Kerala Connections: Will the Internet Affect Science in Developing Areas?*

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Abstract

Three general arguments on the role of the Internet in developing areas have been suggested. The "elixir" argument holds that the Internet does not represent a potential problem but only an opportunity. Information technologies are a developmental tool on a par with educational and agricultural programs. The "affliction" argument holds that Internet diffusion is an engine of global inequality, an insidious form of dependency creating new technology gaps between rich and poor, professionals and laborers, urban and rural dwellers, English and non-English speakers. The third argument holds that there are temporary "teething troubles" that may arise from telecommunications infrastructure or cultural differences that will soon diminish. We describe a project to examine the rapid introduction of the Internet in the south Indian State of Kerala. The "Kerala Model" is unique in the developing world owing to its combination of high social development with low economic development. Using qualitative data from interviews with scientists in universities and governmental research institutes, we examine early views of the Internet in an advanced developing area.

Introduction

Internet technology is a crucial aspect of scientific work. The problems and opportunities afforded by new information and communication technologies were first experienced in the developed world, the US in particular (Abbate 1999). **Modern Internet technology has its origins in the development of means for more efficient scientific communication and holds greater promise of integrating the global research community than any previous technology.** Computer mediated communication is a two way flow that aids scientific researchers by providing (1) access to colleagues, information, and databases for research, and (2) opportunities for sharing findings with the scientific community.

Yet at the turn of the millenium, the Digital Divide is nowhere more evident than in science itself. **Scientists, as part of the professional elite in developing areas, have been projected as early and extensive users of Internet technology, just as in Western countries. Yet many scientists in the developing world may be falling behind, without the basic connectivity—and certainly without the bandwidth—that are taken for granted in the developed countries.** For example, during the course of our project, we came across one research station in western Kenya without a phone connection, in which the only way to make contact with the Director of the station was to call the District Prison located two kilometers away, and request delivery of a message.

In this essay, we explore the early introduction of the Internet among scientists in universities and governmental research institutes in the south Indian state of Kerala. First, we examine the idea of "isolation" of scientists in developing countries. Next we review the basic perspectives on the role of information and communication technologies (ICTs) in development,

and note the lack of empirical research on the role of ICTs in science in developing areas. Next, the social context of Kerala is described. We then present first results from an ongoing exploration of the opportunities and constraints posed by this new technology for science in developing areas. These results are organized in terms of three general perspectives on the role of the Internet in development: as an "elixir," as an "affliction," and as a technology with potential but subject to "teething troubles." While it is too early to declare clear support for any one of these perspectives, this essay is offerred as a "status report" on the introduction of the Internet in an advanced developing area characterized by a high commitment to education and literacy.

Science in Developing Countries

For decades scientists in developing countries have been viewed as "isolated," a state of affairs with both informational and interpersonal dimensions. While conditions have changed since the colonial era, descriptions of the situation in the mid 1960s remains relevant today (Dedijer 1963; Salam 1966). It was obvious to any observer then that access to current scientific information was seriously limited. Articles in scientific journals, books, newsletters, preprints, and manuscripts of current but unpublished work are essential sources of information for active researchers. In developing areas, acquisition costs are prohibitive and scientists are limited by inadequate libraries and documentation centers. Hence, critical deficits were and are faced by knowledge workers in the South in the availability, cost, and timeliness of informational resources.

The second dimension of isolation is interpersonal, involving barriers to contact with active research communities in the West. Access to information is not merely through journals,

but can occur through communication with colleagues, whether by mail, telephone, or face-to-face meetings. Less developed areas have smaller research communities, and these few scientists are often dispersed over long distances. When separated geographically, scientists are unable to maintain regular communication with others in their field, nor can they benefit from the intellectual stimulation that accompanies contact. Isolation was said to exist locally as well as internationally. Owing to infrastructural problems with transportation and communication technologies, it was difficult for reseachers to communicate with regularity and efficiency even with those in their own city or region. The central assumption is that unless scientists can interact frequently with others in the field, they will remain peripheral to the research community and out of touch with developments in their field.

Although some of these characterizations may well be true, evidence based on empirical studies of scientists in developing areas is extremely limited. Jacques Gaillard (1991) surveyed 489 scientists who received grants from the International Foundation for Science between 1974 and 1984. Gaillard found that scientists in developing areas communicate infrequently with others in their own country. Those who had never studied abroad were less likely to communicate with foreign researchers. Because conferences are often held in industrialized countries, scientists from developing areas find it difficult and costly to attend. Methodological problems make it difficult to generalize these findings. First, Gaillard's sample consisted of a relatively "elite" group of scientists—those who received a grant from an international foundation. Second, these results are based on reported frequency of communication with different categories of scientists at the rate of once a year (1991, p. 77-8). Without information on specific ties and their organizational locus, it is impossible to draw conclusions about the distribution of professional contacts.

