New Challenges Facing Asian Agriculture under Globalisation

Volume I

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IT Applications in Agricultural Development

Fatimah Mohamed Arshad

Introduction

ICT sectors are fast becoming the major source of growth as proven in the developed economies. In the case of the American economy, between 1995 and 1999, the ICT sector contributed to 35% of the growth in the economy. By 2006, it is expected that half of the American workforce will be employed in industries that are big producers or intensive users of ICT. Software companies are employing more than 800,000 people; growing by 13% annually. The value of e-transaction was USD43bn in 1999 and is expected to increase to USD1.3 tn by 2003. According to Barua *et al.,* (2000), the share of commerce revenue and attributed jobs from the internet economy in US in 1998 were 34% and 40% respectively. IDC (2000) predicts the world internet economy to reach USD1 trillion by 2001. These statistics are enough to indicate the potential contribution of the ICT sector to an economy. It has been shown also that ICT sectors exhibit high potentials to contribute to economic growth in the developing economies provided that both physical and social infrastructures are restructured in parallel to the ICT development (Quibria and Tsching, 2000).

However, the development process is very uneven in the world and information technology is not equally available to all countries and individuals. The varying levels of access to ICT and the capacity for innovation and utilisation of knowledge information still keep countries and individuals apart — or simply the digital divide. In other words, countries are integrated into the ICT-based, knowledge-intensive economy at very different levels. While the development and application of ICT have already become a norm in some developed countries, low and middle-income countries have been left further behind in this regard, resulting in an even larger development gap. Central and South America, Eastern Europe, and Asia, where most of the middle-income countries are to be found, are left far behind North America and West Europe in ICT in terms of telecommunication access, computer penetration and, more critically, the number of internet hosts. For example, in October 1998, the number of internet hosts per 1,000 inhabitants in North America was 69.74, while in Central and South America it was only 0.91 and, in Asia, just 0.87. North America was thus 80 times ahead of Asia. Three years later, in 2001, this digital divide was further widened. Then, there were 168.68 internet hosts per 1,000 inhabitants in North America, but only 1.96 in Asia, i.e. North America was 86 times ahead of Asia. In terms of PC ownership per 100 inhabitants, the figure in Malaysia is only around 12.6, while the United States is 62.2, i.e. five times as many. In absolute terms, there were 178 million computers in the US in

2001, but only about 3 million in Malaysia (ITU, 2002). What makes matters worse is the fact that information infrastructure sometimes costs more in poor countries than in the richer countries because of the economies of scale that are possible in the latter. Thus, access to ICT in some cases actually costs the poor more than the rich.

Besides the digital divide, many of the world's poor countries find themselves still scourged by massive poverty. According to the World Bank (2000), about 1.2 bn people of the developing economies would be considered poor. Of this poor population, a vast majority – about 900 mn – are found in developing Asia. Various programmes have been implemented to eradicate poverty in Asian economies and the end results are mixed. For instance, 50% or more of the population are illiterate. In countries such as Cambodia or Vietnam, fewer than half of the households have access to safe drinking water. A large proportion of poor people stay in the agriculture sector. Over the past four decades, however, some parts of Asia, particularly the Newly Industrialised Economies such as Hong Kong, China, Republic of Korea, Singapore and Taiwan have achieved spectacular progress in poverty reduction, virtually eradicating abject poor. Several South East Asian economies have also made impressive strides. For instance, in Malaysia and Indonesia, the incidence of poverty between the mid 1970s to mid 1990s fell drastically from 17% to 4% in the former and 11% in the latter.

However, the advent of ICT provides new hope and opportunities to the developing and least developed economies. At the national level, the "information revolution is opening tremendous new opportunities for developing countries, not only by promoting foreign direct investment in emerging markets, but also by contributing to better governance, improvement of public services and amplifying the voice of the poor" (Sierra 2000). At the individual level, it has given people the chance to achieve for the first time more equal opportunities and to participate in shaping their own destiny by getting involved in the leading edge of technological development. This paper aims at examining the possible applications of ICT to the agriculture sector; the major source of livelihood of most of the developing economies in the Asia Pacific region. The exchange of information and knowledge - both local and global - by individuals and communities using ICT will have a critical role in achieving sustainable development and food security. Many examples exist to illustrate this observation, such as the ability of governments to predict areas of food insecurity and vulnerability using appropriate information and software tools, so that action can be taken to prevent or reduce the likelihood of an emergency. Like many communication technologies before it, the internet potentially enables rural communities to receive outside information and knowledge that can spur development. Rural communities require information *inter alia* on supply of inputs, new technologies, early warning systems (drought, pests and diseases). credit, market prices and their competitors. The success of the Green Revolution in Asia and the Near East indicates that giving rural communities access to knowledge, technology and services will contribute to expanding and energising agriculture.

The following two sections define briefly the ICT and review the status of ICT in the Asia Pacific countries. These are followed by a discussion on the role and contribution of ICT in agriculture. A brief review is made on Tani Net i.e. a web-based agricultural community

project in Malaysia and the constraints faced by developing economies in ICT development. The paper concludes with the policy implications of the need of ICT diffusion into the agriculture sector to enhance its competitiveness.

Definition of ICT

The new ICTs can be divided into three categories (1) computing; (2) communications and (3) internet – enabled communications and computing.

Computing

Computers represent the most significant technological innovation and breakthrough of the latter part of the 20th century. The cost of computing has declined exponentially and the use of PCs has increased by leaps and bounds in advanced countries. Computers augment and improve our human and organisational thinking capabilities. Computers have many different uses and have affected many spheres of economic activities. These include business in the area of enterprise resource planning (ERP) software, which has increased efficiency by integrating office function such as accounting and finance. Another important use is computer-aided design and manufacturing (CAD/CAM). This process has radically improved product lifecycles as well as the quality and complexity of product design.

