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Technologies for the people: a future in the making

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Abstract

India's post-independence policy of using science and technology for national development, and investment in research and development infrastructure resulted in success in space, atomic energy, missile development and supercomputing. Use of space technology has impacted directly or indirectly the vast majority of India's billion plus population. Developments in a number of emerging technologies in recent years hold the promise of impacting the future of ordinary Indians in significant ways, if a proper policy and enabling environment are provided. New telecom technologies—a digital rural exchange and a wireless access system—are beginning to touch the lives of common people. Development of a low-cost handheld computing device, use of hybrid telemedicine systems to extend modern healthcare to the unreached, and other innovative uses of IT at the grassroots also hold promise for the future. Biotechnology too has the potential to deliver cost-effective vaccines and drugs, but the future of GM crops is uncertain due to growing opposition. Some of these emerging technologies hold promise for future, provided a positive policy and enabling environment.

1. Introduction

With its strong base of science and technology manpower and a favourable policy environment for science and technology development since independence, India has made inroads into several high technology, globally competitive areas [13]. It is now being recognised as an emerging technological power in the world. In the 21st century, the country will be able to reap the benefits of substantial investments it has made in S&T, especially in space, atomic energy, defence research and information technology.

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It has one of the most successful operational space programs running in the developing world, with capabilities to design, develop, fabricate and launch its own communication and remote sensing satellites. It is also planning to send a scientific payload to go around the moon using its own rocket. The country has achieved a similar position in the atomic energy sector—it built up almost totally independently, a nuclear power program covering the entire nuclear fuel cycle. In the defence sector, the integrated guided missile program has resulted in serial production of locally developed surface-to-surface missile, while five other missiles are under various stages of development after having been tested successfully. The indigenously designed and developed supersonic fighter jet, Light Combat Aircraft, has been test flown and is likely to get operational clearance in the next five years or so [12].

More recently, India's foray into the information technology sector, software development in particular, has attracted worldwide attention. Software exports from India are steadily rising and the demand for Indian software professionals across the globe has risen. Cities like Bangalore, Hyderabad and Gurgaon have become favoured destinations for global corporate giants seeking software solutions. These cities have also become hubs for business process outsourcing or IT-enabled services like call centers, backroom operations and customer relations for some of the top Fortune 500 companies.

Taking advantage of the euphoria, political bosses declared India's ambition to become a software leader and knowledge superpower in the years to come. In the words of India's Prime Minister Atal Behari Vajpayee, " even developed countries have come to recognise India as a software superpower in the making" [14]. But these technological achievements seem to be having little impact on human development in India. This is the reason why India ranks low in the Technology Achievement Index (TAI)—which reflects not just factors like innovation and access but also education and skills required to use technology effectively. Although Bangalore ranks among the top technology hubs of the world, on par with locations in the US and Europe, it is only a small enclave in the country where the average adult has received just 5.1 years of education, adult illiteracy is 44%, electricity consumption is half that in China and there are just 28 phones for 1000 people [20].

While it is true that generally technology is created in response to market needs and pressures, and not according to the needs and purchasing power of the poor, there are some key instances where science and technology in India in the last few decades has been used for the goal of national development. The remarkable success of Indian agricultural scientists in ushering in a green revolution that made the country self-sufficient in food is a case in point. Another example is the use of space technology for natural resources management, weather forecasting and communications. Efforts are being made in developing countries like India and Brazil to develop locally relevant, affordable technologies that can directly address human development needs. These technology developments in India hold promise for the future, but how much impact they can have will depend upon the kind of policies adopted by the government.

2. Communications

Mere availability of technology does not ensure its diffusion among the needy. Telephone—discovered more than a century ago—is a classic example of this. It is a fairly old technology, yet still not accessible to large sections of the poor. While there is more than one mainline telephone connection for every two persons in the rich countries, there is just one phone for every 15 persons in the developing world. In India too, teledensity is far below world average but is improving steadily. From less than 1% in the 1980s, it has improved to 4.9% in December 2002 [3]. A major contributor to this was expansion of the rural network using a locally developed switch in the 1990s.

