Role of information technology in agriculture

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Abstract

This paper highlights the issues related to the role of information technology (IT) in agriculture with emphasis on developing countries, especially Africa and Tanzania in particular. It summarises the importance of information in generating and disseminating agricultural technologies, identifies categories of users as well as the forms and means of information dissemination. The paper further focuses on current developments in information technology covering various IT devices and their applications in information management. The paper also outlines the current initiatives to improve information infrastructure in Africa together with ongoing projects in Tanzania, which aim at facilitating agricultural development through application of information technology. Finally, the paper gives a list of policy statements on agricultural information issues as extracted from the current Agricultural and Livestock Policy of Tanzania.

Introduction

Agricultural Sector, Agricultural Information and Information Technology

The agricultural sector plays a predominant role in economies of many developing countries. In Tanzania, for example, the sector contributes about 50% of the country's GDP, generating more than 60% of total export earnings and more than 80% of the labour force. Besides, the agricultural sector provides the bulk of the Tanzania's food requirements and raw materials for domestic agro-industries. Agriculture is also the single main determinant of the incomes and welfare of the rural majority; thus is holds the key to the socio-economic development of Tanzania. In that connection, constraints on agricultural development can constitute great obstacles to the country's development.

The vast store of information on agriculture has been built up in the world over many years with the ultimate aim of increasing agricultural production. Therefore, improved information flows to-, from-, and within the agricultural sector is a prerequisite for effective agricultural development. Investing in information technology can facilitate effective flow of information in all sectors of the economy. Information technology (IT) can broadly be defined as the science or practice of collecting, storing, using and sending out information by means of computer systems and telecommunications (Longman Dictionary of Contemporary English). Moreover, the combination of old and new information and communication technologies of broadcasting, telecommunications, the Internet, CD-ROM, satellite and cable have created abundant applications of IT to facilitate access to information.

Information and communication (i.e. transfer or convey of information) together with the associated technology go together in the whole process of ensuring access to the required information for various users

hence the popular acronym, ICT (information and communication technologies).
To sum up, the need for information on agriculture is derived from the following crucial factors:

- The critical role of agriculture in economic and social development in most developing countries
- Associated issues of food security and welfare
- The need to increase yields
- The need to improve quality
- The need to avoid costly mistakes

Who needs information on agriculture?

Various categories of users or clients require information so as to carry out their activities effectively. These clients range from senior government officials to the small holder farmers or from the chief executive of a cooperative society to a group of NGOs. These may need different information in different forms or media. The role of information professionals in this case is to match clients' needs with the right information, in the right form, and at the right time.

The main users of agricultural information include the following: researchers and research managers, extension workers (technology transfer agents including NGOs), farmers, policy makers, trainers, consultants, bankers and the business community as a whole. In this account, I shall highlight more on the importance of information for agricultural researchers (generators of agricultural technologies for development) and for farmers (applicators of agricultural technology for development). However, information is of vital importance to the other users mentioned above; for instance;

- **Extensionists** need information to keep abreast of new agricultural technological developments and to produce extension materials for the end users.
- **Research managers** need management information to monitor and evaluate research activities and make sound decisions on research programmes
- **Policy makers** need information to assist government in making sound judgements and correct decisions.
- **Trainers** need information to update their subject knowledge.
- **Agricultural consultants** need information so as to give sound advice to their clients.

Role of information in agricultural research system

Information is a necessary input in the research process in the sense that a researcher must have access to previously recorded knowledge (i.e. information) about the researcher's area of investigation. This knowledge helps the researcher to choose appropriate research topic and gives the researcher standards to compare and judge the quality of work. Further, it offers various methodologies and techniques to appropriately select and address problems facing the farming communities and develop appropriate agricultural technological packages.

Information input to research process also enables researchers to avoid repetition of what has already been done elsewhere and thus save time and other scarce resources, as well as sustaining professional reputation of researchers.

Information is also the major output of research process in form of recorded research results and their dissemination to various users. If research results are not recorded and disseminated, then research loses its validity. Thus, improved information flow to-, from-, and between researchers is necessary for effective re-

search system, which in turn is a prerequisite for agricultural development.

There are, therefore, two sides related to agricultural information:
a) the input, and (b) the output of information to and from the agricultural research process.

Scientific Information

The scientific information required by researchers is largely held in primary and secondary scientific journals (printed and electronic forms), books, newsletters, bibliographic databases in electronic media or printed forms, reviews and other sources. Researchers access scientific information via libraries/documentation centres, national, regional and international networks, and various forms of interpersonal exchange of ideas. Access to scientific information via telecommunications is also very common nowadays e.g. Internet/www, e-mail, fax, television, radio and telephone.

Dissemination of Research Results in Tanzania

Dissemination of research results is vital to ensure that technologies developed from research activities reach the end users for application to improve agricultural production. Researchers need to report results of their work for the following categories of users:

- scientific community at large in order for the results to be evaluated and included in the permanent store of scientific knowledge.
- officials of the government ministry that has provided funds for the research activities, and on whose goodwill the institute will depend for future finding (this might also be a donor agency).
- technology transfer agents and the farming community who might employ the results to improve agricultural production.

The main avenues used in Tanzania to disseminate research results include reports, newsletters, handbooks, conference proceedings, meetings, field/farmers' days, demonstration/on-farm trials, agricultural shows, radio programmes and scientific journals (MALDC 1991, Kaaya 1999).

Reports

All research institutes are supposed to produce quarterly and annual reports in which, apart from the administrative issues of the respective institutes, major research activities undertaken during the period under review are incorporated into the reports as they are the main outlets for information dissemination in Tanzania.