Communication

Communication can be classified into two types: one- and two-way communication. The most common form is one way- communication and includes broadcasting media such as radio and television. Two-way communication devices, such as telephones, telegraphs and pagers, constitute perhaps the most important component of the information revolution. The internet growth is largely a function of two-way communication links (telephone lines) and personal computers (PCs).

Internet-enabled Communications and Computing

The internet has transformed the computer, communications, and the information technology world-wide like nothing before and brought about remarkable integration of the capabilities of each of these technologies. The internet provides a new communication medium that breaks down boundaries between all forms of communication – new and old – by allowing multiple modes of communication The internet is at once a world-wide broadcasting capability, a mechanism for information dissemination, and a medium for collaboration and interaction between individuals with and via their computers without regard for geographical location. On a global scale, internet growth has been remarkable. While it took the telephone close to 75 years to reach 50 mn users, it has taken the WWW only four years to reach the same number. The internet network has increased from a few thousands in 1981 to more than 50mn internet linked computers by 2001 supporting an estimated 544.2 mn internet users (NUA, 2002). It is also estimated that there are about 5 million websites and 1.6 billion web pages. With these characteristics, the internet is fast becoming a multi-function platform for e-commerce, e-learning, e-news and so on.

What characterises the new ICT revolution is the convergence of the above three technological sectors, whose convergence has generated a new way of disseminating knowledge and transferring knowledge, and thus on its capacity to contribute to development.

The convergence of these three sectors has created not only a new technological and production sector, but also a new social and economic reality. The development of the inexpensive desktop computer complemented with high-speed telecommunication links leads to societal communication that is interactive, seamless and multi media in presentation. In short, the industry or the economy is working under a computer-mediated environment. Improved information and communication technologies, increased information and management skills, and decreasing communication costs, are making instant connectivity and much quicker information flows among interested stakeholders possible

ICT in the Asia Pacific Region

A comparative analysis of the ICT environment in some selected Asian countries shows great disparity in their ICT preparedness (Table 26.1). Three of the listed Asia-Pacific countries-Japan, South Korea and Singapore-are among the top ten high-tech countries in the world, according to the United Nations Development Program (UNDP). The UNDP's Technology Achievement Index (TAI) ranked Japan as the fourth-leading technology country with a TAI score of 0.698, followed by South Korea (fifth, 0.666) and Singapore (10th, 0.585). Countries were ranked on several criteria, including number of internet hosts, number of patents granted, technology exports, diffusion of electricity and telecommunication and tertiary education ratios.

Japan scored very highly on the number of patents granted (994 per million people) but poorly in the number of internet hosts (49 per thousand people). By contrast, Singapore recorded 73 internet hosts per thousand people but just eight patents per million people.

Hong Kong ranked 24th worldwide, with a TAI score of 0.455, followed in Asia by Malaysia (30th worldwide, 0.396), Thailand (40th, 0.337), the Philippines (44th, 0.300) China (45th, 0.299), Indonesia (60th, 0.211) and India (63rd, 0.201). The U.N., like the Beijing government, considers Taiwan as a province of China, so UNDP did not give Taiwan its own score.

Thailand, Malaysia and the Philippines scored highly on their exports of technology products and poorly on the number of internet hosts. None of the Asian countries, with the exception of Japan and Korea, were granted patents at anything near the U.S. or European rates, suggesting that most Asian countries are still at the manufacturing rather than innovating stage of technology development. USA recorded the highest patents granted which stood at 98344 in 1993 compared to Japan at 88400 and Korea 11466 during the same year (WIPO, 2000). Malaysia granted a total of 1281 patents and Thailand granted 451 patents.

The disparity of ICT infrastructures between the developed economies and the developing economies in Asia Pacific region is shown in Figures 26.1-3. These figures present the

Table 26.1: Technology Achievement Index: Asia-Pacific

TAI Rank[a]	Level/Country	Telephones Lines (per 1,000 people) 1999	Internet Hosts (per 1,000 people) 2000	Cellular Mobile Subscribers (per 1,000 people) 1999	GDP per capita (PPP US$) 1999
	Leaders[b]				
4	Japan	558	49	449	24,898
5	Korea	438	4.8	500	15,712
100	Singapore	482	72.3	419	20,767
	Potential Leaders[c]				
24	Hong Kong, China (SAR)	576	33.6	636	22,090
30	Malaysia	203	2.4	137	8,209
	Dynamics Adopters[d]				
40	Thailand	86	1.6	38	6,132
44	Philippines	39	0.4	38	3,805
45	China	86	0.1	34	3,617
50	Iran	125	..	7	5,531
60	Indonesia	29	0.2	11	2,857
62	Sri Lanka	36	0.2	12	3,279
63	India	27	0.1	2	2,248
	Marginalised[e]				
65	Pakistan	22	0.1	2	1,834
69	Nepal	11	0.1	..	1,237
	Others				
	Bangladesh	3	0	1	1,483
	Bhutan	18	2.1	0	1,341
	Brunei	246	8	205	17,868
	Cambodia	3	..	8	1,361
	Fiji	101	0.9	29	4,799
	Lao People's Dem Rep	7	0	2	1,471
	Maldives	80	1.7	11	4,423
	Mongolia	39	0.1	13	1,711
	Myanmar	6	0	..	1,027
	Papua New Guinea	13	0.1	2	2,367
	Samoa (Western)	..	5.3	17	4,047

Note: a; Only 72 countries have been ranked. b: "Leaders" are at the cutting edge of technological innovation. c: "Potential leaders" have diffused old technologies widely but little innovation. d: "Dynamic adopters" have important hi-tech but diffusion of old technologies is incomplete e: "Marginalised' countries diffusion of even old technologies and skill building have a long way to go.

