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OPPORTUNITIES FOR COMMERCIAL INDO-U.S. COLLABORATION IN INFORMATION TECHNOLOGY FOR INDIA'S ENVIRONMENTAL AND RESOURCE MANAGEMENT NEEDS

Submitted by

James M. Bellis

ASDG/Advanced Software Design Group,Inc.
Burlington, Vermont

Under Contract to

USAID New Delhi

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The new source of power is not money in the hands of a few but information in the hands of the many.

. . . Knowledge has already become the primary industry, the industry that supplies the economy the essential and central resources of production.

John Naisbitt
Megatrends

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EXECUTIVE SUMMARY

Over-View

This report gives background to and makes recommendations for building a long-term effort in the development and deployment of informatic technologies, particularly knowledge-based decision support systems for serving India's environmental concerns. It suggests USAID's preferred role in this effort, identifies fundamental technical activities to be addressed for India to make a major contribution in this field, and offers implementation strategies at various breadths of scope and commitment for inaugurating such undertakings.

Structure

The background material presented relates to: a) USAID's current goals and objectives for project involvement (SECTION 2); b) India's current computer/software industry situation, with special attention to AI activities to date, as well as the Indian government's policies that effect the industry (SECTION 3), and c) the kind and level of activity in the U.S. in knowledge-based decision support systems that could be brought into working relationships with Indian software developers and environmental technologists (SECTION 4). The report stresses these areas inasmuch as they are the contexts in which concrete efforts in this field in India must take root.

The report's recommendations concentrate on project selections, innovative product development/deployment methodologies (SECTION 5), as well as a small number of selected implementation strategies for launching the effort, which range from modest to ambitious (SECTION 6).

Content

USAID has placed private sector related environmental problems as high priority areas to be addressed with its involvement. Its stated preferred modus operandi in dealing with these concerns is through joint Indo-U.S., private enterprise ventures where America's recognized world leadership in technology services can be brought to bear. Informatics technologies applied to environmental problems would be a particularly fruitful realm of endeavor. Knowledge-based decision support systems, given their growing successes in the U.S., are notable in this regard.

The current state-of-health of the Indian software and computer industries, upon which the endeavors discussed here must be built, offers a mixed picture. Talent and interest are undoubtedly very high. There has, furthermore, been rapid growth and maturation in these fields in the last few years. This has been accompanied by an encouraging attempt at governmental and industrial self-regulation in training and intellectual property rights matters.

Unfortunately, the government has put extreme pressure on the industry players to give their principal effort to export activities and has built exceedingly unrealistic expectations for success.

Little attention has been directed to long-term goals. As a result, India's home software markets have been neglected. This has resulted in the paradoxical situation of India succeeding in exporting its programming talent abroad, without gaining even a toe-hold in the world-wide, multi-billion dollar software development industry.

One of the main points of this report is that India will not gain International respect and recognition for its software -- and thus demand for it -- until it begins to seriously serve its home market needs. Moreover, it must build its reputation in well delineated fields, ones in which it can draw on its strengths.

A promising and natural application area for this is in the development and deployment of knowledge-based decision support systems applied to their many serious environment and natural resource management problems. The software solutions, and possibly hardware creations as well, will, undoubtedly, have applicability to developing nations around the world. India has the opportunity to take a leadership position in this domain, not only in the products it produces, but also in the methodologies it establishes for developing and deploying the technology. Few, if any such products and methodologies currently exist anywhere.

Many leading U.S. workers in knowledge-based decision support systems applied to environmental concerns -- several who have been identified in this report -- have expressed their enthusiastic interest in working with their Indian counterparts in joint private-enterprise ventures to accomplish the goals mentioned here. Collaborative efforts between the Americans and Indians along these lines appear to offer benefits for all the participants involved.

In order to help advance long-term, sustained, and productive activity in this promising field, the initial implementation strategies suggested here are flexible frameworks for supporting communication and collaborative work between private sector firms and public institutions and agencies and between American and Indian associates. Moreover, they take into account the strengths and weakness of the present situation.

In particular, four strategies are rendered in outline form:

a) <u>Information and Network Facilitation</u> involves building communication ties and information sharing between U.S. and Indian workers in the field.

b) <u>Joint-Venture Private Enterprises</u> incorporates the Information and Network Facilitation of strategy a). It uses the Facilitator, however, not only for information sharing and communication linkages but also for establishing Indo-U.S. joint ventures primarily in the private sector.

c) Institutional Spin-offs support the technologically and commercially successful U.S. advent of institutional spin-offs on Indian soil. Several of the various models projects and methodology innovations discussed here along with U.S. technical services could help jump-start these activities.

d) Institute for Knowledge-based Decision Support Systems is the most ambitious strategy of the four presented in the report. The intent here is to carry out many of the functions of strategies a), b), and c), while establishing a long-term, intensive and visible Indo-U.S. commitment to the development and improvement of knowledge-based decision support systems directed toward the solution of environmental, natural resource, and agricultural concerns for developing countries.

1. INTRODUCTION

1.1 Purpose

It is a little over a year and a half since I submitted my first report to USAID on the potential use of knowledge-based decision support systems as a productive technology in addressing India's many natural resource management problems [Bellis]. This spring the New Delhi USAID Mission asked me to return to India to give a series of presentations at various institutions in the country on the topic of Expert Systems as they are being applied to environmental concerns in the U.S. (see Appendix I for my India itinerary). I was asked to also draft a document that would consider some of the fundamental building blocks of a meaningful USAID supported effort in India in the domain of software technology. This report is my response to USAID's request.

I have two major, essentially equally weighted, objectives to be accomplished in the report. The first is to bring into focus the various contexts in which the software development and deployment endeavors are to be carried out. The second is to suggest a starting point. This takes the shape of: 1) Timely and accomplishable model projects that could launch activities; 2) Key technical issues that should be addressed if this is to be something more than a transient effort; and 3) Possible opening strategies that would serve as foundation building for the endeavor.

This report addresses these topics for three distinct but ultimately related audiences: a) USAID administrators, project managers, and consultants who must make decisions about investing in and implementing projects in India for the development and deployment of knowledge-based decision support systems in the service of environmental problems, b) Indian government and institution officials who are responsible for commissioning the types of activities discussed here, and c) U.S. and Indian private sector service providers and developers, the technical and scientific personnel who will carryout the design, development, and deployment tasks that will bring the projects to fruition.

1.2 Scope

During my presentations (mentioned above), I took the opportunity to discuss with many of the technical and scientific staff at the institutions I visited the types of problems they perceived were of major concern to the country related to their particular fields of endeavor (environment, natural resources, agriculture, etc.) and which they felt could be ameliorated by the use of knowledge-based decision support systems. I also queried them about their interest in becoming active in the development and/or use of this type of technology in their work. Our discussions were productive, and far ranging.

By doing this I was able to tap a broad cross-section of institutions and professionals. What I learned from the meetings has been largely supplemented by my readings in both the Indian general press and Indian computer/ software publications.

To a lessor extent because of limited time, I did something similar with Indian software developers and with computer technology journalists in the private sector. These discussions too proved to be invaluable sources of information for this report.

Because a major portion of my task was to bring to India some awareness of what is currently happening in the U.S. with the use of software technology in environmental concerns, especially with Expert Systems and knowledge-based decision support systems, I made contact with several of the American leaders in this field. I had many fruitful discussions with them both prior to my trip and upon my return. They gave unstintingly of their time to discuss with me their current activities as well as their perspective of the field in general (The individuals I am referring to are mentioned in section 4.2, Hubs of Activity). Moreover, many of these same people had available knowledge-based systems they had developed for the PC or MacIntosh which they willingly allowed me to take to India to serve as demonstrations (see Appendix II for a list of Demos and developers).

Another aspect of the report's scope relating to the auspices under which it was written requires some attention. Since this report was originally done under USAID's Office of Natural Resource Management, where the mission's environmental program was then lodged, it did not focus on the activities of the Office of Technology Development and Enterprises (TDE), where those responsibilities now reside. The TDE office, however, does have at least two activities that I believe are germane to the subject matter discussed here, either in terms of offering other examples of the principles espoused or other possible opportunities for applying them.

These are: a) The Project for the Advancement of Commercial Technology (PACT) that does indeed finance new software product development, among many other things; and b) The Center for Technology Development project (CTD), which, in its activity to establish Applied Technology Centers, may be pursuing an activity somewhat akin to my suggestion (model project four) for the software industry (Cf. 36).

1.3 Basic Terminology

I have made a conscious effort to sanitize this report of computer related jargon as well as organizational and technical acronyms, both of which, I know from personal experience, make report reading, at best, a tiresome, head-swimming experience.

There are, nonetheless, a few basic terms which are so central to this document that it would be rather cumbersome -- to the reader as well as the writer -- to try to work around. A brief moment of attention with this section will I hope clarify these terms and make the rest of the report "smooth sailing."

Knowledge-based Decision Support Systems is a generic term referring to computer programs that encompass knowledge of a domain area to assist the user in arriving at a fixed range of problem solving decisions that he/she must make within the context of daily work in that domain.

The domain knowledge built into the program generally comes from outstanding decision making performers in the given domain. This does not imply Nobel laureate concentrating on arcane topics. It is the knowledge of the farmer whose planting patterns result in consistently high crop yield, or the technician who trouble shoots smokestack scrubber unit breakdowns with superior accuracy that become the knowledge-base sources for these programs.

This definition is purposefully devoid of any mention of a specific computer technology. Knowledge-based decision support systems can utilize any and all computer technologies to analyze and evaluate a situation and/or solve a problem, the outcomes of which will assist the user of the program in making a well founded decision. So that conventional programming can be coupled with "database management," "inference engines" as well as "system simulations," "statistical analysis," "neural networks," "fuzzy logic," and "genetic algorithms" to get a job done. (The terms in quotes will not be defined here. They are mentioned simply to emphasis that the technologies used under this rubric can essentially be without bounds.)

They could easily be called "programs" rather "systems." The term 'system' implies a program that provides an integrated set of tools, e.g. database managemnt, statistical analysis and simulations, user query, graphical output, etc., which hook into the problem at various points in order to solve problems systematically. Of course, not all knowledge-based decision support systems are that complex and yet they serve a valuable service to the user.

Expert Systems are "computer programs that give the appearance of human-like reasoning for problems ordinarily requiring expertise" [Pedersen: 4].

If properly designed and used, expert systems can bring the intelligence and knowledge of experts -- singled out for their distinguished capabilities in their particular domains -- to solving problems.

As one can see there is great overlap in the definitions of knowledge-based decision support systems and expert systems. This is because they are two terms essentially describing the same entity. The former term is more explicit about what it is denoting and leaves free the technologies involved. The latter connotes meanings that are easily misconstrued ("expert system" seems to be a loaded word) and, despite the definition attempt made here, is often associated with a small range of inferencing schemes within the artificial intelligence (AI) realm.

Informatics is "all the technologies, collectively, that deal with the computer-assisted collection, processing, and transmission of information" [Darcy et al: 128] along with the techniques, knowledge, and craft for making "data and information useful, applicable, and approachable" [Wurman].

Software Engineering is the systematic application of engineering principles, methods, and techniques for the timely and controlled development of software products and assurance of their reliability, maintainability, and usefulness.

Without a serious software engineering effort, there is little chance of sound and significant software development taking place.

