VETIVER INITIATIVES IN PAPUA AND WEST PAPUA, INDONESIA

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Abstract

We report on several initiatives using The Vetiver System in Papua and West Papua, the New Guinea parts of Indonesia. Apart from some localized trials at the Freeport Mine in Timika, we believe these represent the first application of Vetiver technology in Papua. One of us (DSP) began using The Vetiver System in 2008 after seeing Vetiver work done in Sumatera during the rebuild after the Asian Tsunami by Norman Van't Hoff of Bali. A small Vetiver nursery was created in Sentani with Bali stock, and this provided the plants for a number of projects focusing on Vetiver use or having Vetiver as an important component.

To date two Vetiver Horizontal Sub-Surface Flow (HSSF) wastewater treatment wetlands have been created for large aviation NGOs. The first used Vetiver Grass to treat effluent from a large hanger facility. Later, due to that project's success another HSSF wetland planted with Vetiver was created in the highlands to treat effluent from accommodation blocks of another aviation NGO. Several local community members now use Vetiver to manage overflow of effluent from septic tank systems in floodprone areas. We also used Vetiver plantings in conjunction with rows of rock-filled gabions to arrest severe riverside and cliff erosion at an international school facility in Sentani.

In another large initiative, Vetiver is being used by MPC for community development and erosion control. The rudimentary road system of the *Arfak Mountain* regency of *West Papua*, is a crucial asset, facilitating the provision of resources and services to multiple indigenous people groups and Indonesian immigrants. However it is under constant threat from erosion and landslides and limited resources have prevented the local government from being able to address these issues in a sustainable manner.

The *GPKAI*[3] *landslide/erosion control program* began in 2011 and trains indigenous GPKAI leaders in the application of the Vetiver System (VS), including knowledge of plant characteristics and experience in propagation, extreme slope stabilization (> 45°), and erosion control techniques. The program has successfully established three separate medium-sized nurseries, applied VS for extreme-slope stabilization to several trial sites, has been actively engaging local government since 2013, and is in the beginning phase of partnering with the local government to address the road situation.

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The program's goals are threefold: 1) to establish the GPKAI program as a local technically-proficient and experienced VS organization capable of contracting with the local government, 2) to stabilize the road system using VS, and 3) to empower local indigenous communities to earn an income through the provision of VS services.

We report on these Vetiver System initiatives, discuss problems encountered (especially that of pervasive rust infection) and solutions, and outline plans for the projects along with their monitoring and evaluation.

Keywords

Indonesia, Papua, Wastewater Treatment, Erosion Control

Introduction

Between 2008 and the present we have consulted and implemented several projects centered around phytoremediation of environmental problems utilizing the Vetiver System (VS) in Papua, Indonesia. Apart from some localized trials at the Freeport Mine in Timika, we believe these represent the first application of Vetiver technology in Papua. These focus on the use of VS to foster capacity for community development among local communities, erosion control, and is wastewater treatment.

In the east, two Vetiver Horizontal Sub-Surface Flow (HSSF) wastewater treatment wetlands have been created for large aviation NGOs in Papua and now several local community members also use Vetiver to manage overflow of effluent from septic tank systems in floodprone areas. For erosion control Vetiver plantings in conjunction with rows of rock-filled gabions to arrest severe riverside and cliff erosion at an international school facility.

In the west, the Bird's Head region, Vetiver is being used for community development and erosion control along a steep, highly unstable mountain road system.

This report is thus divided into three sections; wastewater treatment using Vetiver; riverbank erosion control; and mountain roadside erosion control. In the latter we also discuss the problem of disease in Vetiver.

Part 1. Vetiver in Wastewater Treatment in eastern part of Papua, Indonesia

"More people are affected by the negative impact of poor water supply and sanitation than by war, terrorism, and weapons of mass destruction combined."

> Dr Jamie Bartram, Coordinator, Water, Sanitation and Health Program, W. H. O. *'The Lancet'*

"No single measure would do more to reduce disease and save lives in the developing world than bringing safe water and adequate sanitation to all."