Source: Human Development Report, 2001

relationship between major ICT infrastructures (telephones lines, internet host and mobile cellular phones) and GDP per capita. As shown in the figures, the ICT infrastructures are positively correlated with GDP per capita. In other words, ICT infrastructures are well developed with higher GDP per capita. As shown in Figure 26.1, the telephone lines per

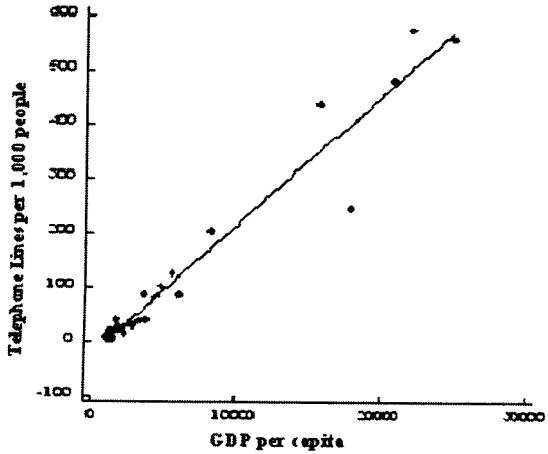

Figure 26.1: Telephone Lines with GDP per Capita in Asia Pacific, 2000

1000 people in most of the Asian economies were less than 200 per 1000 people. Advanced countries such as Japan show the distribution of telephone lines of about 558 per 1000 people. This is to be compared with 576 telephone lines per 1000 people in Hong Kong, 482 in Singapore and 438 in Korea.

The same is observed in the case of the relationship between internet hosts per 1000 people and GDP per capita. The highest is recorded by Singapore which registered 72.3 internet hosts per 1000 people. This is followed by Japan at 49, Hong Kong 33.6 and Korea 4.8. The internet hosts per 1000 population in Malaysia stood at 2 in the year 2000. Most of the developing economies are still behind in terms of this facility for their population.

The relationship between cellular mobile subscribers per 1000 population and GDP per capita is presented in Figure 26.3. Hong Kong registered the highest mobile subscriber per 1000 people i.e. at 636. This is to be compared to 137 subscriber per 1000 people in Malaysia and 36 in Sri Lanka and 12 in Indonesia. In terms of cost of 3 minutes local call (1990=100), it was found that Sri Lanka had the highest cost which stood at 137 in 1999, followed by Korea 94, Japan 91 and Laos 80. The cost of 3 minutes local call in Singapore was zero in 1999 and it was 44 in Malaysia.

The success of IT diffusion in the developed economies is not limited to the availability of the above infrastructure and infostructure. The other pre-requisites for a wider ICT diffusion are: telecommunication pricing, reliability of communication service and connections, infostructure market condition, interconnection and interoperability of networks and most important of all - non-ITC factors and services and distribution channels. The non-ITC factors include: IT literacy, marketing channels, product quality and specification and other logistics arrangement. These factors are of significant importance particularly for e-commerce and e-transaction adoption.

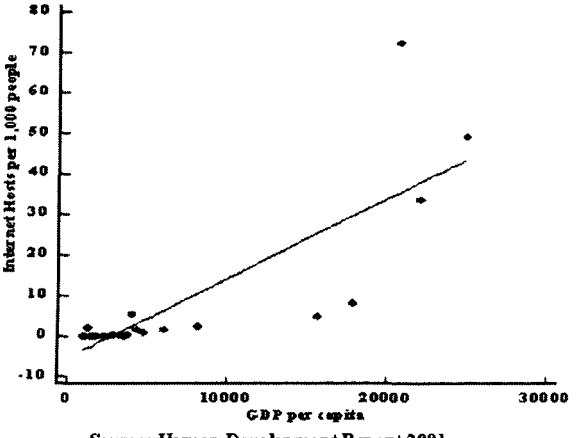

Figure 26.2: Internet Hosts with GDP per Capita in Asia Pacific, 2000

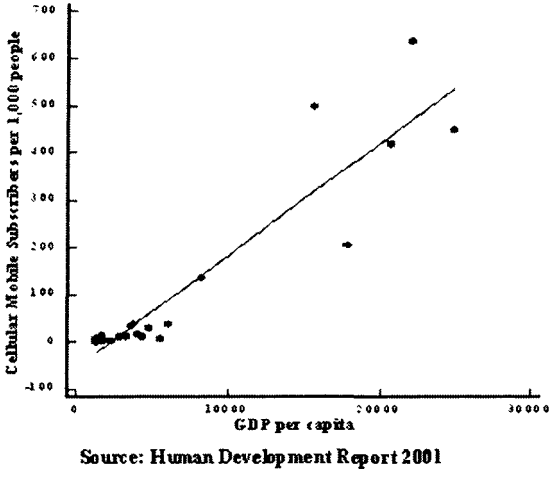

Figure 26.3: Cellular Mobile Subscribers with GDP per Capita in Asia Pacific, 2000

ICT Applications to Agricultural and Rural Development

Given the fact that ICTs are a generic technology, their potential applications to agriculture and to rural development are very extensive. ICT applications to agricultural and rural development can be analysed from two different perspectives (a) the agricultural and or/ rural development activity they influence, and (b) the nature of the service provided by the ICT (Chaparro, 1999). The interrelations of these two dimensions are depicted in Table 26.2 that defines an analytical matrix that helps to identify the most relevant ICT applications, and the functions they play in development.