While scientists in developing areas are not "isolates" in the usual network sense of having no ties to other members of their professional community, the thrust of these studies supports the notion of serious constraints on the availability of information and communication. For some locations, in Africa, Asia, and Latin America, communicative and information-search options were not much different in the mid 1990s than they were in the period when Dedijer and Salam wrote. However, with the gradual development of server and routing technology and the rapid diffusion of Web browsers in the mid 1990s, the Internet rapidly became a focus of development agencies and nongovernmental organizations. Was the Internet the solution to the problem of isolation?

Three general viewpoints on the role of the Internet in developing areas have been suggested: the "elixir" argument, the "affliction" argument, and the "teething" argument.[1] These arguments organize our qualitative findings below, representing a view of present and future. We focus on the present, without any summary judgment of overall effects, but as an account of changes now underway. To be sure, it is important to assess the ways that humans employ new information and communication technologies, but the more critical task in developing countries is to understand the ways the Internet affects the everyday life of those that use it and those who observe its use by others.

The "elixir" argument asserts that the Internet does not represent a potential problem but only an opportunity. Information technologies are a developmental tool on a par with educational and agricultural programs (De Roy 1998). Internet connectivity in general and increased bandwidth in particular are inevitable processes that will aid developing countries. In this view, ICTs first introduced in Western nations represent an opportunity for the South to

[1] We adopt a slightly modified version of Rutger Engelhard's 1999b usage.

leapfrog into the new economic regime and become true partners in the global scientific enterprise. Technology will allow the repatriation and production of data about developing areas that are now often controlled in research libraries in Northern countries (De Roy 1998; UNDP 1999). With respect to educational and research institutions, the Internet will solve the problem of the "isolation" of developing country scientists that has been noted since the 1960s (Dedijer 1963; Salam 1966). By allowing scientists in developing regions to keep in touch with current scientific developments, publish and distribute their work, and develop national scientific communities in areas where researchers cannot currently contact each other easily, the Internet will bring researchers into the global system.

The "affliction" perspective views the Internet as an engine of global inequality that creates new technology gaps between rich and poor, urban and rural dwellers, English and non-English speakers. This is so for three reasons. First, the content of the Web is dominated by the organizations, languages, and actors where it was first developed. Second, the promotion of ICTs by development agencies removes resources from more important areas like health care and food security—the Internet is a harmful diversion. Finally—and of special importance to research and educational institutions—increasing dependence on the Internet and other communications media may increase inequality between institutions in developing areas and their counterparts in the U.S. and Europe. Although connectivity is being introduced in developing countries, the rate of increase in technology required to use the web is increasing more rapidly than the technologies themselves. The Internet may indeed be a beneficial technology, but one that is not disseminating with sufficient speed. As platforms for the diffusion of information shift to electronic format, the absence of connectivity or low availability of bandwidth leaves researchers with greater constraints than previously.

The "teething" argument falls somewhere between the preceding two arguments. It focuses on temporary "teething troubles" arising in less developed areas (Engelhard 1999b), suggesting that a net benefit will eventually accrue to developing areas, but not without significant problems in the short term. These can include problems in telecommunications infrastructure as regulations in some areas have yet to liberalize and national telecommunications companies have been slow to privatize, with power outages, surges, and unreliable telephone circuits common. The teething argument is most sensitive to the temporal aspects of technology diffusion but relies, as does the affliction argument, on the observation of lagging development, spawning a large literature on what has become known as the Digital Divide (Adams 2000; Arunachalam 1999; Hindman 2000). Moreover, the teething argument views cultural differences as crucial. If developing areas emphasize personal, face-to-face relations there is an important adjustment period when communication begins to occur electronically.

Studies of Internet technology in developing areas are badly needed. First, there is tremendous variability in the extent to which a the "connectivity" of a country represents actual access for its population. Second, work on ICTs in development is often speculative and lacks a foundation in empirical evidence, either quantitative or qualitative. While research on the role of the Internet and computer-mediated-communication (CMC) in developing areas is sadly lacking, prior research has demonstrated its importance in the developed world (Robbin 1995; Walsh et al. 2000; Walsh and Bayma 1996a; 1996b).

One important strand of the literature on technology is based on the concept of diffusion, investigating the factors that influence the use or adoption of information and communication technology in scientific work (Abels et al. 1996; Hurd and Weller 1997). Hurd and Weller (1997), for example, document the adoption of technological innovations by university faculty.