2. UPDATE ON USAID'S GOALS AND OBJECTIVES

2.1 Fundamentals

In the report that I submitted a year and a half ago to USAID on "Client-Driven Information Technology" [Bellis], I gave an overview, as I understood it, of USAID's expressed goals that were intended to shape a new generation of USAID activities in the Natural Resource Management (NRM) sector. Since that report, major modifications to those goals have been made that should have notable bearing on USAID's future projects. The most notable of these changes are a clearer emphasis on private sector activities and a conceptual movement from natural resource management to private sector oriented environmental concerns. This is reflected in the movement of these concerns from its office of Natural Resource Management (NRM) to its office of Technology Development and Enterprise (TDE). A brief discussion of USAID's current NRM/environmental goals is the starting point for this report.

In general, AID development activities, need to respond to a series of basic intentions. For a proposed project to interest AID, it ideally will have to: a) be directed toward resolution of pressing problems with the realization of rapid and measurable payoffs; b) enhance indigenous capacities so as to promote sustained effort after the assistance is completed; and c) facilitate the adaptation of the results elsewhere in the country.

In addition, USAID/India sees that these goals will be most fully and efficiently realized when it takes extreme care to: a) restrict its efforts to areas in which the U.S. has outstanding expertise; b) address problems perceived by the recipient country as having high economic priority and motivation; c) select activities for which the beneficiaries are eagerly receptive; and d) focus on undertakings which are to the maximum extent possible located in the private sector and are ideally market led.

2.2 Attention Directed to Non-Governmental Areas

This last attribute represents a major re-orientation of the mission's environmental/resources efforts. USAID has decided to favor de-emphasizing direct support to the beneficiary country's governmental agencies. Instead, private enterprise, in particular small- to medium-sized businesses and other non-governmental organizations (NGOs), are hopefully to become the main vehicles for project execution.

This change has come about for several reasons. USAID desires to circumvent burdensome government bureaucracy. It wishes to take advantage of the significant untapped entrepreneurial resources of India. It also hopes that the involvement of more private sector specialists, with their more flexible and direct way of acting, will help reduce USAID's high degree of project management.

This new direction means USAID's NRM Office is now being phased out. Future activities will be conducted by USAID's Technology Development and Enterprise Office. As much as possible, concentration will be on establishing commercial joint ventures between U.S. and Indian firms. From USAID's perspective, this is rightly seen as a means to better project development, and not just an end in itself.

2.3 Technology Services

USAID is also now recognizing that technological services, as opposed to technological products and contracted self-contained projects, are a powerful means of offering technology transfer to India. Such a strategy requires a pool of talented and well-trained personnel in the recipient country who can absorb the technology and even improve on it. India has such a workforce.

Traditionally, USAID has provided assistance in solving particular problems, like building a dam in a flood plain or reforesting an over-cut timberland. The new approach, however, with its stress on technological services, focuses on problem areas. Thus, rather than USAID building a dam in Rajhistan, private sector U.S. dam construction experts could work directly with a team of private sector Indian engineers to improve dam construction and flood control capabilities throughout India.

Likewise, a reforestation project might take on broader dimensions than had been thought of in the past. For example, a group of private U.S. forestry consultants might help establish or upgrade small, private or NGO-based forestry consultant operations in various locales throughout India.

The reliance on private technology services as much as possible is in keeping with the nature of the U.S. economy, which is increasingly driven by the service sector. On the international level this point has been emphasized by the U.S.'s stated desire to have trade-in-services a recognized part of the General Agreement on Trade and Tariffs (GATT).

Of particular interest to USAID's future environment activities are the rapidly expanding commercial technology-based services directed to cleaner and more efficient use of natural resources.

Technology services as they relate to the environment cover a full range of activities. An earlier USAID report called <u>India Resources Management Analyses and Technologies</u>, by Bromley, <u>et al</u>, emphasized the important support role that technology-service enterprises play in the agriculture/NRM sectors in the West:

> As in the United States and many other countries, firms in the information technology, agrotechnology, and technical management assistance industries supply services to public as well as private clients. For example, "value-added" firms in the GIS industry enhance digital imagery from satellites to supply state and federal governments with targeted information. They also assist large-scale agroindustrial clients in planning production and marketing [Bromley: 42].

It is this sort of private value-added activity that USAID wishes to advance in India, and for which many opportunities definitely exist.

2.4 The New Direction Applied to USAID's Prospective Environmental Efforts

USAID's new direction of designating the non-governmental sector as the preferred project vehicle, encouraging joint ventures between small- to medium-sized Indian and U.S. firms, and emphasizing technology services promises numerous interesting possibilities.

While perhaps initially unintended, the new direction clearly points USAID's future environment projects towards niche-market commercial endeavors. As such, it gives market forces a much greater role than ever before in determining the long-term stability of such projects.

With the new emphases, a project will still need to address a high-priority natural resource or environmental issue. But organizations participating in USAID-sponsored projects will also have to be concerned from the beginning with market size, market penetration, and the company's market share for the project's services or products. When the USAID financial and technical scaffolding is removed from a project, it must endure on its own merits. When private enterprise is involved, this means commercial viability.

In many cases, the potential user-populations, such as agriculture processors, industrial producers, forest managers, or irrigation developers, will have little if any familiarity with the new technologies and technology services. A strong "marketing effort" will therefore be a necessary component of any of these undertakings. This means that not only the benefits of using the technologies or technology services must be demonstrated, but that the incentives for adopting them must be developed as well.

3. UPDATE ON THE STATE OF INDIAN INFORMATION TECHNOLOGY

3.1 Strengths and Weaknesses

Since the government's pronouncement of its "New Computer Policy" in late 1984, computer and information technologies have been moving rapidly towards the center stage of the Indian economy. However, the industry has come nowhere near the potential that some government and industry spokesmen have hoped for. Here are a few aspects of the industry that attest to both its strengths and weaknesses.

Expectations and Current Realities

One of the main forces driving India's software industry is the faith the Indian government has put in it, especially as a major export industry and as a balm for an ailing economy. Indicative of this is that "software" is the only technology identified by name in the Approach Paper to the Eighth Five-Year Plan as offering exceptional possibilities for the economy [Planning Commission GOI].

Reliable current figures on the software industry's output are hard to come by. Most attention is directed toward export capacity alone, and therefore that is basically how the industry's production level is being measured and talked about. The best, albeit crude, estimate of the total current industry revenues (export and domestic) is $160-180 million [Schware: 36; Malhorta]. Of that, exports amount to approximately $100 million, or 56 to 63 percent of the industry's total revenues. Software for mainframe and minicomputers represent roughly two-thirds of the income revenues and data processing services constitute another 25 per cent. PC software accounts for something less than 10 percent of the total [Schware: 36].

These figures are significant when one stops to think that just six years ago no such industry even existed in India. However, they take on quite a different appearance when we do some comparative evaluations.

Over the past few years, Indian software exports grew between 29 and 50 percent annually. However, with 1989-90 exports at $100 million, there is virtually no possibility the industry will come anywhere near the Government's $400 million export target for August 1991 [Telematics Special Correspondent: 62]. It must be noted that this is not so much a fault of the industry as it is the Government's unrealistic expectations and naivete concerning the software development enterprise.

The Indian software industry has a long way to go before becoming a competitor on the world market. Estimates for the 1990 world software market are $100-120 billion. India's participation amounts to approximately one-tenth of one percent of this.

Moreover, the world market is increasing at an average annual rate of between 20 and 30 percent, so that by 1995 it is expected to reach some $340 billion [Roy: 67]. If India's overall software production increases at an annual rate of 50 per cent -- the highest at which its exports have increased in the past five years -- it would reach approximately $1.4 billion in 1995, a mere four-tenths of one percent of the world market. This would also amount to an $18.6 billion short-fall of the Government's $20 billion-dollar target for 1995.

In discussing the technology gap between India and major information-technology producers, a leading Indian software professional (who insisted on anonymity) graphically summarized matters this way:

> In the foreseeable future -- maybe the next eight or ten years -- India's share in the world software market is likely to remain far less than one per cent. Yet [the] software industry is more promising than other [high-tech] industries for exports, because in this industry the technology lag between India and the advanced countries is less. For example, while for computer hardware India lags behind the U.S. by at least 20 years, in software we are behind only 10 years. The hardware industry boasts of a great reservoir of technical manpower, but it has not been able to produce even a 4K memory chip while other countries can produce 4 million bit chips. Such a wide technology gap does not exist between [the] Indian software industry and this industry in advanced countries [Telematics Special Correspondent: 63].

An Industry with High Concentration

In 1988, when the revenues for the industry were in the range of $75 million, it was reported that the three major software companies in the country each sold over $10 million in software products and services. The remaining companies each produced less than $1 million, with the overwhelming majority of these (approximately 75 percent) showing income of under $100,000. Further, two of the three leaders, Tata Consultancy Services and Tata Unisys, Ltd. were responsible for approximately 65 percent of the export trade. As Schware points out:

> In general, most of the Indian companies participating in the market are small independents, having little financial strength to expand, relatively no venture capital support, and who are not closely associated with major financial and industrial groups [Schware: 36].

Export Fixation and Domestic Myopia

While export is the dominant theme of the industry, what it calls export might not find universal agreement. Nearly 90 percent of Indian software exports amount to sending software professionals abroad to write computer programs at the customers' facilities. It

appears that Indian software developers have found favor abroad. Indian software, on the other hand, has not yet met with the same success. Thus, India has really demonstrated its potential more as a programming service exporter to software developers elsewhere than as a software developer itself.

A major impediment to India taking its place in the world software arena, despite its widely recognized talent pool, is that it has not served its home front. Only when foreign countries see that India has something special to offer its domestic market will they begin to take an interest in Indian software, and not just its low-cost professional labor.

Bolstering the Industry -- Software Conferences and Software Hype

The industry's leaders and the Government are working diligently to strengthen the industry. To some extent their efforts are going into image-building, both for domestic and foreign audiences. This is an obvious calculated marketing tactic to get the word out that India has the capability of, say, Singapore, Australia, or England. But with all such schemes, there is an element of wishful thinking.

Of particular note have been the conferences, expositions, and trade shows. All tout superlative titles and big-name participants. None has missed the opportunity for extensive press coverage. The Indian Computing Congress, (Hyderabad, November 1990) was one such event. According to a news report, the meeting "attracted 200 delegates, including scores from overseas" [9:149]. Similarly, INFOTEK '91 (New Delhi, January 1991) was a seminar on information technology trends with the purpose of creating "communications awareness in the country" [10:26]. Noted industry and government officials, along with independent consultants and scientists, were the featured presenters. Probably the most grandiose of these public forums was the one recently put on by the All India Computer Manufacturers' Association (New Delhi, February 1991), which was billed as "The First World Software Conference" [11:89-91].

Taking More Concrete Steps -- Technology Parks

The Government, however, has taken more concrete steps to nurture the infant industry. One that has received attention is the Software Technology Parks scheme.

The Parks function much like industrial or science parks elsewhere in the world in that they provide infrastructure and some shared facilities for the occupants. However, this is where the similarities end. Because the Government has put so much faith in the potential of the software industry, the Indian version caters to software companies exclusively. Furthermore, they operate as a single-point government clearance for various import/export licences, and facilitate the government regulation that allows elimination of duty on the import of capital goods and materials required for their export activities [12:66]. The Parks are also to provide high-speed communication facilities for linking the companies to their international export targets.