A new research organisation, Centre for Development of Telematics (C-DOT), was created in 1986 to develop a digital telephone exchange suitable for Indian conditions. The C-DOT rural exchange was rugged to suit dusty and extremely hot environments of Indian villages. It did not require any air-conditioning, could be operated with little power or solar batteries and needed minimum maintenance. And significant from the point of view of diffusion, it could be manufactured by local industries. Its per line cost of the new exchange was 2–3 times lower than imported switches. Within a short period of time, C-DOT exchanges became a major part of the Indian telecom network and helped in taking the telephone to rural areas.

Nearly 24.7 million lines based on Indian technology have been delivered so far for use in the Indian network, accounting for over 40% of the total lines. In terms of the total number of telephone exchanges in the country, the share is above 90% as C-DOT technology enjoys a leadership position in the rural network comprising small exchanges. The ability of small switches to work reliably in harsh non-air conditioned environments makes them particularly attractive for the developing countries. These rural exchanges have already been exported to over 24 countries in Asia, Africa and Latin America [6]. The social fallout of C-DOT technology was significant, although little empirical data is available to prove this.

While CDOT technology has helped improve rural connectivity, the penetration levels have remained low due to local access problems. In the 1990s, the need to take internet to rural areas added another dimension to the connectivity issue. Inspired by the success of the C-DOT switch, another group at the Indian Institute of Technology Madras took up development of wireless products to further enhance connectivity in rural areas. It came up with an innovative WLL (wireless local loop) product, CorDect, which provides for simultaneous voice and data (for internet) connection. Like the C-DOT technology, this too is tailor-made for developing countries' needs—rugged and cheap. Within 3 years of its launch, more than a million lines based on this technology are in operation in India, Africa and Latin America [7].

If India can scale up to 150 million to 200 million telephone and Internet connections in a short timeframe,[1] like China, then telecom and IT would no longer

[1] Prof. Ashok Jhunjhunwala, chief developer of the CorDect technology, feels strongly that India should do so [8].

remain confined to large cities or amongst wealthier sections of the society, but also reach small towns and rural areas and to all sections of people. This could enable rural youth to receive better education and train themselves to play a suitable role in this fast changing world. It could result in software companies being set up in smaller towns and rural areas, initially as satellites to large software companies in the city but slowly coming into their own.

This could create a high level of confidence amongst the youth in small towns and rural areas—the kind of confidence to deal with the world as equals, that we have started seeing in recent years in large cities of India. It would open up a possibility of comprehensive social development [8], although merely setting up internet connections itself would not be enough for this purpose. The new technologies, however, do open up these possibilities, and active intervention would be required on various fronts to achieve this.

If widely adopted the CorDect technology could revolutionise access to telephone, email and internet in every urban and rural community in India—and the world [9]. In fact, both CDOT and CorDect technologies hold great promise to bring telephone and internet connections to the millions of Indians in the next few decades or so, provided a proper policy environment prevails. (Policy constraints are discussed separately below).

3. Information technology

The cost of access to IT has been high in India so far, because the focus of all IT activity has been the PC. Despite the fall in PC prices, we are still to have a computer that costs less than Rs 25,000 or so—which is something that an average Indian can not afford. Three years ago, a group of scientists at the Computer Sciences Department of the Indian Institute of Science, Bangalore, developed a new device that breaks this price barrier for the first time. They came up with a low-cost internet access device (not a PC) that could be available for about Rs 10,000 (about USD 220). The price could go down further if volumes pick up.

This device is called Simputer or Simple Computer. It is a low-cost PC, though it may not look like a computer. It does not have a keyboard nor a monitor. It has a small touch sensitive screen, and the user is able to write a message using a pen-like device. The Simputer uses free software from the open Linux platform. Unlike a PC, Simputer is targeted as a shared computing device for many users in a community. A local community such as the village panchayat or the village school, or a kiosk, or even a shopkeeper should be able to give this device out to individuals for a specific period of time and then pass it on to others in the community. This requires the device to be personalised for individual use on a changing basis. This has been achieved by making the Simputer work with smart cards.