They argue, using from Everett Rogers influential typology (1995), that barriers exist to the adoption of a new technology based on its perceived attributes. These barriers include the relative advantage it provides over other methods, its compatibility with the needs of the adopters, the ability of users to understand the innovation, the ease of adoption of the technology, and the degree to which the results of the innovation are visible to others. However, to they extent that there is a general lack of access to Internet technology in developing countries, it is unclear how perceived attributes could play a significant role‐such barriers will become important after it is available.

Abels et al. (1994) examine the adoption and use of electronic networks by science and engineering faculty at small institutions, a context that may have more in common with some developing areas. They find that accessibility and the number of people sharing a workstation are both important attributes that influence use of the network. For those scientists in developing countries, who may not have easy access to computers that are Internet connected, these same factors are likely to inhibit their use of this technology.

Another segment of the literature on computer-mediated communication specifically focuses on the networks that are facilitated by this technology. Haythornthwaite and Wellman (1998), for example, examined the communication patterns of researchers located in the same building. They find that the stronger the work tie, the more frequent the communication, the more varieties of information exchanged, and the more media used (including face-to-face interaction). Of course, the promise of the Internet is in connecting scientists who do not work in the same building, or even the same country.

Walsh and Bayma (1996a; 1996b) examined the use of computer mediated communication technology among scientists in four different fields: mathematics, physics,

chemistry, and experimental biology. They found that mathematicians, who have traditionally worked alone, increased remote collaboration through the use of email. For physicists, who have traditionally collaborated with large numbers of other scientists, email was a helpful addition to the face-to-face interaction that is still required. Chemists and biologists reported that email provides more frequent communication than was available previously, resulting in coordinated experiments that are completed sooner. Overall, Walsh and Bayma found that CMC increases collaboration by overcoming geographical barriers, increasing the frequency of communication among those involved in a collaborative research project, and providing opportunities and resources to scientists who are new to the field or located at less prestigious institutions. In a second study Walsh et al. (2000) examined the use of CMC in the fields of experimental biology, mathematics, physics and sociology. They conclude that email use is important to scientific research, though its use varies by field. Email use is related to frequency of contact among scientists and access to information.

Such work shows the increasing importance of the Internet and computer mediated communication technology in facilitating scientific work in the developed world. However, it does not investigate the use of computer-mediated communication in developing countries where access may be limited or problematic. One study that attempts such an assessment is Jimba and Atinmo's examination of the relationship between accessibility to information technology and research productivity in Nigeria (2000). They find no significant relationship between the accessibility of information resources and self-reported publication measures. The authors observe that much of the information now available to Nigerian and African scientists comes from Western countries and may not address the concerns of Nigerian scientists, whose knowledge becomes subordinated and marginalized. However, Jimba and Atinmo include only

those scientists who had some access to electronic information resources. Without a comparison to those who do not have access, it is difficult to argue that informational resources have no impact. In general, there remains a severe deficit of sound empirical work on the adoption and consequences of ICTs in developing areas.[2]

The Kerala Model

Our objective in the present work is to explore the present status and meaning of the Internet among scientists for a location in the developing world that is in many respects special. While our larger project includes east and west African locations, this report centers on the state of Kerala in southwestern India, where preliminary data was collected in the summer of 2001. No claim is made that Kerala is representative of developing areas in general. Many scholars would argue precisely the opposite: the idea of a "Kerala Model" of development is a clear expression of this sentiment (Jeffrey 1992; Parayil 1996). Specifically, Kerala has a combination of features that provide a unique setting for examining the introduction of the Internet.

The central reason analysts have identified a Kerala Model is that the level of social development within the state is much higher than one would expect based on its level of economic development. Owing to its reputation for labor militancy, capital investment and economic growth in the state remain low. Economic growth has been only around half the national level for India (Gulati 1995) Unemployment rates are among the highest in India. In particular there is a problem of unemployment for those with higher degrees (Mathew 1995; EPW 1994). From 1985 through 1994 unemployment registration among professional graduates

[2] One problem when conducting research on communication and information in developing areas is that it is difficult for sociologists in both developed and developing areas to access work that has been done in the region.

increased nearly 200 percent (Iyer and MacPherson 2000). Although extreme forms of poverty are rare, the proportion living below the poverty line is still high. Certain sectors of the population, such as the tribal people who comprise roughly one percent of the state population, remain "backward," and deaths from starvation have recently been reported.