Newsletters

There are several agricultural-related newsletters produced by different institutions in Tanzania to serve as channels for information dissemination but only few of them are widely distributed. One of them is *Research and Training Newsletter*, published quarterly by the Division of Research and Development of the Ministry of Agriculture and Cooperatives (MACs) which is meant for a broad audience including researchers, extensionists and even farmers. Another newsletter, *Extension Newsletter* is published bimonthly the MAC's Extension Services Section. The same section publishes a Kiswahili bimonthly magazine entitled *Ukulima wa Kisasa*. Recently, the Northern Research Zone has launched a newsletter, the *Northern Link* aiming at informing the scientists and other stakeholders of the research activities, and serving as a medium of communication and exchange of experience between those who are involved in agricultural research and extension in Kilimanjaro and Arusha regions. Our scientists contribute articles to all these news-

letters. Besides, different directorates and departments at SUA produce in-house newsletters related to their areas of activities.

Research Meetings

One of the major mechanisms of information dissemination within our NARS is a series of the zonal internal programme review meetings. At these meetings researchers from different research programmes present current year's progress reports and project proposals for the next year's research activities. These presentations are scrutinized and approved by participants who include all stakeholders of the research system (researchers, extensionists, commercial agro-industry representatives, NGOs, marketing boards, etc.). A lot of information is also exchanged informally amongst the participants at these meetings.

Handbooks and Proceedings

The Tanzanian national agricultural research system produces technical manuals to guide farmers and extensionists on crop and livestock husbandry techniques. Some of the handbooks are written in Kiswahili. Also, agricultural scientists are normally asked to prepare and present papers at local and international conferences and these often result in published proceedings. These include annual proceedings of professional societies.

Field Days

Another fruitful means of disseminating information is via farmers/field days, which are organized annually by the various research institutes, particularly those under the DRD. Farmers of different categories, extension agents and political leaders are invited at the research centers where they see at first hand the experiments being carried out to solve agricultural production problems through application of improved technologies. In addition, during these annual events farmers and other participants exchange ideas with scientists through questions and answers related to their agricultural activities. In doing so scientists obtain direct feed back from farmers, extensionists and politicians relating to research work taking place at the research centres and on how the technologies developed can benefit the farmer.

On-farm Trials and Demonstrations

On farm trials and demonstrations are also important means of information dissemination. In Tanzania the adoption of adaptive research approach has encouraged a range of on-farm and demonstration trials such as researcher-managed on-station demonstration trials, researcher/extensionist-supervised on-farm trials and extension-supervised farmer-managed trials. A number of NGOs, notably Sasakawa Global 2000, have played a major role in transferring improved technologies to improve production through on-farm extension-supervised trials.

Agricultural Shows

Agricultural shows also contribute to the dissemination of information in Tanzania. An example is the one organised annually by the Tanzania Agricultural Society in the northern town of Arusha which attracts many farmers.

Radio Programmes

There are a number of radio programmes aired on Radio Tanzania Dar es Salaam meant for disseminating agricultural related information to the farming (mostly rural) community. For example, there are four programmes per week on 'modern farming' (three for 15 minutes each and one for 30 minutes), organized by the Ministry of Agriculture's Farmers Education and Publicity Unit (FEPU).

International Journals

Some scientists in Tanzania get chances of publishing their findings in international journals. However, until recently, not all scientists had access to such journals. Fortunately, a national journal of agricultural sciences was launched in 1998 to foster the science of agriculture and to provide a leading source of information and knowledge in all fields of agriculture.

Information as a vital resource for farmers

Farmers need information on generated technologies from the research system to apply them for agricultural production. The generated technologies may include optimal planting and harvesting times, appropriate methods of pest and disease control, appropriate soil erosion control measures, processing and storage methods, and so on.

Farmers also need marketing information so as to make appropriate decisions on where to sell their farm produce. Marketing information has a major effect on whether a farmer's production is profitable or not. This kind of information not only helps farmers make profitable decisions in the short term on when and where to market produce and what price to expect, it also sometimes helps farmers decide what to produce. Farmers who understand market trends and market opportunities have a better chance of succeeding than those who do not. The businesspersons or dealers have usually much better access to market information than our small-scale farmers they buy from do. It is thus common for farmers to end up bearing the greater low-price risks while the dealers end up with the greater part of the profits.

Current developments in information technology

Information technology offers many opportunities for improving agricultural production in developing countries due to increased possibilities for faster and better-focused access to information, its transfer and communication between different users. Microcomputers and telecommunications, in particular, together with associated electronic networks and digital storage and transfer, are having an increasing impact on the handling of information worldwide. Recent revolutionary advancements in ICT have further resulted in dramatic falls in the cost of processing and transmitting information.

Microcomputers

Microcomputers are effective for rapid handling and huge storage capacities; as such they are used to build and retrieve bibliographic and full-text databases, transfer or import data to from external sources, managing catalogues of volumes of documents in agricultural information centres, and many other functions. The use of microcomputers goes hand in hand with the adoption and use of function-oriented software. The agricultural information systems of many developing countries have adopted the UNESCO's micro-CDS-ISIS for developing local databases. The FAO-coordinated international information exchange systems, i.e. AGRIS (International Information System for Agricultural Sciences and Technology) and CARIS (Current Agricultural Information System) are based on CDS-ISIS.

