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MICROCOMPUTERS AND PROGRAMMABLE CALCULATORS FOR AGRICULTURAL RESEARCH IN DEVELOPING COUNTRIES*

By

Michael T. Weber, James Pease, Warren Vincent,
Eric W. Crawford, and Thomas Stilwell

Department of Agricultural Economics
Michigan State University

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Preface

There is a worldwide revolution in small computer technology underway, and scientists are struggling to find ways to utilize this new technology to help solve development problems in the Third World. We are pleased to announce a number of papers on microcomputers in international agriculture to be published in our International Development Papers series. The aim of these papers is to provide timely information about the rapidly changing state of the new micro-processing technology and its use in research. The papers are also intended as guides to agricultural and social scientists on choosing, installing, and maintaining microcomputer hardware and software systems in developing countries.

This is the first of these new papers. It is based on two major activities: (1) an International Conference on Microcomputers and Programmable Calculators for Agricultural Research in Developing Countries held at Michigan State University on May 17-21, 1982; and (2) staff work by faculty members and graduate students of the Department of Agricultural Economics, Michigan State University, on cost-effective data collection, management, and analysis techniques for use in developing countries. Both activities are carried out under the terms of reference of the Alternative Rural Development Strategies Cooperative Agreement--DAN-1190-A-00-2069-00--between the Office of Multi-Sectoral Development, Bureau of Science and Technology of the United States Agency for International Development and the Department of Agricultural Economics at Michigan State University.

Readers are encouraged to submit comments about these new papers on microcomputers and to inform us of their activities in this area. Write directly to: Dr. Michael T. Weber, Acting Director, Alternative Rural Development Strategies Cooperative Agreement, Department of Agricultural Economics, Michigan State University, East Lansing, MI 48824-1039.

Eric W. Crawford, Carl K. Eicher, Carl Liedholm
Co-Editors
MSU International Development Papers

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List of Abbreviations Used

AC	Alternating Current
ADP	Agricultural Development Project
APMEPU	Agricultural Projects Monitoring, Evaluation, and Planning Unit, Government of Nigeria
Apple	Apple Computer Corporation
BASIC	Computer language
BUCEN	United States Bureau of the Census
CBAS	Computer-Based Analysis Service
CDC	Control Data Corporation
CES	Cooperative Extension Service
CMOS	A low power consumption microchip
COBOL	Computer language
CP/M	Microcomputer Operating System
CPU	Microcomputer Central Processing Unit; "Chip"
DBMS	Data-Based Management System
Digital (DEC)	Digital Equipment Corporation
EDI	Economic Development Institute, World Bank
FAO	Food and Agriculture Organization of the United Nations
Fortran	Computer language
HP	Hewlett-Packard Corporation
IBM	International Business Machines Corporation
IRCT	Research Institute for Cotton and Exotic Textiles
IRRI	International Rice Research Institute
ISPC	International Statistical Programs Center (BUCEN)
ISU	Iowa State University
K	1024 Bytes

LCD	Liquid Crystal Display
LDC	Less Developed Country
MSU	Michigan State University
Northstar	Northstar Computer Corporation
NSO	A National Statistical Office
Osborne	Osborne Computer Corporation
Pascal	Computer language
PDP	Mini-computer line of Digital Equipment Corporation
PET	Brand of Commodore Microcomputer
PL/I	Computer language
PPX	Texas Instrument's Public Program Exchange for Calculators
Purdue	Purdue University
RAM	Random Access Memory
SAS	Statistical Analysis System (Computer Software)
SPSS	Statistical Package for the Social Sciences (Computer Software)
SRS	Statistical Reporting Service, United States Department of Agriculture
Texas A&M	Texas Agriculture and Mechanics University
TI	Texas Instruments Corporation
TRS-80	Various models of Tandy/Radio Shack microcomputers
UCR	University of Costa Rica
UPS	Uninterruptable Power Supply
USAID	United States Agency for International Development
USDA	United States Department of Agriculture

MICROCOMPUTERS AND PROGRAMMABLE CALCULATORS FOR AGRICULTURAL RESEARCH IN DEVELOPING COUNTRIES

I. INTRODUCTION

A. Background

Agricultural research and extension scientists working in projects in developing countries have until recent years been severely handicapped in data collection, processing, and analysis because they had only two extreme options open to them: (1) labor-intensive methods of data processing, analysis, and the preparation of reports by hand; and (2) large mainframe computers which are often inaccessible and underutilized. The emergence of hand-held programmable calculators and (more recently) microcomputers has provided the needed intermediate technology to help overcome many of the shortcomings inherent in hand tabulation and mainframe technologies. Both programmable calculators and microcomputers are now available in many areas of the developing world, but insufficient work has been done to organize and develop relevant algorithms for use by researchers, teachers, and extension agents in these countries. Learning what can be done and how these new technologies best fit into research carried out on agricultural research stations in the field, and universities in developing countries is an important part of the challenge ahead. These issues were the agenda of an International Conference held May 18-21, 1982 at the Kellogg Center, Michigan State University. The conference was attended by some 50 professionals with interest and/or experience with agricultural research in developing countries utilizing microcomputers or programmable calculators.

In organizing the conference, every attempt was made to focus on practical experience over a relatively wide geographical area and to examine how these tools can improve the efficiency and cost effectiveness of both biological and social science research for agricultural and rural development.

The objectives of the conference objectives were to:

1. Review the experiences of conference participants in using microcomputers and programmable calculators as research tools in developing countries.
2. Discuss the future potential of using such hardware and related software in agricultural research, extension, and teaching activities in developing countries.
3. Initiate an informal network and exchange of hardware and software experiences.
4. Develop an agenda and a plan for follow-up activities.

The conference materials and deliberations were largely organized around specific country and/or institutional cases. Presenters of cases were asked to prepare supporting written materials, and these ranged from simple handouts to more formally organized and prepared papers.

B. Plan of the Report

In presenting the results of the conference, our main objective is to identify the critical issues. These are organized under the following topic headings:

1. Alternative Approaches to Data Processing
2. Hardware
3. Software
4. Institutionalization and Training

The discussion of each major topic includes a synthesis of important issues along with direct quotes from conference materials. We also use material produced by the three working groups formed during the conference. In Chapter VI, the conference program is reproduced. We also list in alphabetical order addresses and titles of materials presented by all conference participants.

In Chapter VII, we have reproduced eight of the main papers presented at the conference. These papers do not represent all of the materials presented but are the major ones which can stand alone and be easily understood outside of the context of the supporting conference presentation. If readers are interested in obtaining copies of other materials presented at the conference, they are encouraged to contact the individual author.

II. ALTERNATIVE APPROACHES TO DATA PROCESSING: MAJOR ISSUES

In planning both biological and social science-oriented agricultural research, a team must choose appropriate data processing alternatives (this involves data collection, data file construction and management, and data analysis). What constitutes an "appropriate" alternative varies considerably across problems and countries, yet depends fundamentally upon the research objectives, time and resource constraints, the degree of sophistication of analysis required to answer the basic research questions, and upon the availability of alternative tools for completing data processing requirements. The following discussion reviews the advantages and disadvantages of four data processing alternatives: manual techniques, mainframe computers, microcomputers, and programmable calculators.

A. Manual Data Processing

The most frequently used data processing alternative is manual tabulation. For small applications, the time and set-up costs involved in computerized data processing are often greater than those associated with manual tabulation. In actual practice, the researcher often resorts to manual data tabulation after more sophisticated methods have failed. The result is that manual tabulation is often done in haste and in a disorganized manner, giving rise to unnecessary errors. By planning for manual tabulation, the actual work involved can be greatly reduced. For example, the use of sorting strips is a recognized method for efficient manual tabulation but is difficult to accomplish in haste.

Most small data processing tasks are undertaken only once, but many organizations need to repeatedly process rather large amounts of data. Manual tabulation in this case has several disadvantages, as the following comment illustrates:

> This sequence of treatments suffers from the following shortcomings:
> - long processing time at each step
> - risk of error each time data are transcribed
> - growing simplification of data as it moves up the hierarchy
> - in general, unsatisfactory use of the baseline data available, despite a non-negligible compilation cost.
>
> (Braud)

The disadvantages of manual tabulation go beyond its inherent mechanical limitations, affecting the communication and utilization of the data. There was a widespread recognition of the effect of poor or slow data processing on the entire research program:

> A total of approximately 100 experiments were partially analyzed using very simple (non-programmable) calculators. Normally grain yield data were analyzed and other data were only visually reviewed. Large amounts of paper were generated and the error rate was high. After finally finishing the

> calculations, it was still necessary to interpret the analyses and make conclusions. Then the data and conclusions had to be reworked again to arrive at a form suitable for the annual report. Typically, the annual reports were not completed for six months to one year after harvest. The quality of the interpretation and conclusions was quite poor and led to a lack of confidence in the recommendations.
> (Stilwell)

> Much potentially valuable information in the Third World lies unused, either because those who could use it are unaware of its existence, or because it is not presented in a suitable form. It is usually contained in printed reports, which tend to be ineffective both as a means of storing and of presenting information.
> (Hay)

As a result of these problems, many institutions in developing countries have resorted to other forms of data processing such as programmable calculators and computers.

B. Mainframe Computers

Because many large data processing projects are carried out on large computers, some persons assume that mainframe computers should be used for all data processing. As a result, some small data processing tasks are performed on computers, although they could be done more efficiently manually or with programmable calculators. There is also the tendency to use sophisticated data processing equipment simply "because it is there."

Admittedly, there is justification for use of large computer facilities (mainframes) for many projects.

> The justification for computer centers organized around large mainframes has previously rested on the economies of scale suggested by Groschs' law; that is, that computing power varies as the square of the cost of the hardware.
> (Stuart)

For those projects with only one large data processing task, total costs are often lower due to avoidance of expenses for training personnel, equipment maintenance, and software development. A mainframe computer is often justified when expatriate personnel need only to analyze a single set of data over a short 2- or 3-year project, even if the mainframe installation is based in their home country.

Nearly all of the participants had experience with a mainframe computer installation in a developing country. Their experience was often plagued by so many problems that they were forced to seek alternative data processing mechanisms.

> Statistical data processing in developing countries has often suffered from limited access to scarce mainframe computer resources. Centralized national computer centers are common and have frequently been plagued by management problems. Equipment malfunctions and shortages of difficult-to-obtain

replacement parts have frequently caused many users to experience long delays.
(Stuart)

A Turkish field survey in which I participated collected data in the summer of 1976. The data were to be analyzed on the Middle East Technical University's IBM 370 at their excellent computer center. Shortly after the data were collected, the entire staff of the Center was changed due to a shift in political leadership. The new employees had limited computer knowledge and it was nearly two years before the data were analyzed in Turkey. The work which I myself did with these data was done by counting manually on our dining room table the responses to several of the questions on the survey forms.
(Mann)

Traditionally, the field research staff did their experiments, filled in the reporting forms, and mailed those forms into headquarters to have them analyzed. About a year later, the results came back.
(Bernsten)

The following problem areas are enumerated in priority order:
- Access to the computer
- Hardware failures followed by delays in repair
- Rapid personnel turnover with subsequent need for training new personnel
- Cost involved in equipment rental and maintenance
- Electrical failures
- Printer speed
- Reliance on cards for program development
- Insufficient numbers of disk packs
- Scarcity of packaged software

(Stuart)

These bad experiences serve to emphasize the unfulfilled need for reliable data processing in the developing world. The great potential of mainframe computers is not being realized by many installations in developing countries.

Conference participants reported that the primary constraints on the use of centralized data processing for agricultural research in many developing countries are:

1. Limited access, low priority, slow turnaround, and distance to facilities.
2. Hardware failures, electrical failures, lack of technical support.
3. Rapid personnel turnover, high training costs.
4. Lack of software and "user-unfriendliness."
5. Insufficient personal contact with data processing operations.
6. High purchase and upkeep costs.

C. Microcomputers

Recent advances in microelectronics have made it possible to perform fairly large data processing jobs with microcomputers. (For an excellent background discussion, see Conference Paper E, by Diskin and Stuart.) Although the many problems associated with using this new technology were recognized, most participants were satisfied with the benefits of microcomputer data processing.

> The main advantages proved to be:
> - the possibility to carry out studies that could not conceivably be conducted manually because of the volume of data to be handled;
> - a more complete use of existing data with a smaller risk of error;
> - releasing supervisory and research officers from certain tedious data management and calculation chores, and thus leaving them more time to devote for improving the quality of the data collected and analyzing the results; and
> - the possibility of using powerful techniques for multivariate statistical analysis to improve the descriptive studies (automated classification, typology, ACP) and begin explanatory studies (segmentation, regression).
>
> (Braud)

> Microcomputers now provide the researcher acquainted with mainframe computers the possibility of doing much, if not all, of his/her analysis on site. (Malczynski)

Much of the enthusiasm for microcomputers was tempered by the problems of using them in the field. For example, there was considerable concern about reliability and the difficulty of protecting equipment from voltage variations, high humidity, heat, dust, spiders, etc. The most common problem encountered was the lack of in-country repair facilities and/or trained diagnostic personnel. In nearly all cases, the microcomputer installations relied on expatriate personnel to perform an international shuttle service for spare parts or components.

There are problems with the lack of adequate software and manuals. Program manuals are printed in English, and the great majority of programs produce screen displays in English. (This will be discussed further in a following section.) Lack of compatibility between existing microcomputers also creates frustration.

> Micro and mainframe computers have a common shortcoming: design differences among manufacturers lead to often serious problems of incompatibility. The use of magnetic tape, punched cards, and paper tape as a transfer means and the development of standards for the major language translators have facilitated a degree of compatibility among mainframes, although this compatibility took years to develop. The sheer number of microcomputer manufacturers has, on the other hand, contributed to a serious incompatibility problem among microcomputers. At this time, there is very little likelihood that a 5 1/4-inch floppy disk created on one manufacturer's product will be readable on another manufacturer's product. (There is, however, what appears to be a de facto standard for 8-inch floppy disks.)
>
> (Stuart)

As a result, each microcomputer installation is very much an island, isolated from all others. This gives rise to problems very similar to those suffered by mainframe computers: breakdowns, lack of backup equipment, and delays in processing. In spite of these problems, the use of microcomputers has often produced better results than other methods due to greater accessibility and ease of operation. There was a tendency among participants to favor microcomputers over other data processing methods, even for large regional or national projects. In many of these instances, there are significant economic savings through the use of microcomputers.

D. Programmable Calculators

The fourth approach to automated data processing is the programmable calculator. Although limited capacity is an admitted problem, the advantages of the programmable calculator give it a definite edge in certain situations. While the actual calculations performed are quite similar to those carried out on computers, the applications discussed tended to be different. In many cases, programmable calculators were introduced to carry out a very specific calculation.

In the cases cited by participants, programmable calculators were used primarily to reduce the tedium of mathematical calculations such as analysis of variance or chi square tests. The programmable calculator also enables more accurate calculations than with manual techniques, since nearly all of the redundant data copying and re-entry is eliminated. Normally only one data entry operation is required to obtain all the desired results. The addition of a printer enables the user to have a permanent copy of the results for future verification.

A programmable calculator is more rugged than mainframe or microcomputers, and is much easier to transport. Mobility gives programmable calculators one of their biggest advantages: use at place of need. It is possible to find technicians using programmable calculators in jeeps, homes, offices, and in farmers' fields. Nonetheless, participants reported on a number of mechanical problems.

> In high humidity environments, programmable calculators seem to have a life expectancy of two to three years. While this can be extended by keeping the unit in an air-conditioned room, storing it in silica gel or a closet in which a light bulb is burned constantly, it is usually difficult to take these preventative measures. Eventually, mold will take its toll. Electrical power surges are also likely to damage the recharger, calculator, and printer. While power damage can be prevented by using a voltage stabilizer, effective units will cost US $ 100 or more. Users in Indonesia, Sri Lanka, and Bangladesh all have been plagued with various types of malfunctions. Once damaged, it is typically difficult and expensive to make repairs. In Indonesia, the TI-59 dealer does not recognize the guarantee unless he sold the unit. We resorted to hand carrying units to the TI factory in Singapore, since mailing might result in loss and customs charge upon return.
> (Bernsten)

There are other disadvantages to the use of the programmable calculator. (Surprisingly, many of them are similar to those of microcomputers.) Perhaps the single factor which limits wider use of the programmable calculator is the problem of program memory. Typically, these machines can store a limited number of program steps, and there are severe limitations on data storage. Some of the more advanced calculators utilize small magnetic strips for program and data storage, which is sufficient for very small data sets. For survey data or large experiments, however, programmable calculator utilization often becomes impractical.

> The problems associated with the use of the programmable calculator have had more to do with the specific machine chosen than with the concept of on-site data processing itself. For example (with the TI-59, ed.), the limited number of memory registers (26) and program capacity (224 steps) limits the volume of data which can be analyzed at one time. Several of the statistical analysis programs require the use of two or three magnetic cards in succession.
> (Edwards)

E. Assessment of the Alternatives

Each of the four data processing approaches (manual, mainframe computer, microcomputer, and programmable calculator) has clear advantages and disadvantages. Because microcomputers and programmables are relatively new technologies, technicians are still learning how to best utilize them. Manual tabulation is probably still the best choice for small data processing tasks done only once or infrequently. The participants reported that programmable calculators are best utilized for mathematical calculations performed in a field office by a single technician. The microcomputer is best adapted to a central or regional office to do tasks which require repetitive processing of moderate amounts of data, and the mainframe is useful for very large data processing tasks where turnaround time is not critical.

> The micro and the programmable should be seen as complementary technologies, each fitting into a specific niche in a research system. Programmables will adequately serve field site and analytical requirements. In contrast, micros can be effectively used in central stations and large regional branches--assuming provisions are made for adequate training, servicing, and software.
> (Bernsten)

F. Additional Observations From Conference Participants

Data Processing in the Donor Country

> Up to now, all the data processing has been carried out centrally on a large computer (IBM 3033) in France. This solution, in the long run, will not be satisfactory because of the problems of having the work done remotely and off line viz:

- difficulties in data validation;
- difficulties in ensuring the two-way communication needed to define the processing desired; and
- too much time between data collection and availability of results.

(Braud)

Improving Analytical Capacity

The main objective of this particular project was to assist the Tunisians in analyzing the reasons for the sharp decline in their cereal production which had occurred in the several years prior to the project's start. It had nothing to do with computers. It had a focus on helping them to improve analytical capacity. However, one of the main difficulties was the great amount of time required of the most talented analysts in conducting routine spread-sheet analysis and projection. Moreover, they lacked any means of developing a rapid feedback information system on the degree of realization of planned objectives such as fertilizer deliveries, etc.

Facilitating their putting some of these more routine tasks on the computer seemed to offer a way of helping dramatically to improve their productivity.
(Mann)

Programmable Calculator vs. Mainframe

Before the programmable calculator was acquired, most of the statistical design and analysis computations were done with a relatively simple electric calculator, a time-consuming, laborious, and sometimes unreliable task. The alternative was to take data to the large computer on the main UCR campus located nearly an hour away. It often took a week or more to punch, verify, and run programs, and charges were high.

Compared to previous alternatives, the programmable calculator has allowed for faster, cheaper, and more accurate data analysis using custom-designed programs. Most of all it has relieved the experiment station from dependency on overloaded and unreliable support units elsewhere in the University.
(Edwards)

Use of the Programmable Calculator in Costa Rica

Programmable calculators have been used successfully by the University of Costa Rica for on-site design and analysis of experimental results, with lower costs, shorter turnaround time, and greater accuracy.
(Edwards)

Researcher Involvement in Analysis

The advent of large computers over recent decades made possible the rapid processing of large volumes of data, which has been accompanied, at least for developing countries, by a centralization of (computerized) information handling. Microcomputer technology promises to return the capacity for rapidly processing data to the hands of the researcher, whose personal involvement should ensure better analysis.
(Dixon)

Requirements for Efficient Field Use of Micros

- A well-controlled and gradual inflow of input data during the agricultural season, collected in a decentralized way where information is gathered (project management or even agricultural region).
- Local processing of at least part of the data (mainly the descriptive part).
- Periodical publication of the results, even during the agricultural season, which makes for "real-time" monitoring at the farmers' level and can be used as a control panel or navigational aids to guide an operation and help the decision makers.
- Transfer of the purified data onto diskettes for more thorough analysis (multivaried analysis) on large computers (hence the importance of IBM accounting when using the 8-inch diskettes).

(Braud)

III. HARDWARE ISSUES

This chapter discusses hardware issues involved in using programmable calculators and microcomputers.

A. Programmable Calculators

Reliability Problems

A major issue is the choice of technology necessary to complete the analysis. Would one or more programmable calculators be capable of processing the data generated by the investigation? Can data requirements be limited to the capacity of a programmable? Are sales and service agencies available locally? Are some members of the research team already familiar with data analysis on programmable calculators? What are the total costs associated with programmable calculators relative to the costs of microcomputers? Conference participants felt that careful consideration of these factors often indicates that the most favorable technology is the more portable and reliable programmable calculator. The three most popular programmables for research purposes are the Texas Instruments TI-58C and TI-59 and the Hewlett-Packard HP-41CV. Business and statistics solid-state modules, and commercially available programs on magnetic strips have increased considerably the usefulness of these calculators for research. Their portability and low cost are all factors in their favor. The major problems and suggestions to manufacturers concerning hardware problems mentioned by conference participants are cited below:

> Specific problems encountered include breakage of the flexible battery contact points, burnout of segments in the display, rapid battery wear, battery recharger burnout, malfunctioning of the store/recall functions, inability to read magnetic cards, erroneous internal calculations when using a program and complete failure. . . Breakdowns have been a serious problem to most users, regardless of brand. It would be extremely useful if Texas Instruments and Hewlett Packard would make a survey of users (especially those in the Third World) to identify problems encountered. It would appear that small design modifications could significantly reduce downtime. For example, redesigning the battery-to-calculator contact in the TI-59 would eliminate metal fatigue. Also, a small fuse device could be developed and offered as optional equipment that would protect the unit against power surges that probably cause much of the damage encountered. Finally, manufacturers could extend the calculator exchange service provided to U.S. users (i.e., damaged calculators can be exchanged for rebuilt units) to overseas service centers.
> (Bernsten and Banta)

Programmable calculators are affected by few of the electrical problems which plague microcomputer use in developing countries. Some researchers, as noted above, have reported power surges which damaged their programmables while operating them with the power transformer connected to wall current, but this problem does not seem to arise if the calculator is charged and then disconnected from wall current before operating.

If problems occur, programmables are usually difficult and expensive to repair. Warranties are often not honored by local dealers unless they sold the unit, and several conference participants reported occasional international trips to service centers for repair work. All participants with field experience suggested the purchase of two or three programmables for each application to ensure that one calculator is in good repair at all times.

B. Microcomputers

Obtaining Reliable Technical Information

Since 1976, when the first APPLE personal microcomputer entered the market, microcomputer hardware has evolved at a bewildering rate. However, the diffusion of information about micro hardware has lagged far behind. Until quite recently, it was difficult even in the U.S. to secure materials which dealt with technical aspects in a manner intelligible to the layman. The information gap has been filled primarily by the growing body of microcomputer magazines (Byte, Popular Computing, Call Apple, etc.).

Microcomputer information is likely to be passed by word of mouth, although an occasional report or magazine might filter into the country. Often the only source of information about the performance and reliability characteristics of proposed hardware is the salesman for the brand new local franchise of (for example) Apple, Radio Shack, or North Star. In many cases (perhaps even the majority), these salesmen will know less about the product than the inquisitive customer.

Unfortunately, the costs of remedying problems resulting from ill-informed hardware purchases can easily exceed the purchase price of the equipment. This happens when plans are made for certain analysis and it is found that this cannot be carried out on a given piece of hardware, with resulting loss of time and effort while alternative facilities are brought on line. The moral of the story is that strenuous efforts should be made to obtain information on hardware capabilities before a purchase decision is made.

Selecting a Microcomputer System Configuration

If the decision is made to purchase a microcomputer, the next question is the brand and accompanying configuration. When a purchase is made locally in the developing country, there is often little or no choice of hardware, and the research team will buy a

Radio Shack, Apple, or North Star, etc., depending upon which company has a local franchise. If the choice is somewhat wider, or if the purchase can be made outside the country, factors which should be taken into account are:

1. The relative costs of the available configurations.
2. The environment in which the microcomputer is expected to function, including power supply, heat, humidity, and dust factors.
3. The amount of data which needs to be analyzed.
4. The necessary degree of sophistication of the analysis.
5. The commercial software available for the prospective hardware configuration.

The choice of microcomputer technology depends primarily on the research context within which it will function. Participants generally envisioned three problem settings and corresponding equipment configurations:

1. Field Project. Data entry, most verification, and some analysis without reliable or even 24-hour electrical supply. All necessary program or hardware service is done by the researcher. Capacity to upload to another computer is usually necessary. Portability of the hardware and reliability under harsh environmental conditions are key issues.
2. Regional Office. Data entry, all verification, and most analysis carried out at a regional office. Portability of the hardware is less of a problem, but reliable electrical current continues to be a major concern. Capacity to upload may be less of an issue. Personnel may include a non-researcher programmer (full or part-time).
3. National Headquarters. All data entry, verification, and analysis completed at a permanent organizational office, possibly in facilities dedicated strictly to data processing. Electrical power is a concern in a multi-user, multi-task work environment. There are one or more full-time programmers and other personnel.