> UN Secretary-General Kofi Annan, UN Millennium Conference, September 2000

One of us (DSP) began using The Vetiver System in 2008 after seeing Vetiver work done in Sumatera during the rebuild after the Asian Tsunami by Norman Van't Hoff of Bali.

DSP created vetiver nurseries (Figure 1.) to propagate slips obtained from Bali from Norm van't Hoff and David Booth and this provided the plants for a number of projects focusing on Vetiver use or having Vetiver as an important component.

Figure 1. Setting up the first nursery and training local people to work in it, 2008.

Early in 2008 I became aware that a local aviation NGO was to completely replace their hanger and facilities in Sentani, Papua, Indonesia. The NGO, YAJASI, is a Christian-based Indonesian foundation with the goal of serving remote communities in Papua in the area of aviation. They operate a small fleet of Pilatus PC-6 aircraft and one PC-12.

The existing YAJASI facilities had utilized non-watertight septic tanks which released untreated effluent into a non-secure leach field, both clear contraventions of Indonesian law (SNI 03-6379-2000) governing treatment and disposal of wastewater (though these laws are almost never implemented). At the time, YAJASI management was unaware of these existing laws and proposed installing a similar system for the new facilities, as is normal for most commercial and non-commercial facilities throughout Indonesia. When YAJASI's directors became aware that the existing and proposed replacement system were not only technically illegal under Indonesian law (Box 1) but also grossly irresponsible environmentally and for human health, they no longer viewed such systems as viable options.

Box 1. Relevant basic requirements listed in the Indonesian Building Codes are:

1. Septic tanks must be *Watertight*.

2. No *untreated* wastewater may be disposed of in public drains.

3. In *high* water tables, flows in leachfields must be *horizontal*, not vertical.

SNI 03-6379-2000

We designed a septic tank system and a Sub-Surface Flow Constructed Wetland (SSFCW) that met the requirements of Indonesian law as well as YAJASI's site and operational constraints. A civil engineering intern from the U.S. and created an excellent model in Excel that showed the relationship between sewage volume levels, wetland physical characteristics, and nutrient treatment efficiencies, which allowed us a measure of certainty for the planning. This system was installed and became operational in the middle of 2010 and during the year or so afterward, just as I left Papua for an extended stay in the U.S.

The wetland needed to effectively treat between 1,500 and 2,000 liters of sewage and grey water per day. The septic tanks system is of twin compartment design and effluent is actively pumped out of this into the bottom of the input end of the CW. Active pumping is necessary because insufficient gravity flow of effluent is produced without it, the site being quite flat. The CW (Figure2) has the following dimensions length 8 m., width 1.5 m., and depth 1 m., with substrate filling to 85 cm. The vertical leach field for treated effluent is 1.5 x 1.5 m. and several meters deep.

Most of the construction work was overseen by the local Indonesian contractor and though completed successfully some problems emerged. The CW component was constructed using inexpensive and poor quality limestone-concrete blocks plastered over with a think cement layer (the normal method in Indonesia), rather than with poured, reinforced concrete, as was recommended. These limestone blocks (Indonesian batu tela) are highly porous and crumble easily, and should not be used for applications which need to be waterproof. Consequently, the CW would not hold water and several attempts were made to seal it using more cement plaster. These ultimately proved unsuccessful and so the whole inside surface of the CW was coated with a layer of tar, and this appears to have been mostly successful. Later, a problem with the pumping regime emerged—the wetland was being overwhelmed by pumping pulses too long, and this was adjusted.

Figure 2. YAJASI's HSSF Wetland in construction. Top left: YAJASI technicians responsible for implementing the design. Top right: The wetland. Bottom left: Design of the intake system. Bottom right: Looking towards the outflow system and vertical leach chamber. Note the underlying brick construction can be clearly seen in this photo.

