briefly sketched issues and results pertaining to unstable equilibria and other more general attractors, rates of convergence, bias–variance trade-off and the effect of step-size on these, and motivation for and analysis of multiple time scale and distributed algorithms. He then introduced Markov decision processes, giving an overview of the dynamic programming approach and the associated iterative algorithms. He highlighted the need for reinforcement learning schemes when the exact model is unknown and gave a brief account of the two main strands of such schemes: Q-learning and actor-critic methods, in the context of discounted cost problems.

Mohan Delampady (ISI, Bangalore) gave two talks. The first was on Bayesian analysis of Poisson counts wherein he described his recent work based on a hierarchical Bayesian model using two alternative techniques, importance sampling for accelerated Monte Carlo and a saddle point approximation. The second talk was on the correlation between a parameter and its estimate, where he indicated how this makes sense in a Bayesian framework and can lead to useful performance criteria.

There was also an evening popular lecture by Ayesha Kidwai (JNU) on 'Modelling the language instinct: a case for universal grammar', wherein she described the issues in language acquisition that lead to Chomsky's theory of universal grammar. The rather strong dose of technical discourses was punctuated by a trek in the Dubare forest, several walks in and around the plantation, a social evening with a bonfire, and daily chat sessions by the poolside. It is hoped that this meeting has built bridges across the disciplines which will last (and be used) well into the future.

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Vetiver grass technology for environmental protection and sustainable development

Vetiver plant (*Vetiveria zizanioides* L. Nash.), a native grass of India has been extensively used for land protection and an essential oil used in perfumery industry (Figure 1). Systematic efforts to develop applications of Vetiver Grass Technology (VGT) to mitigate soil erosion and water conservation were first initiated in India in 1986 through several World Bank-funded projects in the low rainfall areas. Researches conducted over the last 10 years demonstrate that VGT is one of the most effective and natural low cost methods of environmental protection. Lately, in view of its ecofriendly nature, vetiver grass has found new uses for construction purposes (bioengineering) and remediation of contaminated sites (phytoremediation). The 2nd International Conference on Vetiver: Vetiver and Environment (ICV-2) was organized in Thailand from 18 to 22 January 2000, by the Royal Projects Development Board, Bangkok. The conference was attended by 325 participants from 31 countries. Besides scientific deliberations, one of the most important attractions of the conference was the technical tour to vetiver project sites. In all 10 plenary lectures were followed by panel discussion on experience in putting together countrywide vetiver programme, policy issues, expectations and results (6 presentations); vetiver and natural disaster (4 presentations); reports on regional and national networks (9 presentations). The conference theme was divided into three paper sessions: (i) Soil and water attributes (16 papers), (ii) Basic research and general studies (14 papers), and (iii) other topics (16 papers) covering 7 broad topics, and a poster session (34 posters). The concluding session had projection about the theme of the next conference and recommendations.

In his opening plenary lecture, Richard Grimshaw (Vetiver Network, USA) emphasized that ever since the first pilot testing of VGT in India in 1986, currently 138 countries know about this technology, 100 are using it in one form or the other, over 800 NGOs and an equal number of government agents are associated with the use of VGT. In 1986, VGT was solely applied as a erosion control measure. In the year 2000 it was used for highway stabilization, mine land rehabilitation, river, canal, drainage bank stabilization, sea shore stabilization, wind breaks, pollution control mitigation associated with municipal trash dumps, and housing construction site stabilization. There is an increasing involvement of private sector in the establishment of VGT enterprises that serve the engineering sector.

