Chapter 1

Vetiver Grass - A World Technology and its Impact on Water

Reviewer

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Abstract: This paper recognizes the important work of worldwide Vetiver researchers and developers. It describes how Vetiver has developed as world technology over four phases of application: soil and water conservation in poor rural areas; infrastructure stabilization; rehabilitation of difficult and often polluted sites; and lastly water quality enhancement and site rehabilitation in relation to industry and intensive commercial agricultural. The paper then goes on to describe how the Vetiver System™ can be used for water conservation and water quality enhancement as applied in the broad categories of upper, middle and lower watershed areas. The paper reviews some progress in technology dissemination and the increasing role of the private sector. Finally the paper looks at some changes in the Vetiver Network and introduces a new program of certification that will recognize those who excel in research and development of the Vetiver System™.

Key words: Vetiver Systems™, soil and water conservation, infrastructure stabilization, water quality, pollution control, technology dissemination, technical certification
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1 INTRODUCTION

Some years ago I sent a potential vetiver user in the Caribbean a copy of John Greenfield's handbook – Vetiver Grass – A Hedge Against Erosion. In his reply of thanks he wrote: "I read, I did, and it works'. This is how most vetiver users get involved and hooked by this remarkable plant and its various applications. This is why we are here in Guangzhou to listen, learn and then apply new uses for Vetiver, particularly those related to vetiver's impact on water conservation and water quality.

We are also here in Guangzhou to honor those who have researched, developed, and applied vetiver techniques world wide, but on this occasion especially those in China. We salute all those who made the effort and commitment to the Vetiver System™ including scientists, government agencies, and the private sector – all represented here today. There are some special people who stand out as China's pioneers in this technology and I would name just three of many:

- Liyu Xu, the Coordinator of the China Vetiver Network who did a wonderful job in taking the technology in its different forms to various agencies, arranging for focused introductory workshops, and for the initiation of hands-on vetiver programs, such as the Dabie Mountain Project (Xu, Liyu, 2003). We are grateful for his contribution to the Vetiver System™ in China, and even more grateful that he survived a dreadful road accident last year in which three of his colleagues were killed.

- Xia Hanping, who has done so much to assure that this conference would take place, and who as a young scientist and research worker at the South China Institute of Botany, started working with the Vetiver System™ more than 10 years ago. Today he is China's leading vetiver researcher, and has done much in its promotion in Guangdong Province (Xia, Hanping, 2001), particular in its application for the bioremediation of polluted sites.
- Julia Xu, who owns and directs a private sector landscaping company, is one of a growing number of private entrepreneurs who have commercialized the Vetiver System™. She has used vetiver for a range of land rehabilitation applications and typifies how the entrepreneurial spirit of the Chinese leads to successful projects that work.

There are others here who have all made their special contribution to the furthering our knowledge of the Vetiver System™. I will mention some of them later in this presentation.

The development of the Vetiver System™ has focused on successful end use. We have not developed strict lines of research; occasionally we have provided a few informal guidelines, but on the whole we have allowed "A Thousand Flowers to Bloom" and practical results to flow from those "Blooms". A lot has been achieved without the support of large and important international institutions. Instead we are fortunate to have been supported by committed individuals agencies that are also looking for practical end use applications for the mitigation of environmental and agricultural problems. Our special thanks is directed to: His Majesty the King of Thailand and his daughter, our Patron, H.R.H. Princess Maha Chakri Sirindhorn, for their continuous commitment and investment in vetiver research and development; the Royal Danish Government for its commitment through vetiver promotion for the development of the 'poor' and their associated environmental problems; the Amberstone Trust of UK for continued support (now nearly 10 years) to TVN and country networks in furthering this technology and in believing in our ability to achieve; the Wallace Genetic Foundation for its generous support for vetiver research in Australia and China; and The William Donner Foundation for funding world wide vetiver research and the 2003 Vetiver Awards Program. In addition we have to thank all those other, mainly NGOs, government agencies, institutions and individuals who have generously supported, both in their time and money, vetiver programs around the world.