We are unaware of the size of rocks used throughout the CW but it appears to be on one grade—an average of half to quarter the size of a man's fist, and with a significant ultramafic component. Vetiver slips were obtained from HIS when their Bali shipment arrived and from the existing vetiver nursery, but there are no records of how many slips were used. It appears they were planted over a period of several months and this led to a high mortality rate, the slips sitting for long periods in "Styrofoam packing containers with an inch or so of water." It appears that the grass was planted with at least a spacing of 300 mm, perhaps greater, again contrary to recommendations. Due to the size of the substrate media and perhaps the newness of the system it was a challenge to get vetiver slips to take at first. Mortality was estimated to be as high as 50%. As a measure of desperation replacement plantings were done adding a little soil around the roots along with a little chemical fertilizer (NPK). Despite that, many large gaps remained.

By the beginning of 2012 the surviving plants were well established and had been trimmed at least twice. Visual tests showed cloudy water smelling of raw sewage at the intake end and clear, odorless water throughout the output end but no empirical tests were done. By the time I arrived back to Papua in October 2012 the CW was looking lush and overgrown, and visual checks showed the same results as described above. In December I commenced maintenance on the system, consisting of trimming the grass to just over 300 mm[4],

[4] Interestingly, and in contrast to some previous studies, goats refused to eat the freshly cut grass. Horses found it quite palatable though.

uprooting the larger clumps, dividing them, and replanting slips at 200 mm spacing or less throughout the system.

Figure 3. Vetiver is growing well in the wetland. Maintenance consists of trimming the grass every three to four months.

The large gravel size made restoration and repair of the system extremely difficult and labor intensive—it is very hard to work with. A smaller grade of gravel or rocks in the upper layers of the CW would make it immensely easier to work with. I understand that part of the issue is a problem of limited availability locally at the time of construction.

The system does not and cannot handle toxic or highly corrosive chemicals such as those commonly used in the aviation industry—these do not flow into the system. There is no local municipal service to handle toxic chemical wastes and this remains a problem that YAJASI should address as soon as possible.

It is possible that the system is overkill, perhaps over-efficient. Transpiration from the grass during extended periods without rain lowers the water level significantly, drying out upper levels of the grass roots, though this is almost certainly not a problem with a mature system. There has been no sign of rust in this Vetiver.

This led to another wetland constructed to treat wastewater from part of a housing complex in the highlands, in Wamena. This was requested by another aviation NGO, Associated Mission Aviation, the aviation arm of the Roman Catholic Church in Papua.

DSP planned the wetland system and trained local construction workers in constructing it and planting it with Vetiver. Dimensions were 4 m. long, 1 m. wide, and 80 cm depth. Media for this wetland consisted of small pea-sized gravel over a base of medium-sized river rocks. Planting and maintaining Vetiver in this media is much easier than in that of the YAJASI wetland.

Both wetlands appear to be working well, though we only have anecdotal evidence: effluent at the intake ends is dark brown and smells strongly, whereas water from the discharge end is clear and has no smell. Water testing for nutrients and pathogens needs to be carried out as soon as possible and monitoring should continue at regular intervals (every six months). DSP plans to set this monitoring up during an extended visit in July,

2015. It is very important that we can provide scientific evidence to the Vetiver community to show how well these systems are working. However, VS expert Dick Grimshaw comments: “We know that this particular design works very well. It is a really good way to go where space is limited as in urban areas.” Based on figures from the model we should be seeing uptake of 75-95% of N, ~50% P and 100% pathogen kill.

Figure 4. Small HSSF Wetland in Wamena at end of construction.

Part 2. Vetiver in Riverine Erosion Control in Eastern Part of Papua, Indonesia

DSP was contacted by Hillcrest International School (HIS). HIS is an international K through 12 school in Papua, Indonesia, founded and run by a number of non-denominational Christian organizations and NGOs, with legal framework provided by an Indonesian private foundation. The High School part of HIS was built at the top of a very steep soil cliff, with a river, prone to torrential flooding at times, flowing from the north near the bottom, around to the east. The river is part of the greater Sentani Watershed and drains a significant area of the Cyclops ranges to the north. There is evidence that at times the river flowed several hundred meters to the east and bypassed the cliff, however now it flows alongside the bottom of the cliff and is primarily responsible for the erosion that created the cliff.

