Vetiver Victorious: The Systematic Use of Vetiver to Save Madagascar's FCE Railway

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Abstract: In 2000, two cyclones hit the island nation of Madagascar in a two-week period. The devastation to infrastructures was enormous. Among the worst hit was the FCE train line in the southeastern part of the country that suffered more than 280 landslides. The line was closed for three months, causing severe hardship to the more than 100 000 people living along its route. Two Thai vetiver specialists went to Madagascar soon after the cyclones to investigate the possible uses of vetiver in restoring the rail line and protecting it from future erosion damage. In the three years since, the Land Development Intervention (LDI) and FCER projects, in collaboration with the FCE Railway, have worked to systematically disseminate vetiver along the line, both in a technical intervention designed to restore areas hit by severe landslides, and in a community-based intervention that has enlisted more than 600 farmers in slope stabilization activities along the train line. Using an innovative "vetiver-for-vetiver loan/reimbursement" scheme and a "modular cropping" system that have facilitated dissemination and implementation with farmers over a three-year period, more than 2.6 million vetiver slips have been planted along the 163 km long train line. This has significantly reduced erosion damage and strengthened slopes and infrastructures along the line. The vetiver intervention also provides farmers with a sustainable agriculture alternative to traditional slash-and-burn practices, enhances soil fertility and improves farmers' income. The success achieved has prompted an adoption of these vetiver intervention techniques by another railway line in the northern part of Madagascar.

Key words: landslide, erosion, dissemination, modules, slope stabilization, soil fertility.

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1 INTRODUCTION

Madagascar, the world's fourth largest island, has often been called a "naturalists' paradise" for its bounty of endemic species found nowhere else on earth. It represents a natural heritage for humankind that needs to be zealously guarded for future generations. However, this "paradise" is jeopardized by rapid environmental degradation, caused in large part by deforestation and consequent erosion, especially on the high plateau, which is home to most of Madagascar's remaining tropical forest.

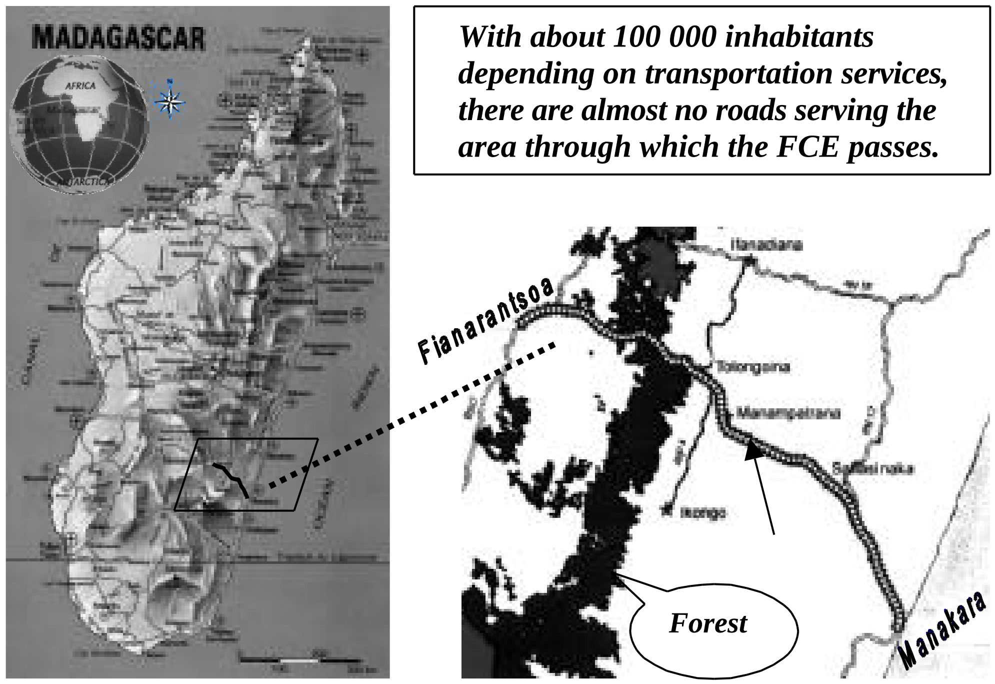
Madagascar's physical geography nearly is as unique as its fauna and flora and poses substantial engineering challenges for people working on infrastructure stabilization. Its soils, usually red in color, are soft when wet and extremely vulnerable to erosion by running water because they are pervasively weathered into extremely fine particles and colloids that, once dislodged, are very easily removed (Wells and Andriamihaja 1997). It is famous not only as a natural paradise but also as the " Red Island" that seems to bleed into the sea (Juliard, 2002).