Indicators of social development—including literacy rates, demographic trends, the presence of social programs, and the status of females—paint a much different picture of the state. Most important for the adoption and diffusion of the Internet is the extremely strong emphasis on literacy and education that pervades the state, placing Kerala on a par with most developed countries (Franke and Chasin 1994; Iyer and MacPherson 2000). The 91 percent literacy rate that is well above the Indian average of 52 percent. The literacy gap between males and females has narrowed in Kerala, counter to the national trend. The emphasis on education in Kerala has resulted in three specific problems for economic development: an increase in labor militancy that has inhibited external investment, increased expectations and decreased job satisfaction among the educated, and greater demand among both men and women for the high quality professional and management positions that remain scarce in the Kerala economy.

Beyond education and literacy, there are numerous and far-reaching social programs and initiatives, including public food distribution, labor market interventions to raise rural and urban wages, health services, and infrastrstucture that includes schools, hospitals, and dispensaries (Franke and Chasin 1994; Kannan 1995). Demographic indicators of their success are low birth and death rates. These have declined so rapidly that Kerala resembles countries that have completed the demographic transition associated with industrialization (Bhat and Rajan 1990). The Kerala sex ratio of 1036 females to 1000 males is, again, closer to European and North American ratios than those of India as a whole. Though Keralites may prefer sons, the practices

of selective abortion, female infanticide, and neglect of females are relatively rare. Recently, there are suggestions of an actual preference for daughters over sons among the middle class.

The status of women is relatively high compared with other Indian states. However, there are indicators of a lower than Indian average workforce participation for females in Kerala (Saradomoni 1194: 508). While lower fertility has increased the number of women in the workforce, there is reduced demand for female labor in agriculture, where food crops are primarily the province of women. In addition, gender relations still display a high degree of inequality. For example, women are still subject to arranged marriages, are nearly invisible in public life, and are largely unable to travel alone even in daylight hours (Saradamoni 1994; Sooryamoorthy 1997). Atrocities and crimes against women are increasing, which is evident from the type and number of cases registered with the Kerala State Women≪s Commission, established to protect the interests of women. The divorce rate has recently increased, and family courts are appearing throughout the state, testifying to the changes in the family life of Keralites.

The diffusion of the Internet in Kerala is likely to be a function of these economic and social conditions. While the level of external investment would predict a reduced rate of diffusion compared with the Indian average, the level of literacy and education would predict a high levels of awareness of and interest in telecommunications technology. Currently, Kerala ranks first among Indian states and union territories in the density of telephone connections. Kerala has the third highest rate of mobile phone usage in the country after New Delhi and Mumbai, with over 300,000 users in the state, about seven percent of the Indian total (Parthasarathy 2001).[3] By late 2000, there were approximately 50,000 Internet connections in

[3] There are approximately two million fixed phones, about five percent of the total in India (Parthasarathy 2001). According to estimates by the cellular operators≪ association, there are 4.29 million mobile phone useres in India (≪Mobile Varikkar Koodunnu.≫ *Malayala*

the state, ranking it eighth among Indian states.[4]

Before the Internet

Our project began in 1994—prior to the diffusion of the World Wide Web—with a series of 293 personal interviews with scientists in Kerala, Ghana, and Kenya. This broad sample of researchers from universities, state research institutes, and NGOs yielded a picture of professional networks that were primarily local in character (Shrum and Campion 2000). An inverse relationship obtained between the size of domestic and international personal networks: for government and academic scientists, those with more ties to the developed world had fewer local ties. Moreover, those that were educated in the developing world did not have more international ties—links to advisors and colleagues were lost owing to the difficulty of communication. In short, we found that local context was more important than the development level of the country in shaping opportunities for professional contacts. Developing countries scientists are not "isolated"—their relationships are simply drawn more from the national than the international arena.

In 1994, only 6% of Keralite researchers reported some access to electronic mail systems (Shrum 1994). During the early 1990s, it would not be an exaggeration to say that modern electronic communication was almost wholly absent from the educational and governmental research sectors. Yet when asked directly about desired facilities, scientists did not consider this

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Manorama (Thiruvananthapuram Edition), 27 August 2001, p. 7).

[4] The number of Internet connections in the country was approximately two million, led by the state of Maharashtra with 0.619 million, followed by Delhi (0.319 million), Tamil Nadu (0.291 million), Karnataka, West Bengal and Gujurat. See also ≙Growth in Internet Connections lopsided.≙ *The Hindu* (Thiruvananthapuram Edition), 10 December 2000, p. 8.

absence to be one of the highest priorities in the improvement of the research system. One of the most surprising findings in the 1994 survey was the low priority given to the development of electronic communication networks both domestically and internationally. From a list of twenty items, these networks were rated fifteenth and sixteenth respectively. An item on "creating international electronic communication networks" received the lowest average rating for any of the seven items on communication and networking. One African scientist said it best:

> It'll be another white elephant. The donors will come in and try to establish electronic links, then leave and not support the system. It's not that important.