The Compact Disc Read Only Memory (CD-ROM)

The CD-ROM is an optical storage medium allowing storage of text, graphics and images. The CD-ROM technology has improved access to agricultural information in Africa as the discs can easily be mailed to remote areas and are non-dependent on telecommunications. Further, one of the advantages of CD-ROMS is their high storage capacity (one CD can store the information equivalent to

250,000 printed pages of text), they are durable, standardized and are resistant to magnetic fields or electric current. Major agricultural information providers in the world have produced their information products in CD-ROMs. These include CAB-International (CAB-CDs), US-National Agricultural Library (AGRICOLA), FAO (AGRIS), the Royal Tropical Institute, KIT (TROPAG & RURAL), CIRAD (Sesame), and others.

Recent developments have witnessed production The Essential Electronic Agricultural Library (TEEAL) on CD-ROM. This is a complete text images of 130 of the core journals in the world covering the period 1993-96 (650,000 pages on 100 compact disks). The product is the result of cooperation between the Rockefeller Foundation, Cornell University in the US and leading scientific publishers.

Desktop Publishing (DTP)

The DTP technology incorporates the use of computers and facilities for typesetting, graphics design and document production. Many DTP software allow simple or complex operation that may result in the production of such publications as newsletters, leaflets, brochures and books. With good-quality printers and photocopiers, many agricultural institutions have been able to produce quality in-house publications.

Telecommunications

The telecommunications is the backbone of the ICT services and applications, and it has been established that the density of telephone lines has a direct and positive correlation to economic development (Dandjinou 1992, ECA 1999c). However, the telecommunications infrastructure in most African countries is generally poor with only 2% of the world's telephone and an average teledensity of less than 2 per 100 inhabitants. Besides, 50% of the available lines are concentrated in the capital cities where only 10% of the population live (Jensen 1999). Efforts are underway to expand and modernize telecommunication networks in many African countries and the number of main lines is currently growing at 10% per year, although much of the growth is in the urban areas.

Traditional information technologies such as wired telephones fail to reach the majority of the rural population in the developing world. This is because wires are expensive to buy and to maintain. Satellite-based wireless phones can be an appropriate option (Pinstrup-Andersen *et. al.*, 1999). Meanwhile, recent decreases in the cost of solar panels and wind energy make it possible for the rural population to provide power for effective use of information technology viz. cell phones, radio, television and access to Internet (as such, vast capital investments in telephone and electrical wiring would be significantly reduced).

Access to information technology opens new opportunities not only for agricultural extension, but also for conveying information on markets, education, primary health care and other aspects related to rural development. Farmers in parts of Africa have begun to use information technology to get market information; in doing so they would improve the competition in agricultural input and output markets (Pinstrup-Andersen *et. al.*, 1999).

Electronic Communication

We are still in the era of information revolution or information age: people the world over are using computers linked to telecommunication systems to exchange messages (e-mail), transfer files, carry out business transactions, take part in conferences and forums, access information on stock markets, and access news and any other information over huge distances at

relatively low cost (Jensen, 1994). The e-mail messages are traveling along global information superhighways, dominated by Internet system which is a world-wide network of computers and people giving access to huge amount of information all over the world instantly. World-wide-web (www) is a premier Internet navigation tool, allowing users to read documents, access images and sound. The www is also an ideal tool for making well-organized information available to users.

Access to Internet has grown rapidly in Africa in recent years. For example, at the end of 1996 only 11 countries had local access but by April 1999 only three African countries were still without local Internet services. This means that 50 out of 53 countries have direct access to Internet (Jensen 1999). However, Internet access in African has been largely confined to capital cities and some few towns.

Geographical Information Systems (GIS), Global Positioning Systems (GPS) and Remote Sensing

Access to these systems can contribute to increasing application of the so called precision farming which helps farmers to use inputs such as fertilizers, pesticides, and efficient use of water. It also reduces waste, use of chemicals, runoff, and water and land pollution, and therefore contributes to lower unit costs of production. This system is practised in developed world especially in the United States and Europe but it is also appropriate for small holder farmers in developing countries like Tanzania. According to Pinstrup-Andersen et.al. (1999), like agroecological approaches, precision farming is "knowledge and management intensive. If appropriate small-scale and inexpensive equipment were developed, GIS, GPS and remote sensing could help small scale farmers get the information they need to apply the principles of precision farming".

Broadcasting

Radio is the most widely used medium in Africa. It is estimated that more than 60% of the population are reached by existing radio transmission networks whereas television coverage is mostly confined to major towns (Jensen 1999). Both can effectively be used to disseminate agricultural information.

Current initiatives to improve information infrastructure in africa

There are several collaborative efforts in Africa aimed at improving the infrastructure for information and communication technology. This is in view of the fact that information is indispensable in the management and overall socio-economic development process of any country and the general under development of information infrastructure, hence information poverty, has contributed to Africa's lack of development over the years. Thus, many countries in Africa and the world over are striving at taking the obvious advantage of the potential opportunities offered by the use of information by developing policy agendas and implementation strategies for ICT. These include creation of infrastructure that will facilitate efficient and inexpensive flow of information.

The current and planned initiatives to improve ICT infrastructure in Africa include the following, among many others:

African Information Society Initiative (AISI)

This is an initiative to use ICT to accelerate economic and social development in Africa. It was adopted by the UN Economic Commission for Africa's (ECA) Conference of Ministers of Development and Planning (including Tanzania) in May 1996 by Resolution 812 (XXXI) as "AISI: an action framework to build Africa's information and communication infrastruc-

ture" (ECA 1999a) and ECA was mandated to work with the various partners to implement the initiative throughout Africa.