1.1 Cyclones Hit the FCE Railway

Madagascar's geographical vulnerability was illustrated all too clearly during the early part of infrastructures. Among the hardest hit was the FCE railway.

The FCE (Fianarantsoa-Côte Est) railway crosses over Madagascar’s last remaining band of highland tropical forest and down a steep escarpment as it wends its way from the city of Fianarantsoa (1100 m above mean sea level) to the coastal town of Manakara (Fig. 1). The railroad is a lifeline for some 100,000 people who live in an area served by no other transportation network (Fig. 1, inset), and serves more than a million people as it transports goods and travelers between the highland and the coast.

Fig. 1 Map of Madagascar and FCE alignment (inset)



In the wake of the two cyclones that hit Madagascar in a 2-week period in early 2000, the train line suffered devastating damage: more than 280 landslides dumped some 150,000 m^3 of earth over its 163 km length. For kilometer after kilometer there were hardly traces of the tracks to be seen, buried as they were under tons of mud and debris. Rail service was disrupted for some four months causing human suffering and serious economic loss to both residents along the line and more distant users.

1.2 Impact of the Train on the Economy and Environment

Efforts to restore train service were bolstered by studies that showed that without rail transport in this remote but agriculturally rich area of the country, farmers would have no means of transporting their crops to market, and therefore no revenues to buy rice and other food crops (PAGE, 2000, Vol 3). With no way to sell tree crops such as coffee and bananas, they would quickly be forced to cut the trees, and instead plant annual subsistence food crops on the steep slopes that characterize the zone. Traditional production techniques for such crops are notoriously unsustainable on Madagascar’s erosion-prone slopes and infertile soils; quickly these lands would become infertile and farmers would be obliged to clear new agricultural lands. Most would head for the tropical forest in search of arable land. Research carried out in the region soon after the cyclones showed that if the train were not put back in service, more than 150 000 hectares of tropical forest would be cut by farmers forced to replace sustainable tree crops by non-sustainable annual food crops over the next 20 years (PAGE, 2000, Vol 1). In short, the demise of this railway would have a disastrous effect on both the economy and environment of the Fianarantsoa region.

which is the poorest province in one of the twenty poorest countries in the world (World Bank, 2000).

1.3 The Search for a Cost-Effective Restoration Strategy

In light of this conclusion, LDI decided to put a major effort into saving the railway. Given the terrible damage and the extremely limited resources to do anything about it, a cost-effective solution was needed. It was clear that merely restoring the line to its previous level of fragility was an exercise in futility; the next round of cyclones would cause a similar level of damage unless more systematic prevention measures were put in place. Attention focused on two issues: (1) putting effective drainage systems back into operation and (2) reducing the cause of hillside erosion, which was traced in large part to agricultural practices along the line. Specifically, in an effort to protect its land from permanent encroachment, the railway had a policy of allowing squatters to cultivate annual crops along the line but did not allow the cultivation of trees and more permanent crops on the 50-meter right of way owned by the railway on both sides of the track. As a result, the track was lined with a patchwork of several hundred fields planted mostly in manioc (cassava) and rice on the steep slopes along the line.

The project team in Madagascar scrambled to figure out the options in what seemed to some to be a hopeless operation. The mess down the line was nearly overwhelming in scale, especially given the extremely limited funds available to deal with the problem.

1.4 "This Is a Job for Vetiver…"

From a continent away in Senegal, Criss Juliard, once a vetiver pioneer in Madagascar, learned of the dilemma and fired off an e-mail to Mark Freudenberger, Regional Director of the LDI project in Fianarantsoa. Criss, who had in January 2000 attended the Second International Conference on Vetiver in Thailand, was cognizant of advances in Thai vetiver technology and recommended that expertise assistance from Thailand be sought. Mark contacted the Office of the Royal Development Projects Board (ORDPB), and consequently two Thai vetiver specialists, Dr Uthai Charanasri (an agronomist with the Doi Tung Development Project) and the senior author (a civil engineer of APT Consult Co., Ltd) were despatched to spend three weeks (July/August 2000) with the LDI project team in Fianarantsoa, volunteering their wealth of knowledge and experience of vetiver practice to finding a cost-effective and sustainable solution to the FCE's problems.