Table 26.2: ICT Applications to Agricultural and Rural Development

Sectors of Application: Service provided	Research & Extension	Production & Extension	Marketing and Trade	Natural Resource Management	Rural Development & Community Action
Access to information and access to internet	-AIS: S&T Information RAIS & Meta databases -Open knowledge market places -Research software	-AIS available technologies -Techno-Economic Info -Farm management software	AIS: Market Info -Market information & marketing boards	-AIS: NRM topics -Sustainable agriculture indicators & minitor Integrating local wisdom (InterDev)	-Info on best practice -Internet community centres (telecentres) -Integrating local wisdom (InterDev)
Monitoring Nat. Resources & Environment/ Remote Sensors	-Development of GIS -Info on bio safety regulations	-Precision agriculture -Info on sustainable agric. -Technologies available -Assessment expansion agricultural frontier	-Information on trade flows -Info on environment regulation & trade	-GIS & NRM -Precision agriculture -Early warning system	-GIS & population -GIS & poverty
Educational & communication technology	-Farmer field schools -Training tools -Continuing education	-Distance learning programs for extension -Rural TV and radio Interactive multimedia & extension	-Info on IPRs and how to negotiate them -E-commerce and impact on trade	Distance -learning progs. on environment Rural TV & radio	-Integrated rural communication Rural TV & radio -Rural information centres
Networking	-Research networks -Electronic res. Networks -Virtual communities of researchers & extension	-Innovation networks -SME development networks	-Distribution networks -Market infos networks	-NRM networks	-Rural development networks -Participation research networks -Leadership development.
Decision support systems (DSS)	-Setting the agenda: DSS for R&D priorities and other research decisions	-DSS for production	-Market intelligence	-DSS for NRM	-DSS for community leaders DSS in development agencies
General objective	Empowering people through knowledge				

AIS: Agricultural Information Systems. RAIS: Regional Agricultural Information Systems
Source: GFAR (1999)

ICT applications can be analysed in terms of the agricultural and/or rural sectors and activities they influence (Table 26.2). These activities are:

a. Research and extension activities
b. Production and processing (primary and secondary)
c. Marketing and trade
d. Natural resource management and monitoring
e. Rural development

The following paragraphs discuss on conceptual basis the possible contribution of ICT on agriculture and wherever applicable, some brief analyses are made on the extent of ICT diffusion into the Malaysian economy in general and the agriculture sector in particular.

Impact of ICT on Research and Extension

The impact of ICT in agricultural research is through the following means. Firstly; the changing nature of agricultural information systems, which is having a profound impact on how research results are communicated and disseminated. With the development of web-based information systems, the possibility of accessing databases and information on-line has increased dramatically with the concomitant problems that is generating from the point of view of the confidentiality of the information and of the economics of information management (economic value of information). The rapid expansion of web publishing leads to the development of metadatabases, based on virtual libraries that provide direct access to the publication, wherever it is located, as long as the publication is accessible through the web. Weak linkages between researchers, frontline workers and farmers have been a major constraint that has resulted in research findings not being applied by poor rural farmers. ICT can improve and strengthen these linkages and ensure knowledge and information, which are essential for improving agricultural and food production, are communicated to all stakeholders.

Secondly, significant advances that are being made in software applications related to agricultural research techniques, coupled with advances in other areas of sciences are accelerating the research process enormously and making it much more efficient.

Thirdly, the emergence of a virtual network of researchers from various disciplines and institutions world wide has created a new paradigm for agricultural research for development. The social organisation of science of research is fast transforming towards interactive knowledge development process. The factors that contribute to this new paradigm are: presence of new actors in agricultural research (such as the private sector, NGOs and universities), the changing composition of the scientific fields related to agricultural research (increasing importance of molecular biology and ICT as compared with agronomy and veterinary), the changing nature of networking, the possibility of working jointly with researchers in different institutional locations by interacting with them in real time, the possibility of developing virtual communities of scholars working on the same topic but dispersed in space, and the increasing importance of knowledge systems and learning systems that are based on interactive knowledge development processes. All these phenomena affect

the organisation of research as well as changes in the relationship between research, education and extension.

The traditional linear relationship among these three functions is being replaced by dynamic interactive processes, based on knowledge systems that combine these three key functions in different and innovative ways.

Production and Processing

ICTs are affecting the production and processing in agriculture through the provision of information on available technologies, techno-economic information and farm management softwares. Unlike before, the producers are able to stay close to the latest development in production and processing techniques through the internet and electronic data bases and communication. ICT facilitates precision agriculture, provides information on sustainable agriculture technology and assessment expansion of agricultural frontier.

Marketing and Trade

The growth of the internet has led to a critical mass of consumers and firms participating in a global online market or e-commerce. The internet has been used as a commercial medium for transaction across the borderless world in computer-mediated environment. Farmers could promote their products and handle simple transactions such as orders over the web while payment transactions for the goods can then be handled off-line. It has been shown to be cheaper and faster to trade online than on paper-based medium, telephone or fax. Electronic-commerce could, therefore, enable entrepreneurs to access global market information and open up new regional and global markets that fetch better prices and increase farmers' earnings.

The rapid growth of internet usage has transformed marketing functions beyond as a medium of communication to a brand new market arena (Ricciuti, 1995). A new market means a new marketing paradigm - system, structure and functions. E-commerce is being defined as "business to vendors, to customers, to employees, and to suppliers via intranets, extranets and the web (internet)". The business processes and technologies include: electronic data interchange (EDI), electronic funds transfer, e-mail, security, electronic document management, workflow processing, middleware, bar coding, imaging, search and retrieval, agent-based computing, digital signatures, smart cards, voice response, and networking. Internet commerce covers both Business-to-Consumer (B2C) and Business to-Business (B2B) transactions, and it is not limited to the purchase of a product.

In the Asian region, Malaysia ranks seventh in terms of the number of internet hosts after Singapore, Israel, Hong Kong, Korea, Taiwan and Japan. Mynic (2002) reported that the number of .COM servers in Malaysia has increased significantly from 100 in 1995 to 10 048 in 2000 and reduced to 7372 in 2002. These .COM servers account for nearly 94% of the total servers in the country. IDC Market Research (M) Sdn Bhd estimates that the current number of Malaysians internet users is about 1.26 million, and is likely to reach more than 3 million by end of 2003. By 2004, it estimates that the number of users should approach 4

Table 26.3: Internet Buyers in Malaysia, 1997-2003 (mn)

Type of User	1997	1998	1999	2000	2001	2002	2003
Home WWW Buyers	0.01	0.01	0.03	0.06	0.13	0.27	0.55
Small Bus. WWW Buyers	0.00	0.01	0.03	0.05	0.10	0.14	0.20
Medium/Large Bus. WWW Buyers	0.01	0.02	0.05	0.07	0.13	0.20	0.31
Govt. WWW Buyers	0.00	0.01	0.02	0.03	0.07	0.10	0.16
Edu. WWW Buyers	0.00	0.01	0.02	0.03	0.07	0.10	0.16
Total WWW Buyers (Adjusted)*	0.02	0.05	0.10	0.18	0.34	0.53	0.87

Source: International Data Corporation, 1999
* Adjusted means taking into account the overlap of business users who are home users and not double-counting them.