But even then we wondered why ICTs were such a low priority for Kerala scientists, and whether this would soon change. There were several reasons. First, we did not provide any background information about electronic communication or how it operated: the term "World Wide Web" was little known in south India in mid 1994. Second, Kerala researchers were more interested in electronic communications than those in Ghana or Kenya, the two African locations in the study. And most significantly, the priority given to <u>improving various forms of linkages</u> was much higher than the priority of electronic communication technology, as an end-in-itself. The four highest priorities for scientists were:

(1) Providing operating funds for field and lab work

(2) Expanding and improving libraries

(3) Improving communication between researchers and extension

(4) Improving links with international research organizations

Excepting the first, the Internet has a potential impact on each of these. Given the high priority

of "libraries," "communication," and "links," one of the central findings of the 1994 study was that the means of communication were not viewed as important as the ends--information acquisition and networking. Of course, these are the promises of the Internet.

In what follows, we present results from 33 interviews with scientists in educational and research institutions. Our informants were drawn from research institutes and teaching departments of the three universities in the state, including Kerala Agricultural University, Cochin University of Science and Technology, and Calicut University. These institutes and universities are located in nine of the fourteen Kerala districts: Trivandrum, Kottayam, Alappuzha, Ernakulam, Thrissur, Palakkad, Kozhikode, Wayanad and Kasaragod. We interviewed respondents in their respective workplaces during the months of May and June in 2001.[5] About three quarters of our respondents were men.[6] Nineteen of these scientists were employed in central research institutes (run by the Government of India) or in research institutes of the State of Kerala. Fourteen were employed in academic settings. All but four had a Ph.D. as their highest degree, and these four were in various stages of Ph.D. work. [7] Our informants represented a variety of research specialities, though half of them work in the areas of agronomy, horticulture, plant breeding and plant pathology. Agriculturalists and agronomists in our sample were more likely to be employed by the research institutes.[8]

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[5] Interviews lasted from one to two hours.

[6] We interviewed 26 men and 7 women.

[7] A variety of training disciplines are represented, with an emphasis on agriculture (30.4%), economics, engineering (12.1% each), statistics, horticulture, veterinary and animal science, and zoology (9.1% each). We interviewed single individuals in botany, oceanography, and plant breeding.

[8] Biotechnology, marine science, microbiology were also represented.

About one-fifth of the sample has some experience abroad∏generally to developed countries∏for study, training, or attending conferences, workshops, and seminars. On average, these seven individuals have spent 1.5 years outside India (five of these were from research institutes).[9] Two of our informants had been employed abroad, one in biotechnology and one in plant pathology. Nearly three quarters of these individuals (24 or 72.7%) did not have a computer in their office for their personal use, but shared computers with others.[10] Using an open-end interview structure, we explored the use and perceptions of the Internet, the opportunities and benefits it implies for their professional lives, and the problems that accompany the introduction of this technology. These views are organized in terms of the elixir, affliction, and teething persepctives reviewed above.

Internet Elixir

One point seems clear even from these preliminary interviews: the advent of the Internet has begun to change the way many Kerala scientists think about their work. During a journey away from India, this fisheries scientist realized the importance of email when it was no longer accessible:

> During my recent visit to Vietnam, I felt it very deeply in the sense that there it was very difficult to get email connections. I realized the necessity of email. Whatever things happen here...my student used to communicate to me then and there. Even if I am away I

[9] Six of the seven were females, which is somewhat surprising in light of findings by Campion and Shrum (Forthcoming) that women have fewer opportunities to work abroad.

[10] Among the nine who have this facility, five were employed by universities and four by research institutes.

> get all the information regarding the activities here. But when I could not open my mail in Vietnam, I was a bit tense because I was cut off from the news of my university and activities. I could really feel it.

A marine scientist at Cochin University of Science and Technology was quite as avid as any dot com marketer in the West. For him, the Internet is indeed an elixir for the state of Kerala:

> The facilities of email and Internet are unimaginable. Now the whole world has become small and accessible to everybody. Even if you are away, you don≪t feel that you are away. We can contact anyone at anytime. The whole world is like a small village.

While many of our informants voiced like sentiments of possibility, we sought evidence that the Internet has begun to generate more specific shifts in the way science is conducted. Most scientists are aware of the large quantity of information available through the Web and the opportunities for communication with other scientists through email. Some report specific benefits from both these functions with respect to their ability to gather research resources through the Internet. One agricultural scientist located just outside the capitol described the information he is able to obtain:

> Internet is used in reviewing literature to find what are the works already done in the area. Internet has helped in understanding statistical analysis of data in different works. It is used in getting photographs. For example, the first photo of the mite which causes

> mandari disease[11] was from England. We downloaded it from the Internet. And we got about 500 pages of literature on the mite from Internet.