Given the multitude of aspects to consider in choosing hardware, it is unlikely that a researcher will have the time to learn all there is to know. Three basic characteristics of microcomputers and their peripherals should be understood before any decisions are made. These are the CPU (Central Processing Unit), mass storage capabilities, and printers. The researcher should understand that the CPU will influence (if not determine) the type of software that can be used and the rate at which analysis can be carried out. Most available microcomputers function with 8-bit microprocessors, although 16-bit machines have recently become available. Displacement of 8-bit micros by the more powerful 16-bit computers will largely depend upon the rate of software development, but most observers consider that the 8-bit microprocessor will be dominant for some time. The most common 8-bit microchips are the Z80A (used by the TRS-80, North Star, and many other micros) and the 6502A (used by Apple and Commodore). The Z80A is faster at performing operations, but there has been an extraordinary amount of software written for the 6502A. The new IBM Personal Computer does not use either of these common microchip processors, but there is a rapidly growing body of software for that machine. In any case, it is generally advisable to obtain a micro with at least 64K bytes of user-accessible Random Access Memory (RAM) in order to load and run large programs.

In terms of mass storage, at least two floppy disk drives should be purchased. Although an industry pseudo-standard exists for 8-inch floppies, there are approximately 75 different disk formats for 5 1/4-inch floppy disks. Disks written on one brand of microcomputer can generally not be used on another. Eight-inch drives offer much larger data storage capacity and will allow a greater degree of compatibility between machines of different companies, while 5 1/4-inch floppies are more portable, cheaper, and mechanically reliable. For applications involving large data sets, a hard disk system should be considered, bearing in mind that current models are sensitive to environmental conditions.

For printer purchases, factors which should be taken into account include the printer speed, the width of the carriage, whether it requires a serial or parallel port, and the type of printing mechanism. In general, dot matrix printers offer acceptable reliability and speed for research applications, although the letter quality of output is not equal to that of a typewriter. Speeds of this type of printer range from 80 to 150 characters per second (about one page of text per minute). The printer carriage should be capable of at least 80-column output, and for some applications it will be necessary to purchase a printer with 132-column capacity. Some printers may require a parallel output port on the micro.

Sales and Service

Most participants had experienced major problems in getting equipment serviced locally. There may be some relief from these problems in the next few years as commercial firms expand into more LDCs, but for the time being there are very few sales and service outlets. Moreover, many existing sales franchises have no spare parts or floor models, and their sales personnel have little or no technical training. The parent companies often compound the problems by granting exclusive national or multinational franchises, which can reduce incentives to provide good service. At the same time, balance-of-payments problems frequently make it impossible to obtain the foreign exchange necessary for foreign purchases. And even when this is possible, it is often necessary to wait months while spare parts are ordered from developed countries, at which point the orginal problem diagnosis may well prove to have been faulty.

Because of the above problems, most researchers who use programmables or micros have been forced to go outside regular channels for purchases and repairs. Some participants reported that they carried equipment into the country as hand luggage or sent it through the diplomatic pouch.

Hardware failures are frequent in LDCs. Mechanical failures of printers, disk drives, switches, and even key pads are more frequent than failure of electronic circuits. The SRS of the USDA cited the following types of problems:

> Frequency of hardware failures has been greater than was initially expected. Most of these problems are attributable to the 'hostile' environment of the developing countries--the heat, humidity, dust, and 'dirty power.' The frequency of these problems has been reduced considerably by:
> - establishing maintenance schedules and training host country personnel in maintenance procedures;
> - installing systems in air-conditioned offices; and
> - utilizing power conditioners.
>
> (Steele)

Many organizations such as SRS of the USDA and the UN Statistical Office have taken on the role of servicing equipment until the private sector can handle the task. This approach, of course, requires a considerable level of technical competency and a substantial commitment from the headquarters agency.

> We have taken an approach that might be characterized as a multi-level strategy in dealing with the maintenance problem, in part because of the diversity of environments in which we operate and expect to operate. It is a conservative one, beginning with the use of total component redundancy that will allow work to continue even though one complete system is inoperable. In the worst case, this allows faulty systems to be sent back to repair points either in the same country or other countries. . . To the extent that systems are modular, it is possible to perform component swapping to assist in fault isolation and return small pieces of the system. . . In every microcomputer installation to date, our projects have included one resident expert for a period of time.
> (Sadowsky)

> To minimize system down-time in other countries, it has been necessary for SRS to provide the hardware support. To accomplish this, installations have been provided with spare integrated circuit boards and tool kits, and host country personnel trained to isolate hardware problems to the board level and replace the faulty board. The faulty board is then mailed back to the U.S. and a replacement board sent to the installation.
> (Steele)

There is relatively little information on the maintenance, trouble-shooting, and repair of microcomputers. Certain software is now on the market which will diagnose hardware and software problems, if the microcomputer is functioning. Several participants reported that it is now possible to obtain such software for the Apple II+. It may also become possible to obtain a diagnosis kit from Apple which until recently was used only to train their own personnel. At a minimum, participants recommended that researchers familiarize themselves with simple diagnostics involving the replacement of suspect boards and other parts. The consensus of participants was that 100 percent redundancy was essential when using microcomputers in areas without repair services.

> There being very little, if any, support for either the Apple or the North Star in Tunisia, we adopted a basic strategy of redundancy to try to assure that one system was always up and running. Two complete Apple systems were provided with acoustical couplers to facilitate their linkage. Each was supplied with two Epson MX-100 printers with a Silentype backup. Two disk drives were supplied for each computer with a fifth as a backup. The relative ease of changing Apple components on the mother board itself was also a favorable factor for Apple.
> (Mann)

A sufficient supply of printer ribbons, printer paper, and diskettes should also be kept on hand. Several researchers reported that analysis was often halted for long periods due to the lack of such items as printer paper.

Power Supply Problems

Microcomputers have serious problems with electrical power.

> The question of how to obtain reliable power has affected almost every one of our computer installations to some degree and has dominated the operational problems of some projects. This is true regardless of whether the computers are micros, minis, or mainframes. . . It is likely that for some time successful computing activities in developing countries will necessarily rely upon some informed technical advice and action regarding power measurement and conditioning.
> (Sadowsky)

Minicomputer and mainframe facilities require a highly regulated power supply. Microcomputers and their peripherals are less demanding but seldom can tolerate more than a 5 percent variation from voltage specifications. Electrical current in developing countries, even in capital cities, is seldom so precisely controlled. Continuous voltage of 10-15 percent above or below specifications is common, along with transient voltage surges that may go as high as several hundred volts. It is also not unusual for a city to have several blackouts in a month. Therefore, some type of power regulation equipment is an absolute requirement for most microcomputer installations.

It is standard operating procedure to recommend a general purpose regulator, line filters for "noise," and a surge/spike regulator with almost any microcomputer, in any location. This equipment may cost from $100-$1,000 in the U.S. In order to protect data files and diskettes, and avoid blackout problems, a research team in a developing country setting may want to obtain an uninterruptable power supply (UPS) for emergency backup.

> SRS has utilized numerous types of power conditioning devices: high isolation transformers, ultra-isolators, and line filters. None of these have proven totally satisfactory. In some countries, they have provided adequate protection--in others, they haven't. Uninterruptable power supply systems (UPSs) provide maximum protection, but they are expensive ($5,000+) and heavy (250-600 pounds) which make them difficult to transport.
> (Steele)

In the future, it is probable that new developments in CMOS and LCD technology will make microcomputer operation increasingly independent of public electrical power. For the present, however, conference participants concluded that new and innovative solutions are needed for the power supply problems which affect microcomputer and other data processing efforts in developing countries.

IV. SOFTWARE ISSUES

This chapter examines issues of software availability and development for both programmable calculators and microcomputers. Most potential Third World users (and a majority of the conference participants) are frustrated by the lack of relevant software for both programmable calculators and microcomputers. This puts a high premium on exchanging information about newly available software.[1/]

A. Programmable Calculators

How Can Field Researchers Obtain Appropriate, Well-Documented, and Flexible Software?

Although programmable calculators are more easily obtained than microcomputers in the Third World, many researchers are hard pressed to obtain appropriate software programs.

> Often, the field staff has only a high school or undergraduate degree and a weak background in mathematics. While they could quickly learn to use programs that are clearly documented (almost no such programs exist that are relevant to their analytical needs), it is unrealistic to expect them to write their own programs.
> (Bernsten)

Land grant universities in the U.S. have developed large libraries of programs for applied research and extension applications, as shown by James McGrann (see "Programmable Calculator Software Sources for Agriculture" in this volume) and J. Robert Strain ("Updated Inventory of Agricultural Computer Programs Available for Extension Use," Circular 531, Food and Resource Economics Department, University of Florida).

Texas Instruments' program exchange (PPX) has a catalog with a large number of programs.[2/] These sources of software are still relatively underutilized by developing country researchers, perhaps in part because the available programs are not entirely appropriate for application in different problem settings in developing countries. There is a definite need for software which strikes a balance between appropriateness for a specific task and flexibility in a range of similar activities. A related problem often cited is the unstandardized and often chaotic nature of program documentation.

[1/] An important objective of the microcomputer papers which are forthcoming in the MSU International Development series is to provide information on existing software.

[2/] See the discussion on page 31 about Texas Instruments' recent decision to stop manufacturing TI-59s in the United States.

> It is true that numerous programs are available from the manufacturers, U.S. universities, user exchanges, and farming systems practitioners. Yet in order for these to meet the existing need, a relevant set of programs must be identified, edited into a standardized format (i.e., all programs should use the same statistical notation, have routines for correcting erroneously entered data, compute widely used statistics, and be written so they can be used both with and without a printer), illustrated by sample problems from a single statistics text, and be compiled into a monograph.
> (Bernsten and Banta)

Programmable Calculator "Friendliness"

Many developing country researchers and field staff members already have some familiarity with programmable calculators. In general, they are not likely to feel as intimidated by the calculator as they would by a microcomputer. On the other hand, the disadvantages of the programmable calculator for major data processing tasks include the inability to display alphanumeric characters, the small keys, the difficulty of implementing data entry error routines, and a lack of user-friendliness. The newly developed pocket computer, however, may combine advantages of both technologies.

Software Transferability Problems

Even if appropriate programs are identified, documented, and disseminated, there are still problems of transferability from one calculator to another. Users in the U.S. have discovered that TI-59 programs which are recorded on magnetic strips in one calculator are not always readable on another, so they disseminate source programs which users can use to key programs into their own calculators. In tropical areas, calculator card reader mechanisms sometimes fail, leaving the researcher no choice but to key in the programs each time they are needed. When using Texas Instrument machines, Iowa State University has relied instead on the development of a removable agricultural program module for easy program access. Some conference participants expressed the desire for comparable modules for standard agricultural research tasks in developing countries.

B. Microcomputers

Word processing software is currently one of the most extensively developed applications area, and many researchers have found these programs to be extremely useful in the completion of timely reports. These programs are often a powerful "selling" point to potential microcomputer buyers. Electronic worksheet programs have also become more sophisticated, and can be powerful tools for project and budget evaluation and the production of data tables to combine with word processing text.

In looking to other research applications, many participants expressed the need for appropriate software for the following: (1) survey data entry, editing, and verification; (2) survey data base management; and (3) statistical analysis (see the report of Working Group A). Each of these applications is liable to present unique problems from country to country, and researchers can easily find themselves "reinventing the wheel" by trying to write or obtain new software for each different setting. Software development is a laborious task which especially frustrates the individual who is accustomed to the powerful and non-specialist orientation of mainframe software. In determining software needs, every effort should be made to use and/or adapt existing packages. When trying to develop new software, researchers might well take note of the following propositions, all of which argue for more flexibility in software program design:

1. Every survey situation requires different data processing procedures.
2. Data quality can be improved by computerized checking in the field.
3. Advantages exist in being able to modify analysis procedures in the course of processing.
4. Faster turnaround of data will improve decision making.
5. Retrieval of data for secondary analysis is desirable.

(Dixon)

Evaluation of Commercial Software

It is generally agreed that the first step in any project involving a microcomputer application is the identification and evaluation of existing commercial software that is at least minimally adequate for the task at hand. Hardware requirements can then be established given the constraints imposed by the desired software.

Unfortunately, there is still relatively little commercial software available for agricultural research applications. Data entry and data base management software have been primarily developed for business applications in industrialized countries. Commercial software is often unfriendly, undocumented, and incapable of processing large data files. Almost all of the available microcomputer statistical packages have been developed within the last year or two, and are still relatively untested. Most developing country researchers have neither the time nor the funds to carry out extensive evaluations of data base and statistical software, and therefore must rely on microcomputer magazine evaluations or word-of-mouth accounts of software experiences. Both of these methods are obviously helpful but are not likely to give sufficient insight into the appropriateness of the software for the particular application. Working Group A recommended that universities and other research groups should play a key role in the establishment of guidelines and the on-going and systematic evaluation of software. (See Working Group A's report at the end of this chapter.)

Commercial Versus Custom-Developed Software

There were strong opinions on the effectiveness of commercial versus custom-developed software. There is a trade-off between the task-specific nature and relatively high costs of custom software against the low-cost, but often inflexible commercial packages. Researchers should not underestimate the time and effort necessary to develop and test custom software for their specific tasks. Several research efforts which had first intended to develop custom software were forced after extensive delays to resort to commercial packages. Whether research teams opt for commercial or for custom software (or a combination of the two), it is highly desirable that they have access to competent programmers who can become familiar with proposed programs and, if necessary, help them modify and adapt software for particular tasks. A list of suggested characteristics of good programs included the following:

1. The programs should be easy to use and "forgiving" of user errors.
2. The programs should be adequately documented, both internally (explanations available interactively) and externally (written materials). In case research is carried out in a non-English-speaking nation, documentation of both types should be available in the local language. Few currently available packages have this characteristic.
3. The programs should store data efficiently. Compressed data storage will be an important factor for some time to come for microcomputers in developing countries, even though new developments have lowered the cost and increased the capacity of disk storage.
4. The programs should provide flexible mechanisms whereby data output can be interfaced with other applications programs. This is particularly important with regard to the output of data base management packages.
5. As much as possible, the programs should facilitate development of a "turn-key" operation, in which a relatively unskilled operator can accomplish most of the tasks required of the microcomputer.

(Malczynski)

Operating Systems and Programming Languages

The potential microcomputer user is confronted with software-related decisions about the operating system (software which accomplishes "housekeeping" tasks in the microcomputer) and the choice of high-level languages. These decisions are critical because not all hardware is compatible with certain operating systems and languages, and with the software programs which will actually accomplish the desired data processing tasks.

> Software for mainframes has traditionally been provided by the vendor... However, software for microcomputers is associated much more with an operating system, which might be written by an independent software house, instead of a vendor... In the majority of cases, a mainframe computer is run under one operating system. However, this is not at all the case in the micro world. There is a wide range of operating systems costing from less than one hundred dollars to several thousand dollars. They are generally dependent on having a particular microprocessor and bus.
> (Stuart and Diskin)

It was generally realized at the conference that the CP/M operating system, although far from ideal, is a de facto standard for 8-bit microprocessors; and that in the interest of program and data transferability it is the recommended operating system for most circumstances. However, it should be noted that a large body of non-CP/M applications programs are available for the Apple processor and operating system.

Although COBOL and FORTRAN remain the preferred languages for mainframe applications, no programming language has yet made a significant dent in the popularity of BASIC for microcomputers. The following illustrates why one research team chose BASIC:

> It was decided in the early stages that BASIC should constitute the main programming language for software on the microcomputing systems even though all of the programming personnel at APMEPU have FORTRAN experience. The reason for this choice may be summarized as follows:
>
> 1. The considerable flexibility of BASIC's data entry screen handling software (VTAB, HTAB, INVERSE, NORMAL, etc.) has no comparison in either FORTRAN or PASCAL.
> 2. BASIC allowed for rapid program development, especially when several available software development 'tools' were purchased.
> 3. Debugging is fast and easy in BASIC.
> 4. Character handling using the BASIC string manipulation functions (MID, LEFT$, RIGHT$, and strong concatenation '+') is excellent.
> 5. The advantage of FORTRAN for faster execution speed and code security could be easily matched by using a standard BASIC compiler.
>
> (Poate and Bennett)

There are approximately 50 different dialects of the BASIC language, which indicates the complexity of the language issue. Microsoft Corporation BASIC-80, however, is nearly an industry standard. As applications programs become more sophisticated, it will become possible for research teams to largely ignore these operating system and programming language issues.

C. Report of Working Group A: Strategies for Software Development/Exchange

A prerequisite for the identification of areas in which software exchange and development could be fruitfully explored is to ascertain what software exists and how good it is. The working group considered how information might be gathered about software. Although much of the information already exists in magazines, newsletters, or inventories as presented at this conference, such information needs to be collated and systematically evaluated. A simultaneous assessment of research needs would help marry up what exists with what is needed.

Application Areas

The working group felt that the conference had focused attention on three software application areas, namely:

1. Data entry, editing, and validation
2. Statistical analysis
3. Data base management systems

The working group recommended particular emphasis on data entry, editing, and validation because these activities do not require specialized knowledge, because validation procedures were application-dependent, and because many conference participants indicated that their work required rapid and accurate data entry.

Compatibility of Software

The working group felt that compatibility of software was a serious impediment to software interchange. In addition to the opinions advocating acquisition of hardware on the basis either of considerations of local support or of software needs, it was felt that adoption of a Z-80 microchip-based architecture running under the CP/M operating system would help promote software compatibility.[1/] However, the working group felt that recommendations about compatibility were likely to be overridden by considerations of a user's immediate needs. The physical incompatibility of discs exacerbates the interchange difficulties, although little can be done at this stage about the problem.

Role of Universities, Commercial Firms, and Consultants

The working group believed that the function of universities should be to set specifications for and to conduct research on software needs. Commercial firms were obviously sensitive to user needs but it was observed that they possibly had a vested

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[1/] Compatibility with the IBM PC and the PC-DOS or MS-DOS operating system may become as important in the future.

interest in retaining incompatibilities between systems. It was felt that consultants should concentrate on the design and training aspects of systems.

Recommendations

The consensus of the working group was that, as a first step, some mechanism should be established to disseminate information on disciplinary rather than machine-oriented lines. The function of such a "clearinghouse" would be to build an informal international network of correspondents to foster software development and exchange.

V. INSTITUTIONALIZATION AND TRAINING ISSUES

This chapter deals with the institutionalization of microcomputers and programmable calculators as data processing tools. It will first discuss the requirements for successful institutionalization, and then summarize certain points on short-run versus long-run institutionalization. The main discussion will apply to both types of technology, but some specific points regarding programmable calculators will be presented. Questions of training and information exchange will be treated as aspects of the institutionalization process.

Before proceeding, it is important to distinguish between short-run and long-run institutionalization. "Short-run" refers to getting microcomputers installed and running during the lifetime of a particular project. "Long-run" refers to integrating micros into the local institutional framework so that their use can be self-sustaining within the constraints of local resources. The issues distinguishing between the two time frames involve the length of the learning and "gearing up" process, and partly the degree of external support.

A. Requirements for Successful Institutionalization

Matching the Technology to Data Processing Needs

Ensuring the proper match between data processing needs and the proposed hardware and software is always a prerequisite for successful institutionalization. When foreign technical assistance teams undertake collaborative research with national research agencies, there is sometimes a tendency to import overly sophisticated analytical techniques. Hence, researchers working in developing country settings need to introduce analytical techniques and related data processing innovations gradually.

If long-term institutionalization is desired, there is a special need for researchers and host country research agency administrators to jointly determine how the microcomputers or programmable calculators should be used, and how to obtain long-term budget support. Stilwell emphasized the need to "sell the boss." He argued that this is done most effectively by giving key decision makers hands-on exposure to the equipment. Stilwell found that all other forms of persuasion were relatively ineffective. These ranged from itemizing the advantages to the technician (quicker, more accurate calculations) to presenting the boss with estimated cost savings, to demonstrations of word processing software for secretarial staff. An implication of the need to convince local administrators is that project staff should expect some demand for administrative applications of the technology rather than simply for research uses.

Solving Environmental Problems

Another major theme of the conference was the need to ensure compatibility of the data processing technology with local physical environmental conditions (i.e., such factors as local power supply, heat, dust, and humidity). The effective operation of micros or programmable calculators over a period of time clearly requires protecting the hardware from environmental hazards. Other aspects of compatibility include the desirability of interfacing the microcomputer with a mainframe computer installation, so that data collected at a remote site can eventually also be processed at a central location if necessary and/or desired. The technology should also be as compatible as possible with local repair facilities, the availability of trained manpower, and local institutional and budgetary support in general. In Bernsten's case in Indonesia, the number and type of personnel in different research locations played a role in determining the choice of technology used. For example, a mainframe computer was installed at the central location, microcomputers were used at branch research stations, and programmable calculators were used at field sites.

Manpower and Training

Considerable discussion was devoted to the issues of training and recruitment of appropriate personnel. One recruitment issue was the type of qualifications to seek in trainees.

> Among all four sites, four sets of institutional problems hampered the installation of a computer-based analysis system. The first problem was a lack of training facilities. The usual climatic problems plus a lack of office space plagued the establishment of a computer service. Secondly, the local staff chosen to attend the training programs ranged from secretaries to architects. The majority of the trainees had little or no exposure to mathematics or statistics. Thirdly, the time available for training had to be squeezed from the daily schedule of activities. Daily activities interfered to the point that group instruction was rendered impossible. It also occurred that the best trainees were also the best at their normal activity; therefore their superiors were against assigning these individuals to the computer service. Finally, the students had little or no incentive to follow the coursework. Studying was occupying their leisure time and they were not being remunerated for the acquisition of new skills.
> (Malczynski)

Training is needed not only for relatively low-level personnel as operators of microcomputers and programmable calculators, but also for middle-level technicians and senior scientists. In the case of the latter personnel, perhaps the most emphasis should be placed on first conceptualizing the underlying research problem and process, and then on using the computer software to analyze and interpret the results. Using programmable calculators as an example, it was suggested:

> Training should include care and maintenance of the programmable, basic programming, the use of selected master library and statistics pac (sic) program, and the use of all biological and economic analysis programs included in the monograph. In addition, periodic refresher training programs should be offered yearly to assist researchers to relearn forgotten programming skills.
> (Bernsten and Banta)

Discussions emphasized not only the importance of at least a minimum educational background but also of motivational questions. Mann observed that "the novice must have a high level of motivation to make the system work. . . Therefore, one of my criteria in judging whether or not someone is likely to succeed with a microcomputer is an assessment of the degree of determination to succeed." Some participants suggested that since it was difficult to predict who would become a good computer programmer or operator, the best strategy was simply to train as many people as possible and then identify at the end of the course those who have done particularly well.

It is most desirable that the training be carried out in the country where the technology is to be institutionalized. Yet exposure to computer hardware and software should also be a part of long-term degree programs for LDC personnel studying abroad.

> We will not be doing justice to teaching of agricultural technicians if they are not introduced to the software that enables them to solve pertinent problems. To do this, they need a hands-on experience in colleges and similar institutions.
> (Morris)

Several participants noted the problems experienced in training due to lack of satisfactory facilities and inadequate length of training programs. Both Steele and Poate discussed the length of the training programs used in their projects.

> The table below shows the type and length of training provided to host country personnel. This length of training generally proved sufficient for host country personnel to start utilizing the system. The training introduces them to the major features of the system and gets them past their initial fears of working with it. Expertise is developed with experience on the system, and by reading and re-reading the system documentation.

Personnel	Training	Time
Data Entry	Enter and edit survey data	1-2 days
Computer Operator	Hardware maintenance and repair	4-5 days
Programmer	BASIC programming	1 week
Statistician and Programmer	Survey data processing system	1 week
Statistician/ Analyst	Use of MICROSTAT package	1-2 days

(Steele)

A typical training session for the Agronomic Analysis survey lasts about two weeks during which time personnel are instructed on how to use the microcomputer system, enter data, and produce the required reports. These sessions are usually conducted by a member of APMEPU's data preparation department who has extensive experience in using the particular system. All specialized training is undertaken by the two members of the computing department responsible for the introduction and application of microcomputer systems. To date, some 25 people have been trained in one or more of the following:

- Visicalc - 3 days
- Visiplot/Apple plot - 1 day
- Wordstar - 5 days

(Poate)

Another issue raised by several participants concerned the incentive structure for those expected to learn more about new data processing techniques. Often, personnel had little incentive within their own institutional framework to participate in a training program. Malczynski observed that students received no work time or monetary compensation for their efforts. Reporting a more positive experience from Nigeria, Poate noted:

> It has been observed over the last nine months that the use of microcomputers has been readily accepted by the personnel involved. Training, of any form, is seen as a means of improving job status and of achieving promotion. Therefore, staff who previously have not been considered industrious suddenly change their work habits, at least during the training periods. The issuing of certificates of attendance for training courses has generally not been adopted, although certain personnel may be given a certificate if they demonstrate a complete understanding of the work involved and where the issue of a certificate may enable them to advance in their job.
> (Poate)

Over the long term, there needs to be a clear career path for those who have specialized training in computer technology. This is especially true for computer programmers.