Table 26.4: Internet Commerce Revenue in Malaysia, 1997-2003

Year	I-Commerce Revenue/Yr (USD mn)
1997	6.31
1998	18.01
1999	49.29
2000	126.91
2001	308.80
2002	704.21
2003	1,572.62

Source: International Data Corporation, 1999

million. Malaysia accounts for about 1.2% of the total Internet population in the Asia-Pacific Rim which is relatively small compared to 49.5% (USA), 18% (Australia) and 14% (Singapore). In 1998, Malaysian spent about RM57mn on e-commerce purchases; a small figure relative to her GDP of RM372bn. There is no statistics available on the extent of e-agribusiness trade in Malaysia.

IDC estimates that the number of internet buyers in Malaysia will increase from 0.1 mn to 0.87 mn in 2003 (Table 26.3). The majority of buyers are expected to come from the home buyer sector, followed by the small-business buyers (22.9%) and medium/large, government and educational buyers with each accounting for 18.3 per cent. The internet revenue is expected to reach USD1.5 mn year 2003 (Table 26.4). Despite the launching of various programmes particularly the MSC (Multimedia Super Corridor) and other incentives, the success has been limited.

The sluggish performance could be attributed to its embryonic stage and a combination of socio-economic constraints. For instance, it is cited that e-commerce has not taken off because firstly, the country has not achieved a critical mass of local internet buyers. Secondly, the current logistics arrangement is not corollary to the needs of e-commerce paradigm (Fatimah, 1999). Besides an enabling policy environment, merchandise e-commerce requires

complementary physical infrastructure, notably a logistics system capable of timely, secure, and affordable small batch shipping to multiple destinations. Thirdly, local consumers are not receptive to the drastic change in buying and selling method - from physical transaction to a virtual or online mode. Fourthly, the firms are generally not ready to shift to electronic dealings and trading due to lack of understanding of the technology and expertise in this area (Fatimah and Kusairi, 2000). Fifthly, there is serious scepticism on the issues of security, privacy and governance both from the perspectives of both firms and consumers.

Electronic commodity trading floors are also an important development in agricultural e-commerce. Electronic transactions could be more liquid and efficient than traditional markets because geographic boundaries are eliminated and the potential number of users could increase. It also improves the price discovery process for market participants. Although most agricultural grain markets (futures contract in particular) in the west have long been established and highly efficient, electronic marketing in agricultural produce could enhance the information flow through agricultural markets. Electronic marketing in agricultural produce in Malaysia is limited to palm oil futures through the formulation of KLCE (Kuala Lumpur Commodity Exchange) in 1987 which now has been integrated with other financial derivatives under one exchange called Malaysian Derivatives Exchange (MDEX). ICTs are very crucial in futures trading of palm oil which is global in coverage. The recent addition of electronic marketing is ePOH which will provide an electronic exchange and hub for palm oil products trading across international boundaries. ePOMEX has been introduced to provide electronic marketing for palm oil products in the domestic markets. These trades are subjected to the rules and regulations of the Malaysian market. Unlike other agricultural produce in Malaysia, palm oil products are global in nature i.e. they are being traded worldwide in large quantities and are subjected to reliable grades and specifications which make transactions meaningful. Since the website is still new, it is too early to conclude on the success of electronic marketing of palm oil products at this juncture. The electronic trading of palm oil futures, however, has been successful in terms of liquidity and quantity.

Impact of ICT on Rural and Community Development

ICT has also a profound impact on rural and community development. ICT applications and the internet have the potentials to establish vertical and horizontal channels of communication to the rural community in order to increase their capacity to generate and use knowledge, and thus increase the effectiveness of their development efforts. The flow of information and knowledge among rural people can be enhanced through: firstly, providing access by farmers and other end-users to the information resources that exist in the internet or in other locations. Secondly, to empower these organisations by strengthening their capacity to enter in dialogue and exchange information among themselves, and with researchers and policy-makers beyond rural communities, on how best to cope with their needs and improve the effectiveness of their action. Thirdly, the integration of modern scientific knowledge with traditional knowledge or local culture, through a two-way flow of information and knowledge that allows to capture *live or uncodified knowledge* at the grassroots integrating it into the existing pool of knowledge available to other users (Gret, 1999).

Experiences of a number of projects of integrating the rural community to the outside world and to the world of science through the internet reveal interesting results which can be used as lessons for Malaysia. It was found that the sustainability of the project hinges on factors like: the degree of appropriation of the project by the local community and the stakeholders and the need for a proper scaling-up or extrapolating from the successful cases if the projects were to be replicated onto other areas.

Nature of the Services Offered by the ICT Application

ICT contributes towards enhancing the performance of major functions in the agriculture sector (Chaparro, 1999). These functions are closely related to ICT applications:

1. *Access to information* through different types of Agricultural Information Systems (AIS). A specific subset of these is the Management Information Systems (MIS).
2. *Monitoring the situation of natural resources and of environmental impact* through different information-processing tools (i.e. analysis of environment deterioration, soil erosion, deforestation, etc.).
3. *Education and Communication Technologies* that are playing a very important role in generating new approaches to learning and to knowledge management.
4. *Networking:* ICT enable the creation of *Virtual Communities of Stakeholders* comprising people/institutions/community to exchange information and knowledge among themselves. Under the current Information Age , networking is a first step in the direction of developing *interactive knowledge development processes* that may lead to learning networks.
5. *Decision-support Systems (DSS):* Tools and practices through which data and information provide relevant knowledge inputs for *informed decision-making.* These tools are playing an important role in converting *information systems* into *knowledge systems.*

Agricultural Information Systems

Agricultural Information Systems (AIS) is the most-widely spread service based on ICT applications. The information component covers both scientific and technological information (generated by research), as well as socio-economic data, market information and environment management information. The purpose of Agricultural Information Systems (AIS) is that of facilitating central access to information that is localized in decentralized databases. The AIS is thus constituted by a *system of interrelated databases and information services,* that seeks to respond to the information needs of the various types of end-users (Harsh *et al.,* 1996).