2 VETIVER – A WORLD TECHNOLOGY

Looking back over the years of my involvement with the Vetiver System™ and its application, I see four distinct phases in its development as a world technology.

2.1 Phase 1

We welcome today John Greenfield from New Zealand, my friend and colleague, who was responsible for renewing the vetiver grass technology for soil and water conservation in India in the 1980s. Without his effort and foresight we would not be here today. He first used vetiver for soil and water conservation in Fiji in the 1950s. In those days vetiver applications were pretty much focused on agricultural conservation uses in the hot wet tropics, and then only by a few users, notably the sugar industry. Thirty years later he "rediscovered" the grass in India (where later we found that a small group of farmers had been using it for perhaps centuries for soil conservation purposes). He made a lot of people rather upset by introducing what was then quite a revolutionary idea of replacing conservation structures by grass hedges. Vetiver was tested for on farm soil and water conservation in many Indian states. It was at that time that he authored the small green book "Vetiver Grass – A Hedge Against Erosion". Tens of thousands of these booklets have been printed in at least 20 different languages including Mandarin. Slowly the 'hedge against erosion' spread to other countries in the world and today it is being used for soil conservation on every major continent and in more than one hundred countries (mainly in the tropics and semi tropics). We need to remember some of those early researchers, including G.M. Bahrad (Bharad and Bathkal, 1991) of India, Ly Tung and Fatima Balina of the Philippines (Ly Tung *et al.* 1991), Ruppenthal (1992) of CIAT, Colombia and others who carried out important research to quantify and demonstrate the effectiveness of vetiver hedgerows in reducing soil loss and increasing soil moisture and groundwater recharge.

Subsequently continued research into soil and water conservation and vetiver has been carried out extensively in many countries including China, (Ye, Hu Jian *et al*. 1997), Kenya (Owino, 2003), Madagascar, Peru, Senegal, Thailand (Howeler, R. *et al*., 2003), Venezuela, and Vietnam, to mention a few.

2.2 Phase 2

In the early 1990s the focus of vetiver research moved to Malaysia where Dr. P.K. Yoon of the Rubber Research Institute of Malaysia carried out some outstanding research on a wide range of vetiver topics. His work was detailed in print and through photographs in his magnificent report "A Look See at Vetiver in Malaysia" (Yoon, 1993). This report is readily available on CD-ROM and should be compulsory reading for all vetiver users. P.K. Yoon studied the basic "technical architecture" of Vetiver grass and how that "architecture" could be applied to the tree crop and plantation industry. He also initiated and demonstrated its use for the stabilization of earthen-engineered structures. He worked with Diti Hengchaovanich, at that time general manager of a highway construction company in Malaysia. Diti Hengchaovanich supported the research into the tensile strength of vetiver roots and its impact on the shear strength of soil and applied the results on a large scale on expressways in Malaysia. This work (Hengchaovanich, 1998), was the first to quantify the impact of vetiver for engineers. Vetiver's birth as a "living soil nail" started to bear fruit and engineers around the world took notice of this "soft" technology. The El Salvadorian Company, NOBS, developed large vetiver nurseries and applied the technology for highway stabilization over

many kilometers of highways (these applications were severely tested by Hurricane Mitch and performed as expected in assuring a stable structure). Soon after, at the instigation of Liyu Xu, Chinese provincial governments, particular those of Fujian and Jiangxi took up the technology for highway stabilization. Research and application for engineering purposes have been undertaken in other countries, notably: Australia, China (Huang, Bo *et al*. 2003), El Salvador, Madagascar (Hengchaovanich and Freudenberger, 2003), Malaysia, Nicaragua, South Africa, Thailand (Sanguankaeo *et al*. 2003), and Vietnam amongst others.