At the time of this study, the main stricture placed on the companies operating within the Parks is they must devote 100 per cent of their effort to export and attain something like a 230 per cent export level above the value of their imports. (This policy will probably change as planned new economic liberalization takes effect in the coming years.)

Three Software Technology Parks have been established -- at Bangalore, Bhubaneswar, and Pune. They are at varying degrees of completion and operation. The Department of Electronics has made frequent pronouncements to the media that it intends shortly to establish 12 more such Parks throughout India. But this is rather curious, since the three existing Parks have yet to prove their worth.

A Little Help From Our Friends

The Indian information-technology industry is also getting a boost from non-resident Indians (NRIs as they are commonly referred to) in the U.S. An estimated 25,000 Indian engineers and scientists at present work in the U.S. [Chandra], and several very successful American high-tech firms have been established by NRIs. Among the more prominent are Sun MicroSystems, Tandon Corp., Excelan Corp, and Silicon Valley Technology (SVT).

Many of these technically and commercially talented NRIs have expressed their concern for India by establishing joint U.S.-Indian ventures, negotiating contracts with Indian companies, returning to India to run the Indian-based facilities of U.S. firms, and advising the Government and private enterprises in India on technical or business matters. The Silicon Valley Indian Professionals Association (SIPA) conducts informational activities to promote better working relations in high technology between India and the U.S. This has been a very significant contribution to India's information-technology industry, and will likely grow in magnitude and importance.

Increase in Information Technology Firms

Dataquest, one of India's leading computer magazines, annually profiles India's software and hardware companies. In its 1989 listing, some 158 companies were identified. One year later the magazine included 192 firms, an increase of 21 percent. As the Dataquest editor noted, "There's a new computer company born every two weeks" [Chellam:9]. In comparison, during 1985-1989, some 95 computer companies came into existence, or slightly over one a month.

This growth augers well for strengthening the information technology talent pool by providing more opportunities for young professionals to gain industrial experience. It might possibly even help stem the brain drain to the West that India has had little means of fighting. Of course, numbers alone do not say much. What is most important is the type and quality of work these companies will be doing. Nonetheless, greater competition can only raise the

level of product quality, service delivery, and productivity.

A Burgeoning Training Field

The Eighth Five-Year Plan (1990-95) indicated a country-wide, long-term shortage of computer professionals. It is estimated that India will need approximately 40,000 computer professionals annually (200,000 over the five years). With the country turning out some 24,000 computer professionals per year, a short-fall of 80,000 is expected by 1995. These estimates have been widely published in the general press as well as in the trade magazines.

It did not take long for enterprising entrepreneurs to sense the potential profits deriving from a market of this size. These figures, moreover, did not take into account the training needs of computer end-users, that army of private- and public-sector office employees whose work methods are being dramatically altered by the desk-top computer. This too was not lost on the training entrepreneurs.

Thus while established companies in computer training have been experiencing massive growth, store-front "computer schools" have been springing up around the country. Their number is hard to establish, but estimates run as high as 2,000 [Tiwari: 92-99].

Indicative of this growth is the National Institute of Information Technology (which works closely with USAID's Water Resources Management and Training Project). The NIIT began in 1982 and now has 33 training sites. The company intends to triple that number by 1992 [Tandon: 127-131]. Datapro Information Technology, one of the oldest training companies in India (founded in 1976), meanwhile plans on nearly doubling its training centers to 100 by the end of 1991. Lakhotia Computer Centre of Calcutta, a company that says it has trained 10,000 students since 1985, announced it has recently inaugurated four computer training centers in New Delhi and plans to open five more elsewhere by May of this year [Observer Corp. Bureau: 11]. Uptron India Ltd., a newer entry, has 24 franchise centers across the country and is planning to add another 31 within the next six months.

There has been concern expressed from many corners about the quality of instruction offered in this runaway situation [Tiwari]. It has been reported that companies with questionable qualifications are charging exorbitant fees and offering very little in return. Several companies have lured students by making inflated promises of employment at the end of their courses of study. Still others have taken students' tuition fees and have folded, leaving students without both their money and their training.

In response, the Government's Department of Electronics (DoE), the Manufacturers Association of Information Technology (MAIT), and the Computer Society of India (CSI) are all doing their part to impose regulations. The DoE is establishing criteria and procedures for accrediting training organizations. The first national examinations sponsored by the Computer Society of India are to be held in July

1991. And the Manufacturers Association of Information Technology has established a code of ethics. Affiliates conforming to the Code will receive recognition from the Association and will be entitled to display a logo acknowledging their compliance. At present, eight schools have received MAIT recognition, and several others are being evaluated. This situation is a good example of the proper relative roles of the private sector as service provider and the public sector as basic standard setter.

Strong Trade Journalism -- An Honest Industry Evaluator

The strength of India's information-technology press is impressive. Seven commercial monthly computer and informatics magazines have nation-wide circulation, and the first weekly is being market-tested. Both the publications and the journalists I have encountered proved to be highly professional and concerned about the healthy development of India's information technology enterprise.

While much promotional propaganda about India's information technology capabilities fills the general press, and pressure from the Government is put on the industry's participants to respond to short-term goals at the expense of long-term planning, the trade reporters and analysts have been holding up a mirror to the industry for it to manage honest self-evaluation and to think about directions it should be moving in for the longer haul.

Crack Down on Piracy and Creating a Domestic Market

A very encouraging sign is the perceptible turn around on protecting copyrights. Software piracy has been rampant in India from the very first day PCs hit the subcontinent. The National Association of Software and Service Companies (NASSCOM) estimates that as much as 95 per cent of all packaged software in India has been pirated. Until quite recently it has gone unchecked. Piracy of course cheats the foreign software producers, but the ultimate damage has been to the fledgling Indian software industry. While it is by no means the sole cause of an underdeveloped software industry, as long as Indians believe they can meet their primary software needs with pirated materials, the Indian PC software industry will be severely impeded. Worldwide, software to hardware budgetary outlay is in the ratio 7:3 ($7 spent on software for every $3 spent on hardware), while in India this figure is estimated at 4:6 [Telematics Special Correspondent].

What is now encouraging is that the National Association of Software and Service Companies (NASSCOM), the Department of Electronics (DoE), and the Manufacturers' Association for Information Technology (MAIT) have joined to fight software piracy on a national scale through the establishment of the Indian Federation Against Software Theft (INFAST). INFAST's Memorandum of Association states that its primary objective is:

> to organize and render protection to Indian and foreign computer software, programs, software-related documentation and literature, technical references, operational manuals, software source codes, object codes, and locking devices against piracy of all kinds, and to protect and advance the interests of its members and others in India and abroad in copyrights [Deendayal: 11].

INFAST has yet to be put to the test, but it is expecting to take a high-profile role. With the aid of the police, it plans to visit companies, hospitals, hotels and other facilities to unearth and to take action against unauthorized use of copyrighted software.

Another of its stated objectives worthy of mention here is that of promoting software development in India "by creating suitable conditions where software developers can expect a fair deal and are not driven out of business by competition from pirated software" [Deendayal: 11]. In this regard it should be mentioned that, at least from my perspective, India should not try to produce broad, horizontal-market PC products for its home consumption, such as word processors, spread sheets, language compilers and operating systems, since the West has had five to 10 years' head start and multi-million dollar development budgets. But there are many other profitable options. India could look to working with the leading foreign software houses to adapt their products to the Indian market, e.g. producing Microsoft's Word in Hindi. Narrower market products could also be developed, such as diagnostic tools, software utilities and development libraries. Concentration could be on vertical (niche) market applications, especially in such fields as energy industries, environmental monitoring, health care, agriculture, recreation, education, and real-time process control. Of special interest here are applications directed to environmental and natural resource management concerns, which will be discussed in the following sections of this report.

The AI Effort

To really appreciate future possibilities, especially in reference to knowledge-based decision support systems, it is important to survey the Indian information-technology field for work in Artificial Intelligence (AI). This will enable us to assess the availability of indigenous support for possible USAID sponsored projects.

Through the Department of Electronics' sponsorship and funding, and with support from the United Nations Development Program (UNDP), India has engaged in AI research and development since 1981. This effort, known as the Knowledge-Based Computer Systems Development

Program (KBCS), is now in the final year of a five-year development plan (a second five-year plan has already been approved). The Department of Electronics is contributing $5 million for the first five-year phase. The UN is funding a comparable sum for equipment, consultancy and training of people abroad. The goals set for the project were stated as:

> Establishment of nodal centers for R&D in different aspects of KBCS (Knowledge-Based Computer Systems), leading to prototypes that demonstrate impact of technology on economy and quality of life; Development of advanced computing environments for R&D and transfer of technology of products; Identification of potential problems and demonstration of their solutions through KBCS technology; and Development of a non-Von Neumann architecture machine for executing logic programming [Jha: 63].

In accordance with the project plan, seven nodal centers were established. The institutions responsible for the centers and their designated areas of concentration are:

Tata Inst. of Fundamental Research (Bombay)	Speech recognition and natural language understanding
Indian Statistical Inst. (Calcutta)	Pattern recognition and image processing
India Inst. of Science (Bangalore)	Computer architecture
India Inst. of Tech. (Madras)	Expert Systems
Nat. Center for Software Technology (Bombay)	Software engineering, educational applications of AI, natural language understanding, and knowledge representation
Dept. of Electronics: (Delhi)	Expert systems for government decision support applications
Center for Dev. of Advanced Computing (Pune)	Parallel processing architecture, natural language understanding

However, most regrettably and significantly, the latest United Nations evaluation report of the project indicates that to date nothing of practical or commercial merit has emerged from the KBCS venture. In fact, the report states that little of significance in basic research has materialized. As one reviewer of the report summarized it:

> After four years, no flagship demonstrator system has been developed which could have a similar impact as the much-cited railway reservation system [a major non-AI project done by the CMC Corp.], and usher in the era of AI. Even in [the] research area, no major waves have been created by the project in the international community. The initial goal of [the] project aimed at developing solutions to socio-economic and industrial problems is very much a distant dream [Jha: 63].

The reasons cited for the disappointing productivity are familiar -- the aloofness of the laboratory from the practical world and a disinclination of the key figures towards communication and cooperation. In short, little pragmatic, client-oriented commercial development thinking entered the picture:

> . . . the KBCS project has some of the finest young brains of the country working amidst what surely must be one of the most open R&D environments available in India. What has been lacking is the realization that knowledge-based systems cannot be created without participatory contribution of knowledge . . . of the user community. Most projects have been done in academic isolation with marginal exposure to users requirements, and even though for over two years the project teams have been linked over a network, there is little evidence that close co-operative and collaborative networking has been done (there is not a single paper with authors from two centers!) [Jha: 63].

3.2 The GOI Policy Environment -- Intentions vs. Realities

The Government of India has taken admirable measures in setting policies and programs for promoting development of India's information-technologies industry, especially computers and software. But we must consider how well these policies and programs are serving the industry's interests.

In the previous section, several GOI policies, effects of policies, and programs were touched upon. Here we will briefly discuss the pros and cons of some of the more salient of these government measures.

Export Rewards \ Import Barriers and Curbs

Rewarding exports, high tariffs, and curbing imports appear to be sound means of coping with India's critical foreign exchange and balance of payments problems. But viewing matters from the perspective of particular industries, in this case the information technologies industry, we see instead a debilitating burden.