Such testimony bears special significance in light of the high prioirity given to the improvement of library facilities by our survey of Kerala scientists in 1994.

The "hypothesis of isolation" discussed above (Dedijer 1963; Salam 1966) pertained directly to the ideal of a globalized scientific community, with scientists throughout the world communicating about their research goals and problems. Some Kerala scientists spoke directly to these issues of connectivity and currency:

> Yes, I am a member of many groups. It gives a lot of advantages to me. When I have some doubts I post them on the Internet. I receive more than fifty replies [on average] every time. That is a wonderful opportunity now possible through Internet. We have now many an active discussion group, based mainly in the US. They are giving adequate support when we are posting some queries.

[11] This disease recently attacked coconut palms throughout the state, causing a significant reduction in yield.

It is not truly "global science" but "US science" that is filtered through the groups encountered by this scientist in a College of Fisheries. Yet fifty replies to a query, while it may not be typical, give rise to issues that are the polar opposite of isolation, i.e., issues of credibility and reliability, and of information sorting and selectivity rather than acquisition. Western scientists are now more likely to complain about volume than deficiency of information.[12]

The issue of information currency is important because there is widespread sentiment among scientists in developing areas that one may be engaged in significant research that has already been done. Kerala scientists often discussed the problem of duplication. Some felt the Internet had brought them the remedy. This environmental chemist felt he now had the ability to remain informed of the latest developments in his field, preventing his research from becoming irrelevant:

> We were feeling that we were getting outdated. We were not informed of what was exactly happening in other parts of the world. Thousands of papers are published every month of which tens of papers will be relevant to what we are doing today. Unless we know what others are doing we will be only duplicating the same thing. People will be working in some area for about four years but after three years you find someone else publishing a paper on the same thing. Then your work becomes irrelevant. Now, with the arrival of the Internet, it does not happen.

What seems novel is the reported sense of gaining the capacity to <u>know</u> where one stands with respect to global standards of scientific work. For one scientist, not only is information

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[12] We did not hear complaints about excessive volume of information in Kerala.

received more rapidly, but the Internet allows him to keep up with developments in other countries:

> Now I know what is going on in my subject and what is going on in the U.S., Europe, etc. I am aware of what is going on in the world [as far as his subject is concerned]. Earlier, the articles in the journals will take two to three years to reach us...Information reached us very late earlier. Now we get everything instantly▱Now we know what others are doing on our areas in other countries which avoids duplication.

A university scientist directly asserted his scientific work would improve because of this new capacity for global awareness:

> We can converse with the world standards. You know what is happening in different parts of the world. We have access to such type of information and that will improve a lot to develop our side also, because, you know, our type of research will be always in comparison with some set standards. Once we get information from such laboratories, we will also try to improve our activities, on par with those institutions and their standards. So that will improve, that will make a lot of changes in our methodology in our search, topics and everything. Career-wise it will always be a revolutionary change with the introduction of email and Internet facilities.

Information flow is not just unidirectional. A scientist discussed the new capacity to publish gene sequences online and participate in a global scientific endeavor, collecting and

disseminating information:

> Once we have a gene, a new gene, we can submit online. So I did that online, once we have found a new gene sequence or new gene, we can submit the data or deposit the data on the day you got it. There is a specific programme for sending and submitting. They will screen it for genuineness and it will be in their web which can be accessed...All over the world, once they have a new sequence or new information, they quickly submit on the web.

Such participation yields the potential for significant changes, not only in the production of scientific knowledge, but also in terms of self esteem. One entomologist granted that the Internet was responsible for his newfound assurance at scientific conferences:

> Now I am very proud when I give latest information in meetings and all. With this facility we download the latest information for the matter on what you are going to present in some forums. It increases my confidence. I have the confidence to argue with anybody on any subject. I feel the same thing when I discuss the subject with foreigners too. Once a professor from the Imperial College of London came. He says that our resources are better than that of theirs, particularly in information technology. For them, it is costly and so they cannot afford them. We are doing a lot of experiments and are ahead of them.

While such sentiments were rare, it is surely significant that a scientist in the developing world

may begin to consider not merely equality, but superiority in scientific work.