In order to get around the lack of trained manpower, Malczynski suggested installing "turnkey" systems. This would minimize the requirement for local programmer input or software development. Poate also emphasized minimizing the need for programmer supervision. This implies either using commercial software or else making a very careful assessment of needs prior to initiating development of custom software.

Service and Maintenance Support

As discussed in Chapter III, most participants complained of the scarcity of dealer service networks in developing countries. The manufacturer's policy can pose a problem here. For example, an Apple Computer representative indicated that it was company policy to provide training for hardware maintenance and repair only to their authorized dealer personnel. This means that in a country where there is no authorized dealer, it is difficult to obtain repair services. Redundancy requirements, spare parts and tools, self-taught diagnostic capabilities, and expatriate "shuttle service" have been used to alleviate this problem. Participants clearly expressed their frustrations with this problem, but few generalizable solutions could be offered.

A noteworthy difference in perspective on the service and maintenance issue was evident between those associated with international donor-supported projects and those responsible for national computer units. Donor-supported projects often are able to maintain their microcomputer installation by having access to special privileges such as the diplomatic pouch, frequent travel by expatriate personnel, and full access to foreign exchange for purchase of equipment or repair expenditures. They are also more able to avoid customs problems in bringing in supplies or equipment. Local personnel, however, do not have these advantages. Peter Fish from Zimbabwe emphasized the difficulty they have in obtaining supplies and equipment, partly due to lack of foreign exchange, and partly due to the time required to obtain the necessary authorization. Also the cost of purchasing supplies and equipment and getting repairs done can be very much higher in local currency terms than it would be in the U.S. or Europe.

Helping introduce new skills, methods, and technology into agricultural research, and bringing about their long-term institutionalization, obviously requires a compromise between the perspectives of foreign and domestic scientists. An example of the need for such compromise was presented at the conference by Crawford and Fall in discussing a case in Senegal. As part of a larger project to decentralize and strengthen agricultural research, the Senegalese government installed an integrated computer system to support agricultural research: (1) an IBM 4331 mainframe computer was installed in Dakar; and

(2) five IBM 5120 microcomputers were located at ISRA field research stations. These IBM microcomputers are obsolete by U.S. standards and cannot be adapted to run much of the currently available commercial software. But there are good repair, maintenance, and other services available for them in the country. The strategy which the Michigan State University technical assistance team has formulated with the national agricultural research service in Senegal (ISRA) is to develop the capacity to fully utilize the IBM 5120's capabilities over the short to mid-term, and also to avoid overinvesting in custom software for the 5120 computer. It is anticipated that more cost-effective hardware and software will become available in Senegal within one to two years.

Operational Procedures

For both short-term and long-term institutionalization, it is important for any organization using a microcomputer or programmable calculator to establish clear operational rules for the organization of backup diskettes, filing and storage of diskettes, routine maintenance, and other procedures. The World Bank-supported project in Nigeria, for example, has established a lengthy list of do's and don'ts concerned with microcomputer operation. (See the paper by Bennett and Poate in Chapter VII.)

User Support

In most cases, those interested in installing microcomputers or programmable calculators in Third World countries will lack the kinds of user support services available in the U.S. or Europe. This includes documentation of software and, more importantly, the availability of consulting advice (e.g., on statistical applications) as well as sources of up-to-date news on computer hardware and software. Stilwell and Vera observed that a large demand for statistical counseling develops once the capability for microcomputer data processing has been established. Often, researchers in field locations feel a strong sense of isolation and an absence of anyone to rely on for advice on hardware or software. Incidentally, this is one reason for the "bandwagon effect" which several participants referred to as affecting the choice of hardware. Given the need to rely on fellow users for advice, frequently a project will choose to buy the same type of hardware that is already in use in the country.

Role of Expatriate Personnel

To date, many projects using microcomputers have been donor-supported and have involved expatriate personnel. As Morris noted, the costs of expatriate programmers are very high. In the future, the role of expatriate personnel will probably be less oriented towards operation of microcomputer installations and more towards training of local staff and setting up appropriate procedures. Indeed, Mann stated that in Tunisia: ". . . once the decision was made to provide no expatriate assistance, the group realized that it was in a sink-or-swim situation. A new spirit of cooperation emerged as they realized that they would have to pull together to make it work." Expatriate staff can also provide instructional materials and training for local staff who will then become computer trainers themselves.

B. Special Comments on Programmable Calculators

Remarks by conference participants and the paper by Bernsten and Banta suggest that programmable calculators are easier to institutionalize than microcomputers for several reasons: programmable calculators are more portable and easier to transport for repair; they are less demanding than microcomputers in terms of protection against the environment; and they are less costly to buy and use, indicating that they can become much more widespread than microcomputers. As a result, certain data collection and analysis needs can be more readily based on programmable calculators and more effectively institutionalized. To be effectively utilized, however, calculators clearly require training and user support, just as do microcomputers. A major attraction of the Hewlett-Packard and Texas Instruments programmables is their extensive user networks which serve as a source of information for users in the field.

Unfortunately, the microcomputer technology revolution is progressing so rapidly that industrialized countries' users (and manufacturers) are quickly losing interest in programmable calculators. For example, Texas Instruments will stop manufacturing TI-59s in the United States in March 1983. It is unclear how this will affect the availability of TI-59s in developing country markets since they will continue to produce TI-59s in Brazil for at least one additional year. Since Texas Instruments will be selling a hand-held computer (BASIC language-oriented) as a replacement for the hand-held programmable, they might not be aggressive in selling TI-59s in foreign markets. A major implication is that hand-held computers could dominate the market, and the abundant programmable calculator software developed in keystroke language may have to be converted to BASIC for use on the various makes of hand-held computers.

C. Summary of Institutionalization Issues

Short-run institutionalization clearly requires not only a proper match of data processing needs to hardware and software, and the ability to meet the environmental problems existing at a computer installation, but also the minimum training, service, and maintenance support, and development of operational procedures for the project team itself. For longer-term institutionalization, however, greater emphasis is needed to develop a strong commitment on the part of local authorities, training of local personnel, developing a service and maintenance capability, institutionalizing operational procedures, and developing user support services in terms of consulting, documentation, and information exchange. The report of Working Group B2 (shown below) on institutionalization illustrates the necessary and sufficient conditions for successful installation and use of computer technology. Creation and staffing of computer units and establishment of recurrent cost budgeting for computer installations are also critical in a long-run context.

D. Report of Working Group B1: Institutionalization of Micros/Programmables

Institutionalization, not computers, is the major issue. How to train people to use microcomputers and programmable calculators is an issue which follows from this. The Working Group concluded that:

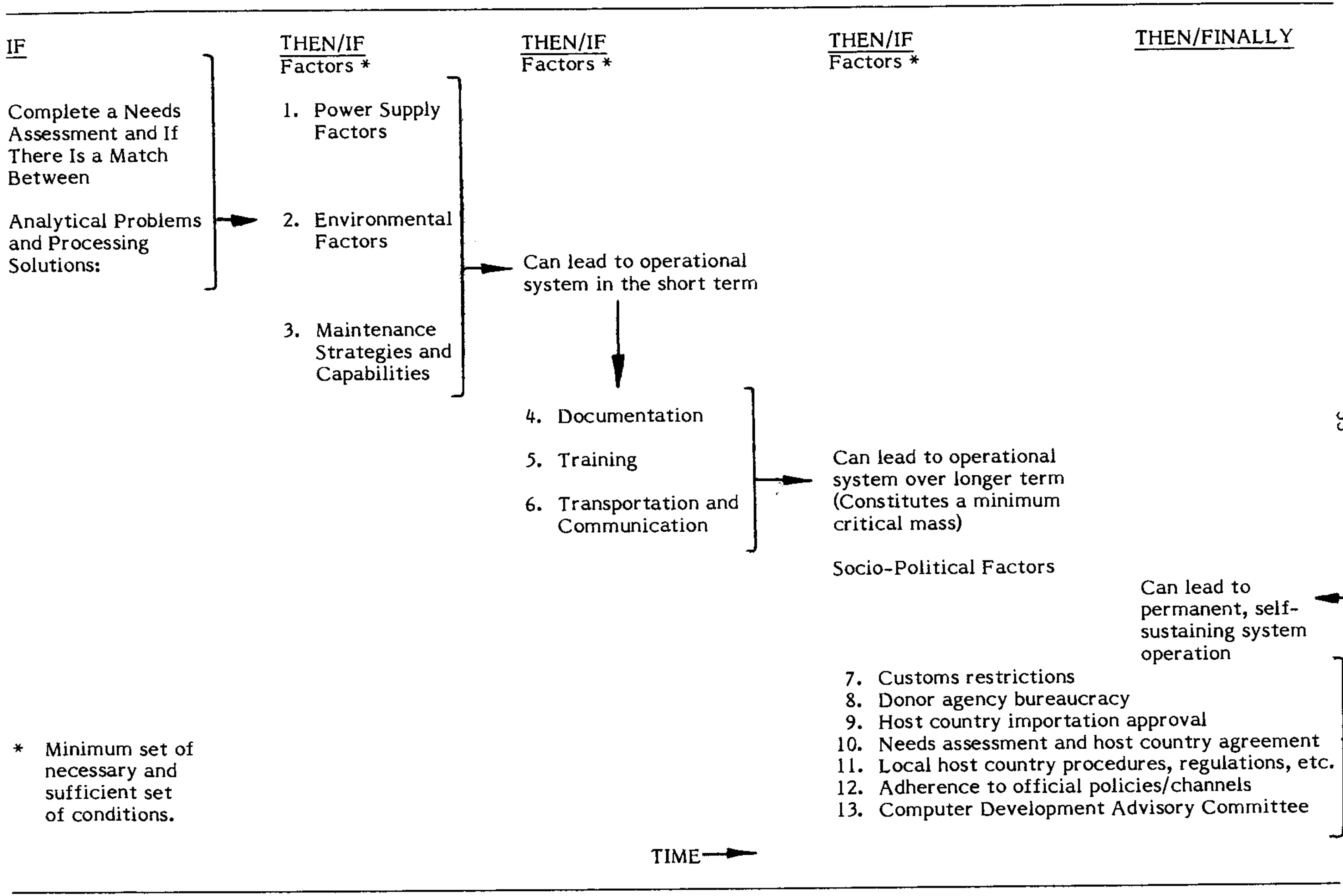
1. Computer literacy should be emphasized in universities with international programs. Training should involve both programming and hardware aspects.
2. Attention should be focused not on micros **per se,** but on data collection, management, and interpretation of agricultural data.
3. There is a recognized need for establishment of permanent capabilities and facilities for agricultural data management in Third World countries.
4. There is an equally critical need for regional and/or international information interchange on data management.
5. Currently available software for agricultural data management and analysis should be evaluated and the conclusions disseminated to researchers, donor agencies, and institutions in the Third World.

E. Report of Working Group B2: Technical Issues in Institutionalization of Micros/Programmables

The working group identified 13 technical factors which can constrain the institutionalization of host country use of micros and/or programmables. They also felt that it is important to consider these factors in a long-term perspective. These factors are shown in Figure 1. If these factors are adequately addressed, then self-sustaining and effective data processing systems can be institutionalized.

The working group also developed the following list of technical recommendations for improving the field use of microcomputers.

Figure 1. Technical Factors Involved in Institutionalization of the Use of Microcomputers



Technical Recommendations for Effective Field Use of Microcomputers in Developing Countries

0. Specify the job to be done and whether a micro is needed to complete it.

1. When you first buy equipment, also buy the tools, spare parts, test equipment, and hardware manuals (with schematics).

2. Dedicate a single line to your equipment, one that is power-conditioned.

3. Stock all fuses (of proper amperage) for <u>all</u> equipment.

4. Stock spare boards, and/or have redundant (back-up) equipment.

5. Stock all needed supplies including diskettes, ribbons, cables, print heads, paper, transformers, etc.

6. Do regular monthly maintenance, including:
   - Open the machine (unplugged first and having touched power supply first to discharge static electricity)
   - Clean contacts
   - Press down all chips
   - Clean heads

7. Protect equipment from food, drink, tobacco smoke, dust, and any other foreign matter (including spiders).

8. Keep diskettes in their jackets and keep backups.

9. Inform yourself about computer maintenance by reading articles, equipment manuals, etc., and learn to diagnose problems.

10. If you use an air-conditioned room, seal all windows shut, have a back-up air conditioner available, have a spring on the door to keep it closed, use a wet bulb humidity measure, and, if necessary, a dehumidifier in the room or inside the computer itself.

11. Keep computer away from air conditioner (moisture and static electricity).

12. Provide common "earth" ground between all system components.

13. Provide adequate ventilation, e.g., fan on computer <u>or</u> in the room.

14. Consider use of UPS in light of budget and power needs (<u>condition</u> your power appropriately).

15. Consider flushing buffers, so as not to lose data if power fails.

16. Learn basic electronic testing rules: e.g., 50/50 rule on isolating problem, 80/20 rule of specific major/typical problems/causes in each sub-module.

17. Power on/off switches can fail. Consider unplugging instead of using the switch.

18. Acquire information on each piece of hardware's dependency on frequency (e.g., 50/60 or is it 60 $\pm$ 5%).

19. Know the different tolerance levels (concerning power requirements) for each piece.

VI. CONFERENCE PROGRAM AND PARTICIPANTS

A. Conference Program by Topic and Speaker

<u>Tuesday, May 18</u>

SURVEYS AND/OR UPDATES ON MICROCOMPUTER APPLICATIONS IN DEVELOPING COUNTRIES

GERDAT-France - "The Importance of Using Computers in a Research and Development Process"
Michel Braud

A presentation and paper which describes IRCT farm management research activities with cotton farmers in the Sahel.

USAID/USDA - "Survey of Microcomputer Use by USAID and USDA Personnel Working in Developed Countries: A Preliminary Analysis"
Noel Berge

Presentation and discussion of summary statistics and tables resulting from a survey carried out in 1981-1982 on microcomputer applications in development projects funded by USAID.

VEERU-University of Reading - Notes on University of Reading Veterinary Epidemiology and Economics Research Unit activities.
Andrew Stephens (presented by Michael Weber)

Brief notes on microcomputer software development for use in animal health, production planning, and monitoring activities, especially in Kenya and Colombia.

PRESENTATION AND DISCUSSION OF CASES USING MICROCOMPUTERS TO ANALYZE RESULTS OF FIELD TRIALS AND AGRONOMIC EXPERIMENTS

Bolivia - "The Agricultural Statistical Analysis System"
Tom Stillwell, A. Stambruk, and Rafael Vera

A presentation and paper which discusses a package of programs for the Osborne I microcomputer and PDP 11/45 minicomputer for use in analysis of agronomic trials.
(The paper is included in this volume.)

Senegal/Michigan State University - Update on Senegal Agricultural Research Institute/MSU Project and Microcomputer Applications.
Moussa Fall and Eric Crawford

Description of a project to develop Senegalese agricultural research capacity, organize production systems research, and carry out macroeconomic research on food and agricultural policy. A system of one IBM 4331 mainframe and five IBM 5120 microcomputers will be utilized for data processing.

Michigan State University - "Mainframe and Microcomputer Software Developments to Assist Plant Breeders in Plant Population Data Management, Experimental Design, and Data Analysis"
Everett Everson and Russell Freed

A brief description of the MSU Computer System for Plant (Wheat) Breeding and current activities to develop an improved version of the software for microcomputers.

Wednesday, May 19

PRESENTATION AND DISCUSSION OF CASES USING MICROCOMPUTERS TO ANALYZE FARM MANAGEMENT DATA

West Africa/ Purdue University - "Notes on the Purdue West Africa Experience"
Wilford Morris and Len Malczynski

A presentation and paper summarizing the Purdue experience with microcomputers in Farming Systems Research activities, including particularly the institutional problems which hampered the installation of a computer-based analysis service.
(The paper is included in this volume.)

Nigeria/ World Bank - "The Use of Microcomputers in Farm Management Surveys"
Derek Poate and John Bennett

A presentation and paper discussing the experience of APMEPU in farm-level research, project monitoring, and project evaluation activities using microcomputers. Also presented are experiences with commercial and custom software and aspects of hardware maintenance and repair.
(The paper is included in this volume.)

FAO - "A Farming Systems Research Data Processing Package"
John Dixon

A presentation and paper describing the FAO farm survey data analysis package FARMAP. The microcomputer programs are designed for data entry, validation and tabulation, and subsequent interface with some external statistics package.

World Bank - Notes on the use of microcomputers for herd projections and for analysis of farm models.
Orlando Espadas

Tunisia/ Rockefeller Foundation -

"Should We Throw the Man an Apple?"
Charles Mann

A presentation and paper reflecting the Rockefeller Foundation/Tunisian Agricultural Planning Office efforts to improve researcher productivity by computerizing routine spread-sheet analysis and projections using off-the-shelf technology and software.

PRESENTATION OF CASES USING PROGRAMMABLE CALCULATORS IN AGRICULTURAL RESEARCH AND PROJECT DESIGN/EVALUATION

Asia -

"The Use of Programmable Calculators in Farming Systems Research in Asia: Selected Experiences, Problems, and Potentials"
Richard Bernsten and G. Banta

A presentation and paper which presents experiences with programmable calculators in farming systems research in Asia, applications which would improve researcher efficiency, and suggestions concerning necessary preconditions for wider use of programmable calculators in research.
(The paper is included in this volume.)

Costa Rica/ Iowa State University -

"Use of the Programmable Calculator in Costa Rica"
William Edwards and Walter Gonzalez

A presentation and background notes on the utilization of programmable calculators in agronomic and economic research at the University of Costa Rica.

World Bank/EDI -

"Use of Programmable Calculators and Microcomputers in the Analysis of Agricultural Projects"
Orlando Espadas

A discussion of selected Economic Development Institutes' course notes concerning calculation of farm models using programmable calculators.

Central and South America/Land Tenure Center -

"Training Courses in Statistical Analysis on Programmable Calculators"
Richard Powers

Summary description of Land Tenure Center short courses in applied research on agricultural policy and agrarian reform.

Michigan State University - "The Use of Programmable Calculators as Aids in Effective Cooperative Extension Service Programs for Farmers"
W. Conard Search and Ralph Hepp

A summary of MSU/CES experiences in developing an extension program to supply farmers and extension agents with relevant software for programmable calculators.

Thursday, May 20

PRESENTATION AND DISCUSSION OF CASES USING MICROCOMPUTERS TO PROCESS AND ANALYZE SURVEY RESEARCH DATA IN DEVELOPING COUNTRIES

Jamaica/ Statistical Reporting Service/ USDA - "Utilization of Microcomputers to Process Agricultural and Economic Survey Data in Developing Countries"
Ronald Steele

A presentation and paper of experiences of the USDA/SRS Remote Area Sensing for Agriculture Project in the procurement, testing, and installation of microcomputer systems for the processing of survey data in various LDC agricultural ministries. Includes problems encountered in training efforts and in establishment of software and hardware systems support.
(The paper is included in this volume.)

"Use of a Microcomputer to Process and Analyze Agricultural Data in Jamaica"
Beulah Edoo

A description and paper on Jamaica Ministry of Agriculture experiences with the software and hardware introduced by USDA/SRS.

Egypt/Michigan State University - "Using Mark-Sense Techniques to Collect and Input Information Into Microcomputers"
James Seale and Leighton Price

A presentation on MSU activities underway in Egypt to collect and input data registered on mark-sense questionnaires for a survey of small enterprises.

United Nations Statistical Office -

"The Introduction of Microcomputers in Developing Countries by the United Nations Secretariat: Some Initial Experiences and Observations"
George Sadowsky

A presentation and brief paper describing UN operations to develop micro, mini, and mainframe systems in various LDC population census offices, with particular description of hardware, power supply, and maintenance aspects.
(The paper is included in this volume.)

Bureau of the Census -

"The Feasibility of Using Microcomputers in National Statistical Offices in Developing Countries: Initial Thoughts and Findings"
William Stuart and Barbara Diskin

This presentation and paper describes some initial results from a BUCEN International Statistical Programs Center study on the feasibility of using microcomputers in LDC national statistical offices. It describes a typical NSO data processing situation, compares microcomputers to mainframes for this type of activity, and briefly describes four current microcomputer applications.
(The paper is included in this volume.)

Friday, May 21

UPDATES ON MICROCOMPUTER APPLICATIONS IN AGRICULTURAL EXTENSION, TEACHING, AND RESEARCH WITH EMPHASIS ON THE UNITED STATES

University of Florida -

"Updated Inventory of Agricultural Computer Programs Available for Extension Use"
J. Robert Strain and Sherry Fieser

A presentation and discussion of a new publication which provides an inventory of software for programmable calculators and computers developed by U.S. universities. This report may be purchased directly from the University of Florida by writing to Publications Distribution Center, IFAS Building 664, University of Florida, Gainesville, Florida 32611.

Michigan State University -

"Microcomputer Applications in Agricultural Teaching"
Alvin Smucker

Described activities underway in crop and soils courses to develop microcomputer-assisted learning modules for classroom and laboratory instruction.

Texas A&M University -

"Microcomputer Enterprise Budget Generator System"
James McGrann

Presentation and paper covering details of microcomputer software under development at Texas A&M which will allow non-computer specialists to develop enterprise economic budgets, enterprise accounting budgets, and whole farm cash flows for crop and livestock operations.

"Programmable Calculator Software Sources for Agriculture"
James McGrann

This paper presents lists of programmable calculator software available from various universities.
(Both McGrann papers are included in this volume.)

Michigan State University -

"Networking of Micros with Other Systems: Experiences of COMNET"
Steve Harsh

A presentation and notes on networking of microcomputers with other systems, including experiences of the MSU COMNET telecommunications network.