In early 2007 a violent rainfall in the upper catchment induced a torrential and unusually violent flood, modifying the river’s course, back to one of its historical channels (squatter gardening alongside the river just upstream from the HIS property was almost certainly a large factor in this also). As a result of the flood the new course came straight to the western edge of the bottom of the HIS cliff and ran along the bottom to the east, scouring what little was at the bottom, before resuming its former channel to the east. This presented a direct and immediate erosion threat to the buildings and land at the top of the cliff, exacerbating the prior existing threat of the cliff to school structures.

Figure 5. Hillcrest International School (middle) looking to the south towards Lake Sentani, March 2007. Photo: Tim Harold.

The HIS board had designated some funding to invest in an erosion control initiative and the director of HIS, Dan Mueller, was searching for solutions. At that time he was only aware of the possibility of continuing to construct gabions (rock boxes) in series stepping up from alongside the river towards the cliff to stabilize it, but this was considered an incomplete solution and he was at an impasse to know what else could work. "The rock boxes were used simply because there was no other real option and because they seemed to provide an easy way to put shape to the wall of protection we were hoping for" (Mueller, pers. com.).

Figure 6. Detail of the primary slip area showing the river eroding the base of the cliff, March 2007. Photo: Tim Harold.

In early 2010, during a flight from Jayapura to Jakarta when by coincidence we sat next to each other, we discovered that we both shared a strong interest in environmentally sustainable technologies. We talked about some of HIS's challenges and then specifically about the river erosion problem. At this stage the first gabion had been constructed by Tim Cripe, a former director, and there was a need to complete their "Phase One." I introduced him to The Vetiver System during that flight and later provided him with materials and examples that demonstrated the uses and effectiveness of VS in other parts of Southeast Asia. In response to the question "What factors helped you decide to use Vetiver in the project, as well as gabions and backfilled earth?", Mueller wrote,

> "To be truthful, you were the only factor. I had never heard of Vetiver grass prior to your pitch. I was at a point of not knowing what to do with the project or where to go with it, so having a tangible suggestion with proven research was a compelling factor."

I provided information and estimates on the quantity of vetiver slips needed and coordinated the purchase and shipping with David Booth (MBE) in Bali. I also provided advice on how to utilize the vetiver grass and maintain it. However, by that time, I completed my responsibilities in Papua and left for the US for just over two years. Therefore, once the purchase and shipping arrangements had been completed I had little to do with the project, until I returned to Papua in late 2012.

Figure 7. (Left) Following first gabion installation and before planting with vetiver, October 2009 and (right) following planting and trimming, December 2012.

The first planting of vetiver grass occurred behind the one previously constructed gabion which ran the length of the cliff and consisted of one row of slips. Then HIS' head maintenance man put in a second row of gabions. The work was done manually by men contracted from the local village to pull rock out of the adjacent river and fill the rock cages. Due to access restrictions (lack of a road) and the fact that no heavy machinery was available due to large municipal projects at the time, back-filling was left uncompleted, despite plans to the contrary (Mueller, pers. com.).

Figure 8. Most of the vetiver grass grew well despite being threatened by weeds, December 2012.

2000 Slips were air-shipped from David Booth in Bali on 2010-05-31 and delivered to HIS in a somewhat timely manner, perhaps a day or two later than expected, though no adverse effects were noticed. An unknown number of slips were sent to YAJASI (see Part 1) for their sanitation system. Therefore, it is uncertain exactly how many slips were actually used in the HIS project, though it would have been more than half of them. Planting was begun immediately on delivery of the shipment and was completed in one day by three local workers. A trench had been pre-dug along the back of the first gabion, the slips were placed in that and soil filled in each side. Two rows of vetiver grass were planted, about 30—45 cm between rows, with side-to-side spacing about 30 cm (though I had recommended 20 cm spacing). An attempt was made to "stagger the plants so that in theory, every 15cm there was a plant either in the front row or the back row, in a zig zag pattern" (Mueller, pers. com.). Nothing else was intentionally planted along with the Vetiver grass although some native tree and shrub seedlings I had provided were planted in the flat ground area between the gabions and the eroding slope (though very few appear to have survived).