There are three different categories of information systems; (1)°local, corporate (institutional) and/or community—level information systems; (2)°National/Regional Agricultural Information Systems; and (3)°international databases and/or global networks with information facilities. All the above can be accessed via online through the web if the document is published on the web. Malaysia has implemented Taninet, an internet-based platform to provide the farming community access and sharing of information and farming practices.

The effectiveness of the project, however, is hampered by the low rate of IT literacy among the farming community and the content orientation (Deraman and Shamsul Bahar, 2000).

The web-based information systems are leading to the concept of *virtual meta-databases* that function as a gateway to the information resources that are located in a given region. Examples of virtual databases include information resources in FAO, CGIAR and CABI.

Monitoring the Situation of Natural Resources and of Environmental Impact

The contribution of ICT in the natural resource management is through the development of GIS, provision of information on biosafety regulation, early warning system and precision agriculture. This information is easily accessible by the industry participants and policy makers, which facilitates efforts towards achieving sustainable agriculture development.

Networking: Changing Patterns of Research Organization

Networks are necessary to bring together research efforts and in facilitating joint research efforts. A *network* can be visualised as an association of individuals or institutions with a shared purpose or goal, that participate in two-way exchanges of information and, in many cases, in collective efforts to achieve the shared objectives. The nature of networking, however, varies in terms of the institutional set up.

A study carried out by Donald *et al.* (1998) on the development of networks among agricultural researchers has indicated drastic changes in the method and arrangement of networking. The changes observed are:

a. The science-base for agricultural research has broadened, with the spectacular development of molecular biology and other areas of science and the growing importance of ICT applications in agricultural studies.
b. Network structure has changed as immediate connectivity is now feasible, i.e. the velocity of the circulation and exchange of knowledge among its members has increased dramatically through the electronic networks.
c. The capacity and amount of information and knowledge disseminated within a network have increased exponentially, given their improved information management capacity through ICT applications and through improved knowledge management skills.
d. ICT enables joint research efforts through cyberspace, given the possibility of interaction among researchers in real time, making it possible to pool the research capacities that are located in different research institutions.
e. ICT enables *interactive knowledge development* in real time. Online dialogue allows not only exchange of knowledge, but also creates new knowledge from the interaction of different knowledge sources.
f. ICT makes it possible for an integration of modern scientific knowledge with the traditional knowledge of the rural people, hence generating an empowering process through the dialogue and exchange of knowledge among practitioners of development.

It was also observed that for effective development-impact one needs to develop closer links between the researcher, the extensionist and the farmer, leading to the need to develop

innovative networks or knowledge systems based on interactive learning and knowledge development processes that take place through the interaction among these various actors (Chaparro, 1999). These types of networks create *knowledge systems* or innovation *systems* that are based on a different approach to the interaction between agricultural education, research, extension and innovation (Engelhard, 1999).

Decision Support Systems

Decision support systems supply information to the decision maker, enhance their knowledge and build wisdom. The components of DSS include data, model base, data base management system, user interface and decision maker. In agriculture, decision support systems have been developed for the diagnosis of plant diseases (Michalski *et al.*, 1982), crop production (Smith *et al.*, 1985), analysing marketing alternatives (Uhrig *et al.*, 1986), selection of appropriate crop cultivars (Bolte *et al.*, 1990), and many others. Sound decision- making is dependent upon availability of comprehensive, timely and up-to-date information. For instance, food security problems facing developing countries demonstrate the need for informed researchers, planners, policy makers, development workers and farmers. Information is also needed to facilitate the development and implementation of food security policies. E-mail and the internet could be used to transmit information to and from rural inaccessible areas

Malaysian Case Study: TaniNet

TaniNet is an internet-based project aims at enabling the Malaysian agricultural community to use the internet as a tool for communication and as a place to share information on agriculture and biotechnology. It attempts to attract Malaysian farmers to use the internet by providing them with valuable agricultural information online (Deraman and Shamsul, 2000). This section provides an evaluation of the TaniNet project performance in terms of page-hit rate, number of queries and number of personalised services.[1]

The TaniNet project was launched in 1999. It is basically an information service toolset. One of the main objectives of this project is introduce the Malaysian rural farming community to agricultural biotechnology through an interactive internet-based service both in English and the Malaysian native language, Bahasa Melayu. Other objectives include:

1. to provide on line information and services on agriculture and biotechnology
2. to increase local understanding of agricultural biotechnology and local applications of new technology
3. to provide a forum for discussion among the rural farming communities through a managed bulletin board and chat room
4. to provide searchable information on agricultural biotechnology
5. to provide access to expert advise and trouble shooting related to agricultural problems via the internet

[1] This section is based on a paper written by Deraman and Shamsul Bahar (2000).