Internet Affliction

If the story stopped here there would be little question about the role of the InternetIIapart from how rapidly all scientists can be connected. But as Engelhard (1999b) points out, elixirs have two problems: no one seems to know the exact ingredients that provide the magic power; and those in charge of administration often leave by the time it is found to be ineffective or worse. Even in Kerala, where many scientists are beginning to gain regular access, the Internet is viewed with misgivings that range from technical to social. Although every scientist in our interviews was familiar with the Internet--a major shift since 1994--levels and types of access varied widely. The following agronomist at a rice research institute has used the Internet but laments the overall lack of access that he and his colleagues experience in Kerala:

> There is lack of facilities here. We do not have Internet. Even the village officers are having Internet connection. But the researchers do not have it. It is a pathetic condition.

Even with access, bandwidth and cost are frequently problematic, issues raised by the following university scientist:

> We have to wait till midnight and get a full speedy download. Another problem is that the infrastructure is not developed, means power cut and all. Power cut is a big problem. There won≪t be enough voltage. We have everything, but infrastructure is not developed. So use of Internet is costly here. The phone charges are very high and we

> have to pay phone charges for using Internet. In the US, there is unlimited use. This is a hurdle here. Keeping engaged with Internet means you are paying for every minute. It is a costly business▱you cannot browse that easily, carefree and without considering the amount of money required for that.

Owing to excessive demand, regular power cuts are scheduled for one or two hours each day. Infrastructural problems such as these are clear reminders that a retreat into cyberspace is not possible for most in the developing world, even if it were desirable.

This is the problem of "theoretical connectivity." Widely experienced in the universities and research institutes of Kerala, the problem of theoretical connectivity exists where a connection is planned but not available, where a connection has been established but is not in working order, where the speed of the connection is so slow that little activity is possible. Although we lack the statistics to document the phenomenon, it is remarkable how often a scientist will report access to the Internet but that now, at this particular time, it is not possible to use it. In terms of research practice, the inability is probably more significant than the reasons why.

Apart from questions of access, many informants challenged the notion that the Internet will provide only benefits to those with access to the technology. Awareness is a double-edged sword for those who are not able to retrieve information they now know exists. A common complaint among those interviewed is that full articles are often not available on the Internet. Though there would seem to be a benefit in gathering references quickly, the source itself is unavailable, or would require an expenditure of scarce resources to acquire. Sources that are accessible for downloading and uploading information are problematic for reasons often

discussed by scientists in the US and Europe: reliability and peer review.

Internet publication by Kerala scientists is still extremely rare. Although it would seem to be an inexpensive means for the presentation of research results, such a venue is neither widely available nor beneficial professionally:

> Because Internet publication is not peer reviewed. The publications which are not reviewed have no value. We can publish articles in Internet. There are many sites for that. But it won≪t help us in any way. In the scientific world, publication in Internet has got limitations. The system of peer review for each article should be essential.

A scientist at a national agricultural research station was critical of sites that contained false or biased information that was detrimental to his research and mission:

> For example, many sites on coconut oil. They are biased ones. The oil palm lobby and soybean lobby are working against coconut. These lobbies are rich. They feed information such as ill-effects of coconut oil. We cannot compete with them as we do not have money or knowledge to start our business [working against this propaganda].

Biased information is not only a concern for professionals with a stake in certain commodities. As a university agronomist reports, Indian research is often inadequately represented:

> In most of the reviews of research on the Internet, the role of India is marginalized.

> [Foreigners] will project only their findings in most of the reviews▱For instance on the Internet we will sometimes find some reviews on some specific topics such as multiple cropping, farming systems, etc. There are some sites from which we can get such information. In these reviews appear in journals, say foreign journals, there may be some bias in favour of their findings and research.

A researcher in veterinary science emphasizes that scientists must view the information received via the Internet with a critical eye:

> Adulteration is everywhere and so in this Internet also there can be such things. We cannot take everything for granted [from the Internet]. We should also have our own perspective, ideas and then only we can be assured of the reliability of information on the Internet. We should not take everything on the Internet.

Finally, a forestry researcher is broadly critical of the changes that have occurred since the introduction of the Internet. His concern was not so much reliability as research practice, changes in habits of mind caused by the speed with which we become accustomed to receiving information. Will this affect the ability to do original work?

> Sometimes people may become lazy also. Earlier you know we were spending days in the library for references but now such reading is not there much. When you read books, although it may not have much information, you get lot of ideas, new ideas. We will think a lot. But when you use Internet, you will get lot of information very fast; but we

> will not spend time for thinking. We will improve our papers with the information you get from the Internet. But we will not think much and so you may not get more and more ideas. I think that is the difference. When you read something carefully you will get more ideas on the topic. But as you watch the television you get more information within a short period but your brain will not process it. This is what I feel.

In truth, the quotation above expresses no more than a prediction, but leads us to the third major perspective.