During the latter part of this phase The Royal Development Projects Board of Thailand, under the guidance of the King of Thailand, carried out research and development of vetiver, propagation[1] (especially tissue cultured plantlets), management and application. This has had a significant impact on other users, and helped strengthen the interest in the Vetiver System™ around the world. The Thai work is published by a number of Thai institutions and by the Pacific Rim Vetiver Network under the coordination of Dr. Narong Chomcahalow. I should like to take this opportunity of recognizing and thanking Dr. Narong Chomchalow for his professional and dedicated service to the promotion and development of the Vetiver System™ and to the committee that supports the continuation of these international vetiver conferences. Thailand must be recognized for its commitment to vetiver through the organization of two international conferences on vetiver (ICV1 and ICV2) and for its continuing support for research and in training people from all around the world – notably the International Training Workshop (Chomchalow, 2000) organized by the Royal Development Projects Board with the sponsorship of the Heineken Corporation. (Office of the Royal Development Projects Board, 2000).

2.3 Phase 3

In the mid 1990s a new figure emerged on the scene – Paul Truong of Queensland, Australia. He was intrigued that a plant like vetiver had the ability to thrive over a wide range of conditions, particular in soils of high acidity as well as high alkalinity. Starting from some rather simple experiments on vetiver and pH, he went on to test vetiver's tolerance to a range of heavy metals (Truong and Baker, 1998). The very positive outcome of the latter, and vetiver's proven tolerance to high levels of these metals led to his and others (Xia, Hanping and Shu, Wensheng, 2003) initiatives in using vetiver for dealing with polluted landscapes and sites, such as municipal land fills, mine tailings, acid sulphate soils, etc. Experiments and demonstrations have been carried out in Australia (Truong and Bevan 2000), China (Ping, Zhang and Xia Hanping, 2003) and Thailand (Srisatit, Thares *et al*., 2003) to test vetiver under extreme conditions, all with positive results. By the end of the century it was becoming clear that vetiver grass had unique qualities that could be put to use in tackling not only land stability issues, but also water quality enhancement. The time had come when we could now put vetiver to use in its native environment, that is, one closely related to water. Vetiver's unique physiology has typical characteristics of a hydrophyte – its origins are swampy wetlands.

2.4 Phase 4

Since the beginning of this new century I see major efforts, particularly here in East Asia and the Pacific regions (Australia, China, Thailand and Vietnam), to expand, research and develop the Vetiver System™ over a wide range of applications to mitigate problems relating to industry and commercial pollution. East Asian countries have fast growing industrial development and supporting infrastructure. Scientists and policy makers in this region are aware that they have to find low cost solutions to deal with the serious environmental problems that their countries face. The Vetiver System™ is one such technology that has great promise (Truong, 2003). This phase also reflects an effort to bring private sector entrepreneurs into mainstream vetiver development, promotion and marketing (Xia, Hanping,2003). There is now sufficient scientific information about the Vetiver System™ to provide technical and scientific quantification and confidence to those commercial enterprises that market and use the technology. We see this private sector involvement in many countries including Australia, China, El Salvador, Madagascar, Malaysia, Senegal, South Africa, Thailand, Vietnam, and USA and amongst others. In the medium term I see East Asia and the Pacific dominating vetiver research with Vietnam probably becoming the research leader for this decade.

3 VETIVER AND WATER

At the conclusion of the last conference (ICV2), held in Thailand in 2000, I suggested (Grimshaw, 2000) that the principal theme of this current conference should be "vetiver and water". Of course water issues were and still are high on the world's agenda and therefore deserve attention. I also knew that vetiver grass impacts on water in one way or the other, and that it has an important role to play in its relationship to water conservation and water quality. I also knew that Vetiver System™ has something to offer that is low cost and relatively easy to apply.

Vetiver and water fits very nicely into a broad all encompassing watershed management approach, and its applications have different functions in different parts of the watershed. During this conference these relationships will become more apparent. Without stealing other speakers "thunder" I will try and show how these relationships work.