It is not only the policy per se that is harming the industry but especially its form of implementation. As noted in the previous section, tax breaks and customs fees are being waived for companies engaged solely in export. Non-exporting companies, however, are often barred from importing goods and equipment needed for production purposes because the items have been designated as "inessentials" and are not eligible for import licenses. Or at the very least, they require foreign exchange to purchase these goods, and their only means of raising the foreign exchange is by exporting.

The ramifications of these fiscal policies are many and diverse. Probably the most pernicious for the industry is that it militates against rational strategic planning. In order to financially survive in the short-run, Indian information technology developers are moving in directions that they perceive will provide them with a place at today's export trough. This can and often does preclude the healthier approach (for long-term survival and growth) of planning on the basis of a technology's potential and a company's capabilities of becoming a significant player in that technology. Because of this, at present, software development in India is largely without long-term direction.

The hardware branch is just as badly affected. Hardware companies are chasing anything that promises export possibilities without asking where it will be leading them five or 10 years from now. The marketing director of one Bombay-based hardware firm has suggested, for instance, that attention should be given to the production of "low-tech" products, the kind many Taiwanese companies are moving out of, like monochrome monitors, or XT and AT boards [Sarker].

These policies are clearly disincentives to developing strong information technologies for domestic applications. As mentioned above, this approach is probably the only promising way for India to gain a worldwide position in this field. Yet, if a company does attend to the domestic market, or if an institution engages in research and development, it will lack government support, which means having to work with inadequate or outdated development tools and equipment.

At the most basic level, the policies are forcing companies to move in directions that are often against their best interests. This can mean, for example, opting for an export push before the company is ready to do so, or committing to an export level it knows it cannot meet.

Setting Unrealistic Productivity Targets for the Industry

In the previous section, it was brought out that current levels of turnover for the information-technologies industry is nowhere near the targets set by the Government. All indications are that the industry will be even further behind the Government projections by the end of the Eighth Five-Year Plan in 1995.

Setting wildly high targets for the industry -- and they are that -- is dangerous. Strategies based on an unrealistic assessment of the industry will not withstand the test of time. A case in point is the Government's plan to establish 12 Export Software Technology Parks and to invest heavily in high-speed, dedicated satellite telecommunications equipment and services. When software exports fall short of the government projections these investments are based on, resources will likely dry up and leave the companies stranded. Moreover, all sectors of the economy would probably be better served by committing many of these scarce resources to improving the country's totally inadequate telephone system. Thirst for the high stakes seems to obscure the importance of attending to first things first.

From industry's side, trying to live up to impractical export levels creates undue stress. This is the type of situation that invites neglecting quality control, R&D, product field-testing, etc, all critical for long-term sustainable commercial success.

Regulatory Actions: Training Program Accreditation and Protection of Intellectual Property Rights

The cooperation of Government, industry, trade associations, and academic societies to regulate the computer-training industry and to crack down on software piracy, as discussed in Section 3.1 above, has been heartening. If these efforts are effective and sustained, then two major problems for the industry (training quality assurance and intellectual property rights protection) may well be brought under control. Moreover, a modus operandi for co-operation between the Government and industry is being established to tackle other industry-related problems.

The Outlook for the Knowledge-Based Computer Systems Project

For the future of AI in India, the Knowledge-Based Computer Systems Project (KBCS) is undoubtedly the most significant undertaking in the country to date. It is the first major endeavor of its kind in India. Its time-frame and budget are expansive enough to do very serious work in the field. And it has recruited some of the best technical talent available. Unfortunately, as discussed above, the results of Phase I have been exceedingly disappointing.

Despite, or possibly because of, the disappointing practical results of Phase I, plans have been proposed for Phase II that, along with attention to an ambitious research agenda, involve a serious level of activities directed at benefiting the public and especially rural India. Target areas of special interest include

health, education, agriculture, energy, and transportation. The proposed KBCS Phase II plan is the first and only substantive recommendation I have seen for the application of information technology to India's rural and environmental concerns. But given the previous performance, the author of the candid article about the KBCS project quoted above strongly feels that the Phase II plans will also not be realized unless the project is opened up to India's private sector software industry. His wisdom on this point is well taken:

> These [the practical applications] don't necessarily need to be done at the nodal centers. The technology for expert systems is with the software industry. They can create, and more importantly, deliver the goods. All the industry needs is the availability of the experts and the payments for cost of development. The proposal for Phase II is aimed at taking benefits of high-technology to rural areas. In many ways it is a recognition that electronic and computer technologies will be the channels for future socio-economic changes even in the rural areas. It is therefore also a challenge to the industry to take up these socio-economic problems and create innovative [commercially viable] solutions.

This position is a blueprint for action. It prefigures the recommendations that are presented in the coming sections of this report.

4. PERSPECTIVE ON THE DEVELOPMENT AND DEPLOYMENT OF KNOWLEDGE-BASED DECISION SUPPORT SYSTEMS IN ENVIRONMENTAL PROBLEM-SOLVING AREAS IN THE U.S.

4.1 Level of Effort

Knowledge-based decision support systems are a rather recent technology. They emerged from the university computer science laboratories that were researching artificial intelligence (AI) in the late 1970s. As the software tools for applications development became increasingly powerful throughout the 1980s, AI began to show significant results in addressing problems in various scientific, technological, and industrial settings [Feigenbaum, et al: 7-8]. As indicated in the professional literature, knowledge-based systems applications in natural resource management and environmental issues began in the U.S., Canada, and Australia around 1983. The pace has increased ever since.

Nineteen eighty-seven seems to have been especially productive. In that year, a journal called AI Applications in Natural Resource Management was established at the University of Idaho. This publication remains the main vehicle for professional communications in the subject. In their analysis of the literature of expert systems in natural resource management, Davis and Clark point out that in its inaugural year, the articles appearing in the journal constituted some 27 percent of all articles on the topic [Davis and Clark: 3-5]. From 1987 through 1990, the journal published 98 articles covering a wide range of topics. It was also in 1987 that Coulson, Folse, and Loh at Texas A&M published an article in Science describing approaches to the application of AI techniques in natural resource management. Given Science's policy of attending only to ground-breaking scientific areas, this is another indicator that 1987 was the year that AI in natural resource management and environment came of age.

By 1988 there were enough actual projects under way or completed to warrant reports documenting the major activities for other workers in the field. Some 60 applications in environmental issues with emphasis on meteorology were identified in one survey [Moniger and Dyer]. Another publication in the same year cited 39 projects dealing with environmental assessment and management [Gray and Stokoe]. A 1989 survey of primarily agricultural AI projects identified some 76 knowledge-based decision support projects at various stages of completion [Lambert and Wood].

Also in 1989, The American Society of Agricultural Engineers (ASAE) published a monograph entitled Knowledge Engineering in Agriculture that makes an exceptionally strong case to agriculturalists for giving attention to knowledge-based decision support systems technology. As the editors of the monograph state in their preface:

> American agriculture faces continuing problems in the next, and last decade of the 20th century. Agriculture faces [a] serious financial squeeze in addition to traditional problems related to markets, weather and environmental protection, that is not likely to be easily alleviated. This book is dedicated to helping to solve agriculture's ill-structured problems [Barrett and Jones].

Since 1987 the pace of work has grown exponentially. The pay-offs that have already resulted from the use of this technology are getting broad attention. These results, along with the rapid development of AI tools and techniques, are involving increasing numbers of workers.

4.2 Hubs of Activity

Despite the comments of the previous section, we must bear in mind that AI applied environmental areas is still in its infancy. The number of projects and the amount of research and development done so far is limited. Centers of activity and individuals devoted to the subject across the country are easy to identify.

The main centers are universities with Schools of Forestry and Agriculture, and especially those with Departments of Entomology, Crop Management, Animal Husbandry, and Agricultural Engineering.

The next most active sector is the federal government, in particular the Environmental Protection Agency (EPA) and the various branches of the Department of Agriculture's Forest Service and Agricultural Research Service. These agencies have carried out most of their AI-related projects in conjunction with universities.

Few software firms have developed natural resource management, environmental, or agricultural knowledge-based decision support applications. This is despite the fact that the private sector has engineered and marketed most of the AI software development tools.

The companies working in these applications areas have mainly been that particular brand of organization known as the university spin-off -- companies started by professors and/or students, usually located near their university spawning ground, that (contractually) tap the university on a by need basis for high quality talent and other resources.

The following individuals are scientists I have contacted regarding knowledge-based decision support systems for India's environmental and natural resources concerns. They constitute the specialists who could help launch a USAID initiative as proposed in the following sections of this report. They might also help stimulate the formation of university spin-off companies in India.

Frank K. Selker
Systems Analyst

Decision Focus, Inc.
4984 El Camino Real
Los Altos, CA 94022

Selker is a senior associate with a technological services company for decision analysis and the development of decision analysis software tools. The company began in 1977 as a spin-off from Stanford Research Institute (SRI) and Stanford University. Decision Focus, Inc. has a staff of 90 persons from a broad range of professions including engineering, economics, decision analysis, and software engineering. The company's areas of concentration are transportation, electric and gas utilities, communications, and environmental risks. Their clients are from both the public and private sectors.

Dr. Richard Mayer
Industrial Engineer

Knowledge Based Systems Laboratory
Texas A&M

Knowledge Based Systems, Inc.
College Station, TX 77843

Mayer is director of the Knowledge Based Systems Laboratory (KBSL) of Texas A&M and president of Knowledge Based Systems, Inc.(KBSI), a private enterprise not formally affiliated with the university laboratory. As noted above, KBSL works in conjunction with Robert Coulson's KEL operation on various research and contractual projects. KBSL, a research and training facility under Texas A&M's Industrial Engineering Division, has approximately 45 associates from such fields as biosystems, computer science, entomology, industrial engineering, mechanical engineering, linguistics, and philosophy. While KBSL staff do not direct their attention solely to NRM topics, they do address these applications in conjunction with KEL.

The main purpose of KBSI, which was founded in 1988 and which employs some 15 persons, is to translate research results into knowledge-based software products.

Ken Pedersen
Software Engineer

Expertise Associates
3S 204 Sequoia
Glen Ellyn, IL 60521

Pedersen is a software developer who has long been engaged in expert systems. He is known for his lucid and insightful writings on the subject [Pedersen], and teaches at Purdue University. His company, Expertise Associates, engages in AI applications development in a broad range of areas including disposal of hazardous waste materials.

Expertise Associates' PC Expert System Shoot-out is a review service of the leading PC-based expert system shells on the market and is delivered as a periodically updated document and software product. It is particularly interesting for the Indian context. Ken Pedersen has indicated an interest in working with an Indian firm on this endeavor. India offers the possibility of high technical capabilities and cost effectiveness though lower labor rates.

Dr. James Berry
Ecologist

USDA - Agricultural Research Service
Rangeland Insect Laboratory
Bozeman, MT 59717-0001

Berry and his colleagues at the USDA-ARS and the University of Montana have developed Hopper, a knowledge-based decision support system for managing grasshopper infestation in rangelands. He is both a research entomologist and software developer. One of his current activities is exploring neural network capabilities for natural resource management and environmental applications.