The proponents of Simputer say that it can be used for a variety of applications in rural areas, including access to agricultural and weather information, distance learning, health data collection and simple internet browsing. It can be an ideal mobile platform for a complete, secure micro-banking solution. The Simputer can solve a lot of our problems relating to IT access in poor, developing countries.

However, a pertinent question is: what can devices like Simputer do when basic infrastructure and utilities don't exist in our rural areas. What can an excellent application like micro-banking using the Simputer do, when we don't have a micro-finance system working on the ground in villages (cooperatives of Maharashtra and Gujarat are an exception)? What use is cheap internet access through the Simputer in rural areas when there is no relevant content available on the net for rural folks? What can applications like health data collection do when the primary health care system is crumbling or is altogether non-existent? Even if you are able to generate excellent health data using the Simputer, what is the use if the government officials don't know what to do with this data? Then there are problems like lack of electricity in villages—Simputer operates on batteries but they get drained out within a few hours of use.

Obviously the Simputer cannot work in a vacuum. Even if its cost comes down to Rs 1000 (USD 22), one tenth of what is projected today, there may be few takers.[2] It will still remain an expensive toy for the villager. Unless we are able to develop relevant content, develop applications around existing operations in rural areas and work with developmental agencies operating in rural areas, it cannot be useful to the villager. For this, collaborative work between government agencies, NGOs and educational bodies and administrators is required at various levels.

4. E-governance

Yet another promising application of IT is in the field of e-governance. The use of computers in governance is going beyond mere computerization of government works and electronic availability of government forms and files. E-governance is supposed to improve the interface between the government and citizens, while bringing in openness and transparency. A major fallout of true e-governance could be reduction or elimination of corrupt practices. A number of e-governance projects are operational in various parts of the country. Perhaps the most successful of them is the 'Bhoomi' project in Karnataka, under which all land records have been computerised and have been made accessible to the common man through touch screen kiosks. Anybody can get a certified hard copy of a land record anywhere in Karnataka by just paying Rs 15. Earlier landowners had to spend a lot of money and time to get such copies from village officers or district or sub-district administration.

The project can be termed successful on two grounds. First, all legacy records have been killed and all land data is now available only in electronic media.

[2] Some believe that Simputer may face tough competition from other cheaper devices. Mobile phones are cheaper than the Simputer, and the most advanced models can send text messages and access the Internet. Communities choosing between the devices may find a mobile phone more immediately attractive for keeping in touch with the outside world and conducting business [4].

Second, the usage of Bhoomi kiosks is very high. Within a short span of 18 months, user fee of Rs 120 million has been collected, as against Rs 180 million spent on the entire project. That means the project is scalable (it has been implemented all over the state), sustainable (existing legacy records have been killed) and financially viable (revenues through user charges are flowing steadily). Another very important measure of the success would be its impact on land-related litigation in courts. These numbers are bound to decline, but it will take a few years before the situation changes on the ground.

Land records are a vital document in an agrarian economy. If a project like 'Bhoomi' can be replicated in all the states, it will have a very significant impact on reducing land-related litigation and conflicts in the future, as land ownership is often a cause of disputes and litigation in rural areas. There are plans to develop similar projects to computerise all property records in urban areas as well. But this will require strong political will and cooperation from the bureaucracy, since deep-rooted vested interests come into play while dealing with highly valuable commercial properties in urban areas. Many influential politicians and corrupt government employees are known to own 'benami' (not in their own name) properties and they will get exposed if land and property record data becomes available in the public domain.

Critics of the Bhoomi project say such projects only help those who own land, not the landless. This may be true in states where land reforms have not been implemented. Poor and marginalized farmers are bound to get into the fold once they are given land rights under various welfare schemes of the government.