The main goal of AISI is to attain sustainable information society in Africa by year 2010 through the following actions by Africa countries:

- Developing national plans for building information and communication infrastructure;
- Eliminating legal and regulatory barriers to the use of information and communication technologies;
- Establishing an enabling environment to foster the free flow and development of information and communication in society;
- Developing policies and implementing plans for using information and communication technologies in the public sector;

- Identifying, developing, and introducing information and communication applications in areas of highest impact on socio-economic development at national level;
- Facilitating the establishment of locally based, low-cost and widely accessible Internet services and information content;
- Preparing and implementing plans to develop human resources in information and communication technologies;
- Adopting policies and strategies to increase access to information and communication facilities with priorities in servicing rural areas, grassroots society and other disenfranchised groups, particularly women and youth.
- Creating and raising awareness of the potential benefits of African information and communication infrastructure.

In building information and communication sector, the African countries need to develop and improve the following four components of the African Information Society Framework:

- Institutional framework and legal, regulatory and management mechanisms
- Human resources
- Information resources (infostructure)
- Technological resources (infrastructure)

The initiative calls for formulation and development of a plan for a national information and communication infrastructure (NICI) in every African country according to its national development priorities. So far, for example, ECA and the Government of Tanzania have organized two national workshops to discuss strategies for application of ICTs to support development needs and for elaboration of national action plans.

One of the envisaged projects under AISI is to open telecentres in all 53 African states in an effort to improve accessibility to ICTs in rural areas through the use of shared public access facilities (Jensen 1999).

UN Secretary General's System-Wide Initiative on Africa

This initiative includes ICTs as one of the major components in a programme, Harnessing Information Technology for Developments supported by different UN partners.

The Leland Initiative

This is a USD 15 million US Government initiative administered by the USAID. (Leland Initiative, 1998). Its goal is to extend full Internet connectivity to 20 or more African countries (including Tanzania) and its activities include Internet awareness training workshops in the beneficiary countries.

African Virtual University

This is one of the World Bank's activities to assist in telecommunication and ICT development in some 25 countries in sub-Saharan Africa.

IDRC's Acacia Programme

This programme is assisting in the development of ICTs in local communities in Africa.

The Africa Link Project

This USAID-funded project through ASARECA aims at enhancing electronic connectivity to agricultural research institutions in Eastern Africa.

Current and potential projects for applying information technology to assist agricultural development in tanzania

Responsibility for agricultural information services in Tanzania is divided amongst a number of different bodies, all of which have mandates in provision of information in agriculture and allied fields. These comprise public-sector institutions such as the government research and extension bodies and universities; and the private sector bodies, including a number of NGOs.

The Ministry of Agriculture and Cooperatives (MAC) is the key player in the execution of agricultural information services through its Division of Research and Development (DRD), its extension services, and other departments.. Other players include the Sokoine University of Agriculture (SUA) including its Library, Tanzania Forestry Research Institute (TAFORI), the Tropical Pesticides Research Institute (TPRI), the Ministry of Natural Resources and Tourism, Tanzania Food and Nutrition Centre (TFNC), Tanzania Fisheries Research Institute (TAFIRI), Tanzania Commission for Science and Technology (COSTECH), the National Documentation Centre (under the Tanzania Library Service), the Centre for Agricultural Mechanization and Rural Technology (CAMARTEC) and several NGOs.

The various functional units of the MAC aiming at improving access to agricultural information have planned the following projects by all stakeholders through application of information technology. Actual implementation of these projects cuts across MAC departments as well the other related institutions in Tanzania.

Expansion and Maintenance of MAC's Information System

The Ministry of Agriculture and Cooperatives Information System (MACIS) was designed and partly implemented by a World Bank Project, Agricultural Sector Management Project (ASMP). The partial implementation of the project has involved supply of some servers and some client PCs, network cabling of KILIMO I (Administration Building) and supply of some software. Under this plan, only two modules are being implemented, which are Agricultural Census and Statistics Information Systems, and Accounting Information Systems (through Treasury). This leaves out too much for an effective information system since it is inadequate and does not cover the whole Ministry.
The Objectives of the envisaged project will be to

- interconnect all the buildings forming the Ministry of Agriculture Campus at Temeke for an effective Intranet as well as access to the Internet. This will add to the present cabled KILIMO I building.
- add other systems to the present Agricultural Census and Statistical Information and Accounting Information Systems currently in place but only in KILIMO I building. These include research information databases.

- establishing efficient communication system between Kilimo HQ and remote sites.
- maintain of Kilimo Website

The main benefit of this will be an increase in efficiency and therefore productivity and promotion of the Tanzania's agriculture to the outside world. *(For further information contact Mr. A. R. Kwayu Department of Planning and Policy, MAC).*

Use of Information Technology in the Management and Accessing Local Agricultural Literature in Tanzania

In 1988 the Ministry of Agriculture in collaboration with the Special Program for African Agricultural Research (SPAAR) engaged the Centre for Arid Zone Studies (CAZS) of the UK to compile the Tanzania Agricultural Research Database (TARD). The aim was to evaluate past research activities in Tanzania so as to identify technology gaps and to avoid unnecessary duplication of research effort. The compilation of TARD was completed in 1989 and it contains some 20,000 references to documents dealing with agricultural research (including forestry and fisheries) in Tanzania from 1900 to 1988. The bulk of these references, especially from 1970 onwards, relate to local institutional reports (the so-called 'grey' literature). The database is therefore a most important and useful collection of information on past trends in Tanzanian agriculture.