2 THE USE OF VETIVER TO PROTECT THE FCE TRAIN LINE

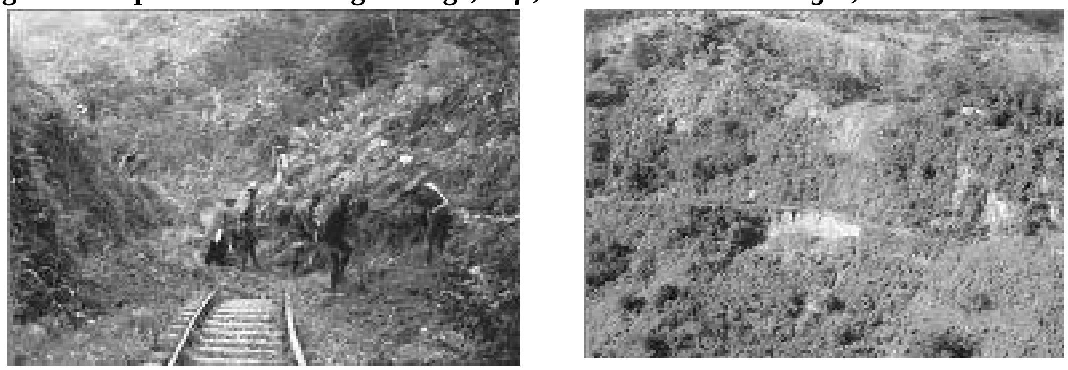
The 163-km FCE railroad line traverses topography as diverse as sandy coastal zones at sea level at Manakara to dense tropical forests and rugged mountains before it reaches its western terminus in Fianarantsoa (1100 m asl).

Cyclones Eline and Gloria smashed Fianarantsoa province in early 2000 and left behind devastating damage. When the second cyclone hit, the earth was already saturated by rains from the first. Streams and rivers rose to new heights as they tried to accommodate the runoff from the largely deforested mountainsides. The result was no fewer than 280 landslides and 28 embankment slides (Fig.2) …all in a distance of 163 km.

In seeking both to repair current cyclone damage and forestall future damage, it was decided to use vetiver systematically in all the interventions in order to obtain the most cost-effective and sustainable results.

Two categories of interventions were carried out: the first were what we called "technical interventions." This included removing landslides, rebuilding drainage infrastructures, and restoring washout areas. The second was a community-based intervention to reduce the cultivation of erosion-inducing annual crops on the very steep slopes abutting the track and instead to introduce a vetiver based sustainable cropping system that would both protect the embankments of the rail line and ensure farmer revenues. Because the technical interventions are more familiar to vetiver enthusiasts, we will only briefly touch on them in this paper (though they were vitally important and extremely effective in terms of stabilizing the rail line) in order to focus on the more innovative approaches taken in the community intervention.

Fig. 2 Examples of devastating damage, *Left,* 280 landslides and *Right,* 28 embankment slides.



Concerning the "technical interventions," the landslides, embankment slides, washouts and rail subsidence were caused primarily by erosion leading to slope instability because the slopes were generally devoid of slope protection measures. In addition, drainage on the slopes and at track levels was either non-existent or non-performing due to lack of maintenance. The project team in Madagascar, in conjunction with the Thai specialists, decided to use vetiver wherever it would be effective. Where vetiver alone was not sufficient, it was used along with 'hard' conventional techniques such as gabions. Furthermore, any new infrastructure (or rehabilitation of an old infrastructure) was immediately protected by vetiver so as to reduce erosion and subsequent silting. For details of technical interventions, the reader is referred to PRVN's Technical Bulletin No. 2003/2 (Hengchaovanich and Freudenberger 2003).

A key concern for the project was ensuring the proper maintenance of vetiver planted on these rail rights-of-way. The railroad rehabilitation project used a two-phase strategy for the maintenance of vetiver plants used in the technical intervention.