Vetiver mortality rate was not recorded. Irrigation by hand (with a bucket with water taken from the adjacent river) was undertaken two or three times weekly throughout much of the summer break—perhaps a period amounting to around two months (June and July). No weeding or thinning was done at this stage.

I returned to Papua in October 2012 and checked on the status of the project. The vetiver was thoroughly overgrown with invasive non-native shrubs and the native pioneer *Imperata cylindrica* grass. In early December I directed the HIS maintenance manager to provide two local men for weeding (he had arrived since the project was implemented and had little knowledge of it, but he did have some valuable previous experience with vetiver grass in erosion control situations on Saipan). They uprooted weedy vines and *Imperata* where possible and slashed other shrubs and herbs, clearing everything out from among the vetiver.

Figure 9. Intensive weeding plus trimming of vetiver, December 2012.

When this was done it became clear that there were large gaps in many parts of the rows, possibly from mortality of newly planted slips, but more likely from plants being shaded out by invasives and *Imperata*. The staggered pattern of two rows was not evident, though in some places the hedge is rather thick. Despite this, the buildup of sediment and soil behind the gabions and the vetiver grass is quite impressive, though probably due mostly at this stage to the gabions. I have made some recommendations (below) to repair the existing vetiver hedge and to add a hedge along the top of the higher gabion prior to the next phase of the project, which will add another gabion (or two?) along with corresponding vetiver grass hedges.

Figure 10. After weeding and trimming, December 2012.

In light of the lack of maintenance and care of the system over the last two years it is difficult to offer any reasonable evaluation of the project. Certainly, expectations were high and remain so (Mueller 2012):

"It seems like a very good fit with the Vetiver root system and the depth these roots go and the degree to which they spread. I think these two, in combination, and in conjunction with a multi-layering system would be very effective in accomplishing an anti-erosion system for the HIS property.
"To me, it's hard to put an actual value to this. If the Vetiver holds up to its reputation in the next hard rain / flood situation, then I think it will be very worth the effort and money we invested in the first layer."

Despite that, the buildup of sediment and soil already observed behind the gabions and the vetiver hedge is evidence that this imperfect planting is experiencing a large measure of success. The cliff is still present and still under threat, though not so much from river and flood-induced erosion anymore, but from direct rainfall-induced erosion.

Though we feel a level of success overall for this project to date, we have identified some problems and mistakes that need to be rectified for this past planting and for future plantings, as well as some missed opportunities.

In order to complete this Phase One of the project it is imperative that the vetiver hedge be upgraded to original specifications. This should consist of planting an additional, estimated, 1500 vetiver slips in gaps and along the top rear of the highest gabion. Slips or plants in polybags should be planted at a spacing of 200 mm and irrigated until well established.

Figure 11. After intensive weeding and trimming.

Maintenance needs to be addressed also, particularly with regard to weeding. Invasives and pioneer plants are far more competitive in this environment than vetiver, yet offer few of the erosion control benefits. The project would benefit from a maintenance schedule that will provide regular weeding and regular replacement of vetiver plants where and if gaps form. Maintenance should also be in the form of trimming the vetiver hedge stems to no shorter than 300 mm every three to four months. This will ensure all plants get enough sunlight and will also stimulate deep and vigorous root growth.

For the next phase: The lack of heavy equipment available for hire at the time meant that all work had to be done manually and from materials obtained "locally" in the extreme sense of the word—adjacent to the project. For the next phase in 2013, which I believe will consist of two more gabion rows each with a vetiver hedge along the top, sufficient rock will have to be trucked in and a significant volume of backfill soil must be available offsite. On the positive side, access via a concrete paved road is now available right down to the site.