B. Conference Participants

Participants	Material Presented
Fatoo N'Dao Ba ISRA Experiment Station B.P. 34 Ziquinchor, Senegal	
Randolph Barker Department of Agricultural Economics Cornell University Ithaca, New York 14853 Tel. 607-256-2105	
Joseph Beausoleil Office of Rural Development and Development Administration Bureau of Science and Technology Department of State Agency for International Development Washington, D.C. 20523 Tel. 703-235-8918	
Noel Berge Thunder, Inc. 805 Devon Place Alexandria, Virginia 22314 Tel. 703-548-3849	Analysis of Known Microcomputer Applications Being Used on Development Projects Funded by USAID (with Marcus Ingle)
Richard Bernsten WINROCK International Livestock Research and Training Center Route 3 Morrilton, Arkansas 72110 Tel. 501-727-5435	The Use of Programmable Calculators in Farming Systems Research in Asia: Selected Experiences, Problems, and Potential (with G. Banta) (Included in this volume)
Ron Boring Apple Computer 20525 Mariani Avenue Cuperinto, California 95014 Tel. 408-906-1010, ext. 2573	
Michel Braud Division d'Agroeconomie Institut de Recherches du Coton et des Textiles Exotiques 42 Rue Sheffer 75016 Paris, France	The Importance of Using Computers in a Research and Development Process
Eric Crawford Department of Agricultural Economics Michigan State University East Lansing, Michigan 48824 Tel. 517-353-8601	Notes on Senegal Agricultural Research Institute/MSU Project and Microcomputer Applications (with Moussa Fall)

Silvio de Franco
Instituto Centramericano
de Administracion de Empresas
Apartado Postal 2485
Managua, Nicaragua

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Barbara Diskin
International Statistical Programs Center
Bureau of the Census
Washington, D.C. 20233
Tel. 301-763-2750

The Feasibility of Using Microcomputers in National Statistical Offices in Developing Countries: Initial Thoughts and Findings
(with W. Stuart)
(Included in this volume)

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John Dixon
Farm Management and Production Economics Service
Agricultural Services Division
Food and Agriculture Organization of the United Nations
Via delle Terme di Caracalla
00100 Rome, Italy
Telex 610-181-FAO-I
Cable FOODAGRI ROME
Tel. 39-6-5797-3709

A Farming Systems Research Data Processing Package

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Beulah Edoo
Ministry of Agriculture
Hope Gardens
Kingston 6, Jamaica
Tel. 809-927-9831

Use of a Microcomputer to Process and Analyze Agricultural Data in Jamaica

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William Edwards
Department of Agricultural Economics
Iowa State University
Ames, Iowa 50010
Tel. 515-294-3000

Experience with Agricultural Software for Programmable Calculators
(with Philip Spike and Gene Rouse)

Use of the Programmable Calculator in Costa Rica

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Carl Eicher
Department of Agricultural Economics
Michigan State University
East Lansing, Michigan 48824
Tel. 517-353-9330

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Orlando Espadas
The World Bank--EDI
1818 "H" Street, N.W.
Washington, D.C. 20433
Tel. 202-477-4436

Notes on The Use of Microcomputers and Programmable Calculators for Herd Projections and Analysis of Farm Models

* * * * *

Everett Everson Department of Crop and Soil Science 307 Agriculture Hall Michigan State University East Lansing, Michigan 48824 Tel. 517-355-2231	Mainframe and Microcomputer Software Developments to Assist Plant Breeders in Plant Population Data Management, Experimental Design, and Data Analysis (with R. Freed)

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Moussa Fall ISRA Experiment Station B.P. 34 Ziquinchor, Senegal	Notes on Senegal Agricultural Research Institute/MSU Project and Microcomputer Applications (with Eric Crawford)

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Peter Fish Computer Center University of Zimbabwe P.O. Box M.P. 167 Mt. Pleasant Harare, Zimbabwe	

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Russell Freed Department of Crop and Soil Science 303 Agriculture Hall Michigan State University East Lansing, Michigan 48824 Tel. 517-355-2231	Mainframe and Microcomputer Software Developments to Assist Plant Breeders in Plant Population Data Management, Experimental Design, and Data Analysis (with E. Everson)

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Steven Harsh Department of Agricultural Economics Michigan State University East Lansing, Michigan 48824 Tel. 517-353-4518	Notes on Networking of Micros with Other Systems' Experiences of COMNET

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Ralph E. Hepp Department of Agricultural Economics Michigan State University East Lansing, Michigan 48824 Tel. 517-353-7185	The Use of Programmable Calculators as Aids in Effective Cooperative Extension Service Programs for Farmers (with W. C. Search)

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Valerie Kelly Department of Agricultural Economics Michigan State University East Lansing, Michigan 48824 Tel. 517-353-7895	

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Len Malczynski Department of Agricultural Economics Purdue University Lafayette, Indiana 47907	West Africa/Purdue Part 2 (Included in this volume)

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Charles K. Mann The Rockefeller Foundation 1133 Avenue of the Americas New York, New York 10036 Tel. 212-869-8500	Should We Throw the Man an Apple? Microcomputers in Tunisia

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James McGrann
Department of Agricultural Economics
Texas A&M University
College Station, Texas 77843
Tel. 713-845-2116

Microcomputer Enterprise Budget Generator System and Programmable Calculator Software Sources for Agriculture
(Both papers included in this volume)

* * * * *

Wilford Morris
Department of Agricultural Economics
Purdue University
West Lafayette, Indiana 47907

West Africa/Purdue
Part I
(Included in this volume)

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Peter Olorunfemi
A.P.M.E.P.U. Office
P.M.B. 2178
Kaduna, Nigeria
Telex N671153

The Use of Microcomputers in Farm Management Surveys
(with D. Poate)

* * * * *

James Pease
Department of Agricultural Economics
Michigan State University
East Lansing, Michigan 48824
Tel. 517-355-9654

* * * * *

Derik Poate
A.P.M.E.P.U.
P.M.B. 2178
Kaduna, Nigeria
Telex 71153 AGDEV NG

The Use of Microcomputers in Farm Management Surveys
(with J. Bennett)
(Included in this volume)

* * * * *

Richard Powers
King Hall
Land Tenure Center
University of Wisconsin
Madison, Wisconsin 53706

Training Courses in Statistical Analysis on Programmable Calculators

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Leighton Price
Lifelong Education Program
42 Kellogg Center
Michigan State University
East Lansing, Michigan 48824
Tel. 517-353-5038

Using Mark-Sense Techniques to Collect and Input Information Into Microcomputers
(with J. Seale)

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Firmena Rivera
Research and Development Center
Central Luzon State University
Munoz, Nueva Ecija
Philippines

The Data Requirements and Computerization Needs of the Integrated Agricultural Production Marketing Project of the Central Luzon State University

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Mandivamba Rukuni
Department of Land Management
University of Zimbabwe
P.O. Box M.P. 167
Mt. Pleasant
Harare, Zimbabwe

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George Sadowsky The Statistical Office, Room 3135 The United Nations United Nations Plaza New York, New York 10017 Tel. 212-754-1234	The Introduction of Micro-computers in Developing Countries by the United Nations Secretariat: Some Initial Experiences and Observations (Included in this volume)
James Seale Department of Agricultural Economics Michigan State University East Lansing, Michigan 48824	Using Mark-Sense Techniques to Collect and Input Information Into Microcomputers (with L. Price)
W. Conrad Search Cooperative Extension Service 226 E. Michigan Avenue Paw Paw, Michigan 49079 Tel. 616-657-5564	The Use of Programmable Calculators as Aids in Effective Cooperative Extension Service Programs for Farmers (with Ralph Hepp)
Alvin Smucker Department of Crop and Soil Science 405 Agriculture Hall Michigan State University East Lansing, Michigan 48824 Tel. 517-355-8370	Microcomputer Applications in Agricultural Teaching
Ronald Steele Statistical Reporting Service International Programs U.S. Department of Agriculture Room 3524, South Building Washington, D.C. 20250 Tel. 202-447-4505	Utilization of Microcomputers to Process Agricultural and Economic Survey Data in Developing Countries: A Summary of Activities of the Statistical Reporting Service (Included in this volume)
Robert D. Stevens Department of Agricultural Economics Michigan State University East Lansing, Michigan 48824 Tel. 517-353-1667	Word Processor Software for the Apple II Microcomputer--Summary of Comparisons (Agricultural Economics Staff Paper No. 1982-21) A Comparison of Data Base Management Programs for the Apple, TRS-80, and CP/M Microcomputer Systems (Agricultural Economics Staff Paper No. 1982-31)
T. C. Stilwell Department of Agricultural Economics Michigan State University East Lansing, Michigan 48824	The Agricultural Statistical Analysis System (with A. Stambuk and R. Vera) (Included in this volume)

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J. Robert Strain
Department of Food and
Resource Economics
McCarty Hall
University of Florida
Gainesville, Florida 32611

Updated Inventory of Agricultural Computer Programs Available for Extension Use

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William Stuart
International Statistical Programs Center
Bureau of the Census
Washington, D.C. 20233
Tel. 301-763-2750

The Feasibility of Using Microcomputers in National Statistical Offices in Developing Countries: Initial Thoughts and Findings
(with B. Diskin)
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* * * * *

Richard Suttor
Office of Agriculture
Bureau of Science and Technology
Agency for International Development
Washington, D.C. 20523

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Rafael Vera
MACA/IBTA
Casilla 3229
Cochabamba, Bolivia

The Agricultural Statistical Analysis System
(with A. Stambuk and T. Stilwell)

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Warren Vincent
Department of Agricultural Economics
Michigan State University
East Lansing, Michigan 48824
Tel. 517-355-9298

* * * * *

Michael Weber
Department of Agricultural Economics
Michigan State University
East Lansing, Michigan 48824
Tel. 517-353-8639

* * * * *

Christofer Wolf
Computer Services--Agricultural Economics
317 Computer Center
Michigan State University
East Lansing, Michigan 48824
Tel. 517-353-5017

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CHAPTER VII.

SELECTED CONFERENCE PAPERS

A. **"The Use of Programmable Calculators in Farming Systems Research in Asia: Selected Experiences, Problems, and Potential,"*** by R. H. Bernsten and G. Banta.**

Introduction

During the past five years, hand-held programmable calculators have been increasingly used as an analytical tool by United States farm management extension specialists, farmers, and students. This technology has enabled the analysis of data in a few minutes that would require several hours if done by hand.

The programmable calculator is also particularly appropriate technology for applied farming systems research programs in developing countries since the scientist can rapidly analyze both biological and economic data.

Over the past ten years, national research programs in Asia have greatly increased their involvement in farming systems research. In Indonesia, there are over 20 sites spread throughout the country. In coming years, each country can be expected to double and triple the number of field sites. The programmable calculator has a role in significantly increasing research productivity at these field sites. In other regions of the world, farming systems programs are also expanding. In order to meet this need, efforts must be initiated immediately to solve the problems that have to date slowed the diffusion of the programmable calculator technology in Asia.

This paper reviews efforts that have been made to introduce programmables in several farming systems programs in Asia and problems encountered; describes applications that would increase research efficiency; and suggests actions that must be taken before programmables will be widely adopted in farming systems programs.

Advantages and Disadvantages of Programmable Calculators

While attempts to introduce programmables into Asian agricultural research systems have faced serious constraints, we are still convinced they are an appropriate technology.

Advantages

As noted by Espadas (1978), programmables greatly reduce the time required to complete a given amount of analysis, reduce human error in chain calculations, guarantee a standardized output regardless of who uses the program, can provide an incentive to do more detailed analysis, and can be programmed to print intermediate output so the

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*Paper presented at a conference on Microcomputers and Programmable Calculators for Agricultural Research in LDCs, May 18-22, 1982, Michigan State University, East Lansing, Michigan.

**Economist, Winrock International, Rt. 3, Morrilton, Arkansas 72110 and Economist, Program Officer, IDRC, Private Mail Bag, Peradeniya, Sri Lanka, respectively. Dr. Banta provided extensive written comments which are incorporated throughout this paper.

researcher can follow the analysis step-by-step. Levine (1981) cites advantages such as low cost (relative to microcomputers and time on a main frame); and that since programmables are portable, they can be taken to the field for on-site analysis. In addition, programmables enable the researcher who collected the data to analyze it himself and immediately use the results in planning the next season's research. Finally, the calculator programming "language" is simpler to learn than BASIC, FORTRAN, or SPSS which make it possible for less highly trained staff to use the technology.

Disadvantages

Hinton (1978) cites several concerns including their limited data storage capacity, limited program storage capacity, and minimal documentation provided by the printer. McGrann and Edwards (undated) suggest that the limited input/output capacity may be a hidden advantage since it "reduces the temptation of researchers to ask the user for more information than he can possibly supply or to provide him with more numbers than he can possibly absorb." This reflection is equally (more) applicable to survey researchers who have a tendency to administer voluminous questionnaires to illiterate farmers in developing countries. An additional inconvenience is that programs recorded by one calculator on a magnetic card will usually not be accepted if the card is used to input the program into another unit.1/ This makes it inconvenient when exchanging programs, since each user has to key in the program by hand and record it for himself.

Selected Experiences in Programmable Calculator Use

Programmable calculators are being used to a limited extent in farming systems research programs in several Asian countries, largely as a consequence of individuals who believe in their applicability and have promoted their use. While the following review is not comprehensive, it covers efforts of which we are aware through our association with Asian research programs over the past several years.

Bangladesh. The Mennonite Central Committee (MCC) has been involved in farmers' cropping systems field research since at least the mid-1970s. Richard Dick (now a Ph.D. student in agronomy at Iowa State) served as agricultural program leader and in 1979 wrote several programs for the TI-59 to be used in analyzing agronomic and economic data, including a program to evaluate a randomized complete block, split-plot, and factorial (3 x 3) experimental design and net returns for cropping pattern trials. Dick trained Bangladesh technicians to use these programs, but did not attempt to teach programming skills. These TI-59 programs are still being used in the MCC research effort. The cost and returns program has been particularly effective since its use resulted in the generation of the same standardized analysis for all cropping pattern trials at all sites each year.

Dr. Clarence Miller, recently hired by IRRI and assigned to The Bangladesh Rice Research Institute, has used the TI-59 previously in project analysis work (Benefit-Cost and Internal Rate of Return Analysis) and plans to encourage its use by the BRRI economics staff. Previously, BRRI had an HP-97, but continual breakdowns have just about stopped their efforts.

1/ A technician at the TI factory in Singapore told me you can solve this problem by opening the unit and adjusting the screw that controls the speed at which the magnetic card is pulled through the card reader. Apparently, if two units are set at the same card reading speed, programs recorded on one unit can be read on another.

Thailand. Gordon Banta has promoted the use of the TI-59 as agricultural program officer for IDRC projects in several countries in Asia, including Thailand. Gordon has focused on making available to national cooperators not only programs for the analysis of experimental data, but also net returns routines. Most of the programs distributed were originally obtained from the Texas Instruments Professional Program Exchange (PPX).

Khon Kaen University has recently acquired two TI-59s. Assistance is being provided by Charles Alton, a USAIA employee working at Khon Kaen on a farming systems program.

Philippines. The Hewlett-Packard HP-67 and TI-59 have been used successfully by economists in both the Economics and Engineering Departments of the International Rice Research Institute for several years. In May 1981, the Economics Department (IRRI) under the leadership of Robert Herdt and Sisera Jayasuriya initiated a "Training Program for Economists in Agricultural Research," to be offered twice a year (4-6 weeks/session) to 10-15 economists per session from research institutes in Asia. Each participant is provided a TI-59 plus printer (included in the registration fee). Programming training is provided initially and at three intervals during the session, and the skills acquired are used to analyze data provided the participants in subject matter units throughout the course.

In addition, the TI-59 has recently been used by staff at an IRRI cropping system field site in Northern Luzon to complete most of the data analysis.

Sri Lanka. In Sri Lanka's cropping system program, both HPs and TIs were acquired, but have had limited use because engineering versions were bought and the acquisition of two brands meant that no uniform programs could be developed. Also, a microcomputer was purchased but has worked only a few days in the past two years due to breakdowns.

Indonesia. In the IRRI/CRIFC program, Rick Bernsten made an effort to introduce the TI-59 and printer into five program areas. First, in the Consequences of Mechanization on Output, Employment, and Income Distribution project--a two-year survey research effort--Bart Duff (project leader at IRRI) made available to the staff one unit at each of our two field sites. These were extensively used with the "stats pac" to do ANOVA, chi-square, and t-test analysis. Second, a TI-59 was made available to two of the Central Research Institute for Food Crops regional stations, primarily for the analysis of biological trials. At one station, a three-day intensive training program was held to teach five staff members how to use about eight PPX ANOVA programs. Third, to give an economic interpretation to multi-treatment biological experiments, a routine was developed and used to perform marginal benefit-cost analysis of a fertilizer trial. Fourth, a half-day training session was conducted for 30 cropping systems economics trainees--mainly to make them aware of the technology in the hope they would ask their superior to purchase units for their sites. Finally, a TI-59 was acquired for the staff at the Central Research Institute for Animal Science where Winrock has a staff economist (Henk Knipscheer) assigned, and an introductory programming session was held for five staff economists. Follow-up sessions will focus on specific programs for biological and economic analysis related to livestock research.

In addition, Dr. Geoff Swenson (IADS), assigned recently to the Center for Agro-Economic Research, has developed a comprehensive set of HP-41C programs for labor cost and returns, material cost and returns (plus means and standard deviations), the construction of cross-tabulation tables (plus various statistics), and magnetic card data entry for multiple linear and polynomial regression. Geoff used these programs while working in Bangladesh and is now training CAER staff in their use.

Electrical power surges are also likely to damage the recharger, calculator, and printer. While power damage can be prevented by using a voltage stabilizer, effective units will cost $100 or more. Users in Indonesia, Sri Lanka, and Bangladesh all have been plagued with various types of malfunctions.1/

Once damaged, it is typically difficult and expensive to make repairs. In Indonesia, the TI-59 dealer does not recognize the guarantee unless he sold the unit. We resorted to hand-carrying units to the TI factory in Singapore, since mailing might result in loss or a customs charge upon return. Yet, this solution depends on staff (generally an expatriate) frequently traveling to Singapore, requires a two- to three-day layover since TI Singapore does not have a calculator exchange policy, is inconvenient, and expensive if all real costs are considered (time, taxi to factory, repair bill, etc.). Furthermore, if a breakdown occurs after the harvest when the bulk of the analysis must be done, analysis will be delayed for several weeks or months--especially if the research site is located in a remote part of the country.

Training. Programmables have frequently been provided as items in a shopping list of equipment provided by donors. Where training has not been provided, these units generally end up in a locked cabinet for safekeeping or used to add, subtract, multiply, and divide.

The HP manuals are clear-cut and written so trained scientists can teach themselves to program. On the other hand, the TI "Personal Programming Manual" is nearly impossible to follow. This deficiency has been somewhat remedied by the publication of a fantastically lucid book on how to program the TI-59, by J. S. Aronofsky, R. J. Frame, and E. B. Greynolds, Jr. (1978), Programmable Calculators: Business Applications, McGraw-Hill (listed at $8.95, but now costs $11.95) which is available in Singapore.

Yet, the target user for the programmable must be the young scientist who actually does the bulk of the analysis. For these individuals, even a good manual is no substitute for a training course.

Added Workload

Traditionally, the field research staff did their experiments, filled in the reporting forms, and mailed those forms into headquarters to have them analyzed. About a year later, the results came back. An important principle promoted by the Asian Cropping System Network is that analysis should be done at the research site so results can be used to plan the next season's research activities. Also, as a result of research programs maturing, these staff are now being asked to conduct a greater number of more sophisticated trials, do statistical analysis which most people have an inherent fear of, and in addition analyze the results to give an economic perspective.

Often, the field staff has only a high school or undergraduate degree and a weak background in mathematics. While they could quickly learn to use programs that are clearly documented (almost no such programs exist that are relevant to their analytical needs), it is unrealistic to expect them to write their own programs. Hence, while programmables could greatly assist the staff in reducing the burden of new expectations, this has not happened because appropriate programs are not available.

1/Specific problems encountered include breakage of the flexible battery contact points, burnout of segments in the display, rapid battery wear, battery recharger burnout, malfunctioning of the store/recall functions, inability to read magnetic cards, erroneous internal calculations when using a program, and complete failure.

Problems Encountered in Promoting Programmable Calculators

There are several constraints that seriously affect efforts to create an effective demand for the programmable calculator in national programs.

Computer Mentality. Many administrators and researchers have come to believe that large main frame computers will meet their data analysis needs. Therefore, the small hand-held calculator is perceived as redundant technology--even though the main frame may be housed miles away, give slow turn-around time, and have a capacity far beyond that needed for the analytical task at hand. This problem is further compounded by the recent availability of relatively inexpensive microcomputers. Pressure is growing to obtain the most advanced computational capacity for research field sites and nearby substations where there are not adequate facilities (air conditioning, etc.), reliable electricity, and a staff trained to use the equipment. With U.S.-based researchers losing interest in programmables and focusing on micros, this pressure is likely to grow.

Software. While it is relatively easy to master basic programming skills, it takes considerable time and effort to develop the expertise to be able to write the sophisticated programs that are actually most applicable. Taking time to develop these programs can only be justified if you are sure there will be a large number of colleagues who utilize these programs. Yet, unless software is available to demonstrate the relevance of the technology, administrators will be unwilling to use scarce research funds to purchase units.

Alternatively, a user could obtain programs from a manufacturer's exchange such as TI's PPX and modify these to meet their needs. Yet, few Third World scientists are aware of the PPX offerings. It is often difficult to differentiate between similar PPX programs which are described as performing a particular analysis, and it may be difficult to obtain foreign exchange to order pay in U.S. dollars. Once ordered, the programs are sometimes difficult to understand or require modifications in order to be useful (i.e., add routines for data entry corrections, additional statistics, printing of data input, and analytical output). Furthermore, until recently TI's PPX would not accept subscription orders to the service from overseas customers. Finally, the annual subscription cost is now $30/year--equal to over a week's salary for a young Indonesian scientist.

Cost. While programmable calculators and printers can be obtained for as little as $300 in the U.S., the price is far higher abroad. For example, in Indonesia a TI-59, printer, and statistics "pac" costs about $1,000 when purchased locally--over three times the U.S. price. It is impractical for foreign scientists to order directly from the U.S. because they may not be able to obtain foreign exchange, customs fees will be charged anyway, and the unit may be lost or damaged in transit. Furthermore, government regulations may require domestic purchase if official funds are used.

Consequently, most efforts to introduce programmable calculators have been dependent on the provision of the unit by an expatriate or international agency able to purchase at U.S. prices. Yet, this dependency makes it difficult for a spontaneous demand to develop, even where local scientists see the usefulness of the technology.

Repair and Maintenance. In high humidity environments, programmable calculators seem to have a life expectancy of two to three years. While this can be extended by keeping the unit in an air-conditioned room, storing it in silica jel or a closet in which a light bulb is burned constantly, it is usually difficult to take these preventative measures. Eventually, mold will take its toll.

Incentives. In most countries, research staff are paid very low basic salaries. Yet, salaries are effectively increased by high per diems while collecting survey data and honorariums paid for each experiment conducted. While programmables will enable the field research to analyze data more thoroughly than otherwise possible, there is no incentive to go beyond the minimum expectation. To maximize income, the rational scientist should conduct as many surveys and experiments as possible at the minimum level of analysis. Making an additional and unrewarded effort to utilize the full capacity of the programmable wastes time that could more profitably be spent collecting additional data.

In all fairness, we must add that it is not always true that more sophisticated analysis provides more useful information that can be used to draw more valid conclusions than would be possible if only basic analysis were performed.

Analytical Diversity. One of the objectives in establishing networks such as The Asian Cropping Systems Network is to develop a general approach and uniform analytical procedures so that data collected at sites in a country can be analyzed and compared, both across sites in each country and across countries. While biological data can be analyzed with standardized statistical procedures (ANOVA), procedures for the economic evaluation of this data are still evolving and vary from site-to-site and country-to-country. Consequently, the possibility of exchanging programs between sites and countries is reduced.

Texas Instruments vs. Hewlett Packard. Given the effort that must be made to develop the needed set of analytical programs, the task is further compounded by the use of both Texas Instrument and Hewlett Packard units in all countries, and sometimes in the same research program in a single country. While advocates of each brand can argue about their relative merits, the need to standardize the unit used in a research network outweighs all other considerations. Our preference for the TI-59 is both arbitrary and rational. While we both learned to program on a TI-59, it has the advantage of being significantly less expensive than the HP-67 and the HP-41C. Also, although the HP-41C has a greater capacity, the analytical needs at the present stage of research development can be more than met by the TI-59. In terms of reliability, for both brands, the record has been discouraging, with colleagues reporting problems with their calculators, card readers, and printers. Taking these points into consideration, network economists have to date informally agreed to focus on developing programs and training for the TI-59.

Communications. While several individuals permanently based in Asia are making a serious effort to introduce programmables into the agricultural research systems in which they work, their impact has been less effective than anticipated. Part of the problem lies with the isolation of individuals who are often not aware of complementary efforts. Most information about new programs is passed around informally, although Sisera Jayasuriya (IRRI) has recently assisted by acting as a distributor among Asian Cropping Systems Network cooperators.

Programmable Calculator Applications in Farming Systems Analysis

Identification of the contribution that programmables can make to agricultural research programs in the Third World, in general, and farming systems programs specifically must arise from examining the type of analysis that is expected of the target users. Farming systems research programs in the Asian context include biological and economic components.

Biological Components and Statistical Analysis Required. The three types of trials typically conducted are superimposed, component, and cropping pattern trials.

1. Superimposed trials are experiments in farmers' fields where a single factor is added on top of the farmers' practices. These trials can be analyzed by using a paired t-test to determine if there is a significant difference between the mean yield on the treated plot versus the superimposed plot.

2. Component technology trials are standard replicated experiments in farmers' fields, usually involving a single factor (fertilizer, insecticide, spacing) at several levels, or various discrete treatments such as several varieties. These trials are analyzed using the statistical analysis appropriate for the design employed.

3. Cropping pattern trials are experiments in farmers' fields in which several factors are combined and grown as an introduced pattern. To serve as a basis for comparison, representative farmers' cropping patterns are monitored in terms of labor use, material inputs, and yield. The paired t-test can be used to determine if there is a significant difference between yields (or any other item of interest).

Economic Studies and Analysis

Most farming systems programs conduct initial surveys and give an economic interpretation to the biological trials.

1. Initial surveys are used to determine basic characteristics of the farming system. While large sample baseline surveys were widely conducted at new sites in the 1970s, several researchers have recently opted for replacing them with rapid rural appraisal procedures in which secondary data, key informants, and farmer group interviews are used to collect the relevant data (Bernsten and Herdt, 1981). Where individual respondent surveys are employed, data analysis typically focuses on estimating the mean and standard deviation for various characteristics, constructing two-way tables, and estimating frequency distributions. Statistical analysis includes the use of t-tests and chi-square tests. When rapid appraisal procedures are employed, statistical analysis is not required since data is not collected from individual respondents.

2. Superimposed trials can be given an economic interpretation through the application of partial budgeting procedures.

3. Component technology trials in which several input levels are included can be analyzed using marginal benefit-cost procedures to identify the optimum treatment. With this technique, the added cost of increasing the level of input application is compared to the added increase in net returns. The optimum is the input level at which the B/C is approximately 2 (Perin et al., 1976). In some instances, input response functions may be estimated and used to determine the optimum input level.

4. Cropping pattern trials are evaluated using complete budget analysis of the farmers and the introduced patterns. Output typically includes estimating yield/hectare (ha), man-days/ha/operation, material input costs/ha, gross margin/ha, net returns/ha, returns to family labor, and similar items. In addition, the B/C ratio for the farmers versus the introduced pattern is sometimes estimated.

The analysis outlined constitutes the basic data evaluation that should be undertaken in an applied farming systems project. While more sophisticated procedures can be identified, it is important that we focus on using the programmable to meet basic needs before moving on into other areas.

Responses to Existing Needs

In order to facilitate the widespread and effective use of programmable calculators in Third World agricultural research programs, several measures must be taken.

Software. The unavailability of appropriate programs is the greatest constraint to widespread adoption of programmables. It is true that numerous programs are available from the manufacturers, U.S. universities, user exchanges, and farming systems practitioners. Yet, in order for these to meet the existing need, a relevant set of programs must be identified, edited into a standardized format (i.e., all programs should use the same statistical notation, have routines for correcting erroneously entered data, compute widely used statistics, and be written so they can be used both with and without a printer), illustrated by sample problems from a single statistics text, and be compiled into a monograph. These programs should also be incorporated into a solid state "farming systems" module in order to facilitate their use, since card readers frequently malfunction. Supplemental programs should be made available in the same format as the monograph, as needs arise.