Dr. Robert Coulson
Entomologist

Depart. of Entomology
Texas A&M

Knowledge Engineering Laboratory
Texas A&M
College Station, TX 77843

Coulson is director of the Knowledge Engineering Laboratory (KEL) at Texas A&M which is one of the most active centers in the country dealing with computer applications in agriculture and natural resource management. In particular, KEL deals with expert systems for diagnosis, tactical decision support, and simulation delivery; knowledge-based systems and knowledge system environments for environmental and natural resource management; intelligent Geographic Information Systems applied to landscape ecology and management; and object-oriented simulation. KEL has a staff of some 15 persons trained in entomology, geography, biology, industrial engineering, and computer science.

KEL also works in conjunction with Texas A&M's Knowledge Based Systems Laboratory (KBS), headed by Richard Mayer, on contractual projects with agencies such as the Park Service and the Forest Service. For example, under this arrangement KEL and KBS have developed ISPBEX, a knowledge-based decision support system for solving pest-management problems.

Dr. Michael Saunders
Entomologist

Dept. of Entomology
Penn State University

Laboratory for Artificial Intelligence
Applications (LAIA)
Penn State University

Laboratory for Integrated Systems
Analysis (LISA)
Penn State University
University Park, PA 16802

Rules of Thumb, Inc.
Harborcreek, PA 16421

Saunders is the director of the Laboratory for Integrated Systems Analysis (LISA) at Penn State University. This laboratory is engaged in the development of knowledge-based systems in the area of natural resource management, and works with government agencies on a contractual basis. Under this arrangement, LISA has been instrumental in the development of a number of systems supported by the USDA Forest Service Gypsy Moth R&D Program.

Saunders is also on the steering committee of Penn State's Laboratory for Artificial Intelligence Applications (LAIA). LAIA was formed in 1988 as a College of Agriculture resource to promote, facilitate, and train faculty and students in development of AI-based applications. Penn State has undertaken several AI projects in agriculture. Of major importance is the Integrated Pest Management Project. This is developing knowledge-based systems directed to the integrated management of agricultural commodities important in Pennsylvania.

Saunders began his own firm in 1988. Rules of Thumb, Inc. is dedicated to the design and development of custom knowledge-based software for agriculture and natural resource management.

Dr. Vincent Bralts
Hydrologist

Department of Agricultural Engineering
Michigan State University
Lansing, MI 48824

Bralts and his research associates at Michigan State University, have developed Designer, a knowledge-based decision support system for evaluating drip-irrigation system design. Bralts works with Dr. Ted Sammis at New Mexico State University and Dr. Muluneh Yitayew at the University of Arizona, under the aegis of the Agricultural Experiment Stations' Western Regional Research Committee, to develop knowledge-based decision support for drip-irrigation. Sammis is responsible for the filter selection aspect and Yitayew is handling irrigation method selection.

Dr. J. Philip King
Agricultural Engineer

Dept. of Civil, Agricultural and
Geological Engineering
New Mexico State University
Las Cruces, NM 88003-0001

King is both an irrigation specialist and software developer. His doctoral work led to one of the early expert systems applied to agricultural concerns. He is engaged in research, development, and teaching of applications of knowledge-based systems in agriculture and natural resource management with specific attention to irrigation design and management. King and Sammis teach jointly in this area.

Dr. Theodore Sammis
Hydrologist

Dept. of Agronomy and Horticulture
New Mexico State University
Las Cruces, NM 88003-0001

As noted above, Sammis works with Vincent Bralts at Michigan State University and Muluneh Yitayew at the University of Arizona, under the aegis of Agricultural Experiment Stations Western Regional Research Committee, to develop knowledge-based decision support for drip-irrigation systems. Sammis and King jointly teach computer methods in agriculture at their university.

Dr. Thomas Rathburn
MIS Specialist

Graduate School of Management
Kent State University
Kent, Ohio 44242-0001

In 1988 Rathburn organized an informal resource network of AI researchers and practitioners from the U.S. and Canada interested in the application of the technology in developing countries. The network, known as AI/DC (AI in Developing Countries), was formed to serve as "a central coordinating facility for the dissemination of information, coordination of research interests, and location of individuals possessing specialized expertise at the request of [developing country] companies, agencies, and governments" [Rathburn]. In 1989, AI/DC sponsored a session at the International Joint Conference on Artificial Intelligence (IJCAI) with 41 participants, including four from India [AI/DC Coordinating Committee].

4.3 Looking for Partners

One of the most gratifying aspects of this USAID assignment has been the enthusiasm I encountered from every American and Indian I spoke with regarding the prospects for the development of applications of knowledge-based decision support systems for environmental and natural resource management problems in India.

Their eagerness springs from the commercial potential they see in this area, the intellectual and technical challenges, and the fact that the efforts will be directed toward a social good.

The Americans, moreover, welcome the opportunity to work in India because of their interest in that country's culture. Significantly, all of the Americans I mention here either have Indians on their staff or count them among their colleagues. They greatly appreciate the caliber of these Indian colleagues, and in many instances their relationships have heightened their interest in the prospect of work in India.

Their Indian counterparts, many of whom have either studied or worked in the U.S. or have worked with Americans in India, meanwhile are eager to gain access to the state-of-the-art skills, technologies, and tools these projects entail. In many instances they too have described the warm working relations they have had with Americans.

5. BASIC CONSIDERATIONS FOR ESTABLISHING DIRECTIONS IN KNOWLEDGE-BASED DECISION SUPPORT SYSTEMS FOR INDIA'S ENVIRONMENTAL SECTORS

In this section, I will briefly present a number of factors fundamental to initiating work in knowledge-based decision support systems for India's environmental sectors.

The foregoing sections of this report suggest the following principles as the basis of the present discussion:

1) The interest in environment related knowledge-based decision support systems is predicated on the potential this technology holds for effectively addressing problems in these areas.

2) The application of this computer technology has significant commercial potential both for the developers and the users.

3) To date, there has been virtually no significant effort in employing computer technology in the service of India's rural sector. USAID's support for a concerted effort in environment related knowledge-based decision support systems for the rural as well as industrial areas would be a significant step in improving that situation.

4) There are several unexplored areas of software development to be addressed, and these will require preparatory study and close observation. Moreover, the first projects must prove themselves or the opportunity for future projects will be lost. This effort, therefore, requires a long-term commitment if it is to be effective.

5) As a result of this effort, the Indian software industry could be positively affected by serving its home markets in a significant way. Moreover, it is an opportunity for the industry to create a niche that could have far-reaching consequences for its future.

6) Whenever possible, non-governmental sectors should be targeted for project execution, with emphasis given to joint U.S.-Indian ventures.

5.1 Information Access

It is difficult anywhere in the world to keep up with the rapidly moving computer field and to be in touch with the key people when they are needed. In India, distant as it is from the mainstream, these things are especially hard. India suffers greatly from information anemia in science. The AI area is no exception.

To help remedy this situation, a productive starting point for all informatics activities in India would be an information resource center for making accessible timely information and for facilitating communication with colleagues abroad. It would serve the information needs of all persons working in AI in India, with special attention to the environment.

The center's main function would be to supply information on request. Any individual, private concern, or academic/research institute could call on the center for information. The resource center would respond as rapidly as possible, primarily by mail.

Staffing of the center would consist of two full-time persons knowledgeable in software development, a full-time secretary/ administrative assistant, and possibly two university students in information studies or computer sciences as interns. The information resource center would build a sophisticated library of books, journals, software and CD ROM databases, and be equipped to do literature searches and to contact experts in the field.

In seven presentations around the country that I made during my recent visit in India, some 48 percent of the persons attending (83 out of 173) indicated interest in being part of an AI network operating along the lines of the information resource center as described here.

The center would be greatly strengthened by simultaneously establishing a comparable center in the U.S. The U.S. center would be responsible for keeping abreast of the field from up close, establishing a network of specialists, and funnelling information and names of experts to the resource center in India.

The U.S. center could also operate effectively with a slightly reduced staffing pattern from that in India (one full-time resource person plus a full-time secretary/administrative assistant as well as one university intern). Thomas Rathburn (see Section 4.2 above) has already taken some steps in this direction with his AI network for developing countries. His experiences could be built upon.

5.2 Model Projects

There appears to be no shortage of valuable and manageable knowledge-based decision support systems for resource management and the environment that could serve as USAID-facilitated model projects.

In the informal needs-assessment that I carried out at my presentations at various facilities around India, the participants, who represented a wide range of disciplines, made several excellent recommendations. Here are topics of special note that were identified:

Environment:

1. Erosion and flood hazard evaluations
2. Environmental impact assessment
3. Landslide prognosis
4. Desertification monitoring and control
5. Integrated drought management
6. Wildlife population estimates in protected areas

Agronomy:

1. Crop selection
2. Crop-pattern planning
3. Crop-yield forecasting
4. Pest management
5. Fertilizer application

Water management and hydrology:

1. Irrigation scheduling
2. Drip-irrigation design
3. Reservoir operations

Forestry:

1. Forest-fire prevention and control
2. Selection of nitrogen-fixing trees for afforestation
3. Afforestation management

It is important to note that my trip from which I attained these recommendations was carried out under USAID's aegis and had natural resource management as its principal focus. I am certain that if a similar survey were conducted with an eye to a broader environmental agenda, e.g. energy management, hazardous waste material disposal, air and water pollution, that many additional and just as fruitful possibilities would rapidly be identified.

5.3 Marketable Products

The intent of the proposed project effort would be to develop applications that are fully developed and commercially viable for the environmental marketplace. The models developed would demonstrate their practicality and robustness for solving problems, and not simply be laboratory studies. This means that they must be designed, tested and demonstrated in field conditions to their potential client populations. The results must be actual and convincing. While the focus of this report has been on the software side of knowledge-based systems, there are some very real possibilities that turn-key products that include hardware design, development, and production may be needed as well.

Since these systems are principally targeted for harsh environments, their eventual success will be determined partly by the reliability of the hardware under extreme conditions. The uses to which these systems will be put and the users for whom they are destined will demand creative hardware solutions.

This in itself could be an attractive direction for responsive Indian computer companies. Increasing numbers of computer applications are appearing on the market for agriculture, forestry, environment monitoring, etc., which often take place in punishing environments. This means a growing demand for hardware that can operate under such conditions. And as developing countries opt for this technology, machines with distinct design requirements may also be called for.

This is an area where U.S.-Indian joint ventures could make their mark, much as U.S. firms like Grid have by building computers for military combat use. It is also instructive that manufacturers entering the booming lap-top computer market these days are attending to structural and functional improvements [Nussbaum]. Instead of moving into the low-status, low-tech niches the Taiwanese are abandoning, (see Section 3.2 above), Indian hardware firms could gain international recognition and respect by developing rugged field computers. It is probably not an exaggeration to say, "if it works well in India, it would probably stand up to any environment."

5.4 Product Development/Delivery Methodologies and Strategies

Knowledge-based decision support systems are a relatively new field, especially as applied to environment and resource management. Their applications for developing countries are virtually untouched territory. It is therefore of utmost importance that the development and delivery of this technology to India be approached with an openness to experimentation and adaptation. Many of the basic assumptions and methodologies of the field, as practiced in the West, must be scrutinized, and modified where necessary. This, of course, is where both the promise and the risks of this undertaking lie.

Here are the key components of any project of this kind that will require special attention:

Feasibility studies

It is assumed that the software development to be undertaken are to offer economic and environmental rewards that justify their development and make them commercially viable. Feasibility studies are generally done for software projects with sizeable price tags. But the analysis that applies to more traditional projects will probably not apply to the projects at hand.