The initial maintenance period for the plants (from the time the vetiver is planted until it is well established with roots at least 1-meter deep) was covered by the contract issued for the vetiver planting. The contractor was required to maintain (water as needed and weed) the vetiver during a period after planting. In addition, he was required to replace any plants that are washed away or do not take root. The final payment is conditional on the contractor demonstrating at least a 90% survival rate on the area planted.

Maintenance must continue, but at a much lower level after the plants are well established. There is rarely a need to water beyond that time; most of the maintenance is for weeding (so those weeds do not take over and shade the vetiver) and for pruning of the vetiver to encourage root development. In order to ensure perpetual maintenance (particularly of the danger points or "*points noirs*" and infrastructures) the project, along with the FCE rail line, signed agreements for the upkeep of each vulnerable site with a neighboring farmer. The exact rights and responsibilities depend on the nature of the site; at less risky sites, farmers may treat the site like his personal field and plant annual and perennial crops in return for pruning and weeding the vetiver. At steeper, more vulnerable sites, the farmer may not plant crops, but has rights to harvest the vetiver for mulch, thatch, or artisanal uses.

3 FARMER VETIVER INTERVENTIONS TO SAVE THE RAILWAY

The second major contributor to the cyclone damage of 2000 (in addition to the failure to maintain drainage systems) was the cultivation of annual crops on very steep slopes above and below the rail line. With the harvest occurring at the end of the dry season, these slopes were left denuded during the heavy rains, contributing to serious erosion problems. Since almost all the hillsides planted immediately adjacent to the railway track are on lands that belong to the railway, one possible approach would have been to ban cultivation by farmers who were, essentially, squatters on land owned by the railway. For both practical and ethical reasons, the project decided that this was not the best solution and instead decided to work with farmers to find alternative measures that would both ensure the farmers' livelihood and protect the train line. In this way, rather than creating a hostile atmosphere with local residents, the project was able to enlist their assistance in an intervention that has had benefits for both the farmers and the train line.

3.1 Agricultural Systems along the Line

In the classic Malagasy system of "*tavy*" (swidden or slash-and-burn) agriculture (which has been credited as one of the principal causes of deforestation and loss of biodiversity in this unique island nation), hill-slope land is cleared of forest, and then planted in upland rice. After one or two seasons of rice cultivation, the poor and steep soils are no longer productive enough to grow rice, and manioc is grown for a year. It is then necessary to leave the land fallow to regenerate the fertility enough so that rice can be planted again. The cycle then continues, with a crop of rice, a crop of manioc, and a period of fallow.

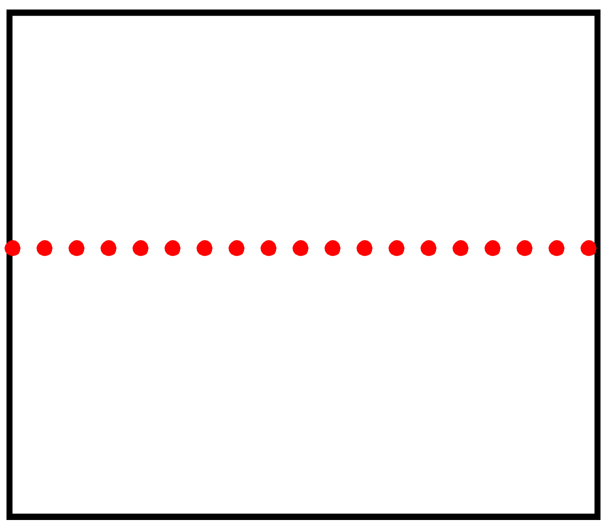
In the past, the fallow period lasted from 10-15 years, giving time for the land to regain significant fertility. Now, with increased population and land shortages, fallows have been reduced to 3-5 years. As a result, many of the lands become totally infertile within 20-25 years of the forest having been cut, after only 5-7 years of crop production (with the rest of the time devoted to fallow). The farmer is then obliged to travel even further in search of new fertile lands, often cutting a parcel in the last remaining tropical forest to satisfy his family's food needs.

The lands immediately along the train right of way belong, as noted above, to the railway. Over time, however, farmers moving into the region (often railway workers) or others whose land has become infertile, have moved into the right of way, cultivating slopes that are 45 degrees or steeper. For the most part, the railway cast a blind eye on such incursions in the past. When they intervened, it was usually only to tell the farmer that he could not plant trees on the land, since the planting of trees traditionally implies a transfer of ownership to the farmer. Farmers therefore planted mostly upland rice and manioc on these steep slopes, sometimes with a few bananas, essentially duplicating the *tavy* production system along the rail right-of-way.