Training. All efforts to introduce programmables must include a training short course. If the TI-59 is used, the text by Aronofsky should be provided--along with a rich assortment of problems. Training should include care and maintenance of the programmable, basic programming, the use of selected master library and statistics "pac" programs, and the use of all biological and economic analysis programs included in the monograph. In addition, periodic refresher training problems should be offered yearly to assist researchers to relearn forgotten programming skill.

Communications. In order to support the programmable calculator users in agricultural research institutes in the Third World, a single institution should take the lead to identify users and publish a newsletter in which sources of new programs and other developments could be reported.

Repair and Maintenance. Breakdowns have been a serious problem to most users, regardless of brand. It would be extremely useful if Texas Instruments and Hewlett Packard would make a survey of users (especially those in the Third World) to identify problems encountered. It would appear that small design modifications could significantly reduce downtime. For example, redesigning the battery-to-calculator contact in the TI-59 would eliminate metal fatigue. Also, a small fuse device could be developed and offered as optional equipment that would protect the unit against power surges that probably cause much of the damage encountered. Finally, manufacturers could extend the calculator exchange service provided to U.S. users (i.e., damaged calculators can be exchanged for rebuilt units) to overseas service centers. Yet, even if these improvements are made, it will probably still be necessary for coordinators of research networks (such as the Asian Cropping Systems Network) in which programmables are used, to carry along units to be exchanged for damaged units found at the field sites.

Incentives and Workload. As programmables became institutionalized and software becomes available, researchers will see the potential of the units to reduce time required to evaluate their data, making it possible to become involved in a larger number of research activities. This advantage should significantly increase interest in the utilization of programmables.

Computer Mentality. It is particularly important that, before promoting microcomputers in the Third World, a careful assessment of each situation is made. Purchasers of micros will face all of the problems that have plagued the programmable calculator user. The micro and the programmable should be seen as complementary technologies, each fitting into a specific niche in a research system. Programmables will adequately serve field site analytical requirements. In contrast, micros can be effectively used in central stations and large regional branches--assuming provisions are made for adequate training, servicing, and software.

References

Bernsten, R. H. and R. W. Herdt. (1981). "Farm Management's Role in Farming Systems Research to Increase Productivity in Small Farms." Paper presented at the Seventh Session of the FAO Commission on Farm Management for Asia and the Far East, Jogyakarta, Indonesia, August 24-29. IRRI Agricultural Economics Department Paper No. 81-15.

Espadas, O. T. (1980). Programmable Calculator Applications for Agricultural Project Analysis. Washington, D.C.: World Bank (August).

Hinton, R. A. (1978). "Programmable Calculators--Micro Computers: Their Agricultural Applications," Series E (No. 79E-73). Urbana, Illinois: University of Illinois, Department of Agricultural Economics (February).

Levine, Joel. "Simulation in Beef Production Systems in the Llanos of Colombia. I. Methodology: An Alternative Technology for the Tropics" in Research Systems (in press).

McGrann, James M. and William M. Edwards. (Undated). "Applications of the Programmable Calculator to Extension Agricultural Management Programs." College Station, Texas: Texas A&M University.

Perin, R. K.; D. L. Winkleman; E. R. Moscardi; and J. P. Anderson. (1976). From Agronomic Data to Farmer Recommendation: An Economics Training Manual, Information Bulletin 27. Mexico City, Mexico: CIMMYT.

B. **"The Agricultural Statistical Analysis System,"** by T. Stilwell, A. Stambuk, and R. Vera.*

The Agricultural Statistical Analysis System is a package of programs designed and written in Bolivia for use by local research technicians. The package has been successfully used by four agricultural research institutions in Bolivia. This paper presents a short description of the project and its impact.

Background and Objectives

In 1978, the technicians of the Bolivian cereals program spent nearly one month doing the basic analysis of variance and mean comparisons for their experimental program. A total of approximately 100 experiments were partially analyzed using very simple (non-programmable) calculators. In general, grain yield data were analyzed, but other data were only visually reviewed. Large amounts of paper were generated and the error rate was high. After finally finishing the calculations, it was still necessary to interpret the analyses and make conclusions. The data and conclusions had then to be reworked again to arrive at a form suitable for the annual report. Typically the annual reports were not completed for six months to one year after harvest. The quality of the interpretation and conclusions was quite poor and led to a lack of confidence in the recommendations.

With the initiation of an on-farm program of applied agronomic research in cereals, it became necessary to consider alternate methods of data processing. It would have been extremely difficult to increase the burden of analysis and still improve the quality of interpretation and recommendations coming out of the program. A review of existing computer facilities showed that none of the existing computers could handle the more popular packages such as SAS or SPSS. Therefore, it was decided to develop a package of analysis programs which would also facilitate report writing by the technicians. The basic objectives of the statistical analysis package were:

1. Programs would be useable by any technician without need for special training.
2. Program files could be maintained and/or modified by a technician with little or no computer experience.
3. The cost of computer time should be minimal.
4. Printouts should facilitate reporting of experimental results.

Software Development

The program package was developed with the aid of a local programmer, Sr. Antonio Stambuk, under contract to the CID (Consortium for International Development). Because the national agricultural research institute, IBTA (Instituto Boliviano de Tecnologia Agropecuaria), had a computer use agreement with the local university, we decided to design the package for the Digital PDP 11/45. However, additional restrictions were placed on the use of core memory so that programs could be easily transferred to a micro-computer when available. This also reduced operating costs of the package.

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*CID Agronomist, Independent Programmer, and IBTA Statistician, respectively.

There are currently four experimental designs included in the system:

1. Randomized Complete Blocks
2. Latin Square
3. Multifactorial
4. Split Plots

These four experimental designs cover over 95 percent of the work currently done by IBTA technicians in Bolivia.

Three manuals have been developed to support the system:

1. Users Manual
2. Support Program Manual
3. Programmers Manual

During programming, local technicians were consulted to verify vocabulary used, the proper sequence of data entry, and ease of understanding of the printouts. In the last stage, over 60 technicians used the package during a statistics training course and a few further refinements were made in operating procedures. Manuals were then refined and copies given to interested institutions.

The use of the programs puts emphasis on sequences and terminology already familiar to the technicians. Each experiment is classified by a series of five codes, which are the same codes used by IBTA to classify experimental projects. Therefore, the coding system was one already in use and established. The entry of experimental data is done in plot order, so that data can be directly copied from the original field book. The traditional method of recopying data only serves to complicate data analysis.

Data classes were established so that certain data types could be given special treatment in the calculations. For example, data of counts (all types of count data) are grouped in data class five. Under certain conditions, count data should be given a square root transformation. Since the data type "weeds/square meter" has been established as a data type within group five, when a technician selects the data type, the program automatically determines if a square root transformation should be performed. Other similar transformations and conversions are included and linked to the data type. The definition of classes of data has thus enabled the inclusion of various present calculations. This greatly aids the technician who has little knowledge of statistics and no knowledge of their application. In addition, it is an aid to the technician who is more conversant with statistics by automatically performing complicated calculations.

As of this date, the following data classes have been utilized:

1. No conversion or transformation
2. 1-5 scales
3. 1-9 scales
4. Percent calculated from counts
5. Counts
6. Economic yield
7. Non-economic yield of 1,000/hectare data
8. Grain moisture content

Various types of general information can also be entered in abbreviated form, such as planting and harvesting dates, name of the researcher, and location. This aids others in their understanding and interpretation of the data when the results are reviewed independent of the original report.

Another very important feature has been the automatic storage of experimental data on disk. It is also possible for the technician to easily transfer these data to magnetic tape, thus saving the expense of disk storage. This feature has been extremely important when problems occurred with the large computer.

Large Computer Use

As previously mentioned, the original program package was originally developed for a PDP 11/45, simply because it was accessible. For one year, there was easy access and very few problems, but a series of student strikes, equipment malfunctions, and periodic closings of the university has forced us to go to a microcomputer.

The advantages of transferring these programs to a microcomputer are significant. On the Digital, the Decwriter printing terminal was used for input and printout. On the microcomputer, both input and data checking are done on the video monitor, while results can go to both the monitor and printer. The result is that a single analysis of variance can be done in 3-4 minutes versus 20-25 minutes on the large computer. The use of the video monitor also aids greatly in guiding the technician through the program steps. The result is a version both faster and easier to use. Modifications have been made to increase the data capacity of the programs. The sequence and vocabulary have been maintained so that little re-learning is necessary. The transfer to a microcomputer has eliminated access problems as well as breakdown problems, since a second unit is also available in the same city.

Problems

The previously mentioned problems with the large Digital computer have been largely resolved by simply abandoning its use. The major limitation of the microcomputer in use is the relatively limited storage available on the single density diskettes. This would be resolved by conversion to double-density disk drives.

A more fundamental problem has been observed in the methodology used by researchers. The use of any kind of field book is still not common in Bolivia and this has created many problems for the technicians who wish to analyze their data by computer. It is common to find data from one experiment recorded on several sheets of paper interspersed with data or observations from other experiments. There have also been cases of extremely poor field procedures which could have been prevented by use of field books. As a result, it was decided to incorporate a second set of programs which would generate field books for experiments. This set of programs would link into the analysis programs in such a way that a technician would need to enter only general experimental information and the raw data in order to complete his analysis. All other information would remain on file as a result of the field book printing by the computer. Unfortunately, due to the abandonment of the Digital computer, this set of programs has also been abandoned. It is tentatively planned as an addition to the set of programs for the microcomputer.

Personnel Training/Impact

Personnel training or preparation for using the program package is minimal. In order to reduce terminal time costs, several forms can be generated for the researcher to fill in before starting his analysis. With this information prepared in advance, only light supervision is needed during the first analysis. Subsequent analyses are normally handled without supervision. Although we did develop a User's Manual, in practice we have found it best for the researcher not to use the manual while at the computer. In those cases where a user attempts to use a manual, he confuses examples in the manual with his own experiment and is forced to begin again. At every step where the user must enter a crop code, data type code, etc., he can receive a list of these codes so that a reference manual is not essential.

The response of the technicians has been the most interesting development. Their initial experience was with the large computer and therefore the initial impact resulted from use of this machine. Experience in Mexico with another package shows a similar response regardless of the type of computer. There are indications that the magnitude of the response may be greater when using a microcomputer. This could be due to the fact that the computer is actually in the researcher's office and the time lag from desire to accomplished analysis is much less.

The first reaction is one of surprise at completing so much work in such a short time. There is then a bit of dismay at the large amount of paper generated. This is followed by a rather detailed interpretation of the data. At this point, there is usually a large demand for statistical counseling. Although the results are in standard form, we find that most technicians have never understood statistics. With the introduction of a new method of calculation, they feel free to express their doubts. Researchers who have been doing their own calculations for years now ask questions like "What does the F value mean?" or "If it's significant, what do I do?"

During the interpretation phase of the experiments, there is always the discovery that some types of data recorded for an experiment serve no useful purpose. This discovery, coupled with the mountain of paper generated by the computer, leads to the realization that it is necessary to record only those data types which are relevant to the experimental objectives. In one case, this resulted in a chart showing the essential data that should be recorded in each experiment. The total data load was reduced by about 30 percent.

The most obvious effects terminate at this point, but in many cases a more fundamental change follows. This is a reevaluation of the entire experimental program. It seems to be a continuation of the problem of excess data. When the technician discovers that some data types serve no useful purpose, he then takes the next logical step of asking if an entire experiment serves any purpose. In some cases, he discovers that even though the experiment was well conducted and gave significant F values, the question was answered last year. This forces a rethinking or clarification of his program objectives and usually some changes are made in next year's work plan.

Although not all researchers pass through the program reevaluation phase, nearly all do participate in the following step: planning experiments for computer-assisted analysis. This usually takes the form of counseling to assure that their experiments to be planted will be easily analyzed by computer. In this phase, much is learned about experimental designs and there is sometimes a demand for more complex designs or analyses. The most common request is for combined analysis (across locations and years). During this counseling, it is also possible to reinforce any conclusions reached during their program reevaluation.

Future Plans

At the present time, we have concluded a series of traveling seminars in Bolivia which included demonstrations of uses for microcomputers. The response has been enthusiastic, and there is a definite desire to implement a system of microcomputers in Bolivia. The major problem remains that of convincing the administrative heads that such a system is desirable. It seems likely that the clamor of regional heads will have an effect.

In addition to administrative persuasion, we are continuing the transfer of the Digital programs to the microcomputer. Although local resources and time limit the number of programs that can be rewritten, it is possible to add at least one more experimental design this year.

C. **"Utilization of Microcomputers to Process Agricultural and Economic Survey Data in Developing Countries: A Summary of Activities of the Statistical Reporting Service,"*** by Ronald J. Steele.**

Background

There is a growing demand in the public and private sectors of developing countries for timely and reliable information. As financial austerity measures are imposed, the statistical infrastructure is one of the first public sector programs to feel the pinch of scarce resources. If statistical offices are to meet the data requirements, they need access to rapidly advancing high technologies for the collection, processing, and analysis of statistical data. In this context, the Office of Science and Technology of USAID funded the Statistical Reporting Service (SRS) of USDA to implement the Remote Sensing for Agriculture Project. This is a transfer of technology project aimed at:

1. Developing area sampling frames in developing countries.
2. Collecting and processing survey data from traditional "ground" surveys.
3. Assessing the capability of the developing countries to utilize high technology remote sensing techniques, i.e., digital classification of satellite data and agro-met modelling.

In implementing the Remote Sensing for Agriculture Project, SRS found few developing countries capable of processing agricultural and economic survey data in a timely fashion. Typically, survey data processing required six months to several years to accomplish. Reasons most frequently cited for the delay were:

1. Lack of in-house data processing capability.
2. Difficulty obtaining a high enough priority to accomplish the task when processing on others' equipment.
3. Inadequate hardware and software technical support.

In an effort to reduce the time required to process survey data, SRS decided to explore the possibility of utilizing microcomputers. The inherent advantages of microcomputers are:

- The low one-time cost of the system makes it feasible for statistical offices to have in-house data processing capabilities and establish their own processing priorities.
- The portability and off-the-shelf availability of the hardware minimizes lead time required to install a system.
- Training time is reduced substantially due to the simplicity of the operating system, language, and interactive programs.

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**United States Department of Agriculture, Statistical Reporting Service, International Programs Office.

Summary

Since 1979, SRS has provided data processing support to developing countries under the auspices of the Remote Sensing for Agriculture Project in the following areas:

- Procured, tested, and installed microcomputer systems in Jamaica, Ecuador, the Philippines, Sierra Leone, Morocco, and Tunisia.
- Developed software for survey data entry, editing, and summarization.
- Trained project and host country personnel in:
  a. Use of the microcomputer system.
  b. Use of software packages for survey data processing and statistical analysis.
  c. BASIC programming.
  d. Routine maintenance procedures.
  e. Procedures for isolating hardware problems to the "board" level and replacing integrated circuit boards.

Based on experience gained in these six countries, SRS has demonstrated that:

- Microcomputer technology is readily transferable to developing countries.
- Utilizing microcomputers to process survey data is feasible.
- Time required to process survey data can be reduced and quality control improved while using microcomputers.
- The technology is very cost-effective. Savings from mainframe processing costs offset the initial investment in one year or less for most statistical offices.

Hardware

The typical two-user microcomputer system installed for this project consists of:

Item	Cost
North Star Horizon microcomputer with two 64K RAM boards and two dual-density 5 1/4-inch disk drives, each disk capable of storing 178K characters	$ 4,500
Additional disk drive and cabinet	1,000
Two (2) Televideo 920C CRTs	1,600
Integral Data Systems IDS-560G printer	1,500
Voltage regulator/transformer	800
Off-the-shelf software	700
Diskettes, paper, and other supplies	1,500
Spare boards and tool kit	2,000
TOTAL	$13,600

The criteria for selection for all equipment were reliability, performance, and versatility. Additional criteria for selection of the microcomputer were a Z-80A microprocessor, S-100 bus, and ability to be configured for bank-switching (timesharing) for two or more users with off-the-shelf hardware and software.

With this configuration, two operators can do independent processing simultaneously. They can both enter data for the same program or different programs, or one can enter data while the other is working on program development. Each operator has 64K of central memory, approximately 40K of which is available for the program and data. Resources shared are the Z-80 processor, the disk drives, and the printer. Typically, for processing survey data, each operator uses one disk drive for on-line data storage, and one drive is used for the operating system, programs, and parameter files. The system can be expanded to accommodate a third user simply by adding a CRT, disk drive, 64K RAM board, and serial I/O board, at a cost of $2,500. Theoretically, the system can accommodate up to seven operators, but three users currently appears to be the practical limit. With three users, there is a noticeable but tolerable degradation in computing speed due to competition for resources. A three-user system was installed in Jamaica and two two-user systems were installed in Morocco and Tunisia to increase throughput and reduce survey data processing time. Two to nine million data elements are processed in surveys in these countries. Processing surveys of this magnitude utilizes the full capabilities of a microcomputer system.

Frequency of hardware failures has been greater than was initially expected. Most of these problems are attributable to the "hostile" environment of the developing countries--the heat, humidity, dust, and "dirty power." The frequency of these problems has been reduced considerably by:

- establishing maintenance schedules and training host country personnel in maintenance procedures;
- installing systems in air-conditioned offices; and
- utilizing power conditioners.

SRS has utilized numerous types of power conditioning devices: high isolation transformers, ultra-isolators, and line filters. None of these has proven totally satisfactory. In some countries, they have provided adequate protection--in others, they haven't. Uninterruptable power supply systems (UPSs) provide maximum protection, but they are expensive ($5,000+) and heavy (250-600 pounds), which make them difficult to transport. SRS is currently procuring two UPSs for installation in the Sudan under another USAID-funded project. Some much needed experience will be gained from this installation. Alternatives to UPSs also need further exploration.

Of the six countries in which SRS has installed microcomputer systems, only the Philippines has local service facilities. SRS negotiated a service agreement with the service center to provide hardware support. To minimize system down-time in other countries, it has been necessary for SRS to provide the hardware support. To accomplish this, installations have been provided with spare integrated circuit boards and tool kits, and host country personnel trained to isolate hardware problems to the board level and replace the faulty board. The faulty board is mailed back to the U.S. and a replacement spare board sent to the installation. The microcomputer industry is rapidly establishing sales and service facilities in developing countries, which will eliminate the need for providing these services.

Software

Off-the-shelf software provided has consisted of:

- 5.1SHARE (Micro-Mike's multi-user bank-switching disk operating system);
- North Star DOS (Version 5.2), BASIC (Version 6), and Pascal (Version 1); and
- MICROSTAT (a statistical analysis package with an excellent data base management system).

In addition to the off-the-shelf software, SRS has developed a generalized survey data processing package. After an extensive search, SRS concluded there wasn't an existing package capable of being modified to efficiently handle the large volume of data normally processed in an agricultural or economic survey. In a typical survey, 5,000 to 25,000 respondents are interviewed, and the questionnaire has an average of 300 to 500 data elements (variables). In the early phases of the project, survey data processing programs were written on-site by SRS personnel on Temporary Duty Assignment (TDY). Through an evolutionary process with each additional installation, the package became more general and more user-friendly, with expanded capabilities. The package has recently been rewritten to make it a comprehensive data management system for processing survey data. Documentation of the new version is underway and will be completed in July 1982. Versions with prompting and documentation in French and Spanish are scheduled for completion in September.

This system was designed to: simplify entry, editing, and summarization of survey data; improve quality control; and increase efficiency of data storage and retrieval. The system is a group of user-friendly, interactive, menu-driven, BASIC programs which allow the user to:

- create, modify, and list parameter files;
- enter, edit, and list questionnaire-level data;
- compute and list totals, variances, and coefficients of variation at desired sampling and geo-political levels; and
- generate MICROSTAT-compatible files to perform detailed statistical analyses on selected variables.

Inputs required for the survey processing system are:

- system hardware parameters;
- questionnaire design parameters;
- edit parameters (the questionnaire data entry program compares data input to user-specified limits);
- survey design parameters; and
- survey data.

The system can readily process survey data with up to 1,200 variables per questionnaire. In an average survey with 400 variables per questionnaire, each data entry person can enter and edit approximately 100 questionnaires per day. Processing a survey with 10,000 questionnaires on a two-user system would require about 50 working days.

As data are entered, they are compared to the edit parameters, and if outside the specified limits, a message is printed. The message states the name of the variable, the value entered, and the range of tolerance limits specified in the edit parameter. The value can then be changed, or left as is. Data are stored on the diskette, and at any time can be re-edited. The data stored are essentially "clean." This procedure actually requires more time for data entry, but eliminates the need for: lengthy edit runs, searching for the proper questionnaire after getting the printout of error messages, trying to figure out what was wrong with the entry, and then correcting it. This approach requires more training for the data entry personnel, but improves quality control.

To date, the system has only been used on North Star Horizon microcomputers. North Star BASIC has some very powerful file management commands which were not available on most microcomputers and which were used extensively to achieve maximum efficiency of data storage and retrieval. Micro-Mike's, Inc. has recently released baZic (sic), a Z-80 code interpreter that's upward compatible with North Star BASIC and available under the CP/M operating system. With this development, the survey data processing system should be able to run on most Z-80 microcomputers with little or no modification.

Training

The table below shows the type and length of training provided to host country personnel. This length of training generally proved sufficient for host country personnel to start utilizing the system. The training introduces them to the major features of the system and gets them past their initial fears of working with it. Expertise is developed with experience on the system, and by reading and re-reading the system documentation.

Personnel	Training	Time
Data Entry	Enter and edit survey data	1-2 days
Computer Operator	Hardware maintenance and repair	4-5 days
Programmer	BASIC programming	1 week
Statistician and Programmer	Survey data processing system	1 week
Statistician/ Analyst	Use of MICROSTAT package	1-2 days

Future Thrust

SRS is willing to provide technical assistance to other countries wanting microcomputer-based survey data processing systems. Two systems are being installed in the Sudan and the Cameroons within the next two months. The Sudan systems will both have 20 mega-byte Winchester drives. This will provide valuable experience in assessing the reliability of the Winchester drive technology. Due to the large volume of data to be processed in agricultural and economic surveys, this approach seems to be the direction in which to move. Data storage and retrieval is much faster, which should increase throughput. Currently, 20 to 100 diskettes are used in a survey, and each diskette is handled numerous times. When handling this number of diskettes, there is a high probability of losing, erasing, or destroying data. Less handling and fewer diskettes will be required when using the Winchester drives.

The Economic Research Service is beginning to use microcomputers in their international programs. Activities are being coordinated such that economists will have access to the data base created by the survey data processing package. This should substantially reduce the time required for economists to get their "hands" on the data and perform their economic analyses.

Leighton Price of Michigan State University has developed a microcomputer-based mark sense reading package. Preliminary discussions are underway to interface that system with the survey data processing package and test it in a developing country. This approach could effectively eliminate the traditional data entry "bottleneck."

A digitizing program has been developed for domestic remote sensing applications. The program is currently being tested and is expected to be operational within one month. The digitizer tablet is connected to the parallel port of the North Star, and areas of multi-faceted polygons are measured and stored on diskettes. Several developing countries with area sampling frames have requested this capability. This will assist them in automating some of the area frame construction and sample selection procedures.

ANNEX A

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D. **"The Introduction of Microcomputers in Developing Countries by the United Nations Secretariat: Some Initial Experience and Observations,"** by George Sadowsky.*

Introduction

The provision of technical co-operation and support of projects in developing countries is now one of the major activities of the United Nations System. Within the system, the United Nations Secretariat is responsible for execution of projects in the area of social and economic development, and the Statistical Office provides technical support for most of the data processing activities involved in that program. At present, we have a small international group of technical experts, and we are providing guidance and support in a variety of ways to projects in about 50-60 countries. The experience reported in this note and in the accompanying talk are drawn from within this framework.

Use of Microcomputers in Developing Countries

Most of our activities involving microcomputers in developing countries have been focused upon population census and survey applications. Our initial step occurred in 1979, when it became apparent that it was economically infeasible to use a classical mainframe or even minicomputer installation to process the 1980 Population Census of the Cape Verde Islands (population approximately 350,000). Instead, we installed an initial billings Microsystem for data entry and editing, and have since then installed four more identical systems to provide for these tasks completely.

Our current inventory of microcomputer systems already installed and being installed in the field is as follows:

1. Cape Verde Islands: Four Billings Microsystems running BOS (a derivative of OASIS) for census data entry and editing. Each system is Z-80 based, has 64KB memory, 2 diskette drives and an integrated memory-mapped VDU. In June 1982 we will install 2 multi-user Onyx systems (model C8001, 256KB, 40MB sealed disk, 17MB tape cartridge) with 2 terminals and 1 printer each for the tabulation phase. The Onyx systems will use the OASIS operating system.

2. Comoros Islands: Two multi-user Altos ACS 8000 systems were installed in January 1981 to process all phases of population census data processing (population approximately 400,000). Each computer is Z-80 based and contains 208KB memory, a 29MB sealed disk, two 8" diskette drives, a 12MB tape cartridge, 4 VDU terminals and a printer. OASIS is used as the operating system.