Although the project to date has resulted in fairly positive results, it is critical that the present vetiver hedge be improved to specifications and that the next phases of the cliff stabilization be implemented. Concerning this, and the overall project, Mueller wrote:

> "In theory, I like the idea of the deep root system of the Vetiver grass helping to anchor the soil as well as the potential for the roots to spread into the rocks/cages to also help anchor them. I like the idea of the rows of Vetiver grass to help catch and stop any erosion that comes off the side of the hill. However, if the hillside erodes down to this first layer of Vetiver grass, then we'll [still] lose some of our facility. More layers need to be added to prevent further erosion and to be proactive against further erosion. … If this first layer [phase] is all the farther the project gets and no fill dirt or additional layers get done, then I'm afraid these efforts will have been in vain."

It is also clear that a significant opportunity was lost when Phase One of this project was implemented. Indeed, Mueller wrote, "I would have loved to utilize students in this project, but the … class never happened." Obviously, there are always serious constraints with availability of teaching staff and even with availability of appropriate courses with which to fit such student involvement, however, this project begs of itself for practical student involvement, with relevance to the environmental sciences, ecological restoration, or even to aspects of civil engineering.

Part 3. Vetiver System and Community Development in West Papua, Indonesia

The rudimentary road system of the *Arfak Mountain* regency of *West Papua*, is a crucial asset, facilitating the provision of resources and services to multiple indigenous people groups and Indonesian immigrants. However, it is under constant threat by erosion and landslides and limited resources have prevented the local government from being able to address these issues in a sustainable manner.

The *GPKAI landslide/erosion control program* began in 2011 and trains indigenous GPKAI[5] leaders in the application of the Vetiver System (VS), including knowledge of plant characteristics and experience in propagation, extreme slope stabilization (> 45°), and erosion control techniques. The program has successfully established three separate medium-sized nurseries, applied VS for extreme-slope stabilization to several trial sites, has been actively engaging local government since 2013, and is in the beginning phase of partnering with the local government to address the road situation.

Collectively begun as a partnership between the Indonesian organizations *YMP3*[6] and *GPKAI*, the program's goals are threefold: 1) to establish the GPKAI program as a local technically-proficient and experienced VS organization capable of contracting with the

[5] Gereja Persekutuan Kristen Alkitab Indonesia (Christian Bible Church of Indonesia)

[6] Yayasan Misi Penginjilan Pemuridan Papua (Evangelism and Discipleship Ministries of Papua). (http://ymp3.org/)

local government, 2) to stabilize the road system using VS, and 3) to empower local indigenous communities to earn an income through the provision of VS services.

Initial Stages of the program

In June of 2011, GPKAI leaders from the indigenous Meyah people group approached the Community Development branch of YMP3 about the landslide and erosion problems they were having with road system in their area. This road system, which is over 80 kilometers in length, passes through the territory of three (3) separate and unique indigenous people groups. Landslides and erosion problems frequently damage the roads so that travel is greatly restricted. As the only publically available transportation option, these problems present a formidable challenge to all those who depend on it for travel, food, supplies, and much more. Limited resources have prevented the local government from being able to permanently address these issues. As a temporary solution, road construction heavy equipment has been stationed in regular intervals along the road such that in the event of a landslide or other road problem, the machinery can quickly assist in reconstruction. Unfortunately, this method is expensive and can take significant amounts of time for normal travel to resume. This is especially true for those that live near the end of the road such as the Meyah GKPAI leaders who originate from a small village a day's walk from the very last stop on the road system—the village of Testega. As the GPKAI leaders learned about The Vetiver System (VS) and saw it's applicability as a potential Appropriate Technology to address the infrastructure stability problems, they were quick to express interest in beginning a collaborative VS pilot program with YMP3's CD branch.

Figure 12. Left: Surveying the road. Right: A typical landslide.