3.2 Agriculture Induced Erosion

Annual plants have shallow root systems and manioc in particular contributed to erosion problems because the crop is harvested by uprooting the plant shortly before the rainy season. Steep slopes along the line were thus left exposed and without any significant ground cover during the rainy season. This caused surface erosion that contributed to siltation of drainage systems. Eventually, the lethal combination of non-functional drainage, exposed steep slopes, and extremely heavy rains would conspire to close the line with landslides totaling 150,000 cubic meters of dirt, as happened after the cyclones of 2000.

Combining knowledge of the local production system and economy with the Thai specialists'



Vetiver hedgerows at 1m

The module system: effective and easy to implement

*The module system facilitates planning and implementation of a vetiver intervention for both the farmer and the project. Based on a 10m x 10m "*__module__*" that includes vetiver, as well as annual and perennial plants, the farmer can quickly determine how many modules will be needed to stabilize his/her field and then "*__customize__*" the intervention based on his/her personal preferences and family needs: 3 apple modules, 2 spices, and 1 breadfruit perhaps. With a few quick calculations, the project can quickly determine how many vetiver plants and trees will be needed to carry out the intervention even for several hundred farmers at a time.*

were excluded). After careful analysis of more than 30 different perennial crops, the project narrowed the choice to five modules that would be offered in the rail rehabilitation intervention: coffee, breadfruit, citrus, apple, spices (cinnamon and pepper). The idea, because we needed to work fast and under fairly difficult conditions right after the cyclones, was to offer enough modules so that the farmer could diversify production in order to reduce risk, but not so many that the project could not provide adequate extension assistance or got bogged down in complicated logistics.

The choice of perennial crops was made to ensure crops with different characteristics (period of production, subsistence vs commercial value, and vulnerability to pests and disease, labor requirements, etc). The choice of modules (and the specific variety of species within the module) differs slightly according to where the farmer cultivates…a farmer with land at 1000 m of altitude has a different mix of apples trees from one who cultivates at 500 m, for example, while the farmer lower on the plain is not offered the apple module at all. In addition, the modules have a different number of trees according to spacing requirements; hence the citrus and apple modules have 4 trees per 10 m x 10 m module, while the coffee module has 9 trees and breadfruit 2.

3.4 Recruitment of Participants

A public education campaign showing the connection between agricultural practices and landslides was carried out to launch the intervention. Just after the train line reopened, a festive Party Train went down the line, stopping at every village along the way. The train pulled a flat bed car, on which a local band performed a specially commissioned song that spoke of the historic importance of the train line and the role of the villagers in keeping the line open. After the song, a puppet show reinforced many of the same themes, especially focusing on the issue of *tavy* agriculture and the threat it poses by provoking landslides on steep slopes adjacent to the tracks. The puppets (Fig. 4) enthusiastically recommended the use of vetiver as an effective solution to reducing hillside erosion. At each stop along the way, the Party Train picked up village leaders who all ended up at a conference the next day in Manampatrana, the mid-point of the train line. The conference focused on the issue of what the local communities could do to keep the train line open and local leaders returned to their villages to encourage farmer participation in the vetiver intervention.

Fig. 4 Puppet show on party train

Shortly after the passage of the Party Train and pursuant conference, project staff went down the line to recruit participants in the slope stabilization effort. All farmers growing annual crops along the line were invited to participate and the project made special efforts to identify and recruit farmers whose fields were located in the most vulnerable sections of the track. While many farmers remained reticent, some 90 signed on as participants in the first year. In some cases the farmers carried out the intervention on only a portion of their field, either because they felt labor demands were too high to plant the whole field with vetiver in the first year, or because they were reserving judgement until they were convinced that the intervention was a sensible one.