The cost of the project must be estimated, but inherent in such an assessment must be the costs of untried methods. Beyond this, the more intractable part of the task is evaluating the gains in using the decision-support system. Planners, for example, must weigh the value of a timely decision over an untimely decision. Or assuming the system enables an "improved" decision (however decisions can be qualified), planners must consider the value of the improved decision vis-a-vis such factors as operational costs or resources saved.

A good starting point will be the approaches used in the software industry in the West. Technology services from the U.S., therefore, will have a part to play here, but again, this is strictly a starting point. Lots of trail-blazing will necessarily follow.

Market Analysis

Those doing basic research seldom if ever ask who might want a product that may result from the laboratory. But for pragmatic R&D, which is what we are dealing with here, the first questions that must be answered, even before a feasibility study is attempted, are a) what will it solve?, b) who needs or can use such a solution?, and c) how much is the market willing to pay for it?

Market analysis has rarely if ever been applied to technological innovations in developing countries. Conducting market analysis in this setting for knowledge-based decision support systems will tax the imagination. A multi-disciplinary, American and Indian team will have to be assembled to do the job.

Knowledge-Based Software Development

With knowledge-based decision support systems still in their infancy, there will be ample opportunity to further this field through model projects. The best of what the U.S. has to offer -- through technology services -- could be coupled with competent and energetic Indian professionals to produce high quality software solutions.

By adopting the cooperative effort proposed here between U.S. and Indian workers, and by honing its skills on its home markets, India can move into a leadership position in this area of software development, especially as it relates to the requirements of developing countries.

For this effort to achieve world-class status, it obviously must be working at the state-of-the-art level. There must be a strong component devoted to keeping up with the techniques and technologies emerging from the laboratories (via the proposed information resource center) and to integrating and applying them in field-tested applications. That is, a strong and pragmatic R&D arm is needed as well.

The current strides in software are coming from hybrid systems, the integration of such techniques and technologies as expert systems, conventional computing, database management, simulation and modeling, linear programming, digitized overlay maps (GIS), and real-time process control.

Integrated systems must be the starting point for the model project effort. However, the newer technologies that are starting to show promise also must be attended to. Especially important are neural nets, fuzzy systems, and genetic algorithms.

Client-Centered Software Design

The intervention of new technology has penetrating effects on the social and organizational structure of the workplace. This is especially true regarding the computer and its allied devices. The changes can be a) beneficial to getting things done and to the quality of life of the workers, b) deleterious and degrading to either one or both, or c) voided because the technology is resisted and ultimately discarded. Its impact depends largely on system design and implementation.

Unfortunately, we in the U.S. have not paid proper attention to this crucial matter. In this area we must take our lead from the Scandinavians who have been especially sensitive to the relationships between technical and human systems.

The main principle of this school of thought is perhaps best summarized in the adage, "Design should be done with users, neither for nor by them" [Ehn and Kyng: 54]. I call this approach client-centered design and implementation.

In expounding on the contributions of the Scandinavian designers, Lucy Suchman of the Xerox Palo Alto Research Center, argues that this perspective leads to

> a radical change in the way we view the knowledge and skill that go into system design; namely that we view those prospective users of the technology as central and that we incorporate into the design process as sophisticated an understanding of the social world as of the technology involved. Such a change could be achieved by having social theory and methods be a serious rather than extracurricular part of the discipline of software engineering or, more realistically perhaps, through collaborations between social scientists and designers. The interactions of designers with social scientists and of both with users must then be a process of mutual education . . . [Suchman: 177].

This approach, I am suggesting, should be the modus operandi of model projects' design and implementation activities.

Product Marketing

A persistent myth says the best product wins. Another myth says that a good product sells itself. If these myths were true, it is unlikely that the high-tech industry in the West would be spending three dollars on marketing for every one dollar devoted to product development.

Product marketing and technology transfer to developing countries are generally not mentioned in the same breath. But for this project, the marketing component is as important as any other. The goal of the marketing effort in this case is to bring this technology to the attention of its potential client populations, to demonstrate the gains it has to offer, to explain how and where to acquire the technology, and to be responsive to inquiries for further information. This is comparable to what in the U.S. is called pre-sale customer support.

As with market analysis (discussed above), product marketing is a well-developed enterprise in the West. But there is little possibility that the techniques and strategies employed there can be transferred intact over such vast cultural, social, and technological distances. Here too we are in virgin territory, where the approaches employed in the West at best may be interesting points of departure. Once again the lessons that will be learned in the model projects will serve as guideposts for future efforts.

Implementation and Training

Implementation has already been mentioned in conjunction with system design. Another facet of implementation concerns introducing and integrating the system into the workplace, and training the users to work with the system and to comprehend its capacities and its limitations.

All of the components of a system development project proposal are important. But if I were pressed to identify the one that should receive much more concerted attention than usual, it would be implementation and training.

Somebody may build the most effective and reliable knowledge-based decision support system on earth to alleviate a major problem; it may be designed with an excellent user interface and be so well-positioned and marketed that clients line up to purchase it; but if it isn't properly introduced and integrated into the workplace, and if the requisite skills of its users are not brought up to speed, it will rapidly fall into disuse. This is happening today in the U.S. with excellent systems, because implementation has not been given the attention that it demands. Implementation and training are service components that should be part of any system development or business plan.

Project Documentation and Evaluation

It is assumed that any early system will be improved with each successive undertaking. But this can happen only if each aspect of a project effort is well documented and the methodologies that are developed and employed are systematically evaluated. Documentation is all too often either forgotten or carried out too late. This especially must not be the case with model projects. Documentation and evaluation strategies must be initiated right from start-up.

5.5 Working Relationships between Joint-Venture Participants

It is hoped that any USAID supported project will produce lasting commercial relationships among the participants in joint-ventures (U.S.-Indian; Indian-Indian; U.S.-U.S. partners) so that the experience gained with the model projects will be carried forward. This, however, is a big order especially when cultural differences and geographical distances are added to the usual constellation of problems that face business partnerships.

Clearly, the business aspect of the effort requires as much attention as the technical matters discussed above. USAID can play a key role in this respect by creating an advisory board of Americans and Indians from the private sector who have first-hand experience in U.S.-Indian commercial ventures. At present, there are some very successful U.S.-Indian high-tech ventures. Representatives from these firms could undoubtedly offer valuable guidance to this undertaking.

6. IMPLEMENTATION STRATEGIES FOR USAID'S PARTICIPATION IN THE DEVELOPMENT AND DEPLOYMENT OF KNOWLEDGE-BASED DECISION SUPPORT SYSTEMS FOR INDIA'S ENVIRONMENTAL SECTORS

Section 4 identified some of the U.S. experts available to work with their Indian counterparts on significant knowledge-based decision support systems development in India. Section 5 dealt with issues that must be addressed when mounting a knowledge-based software development effort. In the present section, we look at implementation strategies.

The strategies discussed here are more in the nature of paradigms than detailed plans. It will be readily seen that the following approaches move from minimum to maximum endeavor:

6.1 Information and Network Facilitator

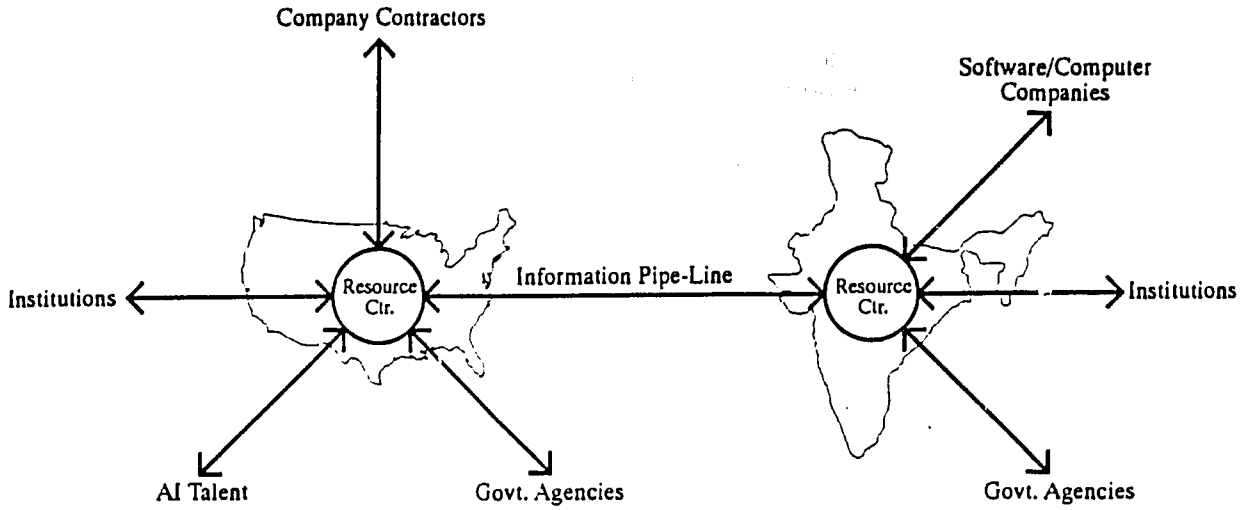
USAID can make a valuable contribution to AI work in India with emphasis on environmental areas by implementing the information resource center and U.S. pipeline, as discussed in Section 5.1. This activity would significantly improve the information flow into India and help facilitate networks between U.S. and Indian workers and companies.

The resource center would play a supportive role to persons and institutions throughout India working in the AI field. Because of the importance of strengthening connectivity between the players (persons and institutions alike), an affiliation of the resource center to any one institution, Indian Government agency, or private company would have to be such that it would not compromise its capability to respond to all in need of its services. Because of this requirement, it might have to function as a non-affiliated facility with an operational budget supported by membership dues.

This activity can be started immediately and can be maintained with a relatively low operating budget. Its value to the Indian AI community can be easily evaluated by its user-frequency records and by the number of U.S.-Indian activities it helps establish.

Time-Frame: Fully operational in U.S. and India -- 6 to 8 months.