The first step the program took was to perform a rapid survey the road system in July of 2011. As a result of that survey, it was readily apparent to all stakeholders that the road system was experiencing erosion and landslides on a massive scale along the entirety of its length, and any effort to address it would require complete buy-in from the affected communities and eventually the local government as a sponsor if the program would have any hope of moving forward. It was also clear that the vast majority of the road batters consisted of slopes exceeding 45°—something the Vetiver System Technical manual warns against. However, it seemed that there were many examples of Vetiver successfully being applied to extreme slopes similar to those surveyed.

Nursery establishment

The second step the program took was to purchase a small amount of high-quality Vetiver plant stock with which a nursery could be established. Due to the sheer scale and number of sites along the road that required stabilization and no access to funding which would enable the purchase of sufficient plant stock to stabilize those areas, it was decided that the most appropriate solution was to establish Vetiver nurseries to propagate sufficient amounts of the plants. The GPKAI leaders petitioned their constituency for enough funds to be able to purchase 1,000 high-quality Vetiver slips from The *East Bali Poverty Project*[7], which were graciously provided at discounted pricing to the community, in order to begin the initial nursery. This initial nursery was located in the Manokwari regency of West Papua in the lowlands, where the rich alluvial soil and warm temperatures allowed the Vetiver slips to grow quickly.

Figure 12. GPKAI community members plant the initial nursery.

After eleven (11) months, with trimming every four (4) months to promote tillering, the plants had matured to the point that they could be vegetatively propagated. At this point, the GPKAI leaders invited various members of the GPKAI constituency to an introductory meeting where VS was formally introduced to community members and YMP3 offered a hands-on training workshop for anyone who was interested helping the pilot program.

Over the next several years as plants matured and were ready to be propagated, the program has continued to expand its modest nursery to the point that there are currently 3 established nurseries varying in capacity from several thousand mature plants to tens of thousands of mature plants. All this was accomplished without funding from external sources, but rather, was a community effort with many individuals throughout the Meyah GPKAI constituency volunteering their time to help.

[7] http://www.eastbalipovertyproject.org/

Figure 13. The Vetiver Propagation Training.

Disease in Vetiver

In parallel with the development of the production nurseries owned and operated by the GPKAI program, another smaller experimental nursery was developed by YMP3's CD branch at a separate location within the capital city of Manokwari, West Papua. Plant stock for this experimental nursery was purchased at an earlier date from the same source as the other nurseries. After ten (10) months of growth, it was readily apparent that some type of leaf blight or rust disease was affecting Vetiver, causing significant numbers of the leaves to die off. A literature review on Vetiver diseases, yielded the research of Dr. P.K. Yoon of Malaysia Yoon in 1991[8], where the leaf blight or rust caused by the fungi *Curvularia sp.* looked identical to that which was affecting our experimental nursery. We subsequently followed Yoon's remedy of trimming the plants to 40cm. New stem growth appeared to be disease free, however after 4 months of healthy growth the leaf blight returned. The experimental nursery plants were then trimmed to 40cm, dug-up as whole clumps, and transplanted to a new location within the same city. Again after 4 months of growth the disease returned.

After several cycles of this with similar results, YMP3's CD branch was able to contact Richard Grimshaw and Paul Truong about the disease. There were two methods suggested (in addition to Yoon's method) to eliminate the disease:

1) The phyto-sanitary practice of burning. This method was employed multiple times by trimming the plants down to the ground, waiting several days for the cuttings to dry, and then burning the entire plot. Results were unfortunately the same – after 4 months of healthy growth the leaf blight returned.

[8] P. K. Yoon. 1991. "A Look-See at Vetiver Grass in Malaysia: First Progress Report"

2) The use of Bordeaux Mixture spray (Copper Sulfate, Hydrated Lime, and water). Difficulty in obtaining these chemicals in West Papua has prevented the attempt of this method to date.

Due to the fact that the road system in the Arfak Mountain regency is at a much higher elevation and different climate than the nursery site (in the Manokwari regency), it was suggested that a series of experimental plots be developed in the Arfak Mountain regency so as to ascertain the survivability of the leaf blight in this different environment. Unfortunately due to a lack of funding, we have not yet been able to implement these experimental trials. However, experimental infrastructure stabilization trials (described in the following section) in the Arfak Mountains have anecdotally indicated little to no presence of the disease to date.