However, this database which was initially packaged on CARD BOX program and later on converted to Micro-CDS-ISIS program is not accessible due to some technical problems. Besides, it requires updating to cover the Tanzanian literature up to 1999. In addition, further work needs to be done on the database such as strengthening of indexing and elimination of duplicates. This project aims at addressing these problems and to ensure that the archive of previous Tanzanian literature is readily accessible by all stakeholders for agricultural development and for sharing this information with the rest of the world as our contribution to the global knowledge pool. The Tanzanian Agricultural Research Project (TARP II) will partially support this task. *(For further information contact Mrs. J. Kaaya, Div. of Research and Development, MAC).*

Establishment of Rural Information Centres (project concept)

Rural people not only receive less information compared to urban ones but also their bulky developmental activities are inadequately communicated or disseminated to other communities. There are so many reasons why such
situation happens. Poor infrastructure (roads, telecommunications, and transport.), illiteracy, health services and poverty just to mention few, tends to increase the rural-urban gap.

In order to bridge such a gap, there are many approaches any one can think of.
However, taking a village as development and managerial unit, something can be done. At the village level we have the village government, development
facilitators like village executive officer, village extension officers, primary school teachers, councilors, community development officers and the like. Such people in collaboration with influential farmers can be organized to form what is called the Rural Information Centre (RIC).

The Rural Information Centre or Multimedia Community Centre is just a place where various information materials in the form of prints, audiocassettes, videocassettes, radio/TV programs and even e-mail and www connectivity, can be organized and made available to the rural community. The above mentioned development facilitators who have wide exposure (both

rural and urban) can be the major sources of information to and from the rural areas.

The main objective is to make the development information more available to the grassroots community particularly the farmers. (*For further information contact Mr. H. Nyangi, Farmers Education and Publicity Unit, MAC).*

Application of Information Technology in the Collection, Analysis and Management of Early Warning Information in Tanzania

The Food Security Department, through its Crop Monitoring Early Warning Unit (CMEWU) coordinates a Comprehensive Early Warning System that caters for the need of information that is relevant for undertaking early warning for food security and the general analyses of food situation in the country. Through its AGSTATS and AGMET components CMEWU collects, collates, analyses and disseminates a wide range of crop and rainfall data including crop growth status and seasonal performance of rains. The information is of great value to the Government, donors, NGOs, inventors and traders in all walks of life. To be useful the information so collected must be available early enough to meet planning needs.

Within CMEWU, the AGSTATS Section plays a double role of statistics and database management. On the part of Statistics the AGSTATS collects data and information from both primary and secondary sources for early warning purposes. The primary source, which forms the main input in the forecasting process, relies on a sample of about 3,500 villages (about a third of the country's total number of villages). Using the data the Section estimates area under all crops and combines it with yield information from AGMET in the process of undertaking production forecasting. Furthermore it conducts self-sufficiency analysis to show the extent of food requirements met through food produced both at national and sub-national levels.

On the part of FSDbase it updates and manages the existing database in such a way that data is available quickly and timely for early warning and easy access for food security analyses and ultimate decision making. The analysed data is currently available in two volumes, namely: *Presenting Forecasts for...* (a given year e.g. 1998/99) *Statistical Analysis of the Forecasts* again *for...* (a given year e.g. 1998/99). Later on this is incorporated into the broad spectral Food Security Bulletin compiled by the CMEWU and then is widely distributed domestically and internationally. *(For further information contact Mr. O. Ntikha, Crop Monitoring and Early Morning Unit, MAC).*

Development of Agricultural Statistical Information Database

The Agriculture Statistics Unit (ASU) of Ministry of the Agriculture and Cooperatives is currently undertaking the Integrated District Agriculture Survey covering 3,100 villages at household level and is developing a database system catering for the MOAC data needs for decision making and planning processes. The Agriculture Statistical Information Database System will be under local-area-network environment with future plan to go wide-area-network thus connecting the twenty regional offices and local governments. It will also be on web-site to connect it to the "outside world" via Internet.

Currently the unit is under system development whereby the first stage of defining the conceptual data model has been completed. Thirty-four subject-oriented entities have been identified and their associated attributes and domains established. An international expert has been recruited to develop and setup the system. He will be supported by local counterpart who will

be the Database Administrator. Hardware and software have been ordered and will be in the country in October 1999. The system will be operational early next year using the existing two large client/file servers interconnected with the various departments of the Ministry under MIS's (Management Information System) control and administration. The system will be available to data users within the Ministry for general browsing, data downloading or data manipulation and analysis purposes. The system will be supported by statistical and other data analysis tools as well as GIS (Geographic Information System) so those data users will have the means and facilities to use the data freely and meaningfully.

When the system is fully operational, it is expected to eliminate the current data harmonization problems, avoid data redundancy and data will be available timely and accurately. *(For further information contact Mr. Tabwene, Statistics Unit, Department of Planning and Policy, MAC).*

Upgrading the Existing Marketing Information System of the Marketing Development Bureau

The Marketing Development Bureau (MDB) was established in the Ministry of Agriculture and Co-operatives as a marketing section with FAO/UNDP assistance in 1970. It subsequently receives World Bank funds. Before trade liberalisation the main objectives of MDB were to provide advice in pricing policies to the government, to review the operations of parastatal marketing bodies and to monitor the food supply situation in the country. With the liberalisation of the food and cash crops and consequential active participation of the private traders in mid 80's, the Marketing Information System (MIS) was established.

The major objective of MIS is to provide agricultural market information particularly on food and cash crops, livestock and agricultural inputs. The information is aimed to traders, farmers, policy makers, researchers and the general public to enable them to contribute to the efficiency and effectiveness of the liberalised agricultural marketing system as a whole.

Market reporters/data collectors and MDB personnel collect the information. Specifically the information collected and disseminated includes prices, production, area, imports and exports, agricultural input, production costs and other agricultural marketing information.