The Calendar for Implementing Farmer Vetiver Interventions

December/January

- *Identify the new farmers who wish to participate as well as vulnerable sites that need stabilization*
- *Training to explain module system to farmers*

February

- *Establish tenure contracts for participating farmers*
- *Training in vetiver planting and contour lay-out*
- *Farmers measure their fields (with extension partners) and choose modules*

March/April

- *New farmers lay-out contours;*
- *Previous season farmers reimburse vetiver that is distributed to new farmers*
- *New farmers plant their vetiver and reimbursing farmers replant (this corresponds with the end of the heavy rains)*

May

- *Project team visits all newly planted fields to verify planting techniques*

September

- *Tree root-stock is grafted according to farmers' choice of modules*

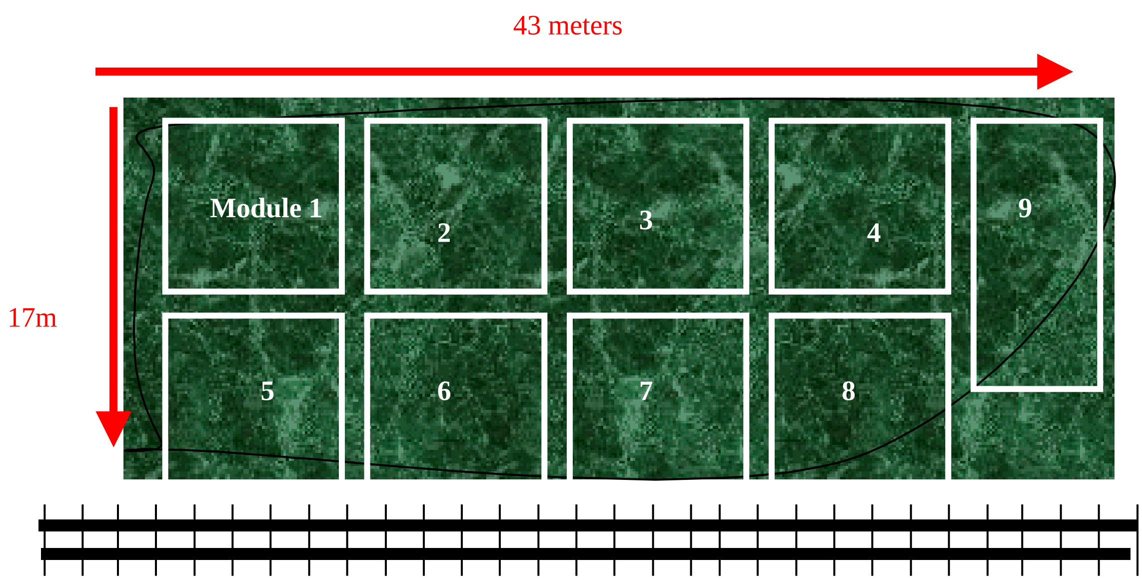
December

- *Farmers plant the fruit trees on their parcels (this should coincide with the start of the rainy season.*

intermediary between the project and participating farmers. There are currently 18 such agents who live in villages along the train line. The agents do not necessarily have prior agricultural training or even formal education. They are chosen because they are respected by their fellow villagers, and are considered to be good and honest farmers. They are required to have at least minimal literacy and numeracy skills to enable them to keep basic records. These agents were trained in the first year to do contours, vetiver planting, and other information dissemination. They work closely with project staff at every stage of the recruitment, training, and follow-up with farmers[1]. Farmers participating in the project initially receive training in contour identification and vetiver planting and then work with their local extension partner to lay out the contour lines (using the A frame method) at 1.0 vertical meter intervals.

Participating farmers receive the vetiver slips that will be planted as a loan from the project and sign a paper saying that they will reimburse the project the following year. A given farmer with 6 modules would receive for example, 4000 vetiver slips. He will plant the slips at 10-cm distance along the contours. Within 6 months, these slips typically tiller into tufts and within a year each tuft produces from 10-20 tillers. When it is time for the farmer to reimburse the loan the following year, he will uproot the tuft by cutting the roots 5-cm below the surface of the ground. He will replant one slip to replace the tuft that was removed and reimburse the 15 slips to the project. He will do this until he has reimbursed the 4000 slips initially borrowed. Typically, for a farmer who planted 42 lines of vetiver on 6 modules, he will have to uproot and replant only 4 or 5 rows of vetiver to reimburse his loan[2].