3. Sao Tome and Principe: Two multi-user Altos ACS 8000 systems were installed in March 1982 to process all phases of population census data processing (population approximately 80,000). Each computer is Z-80 based and contains 208KB memory, a 29 MB sealed Disk, an 8" diskette drive, a 12MB tape cartridge, 3 VDU terminals and a printer. MP/M is used as the operating system.

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*The writer is a Technical Adviser in Computer Methods within the United Nations Statistical Office. The opinions expressed within this paper are his personal ones and do not necessarily reflect either the views or positions of the United Nations or any of its agencies.

4. Ecuador: Two multi-user Altos ACS 8000 systems were installed in January 1981 to house the register of industrial establishments and to collect industrial production statistics. Each computer is Z-80 based and contains 208KB memory, a 29MB sealed disk, two 8" diskette drives, 2 VDU terminals and a printer. OASIS is used as the operating system.

5. Rwanda: Two Cromemco CS-2 systems, each having 64KB, two 5-1/4" diskette drives, one VDU terminal and a printer, have been installed in summer 1981, one a stand-alone system at the Ministry of Planning and one connected to the government's main NCR 8250 system through an asynchronous connection. The computer at the Ministry of Planning is used for word processing and economic calculations in support of the planning process.

6. Mauritania: Two Altos ACS 8000 systems have been installed in summer and fall of 1981 to perform the data entry and editing of the Mauritanian Fertility Survey (sample size about 20,000 women). Each computer is Z-80 based, has 208KB memory, two 8" floppy disks, two VDU terminals and a printer and runs multi-user OASIS. These computers will probably be upgraded by adding a 29MB sealed disk to each within the next 3-6 months.

7. Cook Islands: An Altos ACS 8000 computer with 64KB memory, one VDU terminal and a printer, running under CP/M, has been used to begin processing the Cook Islands census data. The computer was installed in 1981.

8. Romania: An Industrial Microsystems based computer system has been installed in summer 1981 at the Center for Demographic Research in Bucharest. The configuration consists of 2 VDU terminals, one Microangelo Graphics System, two 8" diskette drives, and a printer. MP/M is used as the operating system.

9. Bruma: A Cromemco CS-2 with 192KB, 11MB sealed disk, two 8" diskette drives and two printers and 2 VDUs are being installed in May 1982 at the Foreign Economic Relations Department in Rangoon for maintaining a data base of external assistance projects. CROMIX is used as the operating system.

10. Upper Volta: We are currently planning to install two IBM personal computers in a demographic research center in Ouagadougou. The configuration of each is expected to be 256KB memory, two 5-1/4" diskette drives, a monochrome monitor, a 10MB hard disk, an 8" diskette drive, and a printer. The computers will be used to support a variety of demographic research including secondary analysis of existing data, data collection and entry, edit and analysis, and training activities.

11. Bolivia: We are currently upgrading a DEC VT-100 with a Data Mode upgrade package, which will yield a Z-80 based mircocomputer having 64KB memory and two 8" diskette drives running CP/M. The microcomputer will be used for experimental use within the National Statistical Institute.

Other countries in which we have a good possibility of installing additional microcomputer systems within the next year or two include Djibouti, Somalia, Mozambique, China, the United Arab Emirates, Egypt, Equatorial Guinea, Mali, Malawi, Bangladesh, Surinam, Barbados, Ecuador, Indonesia, the Philippines and Burma.

The installation of microcomputers under the auspices of a United Nations project differs in a number of respects from the personal use of a microcomputer by individuals or groups of researchers, which is more the focus of this meeting. Computing equipment installed within a government office by the United Nations is almost always transferred to the government at the end of the project, and it is generally used on a continuing basis throughout the economic lifetime of the equipment. Further, the equipment is obtained generally to perform a specific function; and while this function is generally not critically time dependent (such as processing a government payroll), its completion is generally essential for planning and policy evaluation (as would be the case for a population census).

Yet there are similarities between research and institutional use in the field. Both types of users generally depend upon having a source of electric power with some degree of dependability and consistency. Both types of users depend upon keeping their equipment in working condition throughout the life cycle of its use. Further, both generally depend upon either writing programs in the field or adapting pre-written programs in the field to conditions discovered locally. Finally, both will often (but not necessarily) incorporate training of local staff to some degree.

Electrical Power

The question of how to obtain reliable power has affected almost every one of our computer installations to some degree and has dominated the operational problems of some projects. This is true regardless of whether the computers are micros, minis, or mainframes. We have had to become knowledgeable in power disturbance measurement and power line conditioning in order to establish preconditions that allow a reasonable probability of making a successful installation of computing equipment. We have experimented with the use of portable power line monitors for measurement and almost all types of power line conditioners for improving local public power supplies. Our current experience does not permit any easy generalization. We hope that the current rapid price reductions in CMOS technology, liquid crystal displays, and battery technology will yield systems that are increasingly separable from public power, but this hope addresses only a part of the problem. It is likely that for some time successful computing activities in developing countries will necessarily rely upon some informed technical advice and action regarding power measurement and conditioning.

Maintenance

While computing hardware has become increasingly reliable over the years and promises to become even more reliable in the future, components do fail from time to time for a variety of reasons. When the failure occurs at a very remote point where good communication or transportation may not be available, the consequences of such a failure may be greatly magnified.

We have taken an approach that might be characterized as a multi-level strategy in dealing with the maintenance problem, in part because of the diversity of environments in which we operate and expect to operate. It is a conservative one, beginning with the use of total component redundancy that will allow work to continue even though one complete system is inoperable. In the worst case, this allows faulty systems to be sent back to repair points either in the same country or other countries. It should be noted that the logistical problems of moving a computer component over two international boundaries and back is a non-trivial one which is ameliorated only somewhat if the user has access to diplomatic pouch or similar facilities.

To the extent that systems are modular, it is possible to perform component swapping to assist in fault isolation and return smaller pieces of the system. This depends upon having the required technical skills and understanding in the field to be able to perform such isolation reliably. If more sophisticated skills are available, either through expatriate or local expertise, diagnosis and repair at the elementary component level can be attempted, provided that some minimal level of spare parts, test equipment, and tools have been provided.

In every microcomputer installation to date, our projects have included one resident expert for a period of time. Apart from achieving the main goals of the project, his most important function is to train counterpart personnel in the technology and use of computing equipment. These objectives are to some extent conflicting ones, and the degree to which such training can be realized depends upon the existing physical and intellectual infrastructure of the country. Our initial results are not all in yet, but they appear to be mixed.

Compatibility

It is often advantageous to be able to link to (or otherwise take advantage of) other data processing resources of a country. For example, many developing countries have diskette recording devices such as IBM 3742 units that are used to record data on 8" diskettes. In other cases, governments are concerned that data gathered in a microcomputer environment be transferable to and usable on its central computing facility. We have used both off-line transfer using 8" diskettes and on-line transfer by using the microcomputer in terminal emulation mode. We expect that off-line transfer using magnetic tape will become increasingly feasible, although slowly. One problem we have encountered with compatibility through diskette transfer is that until very recently all 8" diskette drives have been powered by synchronous AC motors which are quite sensitive to fluctuations in power line frequency. An alternate problem with on-line terminal emulation methods is that they require the mainframe to provide a usable standard communications interface, a condition that is less likely to exist in developing countries because of the generally lesser importance of data communication facilities.

Software

Computing equipment supplied by United Nations projects is often used for peak load type projects such as population census processing. In other instances, it forms a nucleus of computer hardware which grows over time to accommodate increasing demands as the government's awareness of its potential increases. Because of these tendencies, we are perhaps more sensitive to the need to install initial systems that represent our concept of a good model of how computing could be performed.

Microcomputers offer major advantages over earlier computing environments in this respect. They are architecturally more simple, can be made very user-friendly, and are less formidable to use. Many of the skills (but not all!) of the set of support specialists associated with a classical mainframe installation are not required to use microcomputers effectively. Yet some of the most common operating systems (such as CP/M) are rudimentary and provide neither adequate nor appropriate development environments for developing countries. We have chosen to favor system environments such as OASIS (which is essentially IBM's CMS implemented in a microcomputer environment) with the expectation that the increased flexibility and functionality will more than compensate for the disadvantage in terms of availability of application programs.

The operational requirements of establishing an operating computing facility under difficult conditions have occupied much of our time and energies during the past two years, and we have not been able to address effectively yet the problem of making available effective software packages for performing specific applications. In one sense, such software has been less important since it has been relatively easy for field experts to do whatever ad hoc programming has been required to get various jobs done. Such a method of operation, however, does not solve the problem of how to capitalize upon this and other experience to produce more generalized software that is more easily transferable to other developing country environments. This is a crucially important area that we hope to give increasing attention to in the future.

Conclusion

Microcomputers are a viable and appropriate technology for developing countries. Their rapid evolution and the momentum of both the underlying technology and industry result in their being useful for a rapidly expanding set of functions in government, education and research. They are in no sense a panacea, and uninformed users are likely to experience significant difficulties. Nevertheless, problems connected with their installation and use can be identified and surmounted. Significant advances in software development are required before the microcomputers will have exploited their full potential, but we are hopeful that the dynamics of both the technology and the industry will produce such developments.

E. **"The Feasibility of Using Microcomputers in National Statistical Offices in Developing Countries: Initial Thoughts and Findings,"** by Barbara Diskin and William Stuart.*

Statistical data processing in developing countries has often suffered from limited access to scarce mainframe computer resources. Centralized national computer centers are common and have frequently been plagued by management problems. Equipment malfunctions and shortages of difficult-to-obtain replacement parts have frequently caused many users to experience long delays.

National statistical offices (NSO's) in developing countries recognize the need for timely statistics from censuses of industry, agriculture, population and housing, as well as from household and other sample surveys. Insufficient or inefficient data processing is the obstacle to satisfying that need which is most frequently cited by NSO's.

The advent of microcomputing promises a potential solution to NSO's with data processing problems. Microcomputers are small, lightweight, and relatively inexpensive. In most cases they need no special environment in which to operate. Microcomputers can be purchased for a fraction of the cost of mainframe computers, and their cost is decreasing while their computing power and speed are increasing. Moreover, microcomputers are popular and increasingly accessible to users because of an intimacy fostered by their interactive operational mode. Their affordability, their popularity, and their ever-increasing availability practically guarantee that microcomputers will find their way into many government offices in developing countries.

In light of this inevitability, the current study undertaken for USAID by the U.S. Bureau of the Census' International Statistical Programs Center proposes to determine a satisfactory role in NSO's for suitable types of microcomputers. Because of the great variety of microcomputer systems on the market, the strengths and limitations of each, and the special needs of the NSO, it is appropriate and extremely useful for someone familiar with the applications of an NSO in a developing country to study the capabilities of different microcomputers, in order to orient NSO's toward obtaining useful microcomputer systems and using them effectively. That study and the resulting recommendations are the content and output, respectively, of the current project. The project will examine ways in which an appropriate microcomputer can effectively supplement an existing mainframe operation, as well as study the feasibility of a large microcomputer system actually replacing an existing mainframe operation.

The intent of this paper is to convey information on three areas of investigation: a description of the existing data processing situation in the NSO of a developing country, a description of microcomputers with an emphasis on how they compare to mainframe computers, and a summary of three applications of microcomputers in developing countries. As more information is received and digested, the ideas presented herein will naturally evolve. This is simply an attempt to summarize information available at this time.

Existing Data Processing Situation in a Typical Developing Country

In order to address the question of feasibility of microcomputer use, it is necessary to describe the current data processing situation in the NSO of a typical developing

*International Statistical Programs Center, U.S. Bureau of the Census.

country. Although this can take many extreme variations, the overall picture presented below is felt to be representative.

Hardware

The NSO has an IBM 370/115 with 256 kilobytes (KB) of core memory, two disk drives each holding 70 MB removable disks, one 600 line per minute printer, a card reader, a diskette reader, and 2 tape drives. This system is leased at $8,000 per month. There are five IBM 3742 dual-station key-to-diskette devices for data entry. Five IBM 029 keypunches are available to the programming staff.

Software

The 370/115 operates under the DOS operating system. COBOL, FORTRAN, and RPG II compilers and an IBM/ALC assembler are available. SORT/MERGE and standard file maintenance utilities are also provided. The only generalized software package installed on the machine is the COCENTS tabulation package.

Environment

Extremes of temperature and humidity combine with a poor air conditioning system to cause frequent hardware problems. Voltage variation and power outages due to electrical storms and weaknesses in the infrastructure of the system providing electricity are responsible for numerous computer system failures.

Personnel

The data processing personnel consist of the following positions: chief of data processing, assistant chief for systems analysis and programming, assistant chief for operations and data entry, one systems analyst, eight programmers, one systems programmer, four computer operators, and 20 data entry operators. It is difficult to find and keep programmers and systems analysts. Many employees view their positions only as training to allow them to secure better jobs in the private sector.

Activities

The data processing efforts focus on five major activities:

1. A decennial census of housing and population which collects data from 17 million people in 3.5 million households;
2. A decennial census of agriculture covering 500,000 producers;
3. An economic census of 100,000 establishments;
4. Annual foreign trade statistics involving 125,000 transactions yearly; and
5. Monthly processing of the government payroll.

The first four of these activities involve a great deal of editing and tabulation. In addition, there are numerous miscellaneous requests for processing smaller quantities of data and producing tabulations.

Proposed Activities

Proposed data processing activities include a continuing quarterly household sample survey, an automated personnel system, computerized sampling frames, and installation of a data base management system for manipulating summary statistics.

How Work is Accomplished

Specifications for programs are developed by the systems analyst working with subject-matter specialists and are then assigned to programmers. All program development, testing, and production processing is done in batch mode with an average of 1-day turnaround on each run submitted. The workload of the computer system can be broken down as follows:

By Number of Jobs	By Percentage of Time
50% compiles	55% execution-production
30% execution-testing	25% utilities
10% execution-production	15% execution-testing
10% utilities such as SORTS	5% compiles

Problem Areas

The following problem areas are enumerated in priority order:

1. Access to the computer;
2. Hardware failures followed by delays in repair;
3. Rapid personnel turnover with subsequent need for training new personnel;
4. Cost involved in equipment rental and maintenance;
5. Electrical failures;
6. Printer speed;
7. Reliance on cards for program development;
8. Insufficient number of disk packs; and
9. Scarcity of packaged software.

Description of Microcomputers

Defining the term "microcomputer" is not a simple task. Understanding the evolution of the micro and relating this new technology and its accompanying philosophy to the technology and philosophy associated with its mainframe predecessors seems to be the best way to approach a definition.

History of Electronic Computing

The first computer, developed in the 1940's, consisted of banks of vacuum tubes filling an entire room and demanded an air-conditioning plant of equal size. The advent of the transistor in the 1950's followed by the collection of transistors into an integrated circuit in the 1960's were evidence of a trend toward miniaturization and simplicity in architecture that continues even today. The 1970's saw the incorporation of thousands of integrated circuits (large-scale integration or LSID on a single silicon chip no larger than a drop of ink to form an entire central processing unit (CPU) equivalent in power to the room full of vacuum tubes of the 1940's. This was the birth of the microprocessor. This dramatic decrease in size was accompanied by just as dramatic a decrease in cost which has seen the cost of a CPU diminished by a factor of 1000 from the first computer in 1948 to the present. The reduction in size and cost and the perfection of teleprocessing have contributed to the development of distributed processing, whereby a number of smaller machines or components can exist in remote locations and can operate independently or together to process data. The pace of development of computer technology has accelerated over time to the point of creating an explosive technology that defies the imagination and makes it difficult, if not impossible, for anyone to stay current with all the latest developments.

What is a Micro?

It does not suffice to say that a micro is simply the end product of the trend toward miniaturization described above, because this trend has produced a continuous spectrum of machines and it has no apparent end. A definition could conceivably take into account cost, size, capacity, configuration, and purpose; however, within each of these categories there is at most a vague feeling for when one passes from mainframe to mini to micro territory. Carol Anne Ogdin offers the following definition in her book Microcomputer Management and Programming: "When the CPU (the combined control and arithmetic logic units) of a computer is implemented in one integrated circuit (or a very small number of related integrated circuits), we call that device a microprocessor. When all five elements of a computer (Arithmetic Logic Unit or ALU, storage, input, output, and control) are combined together and the CPU portion is implemented as a microprocessor, the result is a microcomputer." This definition clearly delineates a class of computers based on the microelectronic technology employed.

The dramatic reduction in size and cost leads one to ask why anyone would consider buying something other than a microcomputer. However, it is necessary to give a critical eye to how these machines compare to the larger, more costly mainframe computers in terms of their intended market, hardware, software, and applications.

The Micro Market

Microprocessor development has taken place in an environment of demand produced largely by equipment manufacturers that needed processing power for a particular task, generally some form of limited calculation or control. They have proven to be sophisticated controllers in applications such as space travel and navigation. Microcomputers can be used to record water flow, temperature, and pollution levels. Their simplicity and low cost have made them attractive to the small businessman as an accounting tool and to the family as a source of entertainment through video games and as a learning tool. However, until recently the microcomputer has not been seriously considered as a general purpose machine sufficiently developed to challenge its mainframe processors.

Examples of Configurations

Examples of the configurations of a large mainframe computer, an average micro or personal computer, and a networked microcomputer system are provided as a departure point for the ensuing discussion.

Mainframe (U.S. Bureau of the Census)

3 CPU's
16 megabytes (MB) main memory
3 system consoles
36 tape drives
12 300-MB disk drives
2 highspeed printers (2000 lines per minute)
1 card reader
6 communications cabinets
5 remote job entry workstations

Typical Micro (National Statistical Office in Ecuador)

1 CPU
112 KB main memory
1 keyboard for input
1 CRT or video monitor
1 printer for hard-copy output (60 lines per minute)
2 1-MB floppy disk drives
1 29-MB Winchester disk drive

Networked Micro (National Oceanographic and Atmospheric Administration)

9 CPU's
576 KB main memory (9 partitions of 64KB each)
2 telecommunications boards
8 terminals/consoles
1 22-MB disk drive
2 1-MB floppy disk drives
1 parallel port printer (420 lines per minute)
1 serial port graphics printer
1 word processing printer
1 80-character graphics printer

Physical Differences

Microcomputers are far less demanding than mainframes in their requirements for space, environment, and electricity. The microcomputer has often been referred to as a desktop computer because it is so small. Although it is possible to attach a large number of peripheral devices to the micro, all of the components are generally quite lightweight and portable. The typical mainframe, however, is a permanent fixture consisting of a CPU and its accompanying peripheral devices, each of which is too large and heavy to be easily moved.

Microcomputers can operate in a wide altitude, temperature, and humidity range. The significance of this is that the raised floors and large air conditioning plants associated with mainframe computers are no longer necessary. A normal office environment is generally adequate for a micro's successful operation.

Microcomputer technology has made it possible to reduce power consumption to the point of allowing micros to operate on the normal electrical system. Mainframe computers often require that high voltage electrical lines be installed. The low power and voltage consumption of the micro also results in less heat being given off.

Hardware Differences

Microcomputers are often classified with bit qualifiers which refer to the amount of data that can be simultaneously processed. The majority of microprocessors are 8-bit processors, although 16-bit microprocessors entered the market several years ago and 32-bit processors are on the horizon. Mainframe computers have typically had word sizes of 32 bits or more. Statistical calculations can be done more efficiently on machines with larger word sizes, although it has been shown that the majority of all data processed can be represented in 8 or fewer bits.

Memory for microcomputers comes on small removable boards (often 6" by 9" which are standardized printed circuit cards. This makes it a simple task to replace a malfunctioning memory board. This ability for a user to change memory is quite in contrast to the core storage found on mainframe computers which typically require an engineer to locate memory circuits and to work on them. With microcomputers, it is even possible for the programmer to program non-volatile memory boards in order to protect certain software, and these boards may be substituted at will.

The idea of modularity extends from memory into the overall system design of the microcomputer. It allows one to think of a microcomputer system as a set of discrete parts that can conceivably be easily disconnected and sent out for repair while substituting an identical functioning module. The idea of sending a mainframe printer out for repair would never be considered a feasible solution.

Speed is an interesting area for comparison. Mainframe computers are generally able to handle at least 32 bits of data simultaneously within their processing units. Microcomputers, on the other hand, generally handle only 8 or 16 bits of data at a time. Although this size differential does make a difference, it is not always as great as one would expect; doubling the capacity of a microprocessor may not double the system's speed, but instead may offer only a marginal increase in performance. The reason for this is that the nature of the data being processed and the physical limitations of the system in moving data between component parts is also a significant factor in the determination of speed. In this respect, microcomputers are again subject to greater limitations than mainframes. When character manipulation is involved, these limitations may be of little consequence. If the data are large, however, as in the case of large or decimal numbers, these limitations may be severe. A more important factor in speed is the speed of the peripheral devices. Reading floppy disks or cassette tapes and printing on a typical 30 character per second printer are extremely slow operations. However, the cost of a high-speed printer could easily exceed the cost of the entire microcomputer system. On the other hand, with the advent of Winchester (hermetically sealed) disk technology, the disk transfer rate between micro and mainframe computers is much more comparable. The bottom line is that the speed of the system is determined by its slowest component. It will usually be the input-output (I/O) devices that determine this speed.

The range of peripherals associated with a microcomputer is generally quite different from those accompanying a mainframe computer. A card reader of 9-track tape drive will virtually never be found on a microcomputer; instead, the floppy disk has become the means for transferring operating systems, programs, and data. The cathode ray tube (CRT) has reduced the need for a high-speed printer by allowing the programmer to visually examine his output and selectively print portions of it. The CRT also makes it possible to do high-resolution color graphics. Many of the microcomputers on the market have built-in graphics packages; however, this is often an expensive add-on capability when associated with mainframe computers which are not designed for graphics applications. Winchester disks, which are generally nonremovable, have decreased cost and increased reliability over typical mountable disks associated with mainframes. The Winchester disk technology has been applied to mainframe computers, but does not predominate the way it does in the micro area. Tape streaming, or sending massive amounts of data onto 1/4" or 1/2" magnetic tape in bursts with no start-stop capability, has become a common means of backing up disks as opposed to dumping them onto 9-track tapes. Streaming makes a very limited use of the magnetic tape medium, but that limitation is intentional to simplify the function and keep the cost low.

Micro and mainframe computers have a common shortcoming: design differences among manufacturers lead to often serious problems of incompatibility. The use of magnetic tape, punched cards, and paper tape as a transfer means and the development of standards for the major language translators have facilitated a degree of compatibility among mainframes, though this compatibility took years to develop. The sheer number of microcomputer equipment manufacturers has, on the other hand, contributed to a serious incompatibility problem among microcomputers. At this time, there is very little likelihood that a 5 1/4" floppy disk created on one manufacturer's product will be readable on another manufacturer's product. (There is, however, what appears to be a de facto standard for 8" floppy disks.) Further, a manufacturer may incorporate design features to protect its market. The Apple Computer, for example, utilizes a data bus unique to Apples. The consequence of this is that Apple has limited the opportunity for other manufacturers of auxiliary equipment and software and given Apple a more secure market for its products. As another example of planned incompatibility, the IBM Personal Computer supports only a 5 1/4" floppy disk drive that is incompatible with drives on IBM's larger mini and mainframe computer equipment.

Software Differences

At first glance it would appear that software for microcomputers is both abundant and inexpensive. However, one must take a closer look at the nature of the software and its support.

Software for mainframes has traditionally been provided by the vendor. For one brand of equipment, a compiler language might differ slightly from one operating system to another, but it would be largely the same. An example of this would be COBOL on the IBM under OS and DOS. However, software for microcomputers is associated much more with an operating system, which might be written by an independent software house, instead of a vendor. A myriad of software houses have appeared to answer the needs of microcomputer users.

In the majority of cases, a mainframe computer is run under one operating system. However, this is not at all the case in the micro world. There is a wide range of operating systems costing from less than one hundred dollars to several thousand dollars. They are generally dependent on having a particular microprocessor and bus. The user may prefer the PASCAL compiler on one operating system and the graphics package offered on another; so he simply "boots" in the operating system he needs for his current task.

Mainframe computers have generally used language compilers, which translate a source program into object code that can be directly executed. From the beginning, the trend in microcomputer language software was toward interpreters, which execute some code each time a source statement is encountered; i.e., they combine translation and executive into one step. The advantages to this approach are that the high-level program being interpreted can be easily interrupted, changed, and resumed and the often large amount of storage needed for an object program is not needed. The price to be paid is in executive speed that can be 10 to 20 times slower for an interpreter over a compiler.

The COBOL language clearly predominates in software for mainframe computers. FORTRAN is a close second. These languages have persisted through the years, despite their respective problems of verbosity and resistance to structuring, because of the standards that have been developed and the accumulation of software written in either COBOL or FORTRAN. Software development on micros has taken a different direction in moving away from traditional compilers to interpretive versions of BASIC and PASCAL and to a PL/I compiler for micros. FORTRAN is still popular, but enthusiasm for PASCAL and the micro PL/I version may see that popularity wane.