The system is constrained by resources thus market data is collected only from few main district markets (about 45 markets) while the aim is to cover all markets which are estimated to be more than 100. Also communication facilities (mail and radio call) between data collectors and MDB headquarters are not reliable, efficient and timely; and Information dissemination methods are not efficient and timely. Aged data processing, analysis and printing equipment is another constraint.

The envisaged upgrading project would facilitate the following:

- establishment of data collection and data reporting station in each district so as to achieve country-wide coverage.
- provision of incentives to data collectors and MDB personnel.
- to provide training to data collectors and MDB staff.
- improvement of communication facilities between data collecting stations and MDB headquarters by the use of e-mail facility. Therefore purchase of relevant hardware and software.
- improvement of information dissemination methods so as to give traders, farmers and the general public easy access to daily market

information by use computers (by designing MDB Web site), production and distribution of market information newsletters.

- acquisition of new computers with big memory and storage capacity for data compilation and analysis, and new printers. *(For further information contact Mr. S. Toke, Marketing Unit, Department of Planning and Policy, MAC).*

Strengthening Plant Protection Information Management Capacity

Objective: To achieve reliable plant protection information and communication system contributing to sustainable plant pest management by

- Strengthening staff capacity to collect, process and disseminate plant protection information
- acquisition of infrastructure for information technology.

(For further information contact Mr. G. Kirenga, Plant Protection Services, MAC).

Framework for a National Livestock Information Networking in Tanzania

The Livestock Information Network (LIN) has the main objective of providing information needed by authorities, advisors and producers to plan and control livestock production so as to optimize contribution of livestock to economic and social development. In essence, LIN is intended to provide a means of early detection, early warning and early response by systematically collecting production and disease data and its storageorderly retrieve, consolidate, analyse and interpret such datapromptly and regularly disseminate information to those who have the authority and responsibility to act on it and also provide feedback to those who are involved in the data collection. *(For further information contact Dr. B. J. Mtei, Epidemiology Unit, MAC).*

Integrating Management Information Systems (MIS) in Agricultural Research for Development

The management Information System (MIS) is an interrelated set of components -people, process and information technology - that function together to provide information to support the activities of an organization. A major goal of agricultural research managers is to improve the efficiency of their organizations and MIS is one of the many tools, which can be used to make the improvement. MIS provides information to managers at all levels to assist them in making timely and effective decisions for planning, directing and managing the activities for which they are responsible. Managers can use MIS to obtain a wide range of information about their research programs and scientists.

The MIS packages adopted in the DRD system include INFORM (Information for agricultural research managers), GIS (Geographical Information System) and FINPRO (Financial Management System).

INFORM is a computer-based database of the research personnel, budgets, and research activities. Basic data on personnel, budgets and research projects are entered into a database, and then the type of information desired can be extracted. For example, if the user wants lists of research scientists by commodity research, by zone, station, discipline etc., the information can quickly and accurately be produced.

The FINPRO, as a financial management tool, is currently operating in the DRD in collecting financial data related to budgeting and accounting of field trials.

Geographical information system (GIS) is a computer-based medium designed for collection, storage, display and analyses of

objects where geographical location is an important characteristic for the analysis. It is able to support the design, implementation and analysis of agro-surveys in the DRD.

The DRD has managed to establish a farming system database in GIS format. Different maps such as those for topography, soils, soil moisture, drainage, farming systems of Tanzania and agro-ecological zones have been digitised. Currently a model that would provide possibility to link maps with associated attributes is being developed. This will enable the DRD to use the database as a tool for efficient management of research to address farmers needs. *(For further information contact Mr. R. Kasuga or J. Banzi, Div. of Research and Dev., MAC)*

Tanzania agricultural policy statements relating to information

There are statements embodied in the new Agricultural and Livestock Policy (MAC 1997) which have a direct bearing on the Government's realization of the role of information technology in agricultural development. These include the following:

- **Chap. 3.3 (B) (i):** Strengthening information and documentation services, information management and technology, publications and dissemination of research information and networking in information services with internal and external institutions, including national extension services.
- **Chap. 3.3 (D) (4) (i):** In order to strengthen collection and monitoring of information the government will place adequate statisticians in every district with necessary basic facilities including radio-call system, linked computer system, telephone and faxes.
- **Chap. 3.3 (D) (4) (ii):** The Ministry will ensure that data analysed is disseminated regularly through radio programmes, flash reports on regular papers and bulletins to interested parties.
- **Chap. 3.3 (D) (4) (iii):** The Ministry will establish an effective market information system for inputs, in order to make markets transparent and inform traders, livestock keepers and farmers about supply, shortage, availability and prices.
- **Chap. 3.3 (E) (2) (i):** The Government will establish effective information system regarding farm implements, machinery and equipment.
- **Chap. 3.3 (E) (4) (i):** The Ministry will study and establish ecological information to enable assessment of the available rangeland resources and mapping. Based on the available information the Ministry will recommend better range management practices including proper carrying capacities, water distribution, etc.
- **Chap. 3.3.(E) (5):** Key requirements for achieving success in the area of policy formulation and management are an effective management information system and analytical capability supported by financial and material resources.

Conclusion

Let me conclude this keynote paper by reiterating that there are great opportunities in applying information technology in agriculture so as to increase agricultural productivity and bring about development of the sector. The opportunities include improvement of food security through access to timely information; provision of equitable access to new techniques for improving agricultural production; improved information flow for better research and extension service linkages; better coordination and information flow

for each of the five soil subgroups, air dried, ground and sieved through 2mm sieve. About 200g of each of the ground soil samples were further grounded and sieved through a 0.5mm sieve. The 2mm sieved soils were used for the glasshouse incubation pot experiment and particle size analysis while the 0.5mm sieved soils were for the chemical characterization of the soils.