It is this down-to-earth application of IT which will touch the lives of large sections of people not directly using computers or IT in any way. This application, hopefully, would not remain limited to land records but will spread to other sectors. Kenneth Keniston, who visited several 'IT at the grassroots' projects in India, concluded that e-governance remains one of the most promising potential uses of IT for ordinary people. A sustainable and commercially viable model of e-governance has been created at Dhar in Madhya Pradesh under the Gramdoot project. Rural people are willing to pay for services and information provided it is useful to them and transparent. Keniston feels that the fact that this was possible to do in at least one location indicates that it can be done in other areas as well, given strong leadership not only in the local area, but also at the municipal, district and state levels. E-governance is no guarantee of "good governance" but it makes it a lot more likely [10].

Ideally, local village governments run under the Panchayat system will get empowered through the use of computers and networking. Already a large body of data on natural resources and other sectors exists with the government, and in some cases, is being collated. This will have to be made available to Panchayats for effective and efficient local governance. Various ongoing initiatives give us the hope that IT will not remain restricted to e-governance, but will play a key role in education, micro-finance, cooperatives, agriculture, vocational training etc—for each of which a successful model exists today. But these models will have to stand the test of replicability, sustainability and commercial viability.

5. Space technology

As mentioned in the introduction, India's achievements in the field of space technology have been remarkable. Large applications of space technology such as telecommunications, television broadcasting, meteorology, disaster warning and natural resources survey and mapping have touched the lives of common Indians directly or indirectly. The data from Indian remote sensing satellites is being used routinely for various applications in agriculture, forestry, ground and surface water location, drought assessment and monitoring, flood mapping, land use and coastal studies.

The satellite-based disaster warning system has helped in saving thousands of lives in coastal belts. Near real-time monitoring of floods using remote sensing data helps in rescue and relief operations. Digital data can be generated for flood inundation and affected population at the village level. Potential Fishery Zone (PFZ) maps using sea surface temperature (SST) are disseminated to fishermen cooperatives in coastal areas. Preparation of ground water prospect maps for dry regions has resulted in good success at the ground level, with varying range of yield [2].

Remote sensing data is currently being used by various government agencies, state governments, corporates and local cooperatives. A number of applications of remote sensing focus on agriculture—cropping patterns, crop acreage and yield forecasting, biodiversity characterization and so on. It will be some more years before this data could be used at the level of Panchayat or even by the individual farmer or fisherman. Because of the complexity of interpreting satellite data, intermediaries like data services providers will have to be created. Then it will be a matter of buying whatever data you need over the counter. But that will take time and need sweeping policy changes relating to data access. *Technology is available for use, only an enabling environment is needed.*

Weather forecasting will become more focused as more accurate models are developed to forecast local weather conditions. An the Indo-French satellite called *Megha-Tropiques* is proposed to be launched exclusively to ''watch'' the tropics—to study water cycles and energy exchanges in the region. A group of scientists under the New Millennium Indian Technology Leadership Initiative of the Council for Scientific and Industrial Research is working on mesoscale modelling of the tropics and the monsoon. Modelling and forecasting of extreme weather events and rainfall in the tropics will have important scientific, technological and strategic consequences in the future [5].

6. Healthcare delivery

Despite a three-tier healthcare system in place, India faces problem of healthcare delivery in rural areas, particularly remote areas. While primary and secondary healthcare facilities are available at village, sub-district and district levels, tertiary care facilities are concentrated in metropolitan areas and state capitals. People have to travel long distances to come to cities where all tertiary care facilities are available. Sometimes consultation and follow up visits cost more than the actual cost of treatment or medicines. Similarly proper diagnostic facilities are not available in rural areas and small towns. Telemedicine is being used as a shortcut to bring rural and remote areas into the mainstream of healthcare delivery. Various telemedicine models have been evolved using locally designed software and technology, and keeping in view Indian conditions.

