Local initiative - Vetiver grass for protection of bridge abutment along the No. 1 National Highway. Note the sand transported by the flow, only 1 m below the bridge.

Fig. 8. Mid-February 2003 - Post-workshop fiel dtrip. The grass looks green even after the coldest in 10 years winter.

Fig. 9. June 2003 - Nursery at home. A World Vision Vietnam-sponsored field trip for farmers from the neighbouring Quang Tri province.

Fig. 10. Dec. 2004. Local species establish to completely fix the sand dune. Vetiver grass is fading away under the shade of these trees but it has accomplished its mission.

Attending the above mentioned workshop and field visit were more than 40 participants from ministerial and provincial departments of Agriculture and Rural Development; Science, Technology and Environment; Transport; Construction etc., of 8 coastal provinces of Central Vietnam. In addition, there were also several foreign organizations such as the Australian contractor Kellogg Brown & Root (KBR), Canadian Centre for International Studies and Cooperation (CECI), World Vision Vietnam etc. Most participants found the demonstrations very interesting and several intended to try themselves. In particular some departmental

authorities (DARD/DOSTE) from several provinces expressed their intention to set up more demonstrations in dunes. In Quang Binh there are plans to control sand dune erosion in 22.000 ha south of Dong Hoi, to protect about 10 local roads that often fill up with sand.

In fact, as a result of this pilot project and workshop/field excursions World Vision Vietnam decided to fund a similar project in the neighboring province of Quang Tri, for sand dyke and river bank protection. Another pilot project was also approved by an AusAID funded natural disaster mitigation project in Quang Ngai province. In the same year of 2003, the Ministry of Transport decided to mass plant Vetiver grass on cut slope along the newly built Ho Chi Minh Highway.

Some particular lessons can be drawn out from the above presented pilot project:

- ***Planting time***: Planting time in North Vietnam can be a problem because of the cold winter. Planting in March as in this project (just before the hot dry period) was possible and the grass survived well the summer storms in August through November. But this required regular watering, especially in the first 1-2 months, which increased cost and risk. Further, watering in case of mass planting would also be unrealistic that would make the grass unwelcome. Planting a bit earlier, e.g. in December-January could face another problem, i.e. the cold winter, which sometimes goes less than 10^{o}C in North Vietnam. Thus, planting in early February, maybe a better option (in fact this is also the time when other species are planted in North Vietnam).

  On the other hand, planting in October is also well possible, when there is enough water in the sand for the seedlings and the grass has sufficient time to grow before the winter arrives without additional watering. The project once more proved that with proper care Vetiver grass could survive very hostile conditions (very poor nutrition, hot summer and cold winter).

- ***Design***: Having some cross rows, right angle to the water flow direction, appears very effective in sustaining the strong flow during the rainy season. On the other hand, planting more rows, above the 3 already established, is only possible once the grass in these existing rows is mature enough to withstand possible sandflow due to the new planting above. However, it seems not so critical to continue planting more rows above as the major cause for the dune to collapse is the waterflow eroding its foot.

Encouraging news came thereafter from China where Vetiver grass has been planted around Casuarinas seedlings on sand dunes. The faster growing grass protects the Casuarinas seedlings and at the same time, preserves the ground humidity and supplies the seedlings with additional nutrition. The grass does not loose its effectiveness until the Casuarinas seedlings have grown high and strong enough, hence creating shadow to prevent the grass from further growing.

In another pr0vince in China, Jiangxi, shifting sand-dunes are moving northward from the south with a speed of 5m/a. During a period of 30 years, i.e., from 1950 to 1980, 8 villages were destroyed and covered by shifting sands, causing the loss of 660ha of farmlands and damaging a series of water conservation facilities due to sedimentation.

To stabilize the sand dunes, vetiver grass was planted in lines. Although the sand lacks of nutrients, 91% of the planted vetiver survived and grew well. Besides, vetiver promoted other

weeds to grow. Therefore sandy dune was stabilised. The successful experience is valuable not only to this area but also to other river banks and coastal region which covers a large area in Southeast China.

Similarly in Senegal, vetiver grass also demonstrated its effectiveness in stabilising beach sand dunes, preventing the shifting dunes from invading upmarket beach side resort.

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