Diti Hengchaovanich (APT Consult Company, Bangkok) highlighted the unique characteristics of vetiver *vis-à-vis* its utility as bioengineering option for environmental conservation and protection. He further supplemented a remark that 'Vetiver is a living wall' and illustrated its unique properties with respect to tensile strength and growth pattern of its roots. He provided evidence that the grass is able to form a dense hedge within 3–4 months, resulting in the reduction of rainfall run-off velocity, and an effective sediment filter. Its vigorous, massive and dense subterranean root network reaches vertically from 2 to 3 m depth facilitating soil binding and aeration. Further, in view of growing interest of plants for phytomining and phytoremediation/ rehabilitation of contaminated soil and wetlands[1], he emphasized use of vetiver to rehabilitate gold, platinum, coal and other mines. Realizing the significance of VGT for rehabilitation of landfills, Diti Hengchaovanich mentioned that a test section has been established for planting of vetiver at a major landfill at Kamphaengsaen, 90 km northwest of Bangkok, where 5000 t of garbage is being dumped. It has been observed that vetiver plants were able to survive fairly well, despite the presence of leachate and high toxicity. Paul N. V.

Figure 1. Environmental and industrial uses of vetiver. ***a***, ***b***, Contour planting of vetiver grass for filled (***a***) and cut (***b***) slope stabilization of newly-constructed road; ***c***, Vetiver roots of the two varieties selected for faster root-growth (root length may reach up to 3 m just in one year); ***d***, ***e***, Vetiver products: ***d***, hard board, ***e***, flower vase decoration.

Truong (Queensland Department of Natural Resources, Australia) furnished scientific data and field observations relating to high tolerance levels of vetiver grass to adverse soil conditions, heavy metal toxicities and agro-chemicals. The specific data provided have underpinned that VGT is an effective, low tech and low cost method for (i) mine rehabilitation, (ii) off-site pollution control method by trapping pesticides, herbicides and nutrients in run-off water from agricultural lands, and (iii) vetiver is highly suitable as a wetland species, as it is extremely tolerant to high level of agro-chemicals under the wetland conditions. All these have ramifications in protection of terrestrial, aquatic, aerial and social environment, as also mitigation of natural disasters[2]. Songkiert Tansamrit (Petroleum Authority of Thailand) provided the necessary design/construction and planting strategies regarding the use of vetiver grass system for effective control of soil erosion and facilitate slope stabilization along the gas pipeline in the Yadana Gas Pipeline project[3]. Hong Cheng (Ministry of Water Conservancy, China) provided experimental evidence for application of line planted vetiver in sand fixing of subtropical deserts where sand dunes would dislodge the desert soil. James Smyle (Costa Rica) provided a natural resources perspective on the prospects for the VGT in disaster mitigation and vulnerability reduction. W. S. Shu (Zhongshan University, China), Liyu Xu (China Vetiver Network) and several others recalled their country experiences regarding use of VGT in soil erosion and sediment control on sloping farm lands/floodplains, rehabilitation of saline and acidic sulphate soils, landfill and contaminated lands, purification of polluted water, control of algal growth in rivers and dams, removal of heavy metals, trapping of agrochemicals and nutrients, effluent disposal from sewage, feedlots, piggeries and other intensive livestock industries, on site and off site pollution control from mining waste, mitigation of natural disasters such as typhoons,

landslides, floods, steep slope infrastructure, etc.

Due to prolonged draught, caused by El Nino, there is little work left for rural farming communities in several countries. However, a need to planting material of vetiver to support various infrastructure projects facilitated employment opportunities to the affected rural communities. Mary Noah S. J. Manarang (Vetiver Farm Inc., Philippines) said that advocacy for VGT technology and its associated commercial aspects attracted her to take up the vetiver nursery and propagation programme and thus increased employment in villages. She said that currently VGT is being extensively used in several countries of south-east Asia, more particularly, Thailand, Malaysia, China and Philippines where several private entrepreneurs have taken up the job of vetiver propagation and supply. Pisoot Vijamsorn (Thailand) opined that after selection of an elite genotype suitable for the specific purpose, a propagation programme needs to be developed quickly to obtain thousands of seedlings to plant. An extensive programme on propagation was initiated in Thailand in 1993 and by the end of 1999 made some 10 million plants. He said that for faster propagation, the elite source plants are first grown in nursery, followed by propagation through tissue culture to establish multiplication nurseries.