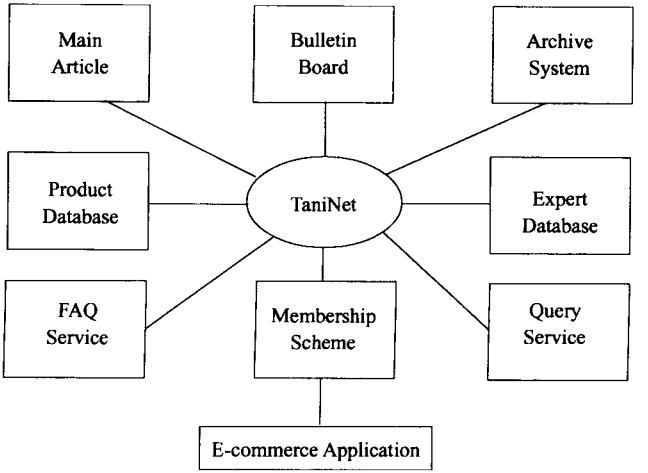

Figure 26.4: TaniNet Software Engine Structure

6. to educate the community how to use internet to access important and useful information and service.

In the long term, TaniNet is expected to hold up-to-date knowledge on agricultural products and experts available within the agricultural community. Finally, TaniNet is also aimed at providing commercial services in order to self-finance its existence. For this. TaniNet is supported with various applications within e-commerce services. The software engine structure of TaniNet is depicted in Figure 26.4. As an ordinary website, TaniNet is equipped with the normal set of facilities such as articles on agricultural related topics with the support of an archiving system, bulletin board system, query and FAQ services and directory. The event-based structure provides an online survey and site visits activities that are planned periodically to get up-to-date information from the farming community.

The Main Article refers to the main article of the TaniNet homepage. It focuses on some agricultural related topics of interest such as on agricultural commodities, services and technologies. BBS is designed to provide an interactive communication where messages can be posted and replied. Message posted can be in the form of text, image or voice. The bulletin board also consists of three other sub components: advertisements, current events and queries. Online survey provides one way of obtaining information that can be used to improve services offered by TaniNet. A membership scheme has been devised to maintain a core of committed TaniNet users while an archive system provides the repository for materials such as articles. Expert Database is a database of information about experts in various aspects of agriculture. TaniNet homepage incorporates a link to a search engine. The search engine is designed to retrieve information from the current edition of the home page as well as from the archive system.

The socio-economic profile of the farming community suggests the following characteristics: About 84 per cent of the farmers interviewed have attained at least primary education. Farmers are accessible to agriculture information from agriculture institutions such as the Department of Agriculture, mass media, Farmers Organisation and so on. Only 15 per cent of the 607 farmers interviewed owned computers and only 20 per cent of the farmers know how to use the computer. These findings suggest that majority of farmers are barely educated, i.e. most of them received only primary education, which is not enough to acquire IT skill. Secondly, the computer literacy among farmers is still very low to prepare them to participate in the ICT-enabled communication or linkages.

The performance indicators of the project are measured using measurements like hit rates, number of online surveys, number of queries, number of membership applications and number of business transactions.

In terms of hit count, a cumulative total of nearly 17874 was recorded in November 2000. As at 18 August 2002, the total number of hits was 58885. Another attribute is the number of online survey respondents (TaniNet Survey, 2000). In September 2000, the cumulative number of respondents was 332. The number of queries posted can be also used to gauge the performance of TaniNet. By November 2000, TaniNet had received 234 queries regarding various agricultural issues. In terms of membership, a total of 2042 members have registered with TaniNet. A total of 94% of those registered were local. A total of 30 companies have already placed their advertisements in TaniNet, but only five internet orders have been executed. This suggests that the B2C portion of TaniNet was not well accepted.

After almost four years of existence, the progress of this internet communication system for the Malaysian agricultural community has not progressed as expected. A preliminary content evaluation of the website at *www.taninet.com.my* indicates that the contents of the site are very minimal and some of the components such as e-commerce, discussion, bulletin board are not functioning. The number of agricultural companies advertised in the TaniNet is less than 20. The two major possible explanations for the lacklustre performance of TaniNet include: poor project and content management. In terms of project management, it is said that the project suffered some financial constraint in ensuring the financial sustainability of the website. In the early stage of development, no charges were made on advertising and queries. Probably, for future viability, the project has to consider imposing charges for advertisements to obtain some financial support for the project.

In terms of content, there is a need to identify further the actual users of the site in order to determine their content preference and willingness to pay for such content. At the moment, it appears that the content or information available tends to be general in nature or not problem or target group specific. A good data base on the profile of the users, their agricultural activities and their information preferences are important in determining the right content to suit their needs.

As concluded by Deraman and Shahrul (2000), the training programme is a vital event in promoting IT in community development. Computer literacy among farmers is very low

particularly among the old farmers. Hence, aggressive training targeting the young farmers is deemed necessary to prepare them to enter the internet age.

Constraints in Community-based ICT projects

The application of ICT into agriculture world wide is still limited relative to the applications in the industrial and business sectors. Even in the agriculture e-commerce sector in USA, according to Morehart and Hopkin (1999), only four per cent of all farms bought and sold online in 1999 and online activity was positively related to farm size. Farm operators that bought and sold online tend to be younger and more educated. A study made by Ehmke (1999) indicate that about half of the Ohio agribusiness community were in favour of e-commerce, with half reporting to have a website and 26% reporting that their suppliers have requested that their inventory records be available to them via online.

In Finland, it has been shown that despite several promotional projects and the wide range of services and material available, use of the internet in agribusiness has not come up to expectations, and is low compared with the technology's perceived potential and with use of the internet in other business branches. According to Ofversten et al. (1998), some 50% of 84 000 farmers in Finland have a PC, half of which are used for business-related purposes. The main applications are bookkeeping, payrolls, invoicing and other aspects of farm economics. They also access agricultural data and market reports. Only 20 per cent of Finnish farmers have experience of use of the internet, yet only 10 per cent have tried using it for business-related purposes, and less than 4 per cent use it regularly in their practical work. Gelb *et al.,* (1999) indicated that the factors that hindered a rapid adoption of IT among farmers in the EU were: inability to use IT, no perceived benefits – economic and others, technology is not user friendly and IT infrastructure. Ramstadius (1998) found that two key factors affecting customers' satisfaction were reliability and the currency of the information provided. Other factors include the perceived added value provided to the farmers' businesses, availability and technical accessibility, versatility, stability and continuity of the services.