3.1 Upper watershed

In today's world the prestine upper watershed of the past is a rarity; these areas are the sources of rivers and springs; and in the past they were generally heavily forested and needed no protection. Today they are mostly denuded, and because they have steep slopes, they are badly eroded, resulting in flash flooding and runoff that carries heavy silt loads. In the tropics, along with other measures such as reforestation, Vetiver System™ applied in the form of gully protection and across slope hedgerows could do much to help bring these areas back to a situation where run off and sediment flows are reduced, where ground water is improved, and where springs flow longer and consistently. We have evidence of this from Ethiopia (Mekonnen, 2000), India, Malawi (Carr, 2000), Thailand and other countries where the Vetiver System™ has been applied extensively in upper watersheds. It is also in these upper watersheds that we find streams polluted from various mining operations. The Vetiver System™ can be used effectively to reduce heavy metal contaminated sediment and leachate from entering these important water sources. Remember, the way in which the upper watershed is treated, or

not treated, will impact those who live in the lower watersheds and floodplains. In fact some of government tax revenues gathered from lower watershed residents and businesses should be reallocated for the specific protection of the upper watersheds. Research teams led or guided by Paul Truong and Xia Hanping (Hanping, Xia and Wensheng, Shu, 2003) involving vetiver and contaminated sites (Lin, Chuxia *et al*. 2003) have important relevance to this topic.

3.2 Middle watershed

In most developing countries the middle watersheds are generally the location of upland farmers. It is in these areas that on-farm erosion is a serious problems and where water quality and water availability limits agricultural growth. The Vetiver System™ does and should play a vital role in improving *in situ* moisture conservation, improving groundwater, stabilizing small reservoirs, river banks, and farm to market roads. In addition vetiver byproducts can support rural families in their use as thatch, mulch, material for handicrafts and numerous other purposes. Wherever the Vetiver System™ is used for soil conservation and land/construction site stabilization it will impact on the quality of water, whether it be runoff or groundwater. One of many good examples of the impact and importance of the Vetiver System™ on middle watershed areas is the recent work in Thailand and Vietnam in the successful introduction of the Vetiver System™ to the heavily eroding (over 40 tons of dry soil per year) cassava growing areas (Howeler *et al*., 2003).

3.3 Lower watershed

These are generally flatlands, often very wide river valleys or plains. Urban and agrarian people normally heavily populate them; they support intensive agriculture, industry and associated support infrastructure. These areas use large quantities of water for irrigation, industry, and domestic purposes, and are dependenct on good quality supplies of water from the upper and middle levels of the watershed, and on currently depleting ground water sources. Both land and people are abused. Both are subject to exposure to over use of chemicals, to dirty water supplies and to serious sewage and waste disposal problems. Infrastructure is intense in these areas. Land is quarried for stone, leaving scars on the landscape that are both unsightly and a source of contaminated soils and water. Dense populations are located on unstable sites that are often subject to flooding and collapse. Communication infrastructure such as highways and railroads concentrate water flows, and unless stabilized are serious sources of contaminates in water runoff. Most industrial sites are contaminated with everything from poisonous chemicals to fuel spills and garbage. River banks and flood embankments are regularly destroyed by wave action created by fast and ever increasing numbers of river boats and by floods, and are often, if at all, repaired at very high cost. The Vetiver System™ has a role in the mitigation of many of these problems. It is reported that 80% of south China's sediment flow comes from industrial and construction sites (highways, railways, building sites and related construction material sources). I would hazard a guess that the majority of sediment is generated in the lower watershed areas. Each particle of sediment carries contaminates that impact on water use, water quality and the cost of making that water fit for use.

You will learn at this conference how the Vetiver System™ can be used to clean up sewage effluent, create artificial wetlands, stabilize river banks, prevent flood damage, rehabilitate landfills, protect industrial and construction sites, reduce excess fertilizers from agricultural lands, and stabilize drainage systems in acid sulphate soils (Truong, *et al.*, 2003b) (typical of coastal lowlands). You will see how recent and extensive research is demonstrating just how the Vetiver System™ works in these situations and you can envisage, if you have the vision, just how the technology can be adapted for the future.