In Kerala, a simple, low-cost, internet-based telemedicine system has been evolved by the Regional Cancer Centre, Thiruvananthapuram, to cut down patient visits at least by 30%. The RCC registers 10,000 new cancer patients every year and the follow up visits reach 100,000 per year. RCC has a network of six peripheral centres, manned by medical doctors and equipped with cytology services. Cancer patients in the nearby areas are advised to go for follow up in these centres. Doctors from RCC travel to these centres with a pile of medical records. Now all the six peripheral centres have been converted into teleclinics connected with the RCC through the internet. Patients don't have to travel long distances to consult their doctor. Most of them on long treatment follow-up need a reassurance from RCC and might have one or two specific problems that can be sorted out through teleconsultation. This helps the main hospital to utilise its resources optimally and concentrate on patients who need active treatment [16].

The Ministry of Information Technology has already initiated a Technology Development Programme for Telemedicine using both ISDN and dial-up telephone lines. Now the basic technology has been developed, a pilot project will be launched to study the feasibility of introducing telemedicine in other villages. Initially, three premier medical institutions at New Delhi, Lucknow, and Chandigarh will be connected. Later, each of these institutes will be connected to one hospital at a nearby town. The main concern now is to find ways to make telemedicine affordable [15].

The Indian Space Research Organisation (ISRO) too has launched telemedicine projects at eight locations across the country, using its satellite links to connect multi-specialty hospitals to district hospitals or health centres in remote areas. For instance a hospital in Chennai has been connected to a hospital in Port Blair islands. Since it is a satellite link, these facilities cater for transmission of patient's medical images, records, output from medical devices and sound files, besides live two-way audio and video. With such facilities, a doctor sitting in a city can advise a paramedic in a rural centre, or even guide a surgery by a doctor [17].

Yet another technology being deployed to improve healthcare delivery in remote areas is a mobile clinic. It is a simple solution, a state-of-the-art diagnostic cum dispensing vehicle having onboard facilities of X-Ray, Ultrasound, Lab and ECG along with dispensing. This has been successful in hilly areas where communication is a major hurdle in ensuring effective healthcare. This clinic could not only provide diagnostics and treatment to people at a nominal cost, but also solve the problem of shortage of medical staff in rural areas since they don't have to be stationed in rural areas permanently [11]. The project has been conceived by the Technology Information, Forecasting and Assessment Council (TIFAC).

In fact, a variety of solutions are available to improve healthcare delivery. An Ayurvedic physician in Faridabad is using a Personal Digital Assistant (PDA) as a means of telemedicine to reach out to patients in the nearby villages. A detailed patient information software has been developed for the PDA. A person goes to the village and collects data from patients on his PDA, comes back to the doctor who diagnoses and prescribes a medicine. The next day the medicine is delivered to the person in the village. All this for a fee of Rs 70, which is much lower than what villagers pay to quacks operating in the village [18].

Telemedicine—via internet, telephone lines, satellite and even human beings—seems to be a viable solution to improve healthcare delivery in towns and rural areas in the future. Again, policy level changes are required to promote telemedicine in a big way.

7. Biotechnology

This is an area in which many promises have been made. The Department of Biotechnology (DBT)—which is at the helm of biotechnology development and transfer of technology—lists biotech applications in agriculture, health and medicine, food, animal husbandry and so on.

The 10-year perspective vision prepared by the DBT envisages that transgenic varieties of crops like rice, cotton, potato, tomato and vegetables like cabbage would be ready for large-scale seed production by 2005. Transgenic wheat with more protein content will also be ready for production by 2005. Similarly edible vaccines (in tomato, cabbage and banana) for cholera, rabies and hepatitis B would be ready for clinical trials by 2004. In the field of medical biotechnology, vaccines for HIV, TB and malaria are expected to enter phase I and II trials by 2004, while a vaccine for hepatitis C would enter Phase I clinical trials by 2003 [1].

But there are question marks on how much can biotechnology impact on the lives of people. Vaccines and therapeutics being developed for various tropical diseases can have a wider social impact, provided there is a conscious policy to keep prices low. Treatment of genetic disorders through a chain of genetic counselling clinics across the country has helped scores of people. But the same may not be true with new gene therapies being developed for various disorders, as costs of development of these therapies are high and so will be the cost the delivery.