The software developed for mainframe computers is mature and complete only because of the time span over which it has been written. In some cases, it would probably suffice to say that it is showing signs of age and could benefit from a fresh start. The software for micros, on the other hand, shows the effect of new techniques, but at the same time is often so rushed in development that it is not fully debugged. Attention has been paid largely to business applications, computer graphics, word processing, and video games. Statistical software is virtually nonexistent. SPSS, Inc. is developing a version of their long established package for the IBM Personal Computer; this will be the first such package developed by a major producer of software for mainframes.

Application Differences

As was mentioned earlier, microcomputers have never been viewed as the general-purpose machines that mainframe computers are. They are generally used for a very specific or limited purpose. The hardware and software are chosen only to satisfy the needs of that purpose. This often greatly reduces the need for a variety of peripherals, operating systems, and other software packages. It may even mean that a turn-key system can be developed whereby the users need very limited knowledge of the hardware and software specifics.

The justification for computer centers organized around large mainframes has previously rested on the economies of scale suggested by Groschs' law; that is, that computing power varies as the square of the cost of the hardware. The most obvious impact of microelectronics in new computing systems is to destroy the stability of existing arguments concerning the relative efficiency of centralized and decentralized computing services. The decreased cost and the orientation toward special-purpose equipment has created an ideal environment for distributed processing. This has resulted in a more immediate involvement between user and equipment and a relationship between the two which was totally nonexistent with mainframe computers.

The majority of statistical processing done on mainframe computers is done in batch mode; that is, a predetermined sequence of code is submitted for execution and the user receives the end result. Once the program is submitted, the user has no flexibility to vary any part of it. By contrast, working in the interactive mode typically associated with microcomputers permits modification of programs or data during execution. This direct interaction can result in a much more gratifying and productive work environment.

A pertinent example of the advantages to working in the interactive mode is the possibility of editing data as they are being entered. While this may place a greater burden on the data entry operator, it alleviates the need to locate the source document once an error is noted and reduces the number of times the data must be passed.

Some tasks which are easy on mainframe computers become more difficult on micros. For example, sorting a file typically involves no more than specifying input and output files and sort keys and invoking a utility sort program. However, on a microcomputer the data may be contained on a series of floppy disks. Sorting also requires a significant amount of storage. The need to physically load in all the floppy disks, the limited amount of storage, and the slow access to data on floppy disks indicate that sorting can be difficult from a management viewpoint if floppy disks are involved.

The idea of evaluating traditional mainframe processing approaches extends to sequential processing in general. In many cases it is far more efficient to move to a data base management system that allows random access of the data instead of sequentially processing each record. This is especially true in applications that need to use only a small fraction of the total data file.

It has been relatively easy to transfer programs and data from one mainframe computer to another. If the programs were written in a standard version of COBOL or FORTRAN and if the data were represented in a standard format, the conversion was generally a simple matter. This portability is lagging in the microcomputer world. Language translators such as BASIC, as implemented under various operating systems, are often quite different. Software is largely operating system dependent, if not machine specific, and conversion could conceivably involve wholesale rewriting.

In the early years of mainframe computers, core memory restrictions forced conscious writing of programs in such a way that sections could be overlaid when they had been executed, thus saving storage space by reusing the same core memory. This overlay technique virtually disappeared with increased memory size and the use of techniques such as paging, or automatically moving sections of programs in and out of memory in a way that the user is unaware that it is happening. With low limits on program size in many of the microcomputers, one is compelled to search for solutions to the memory problem once again. These include overlaying programs, breaking down large programs into multiple smaller ones, and simply deferring some programs to larger machines.

Speed has always been an important area of comparison for mainframe computers and many vendors have made this their primary focus. On the other hand, speed has typically not been as great an issue for microcomputers because of the nature of the applications processed on these smaller machines. Most applications on micros today do not require voluminous output (time-consuming printing), extensive calculations (time-consuming internal operations), or reading large data files (time-consuming input operations). As microcomputer technology develops, speed may once again become a big selling point. For now, the user can use techniques such as random instead of sequential access of files and selective printing to compensate for problems in speed.

Mainframe computers have always had the effect of intimidating the novice or nonprogrammer. Their size and demand for a constant "sterile" environment have made them seem formidable. The microcomputer, on the other hand, is termed "friendly" and "intimate." Its compact, attractive packaging has made it more akin to the typewriter or television set of which no one is afraid. The user becomes personally involved and has ultimate control over the machine. It implies a greater responsibility on the user's part to deal with both hardware and software problems, as there are no intermediaries. This feeling of control may make the user more innovative and productive.

Uses of Microcomputers in Statistical Offices

Several foreign government agencies have acquired microcomputers to assist data processing operations. Three countries' experiences with three different microcomputer systems are described in this section. All three countries are using microcomputer systems for entry and editing of survey data. A description of the microcomputer system developed by the U.S. Bureau of the Census for processing the Puerto Rican economic census is also provided.

Jamaica Agriculture Survey

In addition to data entry and editing, the Jamaican Ministry of Agriculture also uses its North Star microcomputer for all other processing of its quarterly agricultural survey, including tabulations and statistical analysis. The Jamaican experience provides an excellent example of a closed, stand-alone operation of statistical applications for small pieces of work by a single machine. (The other countries, Nigeria and Upper Volta, use mainframes or minicomputers for some other stages of processing of the surveys in question.) The Jamaicans use their North Star microcomputer to handle all data processing operations of a 4,000 questionnaire quarterly agricultural survey. The microcomputer is kept busy every working day from 8:30 a.m. to 5:00 p.m. with the data entry, editing, tabulations, and statistical analysis (variances) for the single survey. The Jamaican operation suggests that the upper limit to stand-alone processing of a survey by a single microcomputer (not a network or group of independent units) is primarily a function of data entry capacity. The Jamaican data processors who have helped develop the system and who use it have stressed their need to be able to program in BASIC and to understand BASIC programming as a prerequisite for setting up and running their stand-alone microcomputer-based survey processing system. Packaged software was not available for the editing and tabulation requirements, and a statistical package which they had wanted to use for analysis was found to have several errors and shortcomings which could only be resolved with a thorough understanding of the underlying BASIC programs. The Jamaicans are a valuable resource for more specific information on various constraints and differences which are unique to microcomputer processing. The manager of the data processing unit in the Jamaican Ministry of Agriculture has offered to share her experiences and those of her staff. Their work on the microcomputer was developed under a project which involved the U.S. Department of Agriculture. Many of the custom-written programs were developed under technical assistance provided by U.S. Department of Agriculture advisors.

Purdue Project in Francophone Africa

In Upper Volta and in other African countries, 16 researchers from the School of Agriculture of Purdue University are utilizing several Radio Shack TRS-80 microcomputers primarily to enter data "in the field" and to run some elementary statistical analysis of the data before shipping the data to Purdue for further analysis and tabulation. Although the Purdue staff had envisioned analysis of data in the country in which the data were collected, incompatibility of existing mainframe computers with the TRS-80's precluded doing all of the analysis in the country. The Purdue staff did learn a great deal from their experience; and, during the first two years of the four-year project, the Purdue researchers made several improvements and necessary modifications to their original procedures. Many of the changes were due to technology improvements. For example, the data storage medium changed from cassette to diskette when diskettes became readily available on TRS-80 systems. The project data manager noted a 50% improvement in interactively edited data entry speed under the diskette-based system. Other changes, such as standardizing encoding and data entry procedures across all questionnaires and making all field procedures as user-friendly as possible, were instituted to facilitate final processing at the Purdue computer center when it became clear that final processing would be done there.

The project progress report does not describe the efforts to find or build data transfer interfaces in-country for mainframes and microcomputers. Those efforts might have lost importance when a working system was established using the Purdue mainframe computer.

The project data manager for the Purdue project foresees the inevitable increased distribution of microcomputers in government offices in the West African countries. (In fact the project has installed a micro in a government office in Dakar.) He also believes that microcomputers with increased capabilities will permit complete data analysis in-country entirely by microcomputers. This will eliminate the need for the now-missing interface. The focus of the Purdue project has been on getting the results for the researchers in the "best" way possible. While the "best" way means, in theory, keeping the data near the source throughout processing (for verification, if necessary), the practical solution to getting any research results (in a timely manner) meant shipping cassettes and later diskettes to the U.S. for processing. Institutionalization, that is, leaving behind a working data processing system, was not of primary interest to this research project.

Nigerian Agriculture Project

A third project involving microcomputers was a study in Nigeria of computer system requirements for the Agricultural Projects Monitoring Evaluation and Planning Unit (APMEPU). APMEPU wished to process several local agricultural censuses. The study and subsequent procedure were done by Phoenix Associates, Inc., for the World Bank. Phoenix Associates recommended and purchased several Apple microcomputers for on-site interactive data entry to diskette. Phoenix also arranged for procurement of a Data General Eclipse minicomputer to be installed at Kaduna, where the APMEPU office is located. The Data General minicomputer will be equipped with diskette readers so that the data entered in the field using Apple microcomputers can be read, further edited, and analyzed using SPSS. Eventually the edited data diskettes will be sent to the World Bank in Washington for processing using CYBERNET and other econometric packages. The Apple microcomputers will be transported from town to town for on-site data entry. The Phoenix Associates carefully included descriptions of controlled environments in which the Apples would operate in order to protect the machines from dust, moisture, and electrical irregularities. Although the planned use of the Apples in Nigeria is very much like the use of the TRS-80's in Upper Volta (namely, only data entry with some interactive editing), the approach taken by Phoenix Associates is quite different. Phoenix employs computer systems specialists whose primary concern was putting together a total system in-country which would be compatible with World Bank's CYBERNET econometric analysis package. Phoenix also had the responsibility of specifying all procurements for the system. Compatibility in-country was the primary concern, and Phoenix had the expertise to assure that compatibility. Phoenix approached the data entry, editing, and analysis from the computer side, knowing what was available and what components would be compatible. Purdue, on the other hand, looked first at minimal processing needs for the research, then found a system that would suffice.

Puerto Rican Economic Census

The Technical Services Division of the U.S. Bureau of the Census is currently implementing its own experimental networked, microcomputer-based data processing system for processing the Puerto Rican Economic Census. This census polls 26,000 establishments and each questionnaire may have up to 1,000 responses. Custom software for on-line data entry and data editing was written in machine language and PASCAL for a network of 10 Apple II+ microcomputers which all serve as data entry stations for keying entries from the Puerto Rican census onto four 20-Megabyte Corvus Winchester Disks. The actual programming of the networked system was difficult because of the required record lockout feature which permits handling of any record by only one of the ten stations at a time.

The system designers and implementers won U.S. Department of Commerce awards for their innovative work with microcomputers. The system itself provides another excellent example (along with the Jamaican operation) of a stand-alone operation devoted to a single task. The U.S. Bureau of the Census system was carefully designed with the task in mind.

The large size of the census dictated the need for several data entry stations so that timely results could be obtained. Networking would be superior to independent stations and would allow controlled access to the common data base. The choice of the Apple II+

machines as data entry and editing stations arose from Apple's networking capability, its rather inexpensive base price, its compatability with Winchester disk drives (for large data storage), and its support of PASCAL, a powerful high level language.

Conclusion

This paper only highlights information that has been collected in the areas presented. It should provide a reference point for future work which will address in greater depth the critical issues of using microcomputers in statistical offices. The following are some specific issues which will be evaluated:

1. Is it practical to think of the microcomputer as a general purpose machine? If so, what configuration is most appropriate?
2. What does the introduction of microcomputers mean in terms of level and kind of support staff required to program and operate the machines? What does this imply in the area of training?
3. How can the problem of incompatibility with mainframe computers and with the outside world best be overcome?
4. If a shift to new language translators is recommended, what will be the impact of conversion of existing software?
5. What print speed will be adequate and can microcomputer printers perform at this speed?
6. If distributed processing is recommended, what problems in control will ensue?
7. What will be the effect of a shift from batch to interactive processing?
8. How severe is the lack of statistical software and what should be done about it?

Answers to these and other questions should provide a realistic appraisal for the use of microcomputers in developing countries' statistical offices.

F. **"Microcomputer Enterprise Budget Generator System,"** by James M. McGrann and Steven Griffin.*

The enterprise budget and whole-farm cash flow analysis are two of the fundamental tools of farm management for economic analysis of resource allocation in production agriculture and the evaluation of alternative technologies, production systems and marketing alternatives. They are widely used in microeconomics research, investment-project evaluation and farm management. Their applications range from aiding very specific farm management decisions to estimating enterprise costs and returns for government pricing policy. High rates of inflation, increasingly variable input and output prices, and changes in technology increase the demand for timely enterprise budget and cash flow information. Computerized budget generator systems are one means of providing reliable, consistent, and up-to-date cost-and-return information quickly and easily.

The mainframe version of the Oklahoma Budget Generator has been widely accepted since its development ten years ago. Over 30 Land Grant Institutions and several government and private firms use this tool. A version of the program is used by the Federal Government to provide cost of production estimates for major crops and livestock in various regions of the U.S.

A microcomputer version of a new budget generator is under development by Texas A&M University, the University of California and Oklahoma State University. This project is funded in part by the W. K. Kellogg Foundation and will be completed in 1983.

The microcomputer budget generator system is designed to be used by the non-computer specialist, including farmers and ranchers. The budget generator is designed from experience with use of the mainframe Oklahoma State version and enhances the capability of the original system. The software will run within a 64K CPU system. The software is coded in the PL/1-80 language to facilitate upward compatibility on mini- and mainframe computers.

The budget generator system is fundamentally a data base management system that includes equations for calculation of machinery, equipment and irrigation cost. A "budget generator" differs from budgeting tools based on electronic worksheet software (e.g., VISICALC, EXECUPLAN, etc.) in that the data used in a budget are stored in their most elemental form in common data files. Therefore, a change in, say, the price of fuel in the data base will update all of the stored budgets. In an electronic worksheet system each worksheet (budget) would have to be updated individually.

The microcomputer budget generator will access and maintain data bases for machinery and equipment, production items and resource inputs, parameter data, and previously constructed budgets. Screen entry of information will facilitate data entry and storage.

Output options for crops or livestock include: (1) an enterprise economic budget, (2) an enterprise accounting budget, and (3) a whole farm cash flow.

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*Associate Professor and Assistant Professor, respectively, Department of Agricultural Economics, Texas A&M Univeristy, College Station, Texas.

Budget summaries are user-selected to provide detail or aggregation by month, stage of production and operation. Economic budgets are divided into variable and fixed (or sunk) cost sections. Accounting budgets are similarly delineated with major partitions into cash and non-cash components.

It is anticipated that further extension will include a whole farm linear programming option and a capital budgeting component for long-term investment analysis.

Manuals and supporting materials will be developed so that the software package will be an educational tool as well as an analytical tool. The primary clientele of the budget generator will be farmers and ranchers, educators, and agribusinessmen and consultants that serve producers.

When completed, the budget generator systems and supporting materials will be demonstrated in a national education workshop. The software package will be maintained and distributed by the three universities involved in the project.

User definable data sets will allow sufficient flexibility to utilize the microcomputer budget generator system in LDC's. Translation of input and output screens from English to other languages would require a relatively small investment. The micro-budget generator will have many applications in research, extension and project evaluation activities in LDC's.

The specific features of the microcomputer budget generator, tasks performed, and components are shown in the following sections. (Examples of the screens and outputs were presented with the original paper but are not reproduced here.)

Microcomputer Budget Generator

Specific Features

Menu driven screens and procedures
Screen entry of data
Data edited on entry
Fully interactive
Non-numeric coding of data
Help instructions and status prompts incorporated in program
Detailed operation users manual
Detailed education users manual
User defined production functions and cost relationships

Tasks Performed

Score data to be used in budgets and whole-farm cash flow
Store user defined production functions and cost relationships
Build a new budget and store it in a permanent file
Build a new budget from an old budget
Update an old budget
Compute costs of machinery, equipment and irrigation (economic and cash/non-cash)
Do computations for budgets and whole-farm cash flow
Print budgets, whole-farm cash flows and supplemental data

Components of the Microcomputer Budget Generator System

Data Sets

- Parameters
  Links
- Production
  Item Names and
  Values

- Resources
- Machinery and equipment
- Irrigation equipment
- Operating inputs and custom services

Calculating

- Equations for machinery and irrigation
- User defined production functions and cost relationships

Output Menu

Enterprise Budgets

- Economic
- Accounting budget

Whole-farm Cash Flow

G. **"Programmable Calculator Software Sources for Agriculture,"** by James M. McGrann.*

Two programmable calculators have dominated agricultural use in the United States. The most popular calculator is the Texas Instruments TI-59 followed by the Hewlett Packard (HP). Large quantities of software are available and the calculators have been widely used. This paper identifies a few of the software sources and briefly describes what effort would be required to assemble a library of programs for use in LDCs (see Appendix A).

Available software from U.S. Land Grant Institutions for programmable calculators places heavy emphasis on decision aids that assist day-to-day farm decision making (see Appendix B). These tools do have usefulness in applied research activities where economic or financial analysis is important. A limited number of programs are available for statistical analysis. Potential exists for adding to this list to handle many of the experimental plot type analyses. Statistical libraries of programs are also available from TI and HP.

Programmable calculator software does exist in international technical assistance institutions. Efforts would be required to contact individuals to acquire the software to put together a library of programs.

If an effort were made to assemble all published programs from libraries and other sources, a very comprehensive set of software for the programmable calculator could be put together. Some efforts would have to be made to standardize formats and to select from similar programs to minimize duplication in a library. An interdisciplinary review of available software would be useful to identify potential additions needed for existing programs especially for analytical programs. Translation of the programs to appropriate languages would also be useful as the software sources identified are mostly in English.

Present available software for the programmable calculators is sufficient to provide a valuable contribution to many research-extension efforts in LDCs. It would be a relative low-cost effort to assemble programs in a complete comprehensive library to make them available in LDCs. Once assembled, an on-going support unit could facilitate acquisition and distribution of a library of software. The programmable calculator could fill a gap in calculation capacity until the microcomputer software availability, hardware reliability, and cost can replace this useful tool.

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*Associate Professor, Department of Agricultural Economics, Texas A&M University, College Station, Texas.

APPENDIX A

Sources of Programmable Calculator Software

Land Grant Institutions

Iowa State University

- Iowa State University Cooperative Extension Service, "Programmable Calculator Programs Applied to Agricultural Decisions," Subscription Library, Publications Distribution, Iowa State University, Ames, IA 50011, $30.

Cornell University

- NRES, "Calculator Programs for Extension," Riley-Robb Hall, Cornell University, Ithaca, NY 14853, $20.

Kansas State University

- Kansas State University, Extension Agricultural Economics "TI-59 Programmable Calculator: Instructions and Programs," Cooperative Extension Service, Waters Hall, Manhattan, KS 66506, $30.

Washington State University

- "Programmable Calculators Library," Cooperative Extension Service, Washington State University, Department of Agricultural Economics, Pullman, WA 99164.

- List of available programs in Land Grant Institutions

  Strain, Robert and Sherry Fieser, "Update Inventory of Agricultural Computer Programs: Available For Extension Use," Circular 531, Food and Resource Economics Department, IFAS, University of Florida, Gainesville, FL 32601.

- TI-program exchange

  Texas Instrument TI-59 Professional Program Exchange (PPX-59).

  User-contributed software exchange program for a wide variety of professions, includes bi-monthly newsletter. PPX-59 membership, $15/year.
  Texas Instruments Service Facility, P.O. Box 53, Lubbock, TX 79408.

APPENDIX B

TEXAS A&M UNIVERSITY TI-59 PROGRAMMABLE CALCULATOR PROGRAMS*

(1) - Beef Cow Enterprise Budget and Production Evaluation
(2) - Stocker Enterprise Budget and Production Evaluation
(3) - Stocker Gain Contract Budget and Production Evaluation
(4) - Stocker Cattle Graze vs. Harvest Budget and Production Evaluation
(5) - Annual Pasture Cost Estimation and Production Evaluation
(6) - Grazing Day Worksheet for Stocker Cattle and Annual Pastures
(7) - Finishing Cattle Enterprise Budget and Production Evaluation

WASHINGTON STATE UNIVERSITY PROGRAMMABLE CALCULATOR LIBRARY**

(Programs for the TI-59)

1. Gross Margins Analysis for Evaluating Alternative Crops

   This program calculates gross margins (returns over variable costs) for up to five crops at a time and allows systematic comparison of crop pairs with a break-even yield and price analysis. Work sheets are provided to record program results, including gross margins, break-even analysis, and crop acreage assignments. For a given crop mix, the program calculates total revenue, total variable cost, and total gross margins.

2. Analysis of Land Value

   This program estimates land value based on the major land value determinants. These determinants are after-tax annual returns from farming, the tax benefits from real estate loan interest deductions, and the after-tax market value of land at the end of the investor's planning period.

3. Analysis of Ability to Pay for Land

   This program determines the maximum financially feasible price that can be paid for additional farmland. The maximum price is based on: equity funds available for down payment, cash flow generated from the farm operation, other financial commitments, the interest rate on the loan used to finance the real estate acquisition, and the number of years over which the loan is amortized.

4. Estimating Farm Machinery Costs

   This program calculates the per-acre and per-hour cost of owning and operating farm machinery. It will calculate costs for self-propelled equipment and a combination of power units and implements.

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*Programs can be obtained from James M. McGrann, Department of Agricultural Economics, Texas A&M University, College Station, TX 77843.

**Programs can be obtained from Herb Hinman and Gayle Willet, 203 Ag. Sciences, Washington State University, Pullman, WA 99164, or Dick Carkner, Western Washington Research and Extension Center, Puyallup, WA 98371.

MSU Library (continued)

5. Investment Analysis - Net Cash Flow and Present Value, Debt Recovery, and Investment Payback Periods

   This program calculates four important measures for evaluating alternative investments, including after-tax cash flow, net present value of the after-tax cash flow for both debt and equity financing, and also the debt recovery and investment payback periods. The program can be run for debt and equity financing or both.

6. Beef Feeder Stocker Break-Even Analysis

   This program calculates the break-even purchase price for feeders or the break-even selling price for stocker cattle. Feed requirements are calculated using the net energy system and the cattle's initial weight, sex, and desired rate of gain. Work sheets are provided to assist with comparative analysis.

7. Break-Even and Culling Point Analysis for Dairy Herds

   This is a program that can be used with DHIA records and business records to help determine which cows should be culled due to low milk production and indicate when is the most economical time to cull.

8. Machine Buy, Machine Lease, Machine Rent/Custom-Hire

   This is a package of three routines that can be used to compare the economic benefits associated with four machinery financing alternatives: (1) cash or credit purchase; (2) lease; (3) rent; and (4) custom hire. The programs calculate the present value of after-tax costs for the four alternatives.

9. Dairy Cow Investment Analysis

   This program analyzes the profitability and liquidity of a proposed investment in dairy cows. The program computes: (1) the value of the cow to the business, or the maximum bid price; and (2) the years needed to recapture debt capital used to finance a cow purchase.

10. Lease vs. Purchase of Farm Land Analysis

    This program analyzes the profitability and cash flow aspects of lease versus purchase of farmland.

IOWA STATE UNIVERSITY PROGRAMMABLE CALCULATOR LIBRARY*

(Programs for the TI-59)

Agricultural Engineering

- Sprayer Calibration
- Measuring Corn Harvesting Losses
- Measuring Soybean Harvesting Losses
- Field Work Sheet for Measuring Corn Harvest Losses (reverse side for measuring soybean harvesting losses)

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*Subscription available at Iowa State University, Publications Dist., Ames, IA 50011. Send check or money order made out to ISU for $30 for the subscription.