I am impressed by the many experimental initiatives, particularly those carried out in Australia, China and Thailand. Among many of the excellent papers that are being presented here at ICV3, those by Paul Truong and his team, on their work on MEDLI, a computer model for nutrient uptake and effluent irrigation [(Veiritz, *et al*., 2003), (Truong, *et al*., 2003a), (Wagner, *et al*., 2003), (Smeal, *et al*., 2003)], will, I believe, have a major impact in expanding the Vetiver System™ water quality application worldwide. It models and quantifies how the Vetiver System™ can be used for water quality improvement particularly in relation to industrial and urban pollution. I put the importance of this modeling work at a similar level as Diti Hengchaovanich's 1990's research on vetiver root strength. The latter provided vital quantification to construction design engineers, the former now provides quantification for those responsible for designing facilities for improving the quality of polluted waters and industrial discharge.

Other papers presented at this conference have direct impact on the lower watersheds (that include the coastal plains of East and South Asia where the majority of people live. Demonstrations and research support previous views that the Vetiver System™ will reduce substantially the wave and flood damage to riverbanks and flood embankments [(Metcalfe, *et al*., 2003), Le Viet Dung, *et al*., 2003), (Islam, 2003)]. Practical applications in Guangdong Province of China and the Central region of Vietnam show what the Vetiver System™ can do. The management of urban waste is a major problem, and the reduction or prevention of toxic leachates from these landfills is essential if down stream water flows are to maintain reasonable quality. You will see how the Vetiver System™ has effectively secured one of China's largest landfills (Wei Liu, *et al*., 2003) in the vicinity of Guangzhou. The recycling of water in urban areas is possible if low cost solutions can be found to remove BODs, phosphates and other impurities (Mongkon Ta-oun, *et al*., 2003). Research clearly demonstrates the use of the Vetiver System™ for this purpose. In many urban areas the 'poor' are sited on the worst sites, that are often steep and unstable - the Vetiver System™ have been shown to stabilize such slopes and reduce the hazards of landslips.

The lowlands are often the most fertile and intensively farmed areas. Intensive farming requires high use of fertilizers and other chemicals; the Vetiver System™ will significantly reduce chemical leachate from agricultural land (Wagner, *et al*., 2003), and at the same time provide added stability to such infrastructure as farm roads, drains and irrigation canals.

We find that with industrial and agriculture growth comes expanded infrastructure and construction sites that are the point source of significant contaminated sediment flows, also contingent quarrying creates unsightly and often unstable landscapes. The Vetiver System™ can be used to stabilize the former and rehabilitate the latter. Demonstration and research support its use. Vetiver is truly a remarkable plant.

Regretfully I do not have time in this presentation to review and discuss the many other interesting papers that be presented at this conference, as my purpose has been to focus primarily on vetiver and water. However we recognize all of you who have contributed to the increased knowledge about Vetiver System™, your work is valuable and often extremely important in moving this unique technology and plant forward to the future.

4 THE VETIVER SYSTEM™ TECHNOLOGY DISSEMINATION

The introduction of new technology is a slow process as we have found over the past 20 odd years working with the Vetiver System™, but each year more users are applying the technology in one form or other. We have to work hard at marketing the Vetiver System™, and we have to use the many alternative avenues that are available to us. I am still concerned that not enough farmers are using the Vetiver System™ for erosion control and *in situ* moisture conservation. I am intrigued by Van den Berg *et al* paper (Van den Berg, *et al*., 2003): "Can Vetiver Grass, *Vetiveria zizanioides*, be used to Manage Insect Pests?". In this instance the researchers have worked with maize as the protected crop. I remember in 1990 visiting Fujian Province of China and being concerned that vetiver was acting as a host plant for stem borer, and that the stem borer incidence for the adjacent rice crop would increase. I wonder if all along the opposite was occurring? This leads me to the point that we must look at all the agricultural benefits of vetiver and that farmers must be made aware of all these benefits, that apart from soil erosion control, includes vetiver use as thatch, mulch, fuel, forage, medicinal value, handicraft potential, paper, ground water enhancer, crop yield enhancement and more. Further we need to put an economic cash value to these benefits.