Fig. 5 Example of the layout of the modules on a typical field adjacent to the railway



In fact, rather than centralizing all the vetiver that is reimbursed, the project has found it more practical to arrange for direct transfers between an "old" farmer and a "new" farmer who lives not far away. This reduces transport problems and encourages the idea that farmers can help their neighbors and friends

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[1] Extension partners are paid a small salary each month to compensate for lost agricultural time since they devote considerable hours to the project. In addition, at the end of the year they receive a bonus for each farmer in their zone who successfully implements slope stabilization techniques along the rail line. In addition to the tasks noted here, the agents maintain tree nurseries in the village and are trained in grafting techniques.

[2] The project has had a 75-80% reimbursement of vetiver within one year of the initial loan. The reimbursement rate is 100% after two years; for some farmers, the vetiver is not well enough established to permit reimburse- ment after the first year (usually because labor constraints due to ill health delayed the planting or impeded the maintenance of the field). Most farmers are eager to reimburse quickly because once the vetiver is reimbursed, they are allowed to

Out of Poverty with Vetiver

Farmer Jaonary has a steep field on the back slope of the train line near the mid-point village of Manampatrana. His field had a few coffee and banana trees, but was mostly planted in manioc. Jaonary, the father of six children, barely eked out a living from the poor soils on his parcel, which occupies a 40-degree slope.

During most years, Jaonary lost at least some of his crop to land slippage, usually a few dozen manioc plants or perhaps a banana tree or two. But during the cyclones of 2000, a good part of his field slipped down onto the track resulting in a significant washout. Given the catastrophic situation on his land, he was one of the first farmers to sign on to the vetiver intervention…after all, what did he have to lose?

Three years later, Jaonary's field occupies a verdant hillside. After initial 12 modules that were stabilized the first year, he went on to stabilize another 9 modules on the side slope below the track in the second year. After reimbursing the vetiver loan in the first year, he was able to sell vetiver this year to a road building project. With the proceeds, Jaonary (who only dreamed of being a cattle owner in the past as he struggled just to ensure his food security) bought his first cow, which now has a calf. His wife sells milk to supplement the family income.

The vetiver on his field is neatly trimmed, with the leaves making a thick bed of mulch between the rows. The trees he planted in the first year are taller than he is and his pepper plants are heavy with small green peppers; the pineapples have already been harvested. The next heavy rains are no longer a cloud on Jaonary's horizon.

removed so that the slope stabilization function is retained.

This system means that every vetiverized field along the line acts as a vetiver nursery and vetiver availability is increasingly decentralized. Road maintenance projects in the province, as well as the FCE itself, can purchase vetiver from participating farmers along the line. The farmers group their vetiver together (assuming a large order) and ensure that it is delivered to a nearby train station on a timely basis. This has significantly brought down the price of vetiver, which was extremely high when the rail rehabilitation effort began. In 2000, vetiver sold locally for 25,000 fmg (approximately US$4) for a tuft of about 25 vetiver slips because stock was only available from a few nurseries that held a monopoly on sales. Now, with essentially each of 600 vetiver fields along the railway line a potential source of vetiver for projects and other farmers, vetiver is selling for 75 fmg per slip, or about 1875 fmg (28 cents US) for a tuft of 25. Even with this lower price, several farmers along the line have gained significant revenues from the sale of vetiver.

3.6 Farmer Reaction to the Vetiver Intervention

Initially farmers along the line were somewhat skeptical about the proposed vetiver intervention. Only by a combination of gentle pressure and incentive (such as providing the trees free) were we able to ensure an initial interest in 90 farmers. Farmer interest expanded significantly after the first rainy season. There were very heavy rains that due to a prolonged tropical depression and many farmers noted that, unlike previous years, they had not suffered any landslips (or crop losses) on the parcels that had been vetiverized. This significantly helped in recruiting participants in the second season.

From the second year, the intervention has consistently had a waiting list as more farmers have sought to participate than the 150 or so who are allowed to join each year. From an initial 90 participating farmers, the numbers have increased by 158 in the second season, 195 in the third season and 172 who have signed up for the current season. A total of 615 farmers are now participating in the intervention. It is significant that after the first year, many of the participants have been " repeat" farmers who want to progressively vetiverize larger parts of their trackside fields. This is a clear indication that they are now convinced that the approach is valid and worthwhile. The demand continues because each year some fields along the line that was previously in fallow are ready to be put into production again. In this way, we expect to progressively vetiverize the line over a 3-5 year period so that no fields are left unstabilized.