R. P. Adams (USA), and Pattana Srifah (Bangkok), through their independent work on genome analysis based on RAPD and SSCP DNA techniques, demonstrated that there exists tremendous genetic diversity amongst vetivers, but this is mainly confined to South Asia. Almost all vetiver grown outside this region represents a single genetic stock. U. C. Lavania (CIMAP, Lucknow, India) attempted to further classify the vetivers of South Asia from their origin and dispersion angle. Based on analyses of morphotaxonomic and cytotaxonomic observations, he suggested that peninsular India is most likely the primary centre of origin of vetiver, from where vetiver may have dispersed to different directions: towards north in Indian subcontinent on one hand and to South-East Asia on the other. Seshu Lavania (Lucknow Univ., India) presented a case study on nematode-induced root-knot infestation in this otherwise very hard plant.

Through an experimental study on externally applied heavy metals (Mn, Zn, Cu, Cd and Pb) to elucidate uptake potential by vetiver grass, Nualchavee Roongtanakiat (Bangkok) suggested that vetiver grass has vast potential to uptake and tolerate toxicity to heavy metals – but to further enhance the efficiency of heavy metal uptake it is desirable to have regular trimming of upper-ground biomass. It was further mentioned that mature vetiver grass shows better absorption of heavy metals than the young seedlings. M. Sharif (USA) highlighted the significance of vetiver in combating severe land disturbance and soil erosion/sedimentation problems encountered in Army training missions. He emphasized that to minimize the damage caused by tank movement, planting of vetiver could be an ideal choice.

The exhibition on Vetiver Technology and Products displayed accomplished works of 24 agencies in Thailand involved in the implementation of vetiver research and development works[4]. The display had live materials showing use of vetiver in preventing soil deterioration/erosion, stabilization of pond ridge, vetiver multiplication, vetiver planting patterns, use of vetiver in different agricultural/cropping systems/forest and orchards management/pollution control from pesticide leaching/disaster prevention in critical areas, breakage of hard-pan soils, planting of vetiver hedgerows along slide slopes, vetiver multiplication, propagation using inflorescence and axillary bud culture, propagation through the use of dibbling tubes and samples of vetiver ecotypes. A mini live model depicting utilization of vetiver grass technology system for soil and water conservation in different areas (slope, agricultural land, edge of farm pond, reservoir, canal, and small check dam) was also displayed.

A one-day technical tour to major project sites provided an on-the-spot demonstration of VGT in rehabilitation of degraded and hard pan soil and industrial utilization of vetiver products. Vetiver grass planted along the ditches under broad-bed based vegetable cultivation and fruit trees helps to prevent soil erosion on the broad-bed from collapsing, and also in conserving soil moisture. This has facilitated revegetation of once barren land just in a period of 10 years. Planting of vetiver rows at vertical intervals of 1 m along the little slopes, 2 m for areas with moderate slopes and 4 m in mountainous area, has helped maintenance of topsoil and retention of moisture. In a period of 5 years this has improved ecological conditions and restoration of green cover. The programme activities of this project demonstrate: (i) forest rehabilitation area by using vetiver system *vis-à-vis* hard pan soil profile, (ii) display of the use of vetiver system for preserving soil erosion, maintaining moisture in the forest rehabilitation area and also strengthening and preventing the collapse of check dam, (iii) vetiver multiplication and nursery, (iv) product development from vetiver leaves from cottage type activities, such as weaving of decorative and household articles to hi-tech products such as vetiver boards, pots, compressed partition walls, floor tiles, and interior decoration items. The orchards of a farmer and volunteer 'Soil Doctor' display the strength and potential of VGT in maintaining the soil fertility in the inundated areas. Ring planting of vetiver around trees brings about reduction in silt inflow and also facilitates maintenance of soil aeration on account of their massive root system, thus mitigating the adverse effect of water logging.

Highlighting the significance of vetiver in detoxification, conservation and recharging of water resources, Grimshaw of the Vetiver Network stressed for intensification of efforts in this direction, and suggested 'vetiver and water' to be the focal theme for the future.

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