It is interesting to note that while the same type of leaf blight is also present within the GPKAI production nurseries, the damage is not even remotely close to the kind of damage we were witnessing with the experimental nursery in Manokwari, which is less than 20km away.

Figure 14. The Vetiver leaf blight/rust.

Extreme Slope Stabilization

As soon as sufficient quantities of Vetiver were being produced in the nurseries, the program stakeholders made preparations to begin the stabilization of road batters in the Arfak Mountain regency. As previously stated, the majority of the unstable road batters have slopes exceeding the 45° limit suggested in the Technical Manual and Field Handbook. However, seeing examples of extreme slopes being successfully stabilized throughout multiple regions of the world such including Indonesia[9] encouraged us to

[9] P. Truong. 2008. "Cut batter stabilization trial on a very steep slope near Bandung, Indonesia".

try…indeed it was clear that if VS was to be successful, it would have to be able to succeed on these extreme slopes. The first trial site was identified near the village of Testega because the stakeholders felt it represented one of the more challenging slopes to stabilize while logistically it would be simple to access and plant (close to a large village). In similar fashion to the nursery propagation activities, the stabilization planting was accomplished without funding from external sources, but rather, was a community effort with many individuals throughout the Meyah GPKAI constituency volunteering their time to help.

Figure 15. Left: Using rappelling equipment to plant. The slope varied from 60° to almost 90° in some sections. Right: Nearly finished planting.

Figure 16. Success! Twelve (12) months after planting, the control on the left portion of the slope continues to experience erosion while on the right-hand side the Vetiver is protecting the slope.

Government Involvement

From the beginning it was known that in order for the entirety of the road system's stability problems to be addressed, there would have to be government support. In the next phase of the program, the stakeholders began to engage the local government, seeking to inform the Arfak Mountain, Manokwari, and South Manokwari regencies about VS and the *GPKAI landslide/erosion control program*.

Figure 17. The program engages the local government

Initial reactions from the Arfak Mountain regency government have been promising, and have resulted in a government-funded slope stabilization trial on a highly-traveled portion of the road-system. With the introduction of government funding, the program was able to invite the participation from the surrounding communities, to train those individuals in VS slope stabilization methods, and offer wages for those who chose to participate in the planting. As stated in the abstract, providing employment opportunities to communities in these remote areas is one of the primary goals of the program. Another primary goal of the program is its establishment as a technically-proficient and experienced VS organization capable of contracting with the local government to address these problems. To this end, the program's stakeholders are in the intermediate stages of negotiating this new partnership with Arfak Mountain regency government and initial stages with the other regencies mentioned. Politics continues to be the primary factor that continually threatens to nullify the amazing potential this program has.

Figure 18. Initial stages of the partnership with local government.

Conclusions

Aside from the natural continuation of these development initiatives involving Vetiver System, particularly the West Papua road stabilization program and its goals, there are areas where investment of future efforts and research promise to deliver valuable dividends.

1) Rust disease. The disease-causing agent needs to be positively identified. Funding permitting, we would like to complete the experimental trials suggested by Dr. Paul Truong and Richard Grimshaw to determine the Arfak Mountain climate's influence on the disease. Also, trials with Bordeaux Mixture to eliminate the disease need to be undertaken.
2) Empirical data Vetiver benefits. Aside from anecdotal stories and pictures, we need to gather hard scientific data based on well-designed monitoring and experiments, revealing just how effective Vetiver hedges are is at preventing soil loss in these applications. For erosion control situations this will most likely take the form of sediment load monitoring of many sites with similar and differing attributes as the projects progress. For the wastewater treatment wetlands, this involves implementation of water quality analysis, projected to start in July 2015.
3) Handicrafts. West Papua program stakeholders are keenly interested in developing a Vetiver handicrafts component that will teach individuals how to create handicrafts from Vetiver materials to provide further income.

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