While farmer appreciation after the first six months was largely limited to vetiver's contribution to erosion control, by the second season farmers are increasingly extolling its virtues in improving soil fertility as they begin to see the impact of mulching with nutrient-rich vetiver leaves. They are also seeing the vetiver as a potential source of income, both from direct sales of the plant and from nascent artisanal ventures. It is still too early for them to have benefited from the higher revenues that they can expect once the fruit trees are in full production, but no farmer in a recent evaluation reported feeling worse off economically as a result of participating in the intervention. From skepticism, the intervention has now evolved to the point where it is a mark of considerable pride to earn a gaily painted sign, which sports the farmer's name, the kilometer indicator of the field, and the slogan, "the railroad is our heritage, let's protect it" as 600 plus fields along the line now do.

4 RESULTS AND CONCLUSION

Exactly three years since the passage of the cyclones, more than 2600,000 vetiver plants are, with little fanfare but much efficacy, doing their job of erosion prevention and slope stabilization along the railway line. Gone are most of the erosion inducing upland rice and manioc fields on slopes adjacent to the line, replaced instead by perennial tree crops on vetiver stabilized slopes. The system was put to the test this year, when a sustained tropical depression caused torrential rains over a two-week period in January (2003). There was only one area that suffered any significant erosion damage (km 59, where a landslide of approximately several cubic meters briefly blocked the track) because the vetiver was not yet fully established. Aside from some minor problems of surface erosion (causing landslips of less than 1-cubic meter that could be easily cleared in the course of "normal" maintenance operations), the rest of the slopes held firm. Furthermore, not a single slip occurred on zones where the farmers had stabilized the slopes.

The introduction of the modular system to plan and implement the vetiver intervention on farmers' fields was instrumental in helping the project to move quickly right after the cyclones and to work with many farmers in a relatively short period of time. It allowed the project to intervene efficiently and effectively, but also to maintain the critical element of farmer control over the activity. This was key in avoiding a "blueprint" approach (common to rapid interventions) where everyone would have to follow an identical model.

Madagascar's northern railroad line, which is subject to similar geological challenges, is currently being privatized. The new operator has taken much interest in the FCE slope stabilization model and is now beginning to intervene with similar measures on that longer rail system. A manual is now being prepared based on the *modus operandi* of the FCE project to facilitate their application elsewhere.

The team that has worked on the FCE vetiver intervention is excited by the results but optimistic that even more is possible in the years ahead. Madagascar's problems of soil erosion and infertility are as legendary as its disappearing forests. Vetiver has a potentially vital role to play in reversing both trends. The highlands of Madagascar are characterized by massive stretches of barren hillsides and in many villages more than half the land can no longer be cultivated due to soil infertility. We dream that, someday, the same sort of intervention that stabilized and revitalized land along the rail line, will also be applied to those hillsides, bringing land back into production, ensuring sustainable production on land that is now quickly degrading, and reducing pressures on the last remaining tropical forests. Now THAT is a challenge worthy of vetiver.

Acknowledgments

Many thanks, first of all, go to Criss Juliard. Without his recommendation that the Office of the Royal Development Projects Board (ORDPB) in Thailand be contacted, we might never have been where we are today. The Ministry of Transport and Meteorology, Madagascar, the LDI/FCER offices and the authors wish to thank most profoundly His Majesty King Bhumibol Adulyadej of Thailand and the ORDPB who answered their plea for help at a time when most of the rest of the world was ignoring the catastrophe in Madagascar. We are also deeply grateful to Dr Uthai Charanasri for his very valuable advice and guidance. Last, but not least, we thank all the participants in Madagascar who made this intervention so successful.

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A Brief Introduction to the First Author

Diti Hengchaovanich is a geotechnical engineer who has been for many years involved in slope stability and erosion problems, especially in the high-rainfall regions of Southeast Asia. Following his studies and research on the properties of vetiver that reveal it to be an outstanding plant ideally suited for soil bioengineering purposes, he has written several technical papers and made presentations in a number of countries, expounding its attributes and efficacy. He has in no small measure lent credence to and helped promote wider engineering applications of vetiver, thereby making it a viable 'green' tool for infrastructure protection or rehabilitation