Planning Phase -- 3 to 4 months
Implementation Phase -- 3 to 4 months



INFORMATION AND NETWORK FACILTATOR

6.2 Joint-Venture Private Enterprises

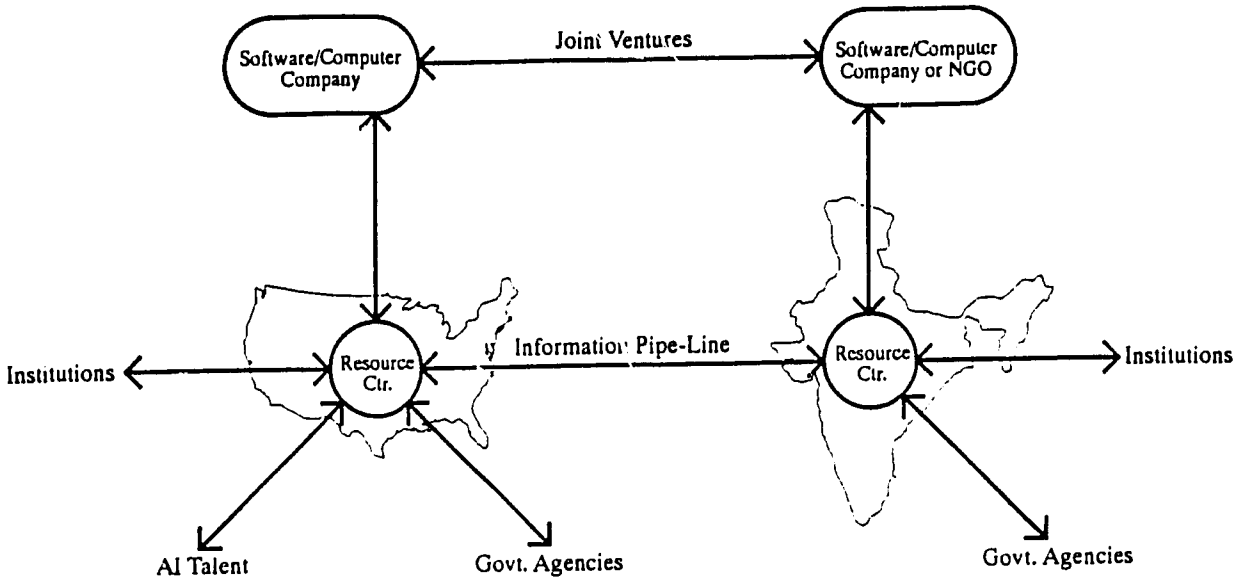
This strategy calls for the information resource centers to continue operating in their facilitating role as described in Section 6.1, but also to become instrumental in establishing joint ventures between private U.S. and Indian companies or NGOs. This would undoubtedly require a slight enlargement of staff for the center in India and possibly at the U.S. center.

The Americans and Indians with whom I have discussed these matters have told me repeatedly that they have strong interests in U.S.-Indian projects, but do not know how to search out appropriate partners, to find develop funding, and to get something under way. These are precisely the issues the information resource centers would deal with.

Time-Frame: Fully operational in U.S. and India -- 10 to 16 months

Planning Phase	-- 3 to 4 months
Implementation Phase	-- 3 to 4 months
Project Initiation Phase	-- 4 to 8 months

NOTE: Fully operational here means that the first prospective project has been identified, a contract has been negotiated between the joint-venture companies, and the project is ready to be launched. The planning and implementation phases are the same as that for the strategy discussed in Section 6.1.



PRIVATE ENTERPRISE JOINT-VENTURES

6.3 Institutional Spin-offs

Suresh Mather, secretary of India's Department of Industrial Development and Company Affairs, recently noted that in the Indian economy there has been "the near absence of any progress of laboratory-business, joint efforts in developing indigenous research and development, [and] technology absorption and adoption ..." [The Business & Political Observer: 9]

In essence, Mather is saying that the "spin-off phenomenon," (referred to in Section 4), which has proved so effective in the U.S. for launching high-tech accomplishments and successful technology enterprises, has not emerged in India to any extent. Why this so is debatable. What is important is that spinning off is a promising organizational strategy -- especially with the technology discussed in this report -- and deserves to be tested in the Indian context.

A successful spin-off strategy requires that: a) the commercial company formed from the parent academic or research institution remains associated with the institution; b) the institution in turn remains available to assist the company without smothering or controlling it in the process; and c) the institution and staff that work with the company must welcome the opportunity for their expertise and facilities to be enlisted for something other than pure science.

These characteristics all point to proper selection of the institution as being paramount to the success of the undertaking. In most instances in the U.S., it is a small cadre of staff or students from an academic or research institution who initiates the venture. In such cases, it is a matter of institutional self-selection. The approach suggested here, however, is different:

USAID would identify institutions that it feels have the right ingredients for generating viable spin-off operations, and then try to help get them going.

In my brief exposure to a cross-section of India's academic and research institutions, I found two in particular that have the essential qualities for supporting spin-off enterprises.

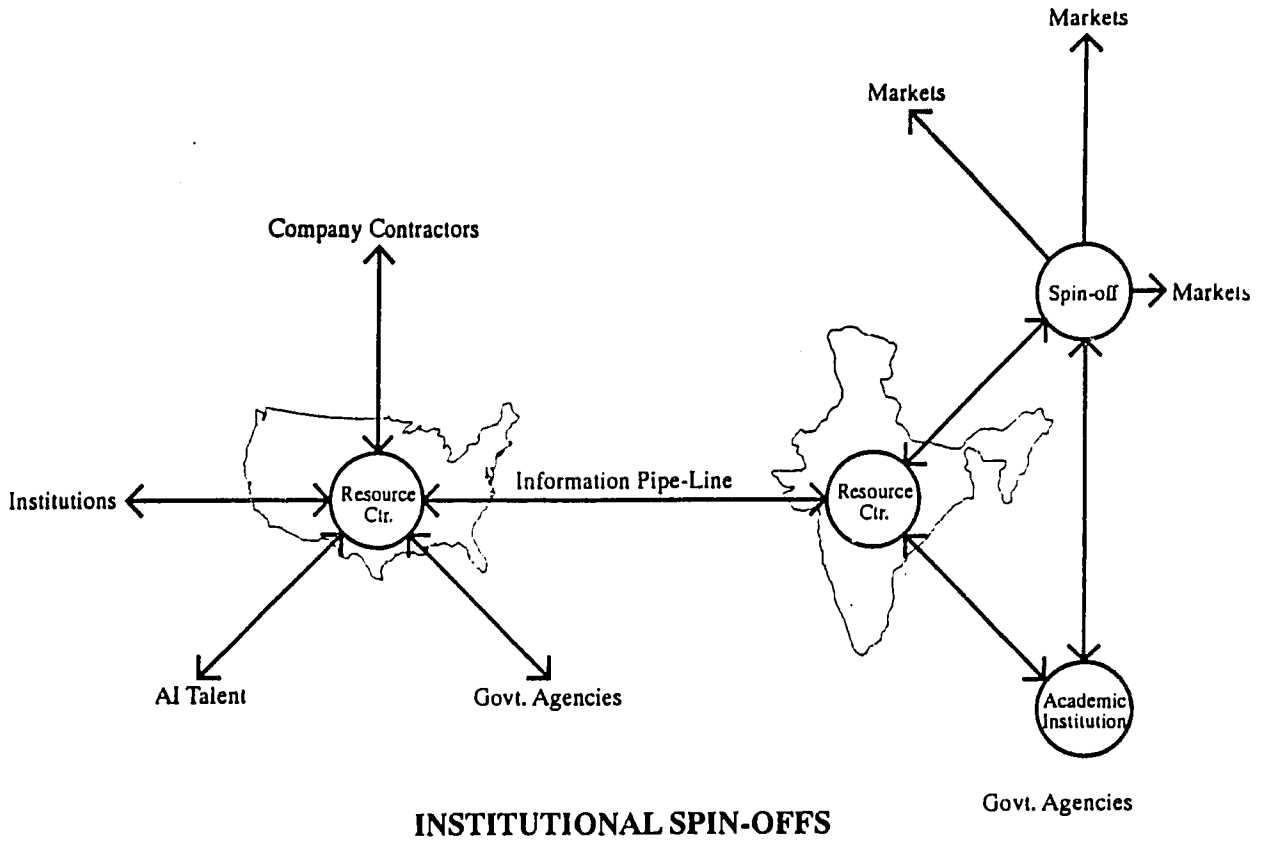
The India Institute of Management (IIM) in Ahmedabad is a dynamic place with an open and imaginative climate. It has a strong interest in AI, commands an impressive computer center with in-house software developers, and works in forestry and agriculture.

The Forest Research Institute (FRI) at Peechi, Kerala, is much smaller than IIM(A), and does not enjoy the same degree of national recognition. But FRI has an energetic, highly qualified multi-disciplinary team of researchers which, for all their geographical remoteness, keeps very much on top of what is happening in their diverse fields. Further, the team members take every opportunity to make the computer central to their work, and are particularly motivated to experimenting with new possibilities for its use.

The exact division of labor between the academic or research institution and the spin-off company is, of course, something that must be decided during the planning of the undertaking. It has a lot to do with the strengths of the institution and the amount of financial backing of the spin-off. In general, however, it can be assumed that the spin-off will be responsible for the execution of the various software development tasks, including marketing, implementation, and training, while the institution provides methodology development in some or all of these areas. The information resource center and U.S. pipeline meanwhile will assist both the institution and the spin-off (see figure below).

Time-Frame: Fully operational in U.S. and India -- 19 to 26 months.

Planning Phase	-- 6 to 8 months
Implementation Phase	-- 7 to 9 months
Project Initiation Phase	-- 6 to 9 months



INSTITUTIONAL SPIN-OFFS

6.4 Institute for Knowledge-based Decision Support Systems

The institute for knowledge-based decision support systems is by far the most ambitious of the four strategies presented here. At the same time, it offers the most promise given its emphasis on comprehensive and sustained effort.

Working closely with its U.S. consultants, this institute would operate as a kind of super-R&D facility. It would be responsible for keeping abreast of, implementing, and furthering all the development and delivery methodologies as discussed in this report (namely, feasibility studies, market analysis, knowledge-based software development methodologies, software design, product marketing methodologies, implementation and training methodologies, project documentation, and evaluation). The institute would do this by either initiating projects from start (conceptualization, feasibility study, market analysis) to finish (implementation and user training) or by assisting private companies and NGOs with the development and/or implementation of their commercial products.

The institute would be available as a national resource to any academic or research institution in the country, as well as commercial enterprises seeking technical support.

In all instances where a commercial product is the intended goal -- this would be the case except for when academic or research institutions seek assistance for non-commercial purposes -- the institute would arrange for private companies or NGOs to produce, maintain, and market the software products that are developed or facilitated under its aegis.

The institute's organizational structure would be kept flat for efficient, and cost effective operation (see figure below). It would be comprised of small, two to three person semi-autonomous departments, each of which represents one of the institute's domain areas of interest (feasibility studies, software design, etc.). The departments would be tethered by a small administrative staff. The institute's director would work closely with the professional staff and a U.S.-Indian joint-venture advisory board to steer the course of the institute and be responsible for its on-going operations.

The structure would be somewhat reminiscent of the U.S. medical school model with its departments of pediatrics, internal medicine, psychiatry, etc. sharing resources, interacting in areas of common interest, and coming under the tutelage of a central administration. This analogy cannot be taken too far, however, inasmuch as the institute would have stronger inter-departmental bonding brought about by the departments' involvement in common software development projects.