Farm yard manaure (FYM) collection

About 30kg of the FYM (mixture of cow and goat dung) were collected dried, ground and sieved through 2mm sieve. The 2mm sieved FYM was used for the characterization of the FYM and for the glasshouse incubation pot experiment.

Soil analysis

Some physical and chemical analysis for the characterization of the five soil subgroups used in the study were undertaken in the Department of Soil Science, SUA. Particle size distribution was determined by the Bouyoucous hydrometer method (Day, 1965). Soil pH was measured in soil water and 0.01 M$CaCl_2$ suspensions using a soil: solution ratio of 1:2.5 (McLean, 1982). Organic carbon was determined by the method of Walkley and Black (Nelson and Sommers, 1982). Total nitrogen was determined by the macro-Kjeldahl method (Bremner and Malvaney, 1982). Available phosphorus was determined by the Bray and Kurtz no 1 method (Bray and Kurtz; 1945). The cation exchange capacity was determined by the ammonium acetate saturation method at pH 7.0 (Thomas, 1982) and exchangeable Ca^{2+} and Mg^{2+} in the ammonium acetate filtrates by atomic absorption spectrophotometer.

Analysis of the farm yard manure

The pH of the FYM was determined in FYM: water and FYM - 0.01 M $CaCl_2$ suspensions at the ratios of 1:5. Total organic carbon, nitrogen, phosphorus, total sodium, calcium, magnesium and potassium were determined using the procedures by Okalebo *et al.* (1993).

Glasshouse incubation pot experiment

Fifteen 2kg soil samples for each soil subgroup were weighed into 3-litre capacity plastic pots with holes at the bottom for drainage. The fifteen 2-kg soil samples in the plastic pots for each soil subgroup were thoroughly mixed with five rates of 0, 2.5, 5, 10 and 20g FYM/2kg soil and replicated three time. The soils - FYM mixtures were incubated for 35 days at 75% field capacity using distilled water. At the 35^{th} day of incubation, samples were taken from each pot and analyzed for soil pH, exchangeable Ca^{2+} and Mg^{2+} and cation exchange capacities.

The soil pH, cation exchange capacity and exchangeable calcium and magnesium values for each soil subgroup at various levels of FYM were statistically analyzed.

Results and Discussion

Some of the physico- chemical properties of the five soils

Some of the physico - chemical properties of the Paleustult, Typic Paleustalf, Vertic Ustifluvent, Typic Rhodustult and Typic Ustorthent are presented in Table 1

The percentage total nitrogen, available P (mg kg^{-1}) and cation exchange capacities of all the five soil subgroups were low according to the rating by Landon (1991). The % organic carbon contents were medium for the Paleustult, Typic Paleustalf and Vertic Usifluvent while for the Typic Ustorthent, the % organic carbon was very high (Landon, 1991). The Typic Rhodustult was characterized by low % organic carbon. exchangeable Ca^{2+} and Mg^{2+} on the other hand were low (Landon, 1991).

The low content of total nitrogen could be attributed to the high rate of decomposition, mineralization and oxidation of the organic compounds and plant residues added to the soils. This phenomena is common in soils under tropical conditions. The low values for Bray -1- P for all the soils could probably be due to the inherent low P contents in the soil parent materials from which the soils were developed or the phosphate occurring in strongly fixed forms not extractable by the Bray - 1 - P- reagents. The low CEC values are in conformity to the low pH of the soils (Landon, 1991) Based on the data in Table 1, the five soils used in the study are of low fertility status.

Some of the properties of the FYM

Some of the properties of the FYM are presented in Table 2. The farmyard manure contained low amount of total nitrogen, phosphorus and exchangeable bases but very high total organic carbon. The manure consisted of a mixture of cow and goat dung. The C:N ratio of the FYM was 29: 1 indicating that the FYM would take long time to undergo decomposition and mineralization

Effect of incubation of the five soils with different levels of FYM on the pH of the soils

The effect of different levels of FYM on the pH of the soils is as presented in Table 3 Generally the soil pH increased with increasing levels of FYM in all the five soils. The increase in soil pH were in the following ascending order for the soils; Typic Ustorthent, Typic Rhodustult, Vertic Ustifluvent, Typic Paleustalf and Paleustult. The increases in soil pH for the five soil were due to the fact that, upon decomposition, exchangeable bases were released into the soil and the aluminum and hydrogen ion activities reduced and thus increased soil pH. Frequent additions of FYM to acidic soils would increase the soil pH in the long run

Effect of incubation of different soils and FYM levels on the CEC of the soils.

The effect of 35 days of incubating the soils mixed with FYM on the CEC of the soils are presented in Table 4. Incubation had marked effects on the CEC of the soils. For all types of soils there were significant increases in the CEC. These results are in agreement with those obtained by Ochwoh and Kitungule - Zake (1981) who investigated the effects of organic materials of which one of them was FYM on the CEC of three Ugandan soils. The increase in CEC was attributed to the release of the nutrients (cations) by the FYM through decomposition and mineralization and synthesis of humus which has high capacity to retain cations in exchangeable forms.

Effect of incubation of different levels of FYM with the five soils on the exchangeable Ca^{2+} and Mg^{2+}

The effect of incubation of different levels of FYM with the five soils on the exchangeable Ca^{2+} and Mg^{2+} were as presented in Table 5 and 6, respectively. The exchangeable Ca^{2+} and Mg^{2+} increased with increasing levels of applied FYM but the increases were not that dramatic. The increase in the amounts of exchangeable Ca^{2+} and Mg^{2+} could be attributed to the low contents of Ca and Mg in the FYM used in the current study.