As far as GM foods and vegetables are concerned, approvals for commercialisation are facing stiff opposition from environmental and activist groups. They argue that the problem of the poor and the undernourished resides in lack of access to normal food. When there is no equitable access to traditional food resources, how will they access GM foods like ‘golden rice’ and protein-rich potato, which are being touted as panacea to the problems of hunger and malnutrition [19].

Biotechnology can have wider social impact if technologies like plant tissue culture, bioremediation, biofuels, vermiculture etc are packaged in usable forms for village communities and individual farmers. Availability of diagnostic kits as well as vaccines—with proven efficacy and affordable cost—can bring down overall healthcare costs for the poor. Otherwise, like the 'digital divide', India will be creating a 'biotechnology divide' with 'haves' accessing protein-fortified foods and personalized genomic medicines and 'have-nots' without any access to these foods and medicines.

8. Conclusion and lessons for the future

India has had an excellent scientific base, which has given it an edge in so-called high tech areas of space, atomic energy, missile development and supercomputing. However, barring space technology (and in a small way atomic energy), developments in these high tech areas have not been able to touch the lives of the common man. In the past two decades, the country has made some notable strides in developing new technologies—in areas other than the high tech domains mentioned above—which have found application not only in India but all over the developing world. It is significant to note that this kind of technology development has taken place in academic institutions like the IITs or mission-oriented groups like C-DOT, and not under the umbrella of traditional Research and Development agencies like the Council of Scientific and Industrial Research. This implies that we must consciously nurture innovative ideas and socially relevant projects in academic institutions where motivation levels may be higher than R&D institutions where the focus is still on writing research papers or patent documents.

Past experience shows that these technologies have grown in an atmosphere of stiff opposition from the establishment. Both C-DOT and CorDect have faced hostile lobbies within and outside the government. If C-DOT was nurtured well in its initial years, it could have delivered many more products. In fact, it has developed a GSM mobile switch as well, which has virtually been denied entry into the Indian market since it is fully occupied by MNCs. There is no deliberate government policy to protect or nurture Indian technology in vital areas like telecommunications. In fact, sometimes specifications for purchase of telecom equipment are drawn in such a way as to exclude Indian technologies and products. Similar is the story of the linear accelerator for cancer treatment developed by a consortium of government laboratories. Despite the availability of this cheaper and more advanced machine locally, the Ministry of Health continues to fund purchase of imported cobalt machines for cancer treatment. China, on the other hand, has started using locally developed linear accelerators for cancer treatment.

The 'Bhoomi' project has been adopted as a model by the central government for replication in other parts of the country, but it needs strong political will and leadership at the state level for implementation. The concept of 'Bhoomi' can easily be extended to metropolitan cities and other urban areas, but vested interests inside and outside governments are against such 'openness' in governance. Some states may not implement it even in rural areas for the same reason. They also lack proper legal framework to do so.

A proper policy and enabling environment is needed for the technologies discussed here to thrive and contribute to a beneficial future for the common man.

For instance, if remote sensing imageries have to be made available off the shelf in the market, data access policies have to be radically modified. Although the map-making process has been revolutionised by high resolution satellite imageries, the Survey of India and the Ministry of Defence continue to restrict supply of base maps.

The use of new technologies discussed above transcends across sectors and boundaries created by various administrative ministries in the government. For instance, Ministries and departments of Information Technology, Communications, Space, Health and Rural Development need to coordinate and work closely at central and state levels, if full benefits of telemedicine are to be realised on a large scale. For e-governance to be effective at the Panchayat level, more powers have be delegated to local bodies through necessary legislative changes. States need to adopt liberal right to information laws.

Undoubtedly, technological solutions for various pressing problems of the people are available and will continue to emerge from motivated scientific and academic groups. But mass application of these technologies will need changes in policies, coordination among various wings of the government, a clear preference towards locally developed technologies, recognition and promotion of innovative ideas, and above all, a change in the mindset of politicians and the bureaucracy.

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