Evidence points to the fact that promotion of the Vetiver System™ by the private sector is likely to be the most effective. Experience in Central American countries, Madagascar, Senegal, China (Hanping Xia . 2003), and Australia all indicate private sector success and vigor in the Vetiver System™ promotion. It is interesting to see the contrasting success of the introduction of the Vetiver System™ to East Bali by a private sector NGO (Booth and Ardika, 2003) compared to the relative failure (Prayogo, 2003) by government agencies in Western Java – both located in Indonesia - both having ideal climates for vetiver growth and effectiveness.

Other avenues include teaching school children about the Vetiver System™. Also the inclusion, where and when relevant, of Vetiver System™ applications in community programs, and getting budget conscious quasi government agencies, such as railways and highways, that have to worry about their budgets to use the technology.

There are roles for government agencies – and an important one too. That is to sponsor sector focused workshops for potential users. Liyu Xu, China's Vetiver Network Coordinator has done this most successfully. So has the Royal Development Projects Board in Thailand, and Criss Juliard's introductions to Madagascar and Senegal of the Vetiver System™ through small business enterprises. Government agencies can help by contracting small private companies put initial vetiver multiplication centers into place, for as we know unless the plant material is readily available, potential users are unlikely to use it.

We can do a lot more in making knowledge more available on a wide basis, and I hope that interest generated by this conference will provide incentives to get the Vetiver System™ information out to all sectors.

5 THE VETIVER NETWORK

Before closing I would like to say a few words about The Vetiver Network (TVN). Earlier this year we appointed a new volunteer coordinator, Dale Rachmeler, who took over from Joan Miller. Joan did a wonderful job first establishing the Latin America Vetiver Network and then coordinating the Vetiver Network. Dale has excellent qualifications for the task, and I hope that because of his travels he will be able to do more work with vetiver in Africa. TVN, through funding support of the Amberstone Trust, has recently commissioned the Southern Africa Vetiver Network (SAVN) to undertake a study in southern and eastern Africa to see what is actually happening on the ground with the Vetiver System™, what the future might be, and to report on how accelerated use of the Vetiver System™ might be achieved. SAVN coordinator, Jon McCosh, is attending this conference and I hope that those of you from Africa meet with him.

More than a year ago I set up a Discussion Forum on our website: ***http://www.vetiver.org/discus.*** It has proved a good way of having an informal exchange about the Vetiver System™ and I would hope that as a result of this conference more of you register to use the Forum. The advantage of registration is that the registered person will receive automatic emails of the Forum postings. For those who have difficulty in accessing a web page, the next best thing is an email.

During my last visit to China in April 2002 I was asked whether TVN would provide certificates to the Vetiver System™ users and developers who had a proven record of technical excellence and accomplishment. We have now created these certificates. They will not be given away lightly, but will be given to those who can prove their ability. There will be three classes of excellence:

- ***First Class*** - will be truly exceptional people who have a wide range of knowledge, have proven ability in at least three areas of application, and have capability of training others.
- ***Second Class*** - will be those with proven ability in at least two areas of application and with an ability to plan and cost out at he Vetiver System™ project/job.
- ***Third Class*** - will be people who can demonstrate their ability in the understanding, use, management and proper application of the technology in one particular area.

Information about this certification process and examples of the certificates can be down loaded from our web site. You should note that TVN will accept for consideration applications forwarded by country coordinators, and will keep a worldwide list of certified persons that will be made public on our web site.

Finally I wish to thank the organizers of this conference for doing the hard work and look forward to some interesting days to come.

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