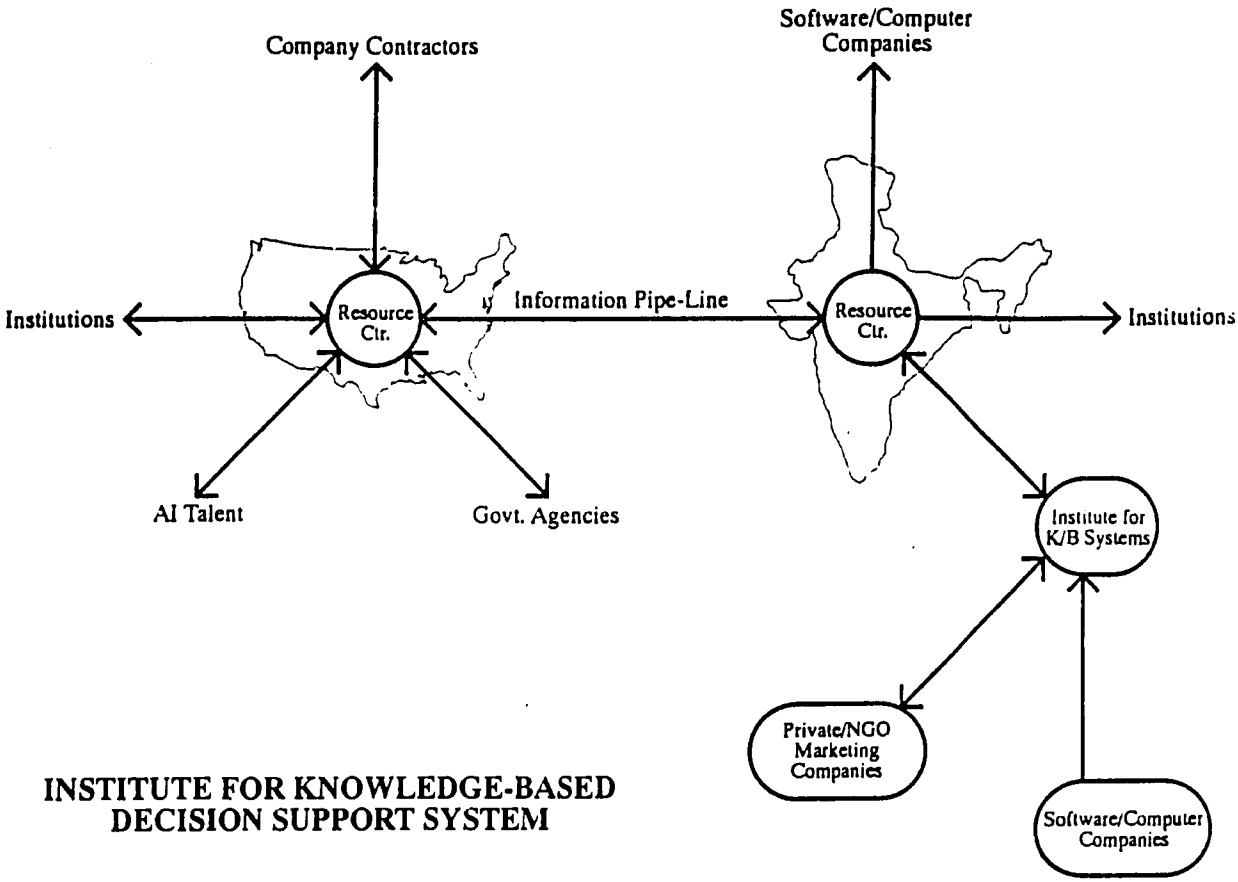
Following the sound advice of not putting all one's eggs in a single basket, the institute would, undoubtedly, benefit by building its financial base from various sources. The most obvious of these are USAID, the GOI, membership fees from participating institutions, royalties or profit sharing from commercial products that are nurtured by and/or developed at the institute, and consulting fees.

The Institute for Knowledge-based Decision Support Systems, as I have briefly presented it here, can productively borrow a number of organizational, financial, and conceptual aspects from various institutes, past and present, in the U.S. -- besides from the generic U.S. medical school model just mentioned. Xerox PARC, Ohio State University's Center for the Commercial Development of Space, and SRI (Stanford Research Institute) have much to offer in this regard.

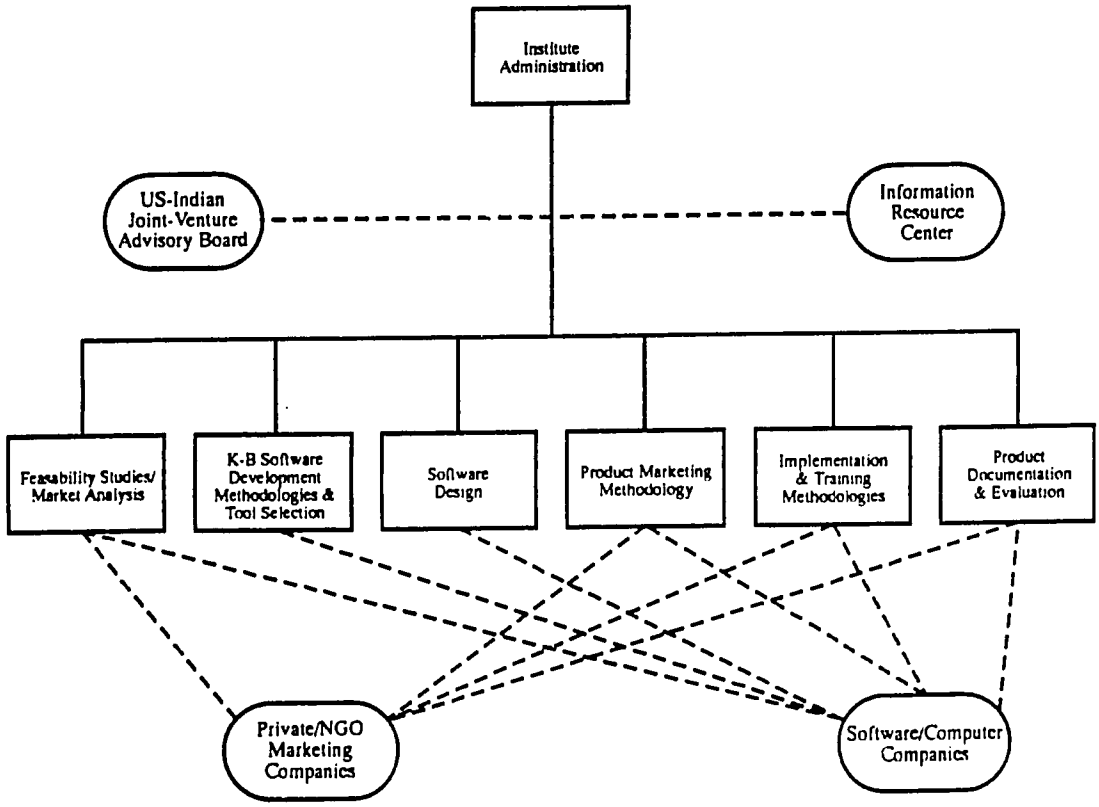
As with all of the proceding strategies, the information resource center and U.S. pipeline would be very much part of the institute's infrastructure.

Time-Frame: Fully operational in U.S. and India -- 24 to 32 months.

Planning Phase	-- 9 to 12 months
Implementation Phase	-- 9 to 12 months
Project Initiation Phase	-- 6 to 8 months



INSTITUTE FOR KNOWLEDGE-BASED DECISION SUPPORT SYSTEM



INSTITUTE FOR K-B SYSTEMS ORGANIZATIONAL STRUCTURE

The above four strategies are initial recommendations for ways of productively developing and deploying knowledge-based decision support systems in the service of some of India's serious environmental concerns. Given the talent -- both in India and the U.S. -- willing (more accurately, enthusiastic) and able to jointly engage in this enterprise along with the current level of AI technology, the opportunities are waiting to be seized. USAID can be the catalyst of this worthwhile endeavor if it is ready to recognize the opportunities and take the initiative to invest in them.

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APPENDIXES

APPENDIX I

Itinerary of Presentations and Discussions

Each of the Events noted below was a presentation of a talk entitled, Getting Started with Expert Systems in Natural Resource Management, Agriculture, and Environmental Concerns. At each of the venues, the talk was followed by informal discussions with interested participants.

Date	Location	Institute / Participants
March 7, 1991	New Delhi	Louis Berger Intl. Inc. Water & Power Consultancy Services (India) Ltd.
March 11	Madras -- Anna University	WRM&T Project Training Program
March 12	Madras -- Anna University	Institute of Remote Sensing; Gandhigram Rural Institute
March 12	Madras -- Indian Institute of Technology	Indian Institute of Technology
March 13	Peechi -- Kerala Forest Research Institute	Kerala Forest Research Inst.; Calicut Water Management Inst.
March 14	Bombay -- India Institute of Technology	Centre for Studies in Resource Engineering; National Centre for Software Technology; Tata Institute of Fundamental Research
March 15	Ahmedabad -- Indian Institute of Management	Indian Institute of Management; State Forestry Dept.; Centre for Environmental Education
March 18	Okhla	WALMI
March 21	Solan -- Y.S. Parmar University	Y.S. Parmar University of Forestry & Agriculture
April 7	New Delhi	TATA Energy Institute

The events noted below constituted brief presentations and discussions the subjects of which are noted.

Date	Location	Presentation Subject
March 19	New Delhi -- Central Water Commission	Some current U.S. Expert System Applications for environmental management problems
April 5	New Delhi -- USAID	Prospects for Indo-U.S. activities in knowledge-based decision support systems for environmental applications -- Summary Report

The events noted below were exploratory discussions with companies in the Indian private sector.

Date	Location	Company & Contact Person
March 26, 1991	New Delhi	Mr. Ashish Basu, Div. Manager Instructional R&D NIIT National Institute of Information Technology
March 27	New Delhi	Mr. Sudip Sarcar, Marketing Rep. Informatics Infotel Online Service Centre Bangla Sahib Road New Delhi 110 001
March 27	New Delhi	Dr. Sharad Singhal, Director Eclipse Systems Pvt. Ltd. 24 Community Centre East of Kailash New Delhi 110 065
March 28 (Phone conversation)	New Delhi	Mr. Probhat Roy, Staff Writer Telematics India (Magazine) Vimot Publishers Pvt. Ltd.
April 5 (Phone conversation)	New Delhi	Mr. Adul Dev, Chief of Bureau and Resident Director Business Computer (Magazine) Sterling Newpapers Pvt. Ltd.
April 9 (Phone conversation)	Bombay	Mr. Sanjaya Saxena, Director TATA Divergent Technologies

APPENDIX II

Knowledge-based Decision Support System Demos

DEMO Program	Developer	Program Task
CALEX/Cotton	Statewide IPM Project IPM Implementation Group University of California Davis, CA 95616 (916) 752-8350	Manages Cotton Crop
Designer	Dr. Vince Bralts Department of Agricultural Engineering Michigan State University East Lansing, MI 48824	Evaluates Drip Irrigation System Design
Filter	Dr. Ted Sammis Department of Agronomy & Horticulture New Mexico State University Las Cruces, NM 88003-0003	Recommends Preferred Filter Selection for Drip Irrigation
GYPSES	Max McFadden, Program Mgr. Mark Twery, Coordinator Gypsy Moth Research Project USDA Forrest Service 180 Canfield Street Morgantown, WV 26505 (304) 291-4613	Recommends Optimum Treatment for Gypsy Moth Infestation
HOPPER	Drs. James Berry, Wm. Kemp & Jerome Onsager USDA Agricultural Research Service Rangeland Insect Laboratory Bozeman, MT 59717- 0001 (406) 994-3051	Recommends Optimum Treatment for Range land Grasshopper Infestation
PC Expert-System Shoot-out	Ken Pedersen, President Expertise Associates 3S 204 Sequoia Glen Ellyn, IL 60521 (312) 858-9614	Assists Evaluation of Expert-System Shell for Project Development

DEMO Program	Developer	Program Task
QuickTanks	Frank Selker, Sys. Analyst Decision Focus, Inc. 4984 El Camino Real Los Altos, CA 94022 (412) 960-3450	Recommends Optimum Replacement/Repair Options for Underground Tanks
Statistical Navigator	The Idea Works, Inc. 100 West Briarwood Columbia, MO 65202 445-4554	Recommends Preferred Statistical Methods for Projects (314) Requiring Statistical Analysis