Teething Troubles

As indicated in the "affliction" perspective, a pervasive theme in these materials is the extent of technical problems experienced in attempts to utilize communication technologies. Perhaps the most significant problem in the sociology of technology is the conditions under which a technology is defined as "working." A scientist who studies the biochemistry of aging described the state of connectivity in his department with a comment that summarized a variety of typical issues:

> We have a connection...but it is not working now for some reason. We are supposed to get this Ernet education research network. It is not working in full swing. Because of it downloading is very low. Very low download speed. So most often we won≪t use it other than for sending email. Now also there is some problem. Other than email, the browsers in the university is not working in good condition. The users have to wait hours and hours. They will have to wait twenty to thirty minutes to open a site. It is not

> productive. So I use and depend on my personal connection.

What may not be immediately evident from such comments is that they are often not wholly negative, but imply a future in which the problems do not occur. This scientist uses a "personal" or home connection because his professional setting does not offer a comparable experience. A spice researcher reports that the problem of blocked phone lines now constituting a barrier to use will soon be resolved:

> This connection▱I can use it. But of course, when I am using it this phone will not be free and so that problem is there. That is why we are going to get a leased line. Once leased line comes into effect this phone and all phones will be free.

Our informants were often quick to indicate their future expectations of the Internet, including its potential usefulness for collaboration:

> Now I think the present facility is okay. I think if we are able to pursue on this line in future it will be a must for collaborative research rather than individualistic or institutional research projects. If we are having some collaborators outside it will be a faster way of communication and also for getting information from other institutions and scientists. I think these are the possible uses.

Such expectations represent possibilities, but not, for most, possibilities that have been realized. Some report a realization of falling behind the technological curve, as in this comment by a

forestry professor, concerned with the limitations of the technology available in India:

> When you are linked with Internet network to large number of people you know what is going on in some places and what they have encountered which you can avoid in your research. You can either avoid the pitfalls or take advantage of that situation▱Many people are not knowing what others are doing and what is happening in Delhi or in other institutions. Now that problem, to a great extent, is over because of Internet. But most of the Indian information or Indian organizations are not, I think, in the forefront of this revolution. Even if we look at [our] web page this is true. It does not give the information one may require. I don≪t know you have seen our website or not. Suppose a student will be visiting our site and would like to make an application to a programme, say field forestry. But how can he make an application? Is it possible through Internet? Unfortunately, it is not possible right now at our website. But, you know, these things are possible elsewhere (laughs). So we are still in that old age. That is my feeling.

Discussion

Interviews with Kerala scientists show high levels of awareness and increased levels of Internet use. Virtually all are conscious of the Web as a vast storehouse of information and email as a rapid and efficient technology for communication with other scientists throughout the world. Many are eager to ensure their work does not duplicate that done elsewhere, keep up with cutting edge research, and perhaps publish their findings online as a means of participating in a global scientific community. A few have begun to address the issues selectivity and credibility that accompany the transition from deficit to excess of information. Clearly, the Internet has

begun to alter the way professionals in the educational and research institutions of south India reflect on their work.

Still, much of this story reflects sentiments of possibility rather than realized aspirations, a kind of teething trouble we have discussed as connectivity that is "merely theoretical" in the hard reality of the present. Such connectivity is still in the planning stage, established but nonworking, a matter of high cost and low bandwidth that renders web browsing a curiosity or midnight obsession. But theoretical connectivity is something different from absenceÎit is an implied future in which these problems have been resolved, if only to the extent that they have been in the West.[13]

The summary perception of the Internet by Kerala scientists is best understood by comparison with their characteristic preoccuption with education and literacy. While it is not strictly true, "total literacy" is frequently claimed by Keralites, declared by state fiat in 1991 in the wake of a highly successful Total Literacy campaign led by the most prominent NGO in the state, the Kerala People's Science Movement (Kerala Sastra Sahitya Parishad, or KSSP). For professionals in Kerala, the Internet bears this constrast well. A marine scientist, asked what motivated him to use the Internet, highlighted its importance as a basic skill:

> You get new...information. Interesting▭and there is entertainment. Nowadays, lack of knowledge about Internet means something like a situation of lacking in education. Isn≪t it? It is almost like having literacy.

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[13] As we write this, the server in the Department of Sociology at Louisiana State University has been down for several weeks, infected so badly with viruses that technical personnel have declared it unsalvageable.

Such a judgment renders it close to a sociological inevitability that the Internet will diffuse throughout Kerala. The same social motivations that produced Total Literacy are likely to produce Total Connectivity, but questions of consequence remain. Total Literacy has not solved the problems that have left Kerala an average Indian state in terms of economic well being. It remains to be seen whether the Internet will do better.

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