Most of the studies on the use of the internet in agribusiness and farm sectors conclude that current internet services have not yet broken down the social and cultural barriers preventing the agribusiness firms from exploiting the full potential of this new technology. More attention should be paid to overcoming the agro-industry's natural reluctance to adopt new technological tools. The focus must be on simple services, close co-operation between users and service designers, promotion of the technology and services on all possible occasions, and continuous training of farmers and other rural people. There is also a need for tailored internet services for coherent user groups. Moreover, as in any business, it is the task of the service producer to identify the real business needs of the potential interest groups, then design the services to meet these needs, and finally lure the potential users to use them.

The above discussion suggests that application of ICT in agriculture generally has not been to the optimal level. There is a clear gap between the potential benefits of ICT and the perceived benefits from the farmers and agribusiness community in general. The situation is expected to be more serious in the developing economies. The following paragraphs

provide a brief review of the problems that have been experienced in the establishment and management of ICT projects in a number of developing countries which include:

Policy Consideration

In most developing countries, the ICT policy is still rudimentary and calls for an integrated set of laws, regulation and guidelines that are required to shape the generation, acquisition and utilisation of ICT. Most countries lack policies and strategies that facilitate the harnessing of new ICTs for rural development. Besides, proper implementation plans are needed.

Some ICT developments in some developing countries are hampered by the high communication costs. Although market liberalisation has led to the entry of several private sector ISPs, service provision is through government phone companies, whose service is inadequate in terms of robustness, low bandwidth, congestion and noisy lines. Some countries are charging high rates for calls to ISPs in USA or Europe. Hence, the cost of basic internet remains a strong deterrent in many developing countries such as India, Sri Lanka, Fiji and Bangladesh.

The ICT infrastructure in developing economies is lacking and poorly developed in rural areas. The urban cities are equipped with satellite and wireless technologies but in the rural areas there are problems of low bandwidth and there is a need for strengthening the internet backbone.

The rural and the agricultural community in the developing economies are not provided enough and appropriate content that supports their needs and requirement particularly the local content. Information available through ICT is mostly in English which is not the language of the rural communities in general. There is a marked shortage of relevant material in local languages that satisfy their needs. Special emphasis could be placed on developing and disseminating local content, i.e. improving the relevance of the information to local development, as well as capturing and auditing all relevant local resources using ICT. Resources produced should involve the participation of local communities and be packaged in local languages, to make the services offered more valuable and accessible

Despite the technological revolution that has swept the globe, the rural communities in developing countries are generally illiterate, and hence their computer literacy is very low. This means that these individuals are disadvantaged and lack the basic skills required to harness the benefits of ICT. One major constraint for market signals initiatives in rural areas is weak institutional capacity and insufficient co-ordination. Non-governmental organisations and the private sector in particular possess a vast but often untapped potential. Clearly, a smart partnership between the government, private sector and the community themselves are needed to ensure proper coordination and capacity building. The partnership could also assist with building the required human and institutional capacities at national and regional level to provide training and education to rural communities on how to manage local knowledge and information, using ICT.

The IT revolution seems to favour men although women are the major labour force in producing world food. ICT appears to be the domain for men, and women have often been left out of initiatives associated with new ICT. Women face many problems in addressing food production and rural development. These include weak extension services, non-adoption of technologies, low status and therefore non-involvement in decision and policy-making, varied and heavy workload, poor access to credits and lack in access to education and training. Training these women with ICT will help improve their welfare and hence have a greater impact on increasing agricultural productivity and quality of life. The other group of population that deserves intensive training is the youth as they make up a larger portion of the developing economies. In short, women, youth and the disabled should be integrated into all ICT projects and initiatives through gender-sensitive project development and implementation. Only through these means, a critical mass of information-aware people can be created to reap the full scale benefits of ICT.

Developing economies are still plagued with inadequate human resources in the ICT sector to pave way for the creation of critical mass of people that effectively harness ICT application. Users of ICT have to be trained in the use, application and maintenance of ICT. HRD policies have to be geared towards producing more engineers and other ICT-related professionals. In 1993, the number of scientist per mn population in the USA was 3732 while in Japan it was 6300. These figures are to be compared to 87 in Malaysia, 119 in Thailand and 181 in Indonesia.

As proven in the case of TaniNet in Malaysia, the sustainability of the project is a serious issue. Most projects established with external funding face major challenges after the project period has ended. The project should receive support from the government, private sector and community in order to sustain its existence.

Conclusion

The above paragraphs provide a brief overview of the potential roles and contribution of ICT in the agriculture sector in general. It is clear that the ICT revolution has not only improved the traditional network of information dissemination and exchange, but it has also created a new paradigm in almost all aspects of agricultural sector development such as research, business, marketing and trade, networking, knowledge system and social integration. As indicated earlier, the ICT has revolutionised the communication method, which redefines the processes, functions and activities in agriculture. ICT has the potentials and in fact been proven to improve the following agricultural activities research and extension, production and processing, marketing and trade, natural resource management and rural development in the developed economies. The emergence of new structures in agricultural institutions and processes is expected to increase value added and competitiveness. These emerging traits include: wider network for researchers, extension agents and practitioners, rapid exchange and dissemination of knowledge, borderless trade and commerce and integration of scientific knowledge to the rural community. In short, the ICT revolution is empowering the industry participants through knowledge.

However, to reap the full benefits of the ICT revolution, the country needs to address the main impediments to digital economy. The main challenges we confront are not the technological constraints, such as access to the web. Technology is only one dimension of the problem. The main challenges we confront are more of an institutional, organisational and a socio-cultural nature. The agenda for ICT applications in agriculture includes the following: Improvement in infrastructure and infostructure, conducive policy toward ICT application in agriculture, better marketing logistics, competitive telecommunication sector, capacity building, improving IT literacy and tailoring the ICT application according to the needs of the rural community both in design, architecture and content.

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