Conclusion

FYM could supplement inorganic fertilizers in sustaining soil fertillity and crop production. However the high rates of FYM to be applied may enhance the immobilization of other plant nutrients and disturb the equilibria in the soil. Further application of FYM increased the cation retention capacities of the soils.

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Table 1: Some of the properties of the five soil subgroups

Soil Type(US soil taxonomy	PH H_2O	PH 0.01M $CaCl_2$	OC %	Bray-1-P mg/kg	Total N %	CEC Cmol/kg soi	Exchangeable bases Cmol/kg soil K	Na	Ca	Mg	Particle size distribution (%) Sand	Silt	Clay	Textural Class
Paleustult (P_1)	4.77	3.83	1.58	0.93	0.04	7.94	0.51	0.09	1.80	0.46	28.74	5.07	63.46	C
Typic Paleustalf (P_2)	5.56	4.45	2.24	0.87	0.05	10.69	1.26	0.08	4.20	1.17	27.44	7.15	61.50	C
Vertic Ustifluvent (P_4)	5.82	4.60	2.31	1.02	0.04	9.78	1.08	0.10	3.50	0.26	29.30	7.16	59.55	C
Typic Rhodustult (P_{11})	5.97	4.93	2.33	0.64	0.04	5.73	0.59	0.07	3.00	0.97	40.24	5.03	50.70	Sc
Typic Ustorthent (P_{14})	5.83	4.84	8.33	1.04	0.04	5.93	0.79	0.05	3.50	1.07	44.20	2.98	38.40	Cl

Key: C = Clay
SC = Sandy Clay
Cl = Clay loam

Table 2: Some of the chemical properties of the FYM

pH H_{20}	OC (%)	Total P (%)	Total N (%)	Total K (%)	Totlal Na (%)	Total Ca (%)	Total (%)
8.75	54.27	0.37	1.90	2.0	0.1	0.9	0.55

Table 3: Effect of incubation of different levels of FYM and different soils on soil pH.

FYM levels (ton/ha)	Soil Subgroups P_1	P_2	P_4	P_{11}	P_{12}	Marginal mean
0	3.65n	4.451	4.551	4.8ghij	4.76hij	4.45+b
2.5	3.69n	4.521	4.72ijk	4.99cdef	4.85fghi	4.55^c
5.0	3.74n	4.58K1	4.80ghij	5.12bc	5.00cde	4.65^b
10	3.75n	4.70jn	4.87efgh	5.20b	5.03cd	4.71^b
20	3.90m	492defg	5.0cd	5.47a	5.36a	4.94^a
Marginal mean	3.75e	4.63^d	4.80^c	5.12^a	5.00^b	

*Data in the same column with the same letter and the marginal mean of row or column do not differ significantly at P 0.05 according to Duncan's Multiple Range Test (DMRT)

Table 4:Effect of incubation of soils mixed with manure atdifferent levels on the CEC of the soils (Cmol/kg soil)

FYM (ton/ha)	Soil subgroup P_1	P_2	P_4	P_{11}	P_{12}	Marginal mean
0	8.0q	10.7i	9.8j	5.9w	5.90y	12.78^{c}
2.5	12.820	16.98g	16.56h	11.73t	12.01s	14.02^{d}
5.0	13.13n	18.01c	16.56h	11.40u	12.19r	14.26^{c}
10	13.29m	16.16i	17.25f	12.45p	13.751	14.58^{b}
20	18.27b	18.4a	17.56e	13.88k	17.78d	17.29^{a}
Marginal mean	13.96^{c}	17.25^{a}	16.38^{b}	11.99^{e}	13.434^{d}	

*Data in the same colmn with the same letter and the marginal mean of row or column do not differ dignificantly at P 0.05 according to Dancun's Multiple Range Test.

Table 5:Effect of incubation of different levels of FYM and different soilson exchangeable Ca (Cmol/kg soil)

FYM levels (ton/ha)	Soil Subgroup P_1	P_2	P_4	P_{11}	P_{12}	Marginal mean
0	2.13n	5.00d	4.80f	3.80j	4.00i	3.96^{e}
2.5	2.20m	5.20c	4.90e	3.90j	4.05i	4.05^{d}
5	2.25m	5.20c	4.90e	4.00i	4.13h	4.10^{c}
10	2.531	5.32b	4.90e	4.15h	4.73g	4.33^{b}
20	2.80k	5.73a	4.93e	4.15h	4.80f	4.48^{a}
Marginal mean	2.38^{e}	5.29^{a}	4.89^{b}	4.02	4.34^{c}	

*Data in the same column with the same letter and the marginal mean of row or column do not differ significantly at P 0.05 according to DMRT

Table 6:Effect of incubation of different levels of FYM and different soils on exchangeable Mg. (Cmol/kg soil)

FYM levels (ton/ha)	Soil Subgroup P_1	P_2	P_4	P_{11}	P_{12}	Marginal mean
0	1.42n	3.20b	3.03c	2.52h	3.30j	2.51^{d}
2.5	1.49m	3.29a	3.20b	2.63g	2.52h	2.63^{c}
5	1.50m	3.29a	3.29a	2.70f	2.451	2.65^{c}
10	1.821	3.32a	3.32a	271f	2.94d	2.86^{b}
20	2.04k	3.33^{a}	3.33a	2.83e	2.96d	2.90^{a}
Marginal mean	1.65^{d}	3.28^{a}	3.23^{b}	268^{c}	2.65^{c}	

*Data in the same column with the same letter and the marginal mean of row or column do not differ significantly at P 0.05 according to DMRT.