ISU Library (Continued)

Agronomy

Determining Fertilizer Needs to Supplement Liquid Manure
Crop Yield Calculation
Soybean Yield Contest
Corn Yield Contest
Field Population
Field Population: Planter Calibration
Field Size: Acres/Hectares for Rectangular Fields
Soil Erosion of Corn Fields: Quantitative Estimate
Soil: Agricultural Lime Recommendations
Corn: Early Freeze Yield Reductions
Growing Degree Days: Weather Service Method
Universal Soil Loss Equation
Corn: Estimate of Yield

Animal Science

Net Energy for Feedlot Cattle
Ration Analyzer for Feedlot Cattle
Protein Supplementation for Feedlot Cattle
Metabolizable Protein and UFP Determination of Feedstuffs and Protein Supplements
Adjusting British Breed Weaning Weights with No Birth Weights
Adjusting Exotic Breed Weaning Weights with No Birth Weights
Adjusting Calf Weaning Weights with Known Birth Weights
Weaning Weight Ratios and Sire Summary
Yearling Weight Adjustment and Weight per Day of Age Determination
On-Farm Bull Test Record
Ration Analyzer for Beef Cows
Adjusting Beef Cattle Weaning Weights
Month Data Tape
Yield Grade, Cutability, and Percent Lean Determination in Beef Cattle
NPPC Pork Carcass Evaluation
NPPC Swine Carcass Evaluation Age Units Required to Produce 85 lbs. of Muscle
Ration Formulation (Pearson Square)
Standardizing Swine Carcass Measurements
Swine Ration Analyzer
Adequacy of Swine Ration
Comparative Value of Various Feeds for Swine
Scoring Judging Cards
Ration Analysis for Swine and Poultry
Sow Productivity Index
Gestation and Livestock Management Calendar
Ration Analyzer Utilizing Master Library Module Program 03
Ration Formulation and Premix Balance with FM-09 (Agricultural Module)

Dairy Science

Dairy Ration Balancer
Dairy Ration Analyzer
Grain Mix Formulator
Comparative Feed Pricing

ISU Library (Continued)

Farm Management

Cattle Feeding Work Sheet
Feeder Pig Work Sheet
Grain Marketing Costs and Returns
Estimating Farm Machinery Costs
Income Tax Estimation
Farm Loan Analyzis: Installment Loans
Combine Ownership or Custom Hire: After-Tax Cost
Gross Margin Equating Formula for Corn and an Alternative Crop
Farm Depreciation and Investment Credit
Feeder Lamb Work Sheet
Discounting a Combination of Uniform and/or Non-Uniform Series
Internal Rate of Return for a Combination of Uniform and/or Non-Uniform Series
Land Purchase: Financial and Economic Analysis
(an extended version of FM-1730 (4) - TI)
Investment Payback Period Determination
Break-Even Price for Stored Grain Compared to Selling Wet or
Drying Cow-Calf Work Sheet
Time Series Deflator
Motor Vehicle Cost Analysis
Moving Average
Feeder Pig Production Work Sheet
Ewe Work Sheet
Farrow-to-Finish Work Sheet
Farm Business Record Analysis
1979 Feed Grain Program Work Sheet
Investment Repayment Capacity Analysis
Cost Comparison for Fertilizer Application
Triangular Probability Distribution

Marketing

Feeding Cattle to Higher Grade
Economics of Feeding Hogs to Heavier Weights
Evaluation of Live and Hot Carcass Weight Alternatives for Fed Steers

IOWA STATE UNIVERSITY AG. MODULE FOR THE TI-59

- Cow-Calf, Ewe, Feeder Pig Production, or Farrow to Finish Work Sheet. Performs an economic analysis of the cattle feeding, lamb feeding, and the feeder pig finishing enterprises.

- Cattle, Pig, or Lamb Feeding Work Sheet. Performs an economic analysis of the cattle feeding, lamb feeding, and the feeder pig finishing enterprises.

- Land Purchase and Farm Loan Analysis. Performs a land purchase, financial and economic analysis, and also evaluates three types of loans commonly used by farmers.

- Batch Mix. Designed to determine quantities of n ingredients for x sizes of total mix.

- Beef Cow Ration Analyzer. Designed to determine the nutrient requirements of gestating and lactating beef cows and compare them to the nutrients contained in a ration that is being fed. Analysis of crude protein, total digestible nutrients, calcium, and phosphorus is included.

- Feedlot Ration Analyzer. Designed to project from a ration being fed the average daily gain, cost per pound of gain, amount and type of protein supplement required, and the amount of calcium and phosphorus supplied.

- MP and UFP Determination. Calculates metabolizable protein and urea fermentation potential values for feedstuffs and supplements.

- Dairy Ration Balancer. Calculated grain feeding requirements necessary to supplement different levels of milk production on various forage feeding programs for dairy cattle.

- Swine and Poultry Ration Formulation. Designed to provide amounts of ingredients required for specified protein or lysine levels. Also calculated percent protein, lysine, calcium, phosphorus, and amount of metabolizable energy per pound.

- Swine and Poultry Ration Analysis. Calculates the average composition of up to seven nutrients for any number of ingredients that are used in a ration or formula.

- Relative Value of Swine Feed Ingredients. Uses the prices of corn, soybean meal, and dicalcium phosphate to determine the competitive value of other feedstuffs as sources of energy, lysine, and phosphorus.

- Gestation Management. Uses breeding date to calculate expected birth date, and dates that various management practices are to be carried out either prior to (or after) either the breeding date or the birth date.

- Beef Weaning and Yearling Weight Adjustment. Designed to adjust weaning weights to a 205-day basis and yearling weights to 365 days. Any birth weights and age of dam adjustment factors can be utilized.

CORNELL UNIVERSITY PROGRAMMABLE TI-59 CALCULATOR LIBRARY*

5.1 Determination of Water Removal or Addition to Condition Feedstuffs
5.2 Estimating Agricultural Aircraft Cost
5.3 Corn Crop Selection
5.4 Calculating Water Flow in a Pipe
5.5 Standardization and Statistical Analysis of Plot Samples
5.6 Comparing Fuel Costs
5.7 Drying Fan Selection
5.8 Estimating Farm Machinery Costs and Mimeo #431
5.9 Manure Storage

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*Available from: NRAES, Riley-Robb Hall, Cornell University, Ithaca, NY 14853. Cost is $20.

Cornell Library (Continued)

5.10 Product Storage Refrigeration or Heating Load
5.11 Ration Analysis and Formulation
5.12 Batch Size Calculations for Complete Feeds
5.13 Simplified Feed Requirements for the Lactating Cow
5.14 Dairy Ration Balancer
5.15 Prediction of Daily Dry Matter Intake
5.16 Formulating and Blending Complete Feeds Calculator
5.17 Calculation of Nutrient Allowances for Dairy Cattle
5.18 Estimating Operative Costs for Bulk Milk Assembly
5.19 Cost Evaluation of Dairy Feed Using Corn and Soybean Meal Constants
5.20 Calculating Soil Loss
5.21 Drive Belt Length and Center Distance
5.22 Building Heat Loss and Heating Cost
5.23 Economic Value of Cropland
5.24 Financial Feasibility of Land Purchase
5.25 Greenhouse Heat Loss Calculator
5.26 Home Canning Cost Analysis
5.27 Warm Dairy Barn Ventilation Calculator
5.28 Matching Grain Depth to Drying Fan
5.29 Lime Calculations
5.30 Wood Beam Analysis - Uniform Load
5.31 Wood Beam Bending Analysis - Point Loads
5.32 High Moisture Corn Pricing
5.33 Tank Calibration
5.34 Tractor Ballasting
5.35 Investment Table Generator
5.36 Social Security Program
5.37 Laying Flock Records - Program Description
5.38 Wood Column Design for Grain Storage
5.39 Determining Air Flow per Volume of Grain
5.40 Vehicle Fuel Cost
5.41 Bovine Nutrition - Program Description
5.42 Volume and Tonnage of Grain or Forage in Various Storages
5.43 Grain Drying Time Estimator and Psychrometric Calculator
5.44 Silo Hoop Spacing
5.45 Fieldwork Horsepower Requirement Estimator
5.46 Fuel Cost Comparison
5.47 Subsurface Drain Design

KANSAS STATE UNIVERSITY TI-59 PROGRAMMABLE CALCULATOR NOTEBOOK*

Beef

1.1 Beef 4-80, Revised 7-80
1.2 Beef Cows 4-80
1.3 Feed Lot Cattle 7-79
1.4 Beef Feed 1-80, Revised 6-80
1.5 Adjust Calf Wean Weight 11-79
1.6 Beef Frame 11-79, Revised 7-80

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*Order from: Extension Ag. Economics, Waters Hall, Kansas State University, Manhattan, KS 66506. Cost $30 for 3-year subscription.

Crops-Dry

2.1 Dryland Crops 4-80
2.2 Government Participation (Feed Grain, Corn, or Grain Sorghum) 11-78
2.3 Government Participation (Wheat) 12-78

Crops - Irrigated

3.1 Irrigated Crops 4-80, Revised 7-80
3.2 Corn Water Use 6-79
3.3 Irrigation Pumping Program

Dairy

4.1 Dairy Ration (Lactating Cows) 7-79
4.2 Dry Cow Ration 7-79
4.3 Dairy 4-80, Revised 7-80

Financial

7.1 Land Purchase 4-80
7.2 Compound Interest 4-80, Revised 7-80
7.3 Sto-Sell Grain 5-80
7.4 KSU Ext. Share or Cash Lease 5-80
7.5 Feed Price Calculate 6-80
7.6 Lease or Purchase Machinery and Equipment (Custom Hire Option) 6-80

General Livestock

8.1 Feeder Lambs 5-79
8.2 Lamb Grower 1-80
8.3 Ewe 4-80

Swine

9.1 Sow and Litter 4-80, Revised 7-80
9.2 Finish Feeder Pigs 4-80
9.3 Swine Feed Analysis 11-79

Miscellaneous

KSU Flight Man Calculator

REFERENCES

Aronofsky, Julius S., Robert J. Frame, and Elbert B. Greynolds, Jr., Programmable Calculators: Business Applications, McGraw-Hill, New York, 1978.

Iowa State University Cooperative Extension Service, "Programmable Calculator Programs Applied to Agricultural Decisions," Subscription Library, Publication Distribution, Iowa State University, Ames, IA, 1978.*

Iowa State University Research Foundation, "Agriculture Module," Solid State Module for the TI-58/59 Calculator, Iowa State University Research Foundation, 213 Beardshear Hall, Ames, IA, 1979.*

Kansas State University, Extension Agricultural Economics, "Kansas State University TI-59 Programmable Calculator Notebook," Kansas State University, Manhattan, KS, 1980.*

McCullough, M. E., Programmable Calculator Programs: For Dairy and Beef Cattle Rations, International Stock Food Corporation, Waverly, NY, 1979.*

McGrann, James M., "Basic Operational Procedure: TI-59 Programmable Calculator," Department of Agricultural Economics, Texas Agricultural Extension Service, College Station, TX, June 1980.

McGrann, James M. and William M. Edwards, "Application of the Programmable Calculator to Extension Agricultural Management Programs: Experience from Iowa," North Central Journal of Agricultural Economics, Vol. 1, No. 1, July 1979.

NRAES, "Cornell University Programmable Calculator Library: Program for the TI-59," Cornell University, Ithaca, NY, 1978.

Tax Management Incorporation, "CAL-Q-Tax: Program for Estate Planning," Solid State Module for the TI-58/59 Calculator: Customer Service Room S-500, 1231 25th Street, N.W., Washington, DC, 20037.*

Texas Instruments Incorporated, "Real Estate/Investment," Solid State Module, Lubbock, TX, 1977.*

Washington State University, "Programmable Calculators Library," Department of Agricultural Economics, Cooperative Extension Service, Pullman, WA, 1980.*

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*Sources of Programmable Computer Programs.

H. **"Experiences of Purdue University in West Africa,"** by W.H.M. Morris and Len Malczynski.*

Part I

At Purdue we started on FSR in West Africa in 1978 with the purpose of obtaining a better understanding of indigenous farming in order to understand why our agricultural development projects were so ineffective and to design and evaluate projects.

We decided to use a two-stage system with an introductory survey and then a cost route survey of a small sample of farmers. The cost route was similar to that used by David Norman in Samaru, Nigeria. We had 13 sites in all ranging from Senegal to Chad.

The forms were supposed to be designed for computer analysis, but we employed both graduate students and experienced research workers. Some experienced researchers were reluctant to count on the use of computers for the analysis, and did the analysis manually -- about as quickly as we did with computers but unable to use any degree of complexity in analysis.

As it became apparent that we would have serious problems with analysis, we reviewed the alternatives open to us and came up with a phase program.

1. Send the forms (hopefully corrected in the field) to Purdue for data entry into the computer;

2. Enter data in the field and send tapes or diskettes to Purdue for entry into the CDC mainframe computer and use SPSS for analysis. This involves a micro-mainframe interface;

3. Enter data in the field with use of error-finding routines and provide tabulation capability in the field, plus analysis at Purdue;

4. Move the analysis to the field except for complex models (large LPs -- Linear Programming); and

5. Develop the capability to run all that may be required in the field including LP.

We should add that we have not so far been successful in our rather limited attempts to transfer programs to mainframe computers in West Africa. For example, we tried to install an LP on an IBM 360 system computer in Dakar. Mainframe computers seem to have an individuality which microcomputers do not.

Currently we are working in the Farming Systems Unit of the SAFGRAD in Upper Volta and in institutionalizing a monitoring and evaluation unit in SOMIVAC in Casamance. Purdue University is about to sign a contract for the Niger Cereals Research which involves FSR as well as other forms of agronomic research.

Our philosophy is that Farming Systems Units (FSU) and Monitoring and Evaluation Units (MEU) have rather similar problems in data gathering, correction, and analysis; and

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*Professor of Agricultural Economics and Agricultural Economist and Field Researcher, respectively, Purdue University, West Lafayette, Indiana. Part I prepared by Morris; Part II prepared by Malczynski.

that mathematical models will prove very useful for evaluating constraints and the effect of change in technology on the farm/nonfarm economic system of the families. However, the caveat of R. Slade of APMEPU Kaduna (an IBRD Agricultural Projects and Monitoring Evaluation and Planning Unit) which appears in FAO Economic and Social Development Paper 12 (English edition) 1/ should be noted: "The system has generated a large amount of data, the processing and analysis of which has been subject to long delays . . . The processed data that have been transmitted to project management have, however, been unrequited, commonly disbelieved, and invariably unused." It is not clear whether this applies to the subsequent effort of J. C. Balcet and Candler on the same monitoring project, which will clearly be one of the classic reports of its kind.

The reaction to the Nigerian situation and the realities of the situation in the rural areas of Africa suggest that the MEU function will have to be carried out by (or closely integrated with) the Rural Development Organization. Even then, there is a marked reluctance in many organizations even to do self-evaluation.

Currently we are testing a system of using what we call first generation microcomputers (TRS 80 Models I and III) in the FSU at Ouagadougou and in the MEU of SOMIVAC in Senegal; these systems, using developments of commercial "canned" programs (as will be described by Len Malczynski), are to do all of the analysis of the various surveys in which they are involved (Base Line FSR-type survey) in the field. At present, modeling is not included. Both units have African programmers in place.

We are now interested in developing a system with a larger capacity, using the next generation of microcomputers (e.g., Radio Shack Model 16 or similar) to include modeling. The utility of microcomputers with small LP programs has already been demonstrated by Candler, so this generation of computers will take us near the final phase in our original scheme. Reliability is often raised as a problem. We think that at least two terminals or units are required, one for data entry and one for analysis and teaching; this is based on Len Malczynski's experience. Our main problem in reliability has been with static with the cables of the disk units with the TRS 80 Model I. The cable problem does not occur with the Model III; otherwise, we have not had many difficulties in the field. We regard the units as consumable items. A couple of computers cost $4,000, with $1,000 more in transformer and printer. The cost of the time invested in programming, if done by expatriates, is many times greater. They may also have a tendency to try to "reinvent the wheel." The old units continue and will continue to be servicable as the new units (e.g., TRS 80 Model III or Model 16) move into place. Thus, the software availability is a matter of much more value than the computer hardware. Funding agencies have not yet gotten used to the idea of treating a computer, if suitable programming is available, as a consumable item and a useful tool in most large projects. They could perhaps learn from the experience of the U.S. universities and businesses. This is not to say that a realistic approach should not be used: considering what needs to be done with a microcomputer, what software is needed and what exists, and what hardware is needed to run it. However, bearing in mind the volume of funds involved in project operation and in buying a microcomputer, the micro does not have to produce much to "earn its keep" once the donor has decided that the project funds may be used to buy it. In fact, some of the project staff are buying their own micros anyway; the major problem will then become to minimize the waste of their time in trying to create programs that could be more effectively purchased or obtained in the public domain.

1/ Monitoring systems for agricultural and rural development projects, 1981.

There is no question of the microcomputer versus the mainframe; both have a place. For example, to suggest at MSU or Purdue or in a major corporation that one or the other should be exclusively used is nonsense. I believe that a microcomputer is appropriate in many cases for a hands-on experience and for problem solving, accounting, planning, etc. in development and research in developing countries. There will always be some problems too big for the existing microcomputer that need a mainframe. There is a problem in Africa and elsewhere that many mainframe computer centers are underutilized and were equipped with older computers which could be replaced by minicomputers at much lower cost today; as a result, the computer costs are too high for obtaining widespread use.

We have not mentioned the teaching function. We will not be doing justice to teaching of agricultural technicians if they are not introduced to the software that enables them to solve pertinent problems. To do this, they need a hands-on experience in colleges and similar institutions.

A last thought: microcomputers are here, not just to stay but to develop at an almost incredible rate. They certainly have a place in developing as well as in developed countries. Let us then encourage their rational use and foster it rather than try to control it. Fostering could include provision of training and of a series of packaged programs to cover most of the standard needs.

Part II

Microcomputers now provide the researcher who is acquainted with mainframe computers the possibility of doing much if not all of his/her analysis on site. The lack of software and training has limited the use of the microcomputer in the LDCs. The following is a brief description of the activities involved in establishing a computer-based analysis service (CBAS) at various projects in Mali, Upper Volta, Senegal, and Indonesia.

The initial attempt was in Mali at the Institute d'Economie Rurale. Purdue University decided to place a programmer/agricultural economist on site to facilitate the analysis demanded by Purdue's team and to provide training for host country nationals who would assume responsibility for the microcomputer once the project was completed.

Among all four sites, four sets of institutional problems hampered the installation of a CBAS. The first problem was a lack of training facilities. The usual climatic problems plus a lack of office space plagued the establishment of a computer service. Secondly, the local staff chosen to attend the training programs ranged from secretaries to architects. The majority of the trainees had little or no exposure to mathematics or statistics. Thirdly, the time available for training had to be squeezed from the daily schedule of activities. Daily activities interfered to the point that group instruction was rendered impossible. It also occurred that the best trainees were also the best at their normal activity; therefore, their superiors were against assigning these individuals to the computer service. Finally, the students had little or no incentive to follow the coursework. Studying was occupying their leisure time and they were not being remunerated for the acquisition of new skills. Exceptions to the rule occurred, notably with two students who spent two months each at Purdue previous to on-site training.

The most successful experience has been in Senegal, with SOMIVAC (Societe pur la Mise en Valeur de la Casamance). A staff dedicated to the CBAS consisted of a library assistant (strong in math) who completed two months of intensive training at Purdue, and an air photo interpreter. A semi-autonomous bureau was created within the Division of Studies, Planning, and Evaluation (DEEP). The bureau was channeled work through the division's economist.

The analysis service provided short courses in questionnaire design (ultimately to encourage the use of field coded forms) and courses in computer use, software, and programming. The backbone of the software was STATPAC, by Walonik Associates of Minneapolis. All of the video prompts and some of the documentation were translated into French. A small group of data manipulation programs was also written. In addition, programs were written on demand for hydrology, agronomy, animal science, and accounting problems.

The preliminary results showed that the computer-based analysis service had an impact on the labor-intensive methods of data processing. Results of descriptive studies encouraged researchers to design and redesign questionnaires for rapid analysis. Several astonishing results were found after analyzing previously collected data.

As Slade comments in the FAO monitoring bulletin, "Computers do not substitute for analytic ability and programming skills." We, too, suffered from a lack of statistical knowledge and analytic ability. In many cases, the staff would never be able to analyze the data collected. Often this was the case due to unavailability of staff assigned to the organization. Therefore, in most cases, we moved toward a standardization of questionnaires and toward prepared sets of statistical analysis for each study.

The time span since installation in Senegal doesn't permit an adequate evaluation of the CBAS success. However, the Indonesia installation is operating and has been operating since October 1980. The experience gathered from these four attempts yields the following "rules of thumb."

1. Carefully identify the objectives of the CBAS;
2. Never install only one micro, redundancy is essential;
3. Provide programming or a programming backup;
4. Have a dedicated operating staff;
5. Select the softwar, then the hardware;
6. Realize and temporarily accept software limitations, design the questionnaire and analysis around it;
7. Acquire software/hardware in the host country language; and
8. As much as possible, install a turn-key operation, this will not prohibit custom modification, but should permit getting an analysis out quickly.

Hardware employed:

Dakar, Senegal	SODEVA	TRS-80 Model I
Ziguinchor, Senegal	SOMIVAC	2 TRS-80 Model III
Bamako, Mali	IER	TRS-80 Model I
Ouagadougou, Upper Volta	SAFGRAD/FSU	3 TRS-80 Model I TRS-80 Pocket Computer
	ICRISAT	TRS-80 Model III
Samarinda, Kalimantari Timur Bappeda Indonesia		TRS-80 Model II

I. **"The Use of Microcomputers in Farm Management Surveys,"** by John J. Bennett and Derek Poate.*

Background

The Agricultural Projects Monitoring, Evaluation, and Planning Unit (APMEPU) is a specialist unit of the Federal Government created in 1975 to monitor and evaluate a number of Agricultural Development Projects (ADPs) throughout Nigeria. The evaluation program is based on a set of statistical surveys carried out on a sample of smallholder farmers at each of the ADPs.

Initially, the unit dealt with three projects, all in northern Nigeria. However, the program has since expanded to nearly ten projects, three of which involve whole states of the Federation, and which consist of three or four zones each as large as the original three projects. In the 1982/83 cropping season, surveys will be conducted in 15 zones or projects.

Clearly, such a program generates a considerable volume of data. This was especially true of the early years when detailed cost-route surveys were undertaken annually on large samples of households. Data processing has therefore always been critical to the unit's activities and for a number of years was the major constraint to the unit's successful performance.

The original plan of the data processing system was for survey documents to be completed at the projects by enumerators who conducted interviews with farmers. Forms were then checked and sometimes coded for response at the project headquarters prior to being forwarded to APMEPU, where the data were transferred to punched cards in preparation for computer processing.

The computer facilities in use consisted of a CDC Cyber 72 mainframe located at Ahmadu Bello University, Zaria. Although adequate in terms of processing capacity, a number of problems were encountered with the installation. Power failures, voltage surges, a lack of standby facilities, and poor maintenance were commonplace. In addition, a software bottleneck developed, arising from the size and complexity of the data sets and the difficulty of operating remotely from APMEPU, which is some 80 km from Zaria.

The net result was that no substantive analysis was conducted during the life of the first three projects. The data sets were eventually processed outside Nigeria and a lack of confidence in the evaluation system developed.

In response to this, a number of studies were undertaken to determine the data processing needs of the unit. The findings led to the decision to purchase a Data General MV8000 Eclipse minicomputer with a 1 megabyte central processor to be operated with two 200 megabyte disks and three tape drives. At the same time, developments in microcomputer technology gave rise to the idea that survey data could be recorded electronically at remote project sites for transmission to the minicomputer on floppy disks.

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*Senior Programmer and Principal Evaluation Officer, respectively, Agricultural Projects Monitoring, Evaluation, and Planning Unit (APMEPU), PMB 2178, Kaduna, Nigeria. (Paper presented by Derek Poate and Peter Olorunfemi.)

The decision to experiment with this approach was made early in 1980, although the first machine was not received in Kaduna until August 1981. Rapid progress has since been made and already 5 projects have microcomputer installations, operating 17 machines with a further 11 on order. The microcomputer has directly replaced punched cards as a data entry technique, but has brought additional benefits of timeliness in validation and reporting at the project site, together with the convenience and ease of transport of floppy disks compared with survey forms. The transfer of data to the minicomputer and subsequent analysis awaits the installation of the Eclipse in the second half of 1982.

Selection of Computer Hardware

The original selection of the APPLE II microcomputer took place early in 1980, and was the result of an informal review of available equipment and consultation with microcomputer users in the World Bank. Key factors in the decision were the flexibility and ease of operation of the Apple, its robust power supply unit, and the wide range of software available. In addition, the Unit's Senior Programmer had extensive experience with the Apple II, which was to prove invaluable in developing the survey programs. A recent survey of microcomputer equipment by the University of Jos, covering some 50 makes of microcomputers, has also come to the conclusion that the APPLE II is a computer which is flexible enough to serve the needs of a wide range of potential users.

The flexibility of the computer with its associated peripheral hardware has enabled the same units to be used across various application areas including data collection, word processing, and simple data analysis; while the modular nature of the equipment allows for easy maintenance and optimum use of peripherals. The following list shows the current hardware recommendation for a project unit. It is all standard equipment, with no special modifications for the extremes of climate and power supply frequently encountered at project sites.

48k byte Apple II Plus
Diskette drive with controller
Diskette drive without controller
EMC 12-inch Green Monitor
Qume Sprint 5 character printer with tractor drive
C.C.S. Serial printer interface card
Videx Video Enhancer
CP/M Microsoft softcard
Microsoft Ramcard
Apple juice battery backup system
Numeric key-pad
200 diskettes
3 dozen Qume printer ribbons (1 dozen carbon and 2 dozen fabric)
6 Qume daisy wheels

Two items require comment. First, the selection of 5 1/4-inch disks as standard. Experience with the use of 8-inch drives for a word processing application revealed the drive units to be particularly sensitive to power supply problems which did not affect the smaller units. Second, the choice of a high-quality character printer. We have found that the printer is commonly the most sensitive unit under adverse power conditions. Our original selection was the IDS Paper Tiger 560 dot matrix printer, but innumerable problems were encountered and the Qume has proved more reliable. We are still seeking a robust dot matrix printer.

One enhancement made to the Apple microcomputer is to enable the use of CP/M-based programs and therefore considerably expand the availability of software. An example of this is the selected word processing package "Wordstar." This package, which is widely acknowledged as a leader in this field, is recommended for all of the ADPs using microcomputer equipment. The use of this package further justifies the high cost of the Qume Sprint 5 character printer which is capable of producing a high-quality output.

General Overview of Systems Design and Programming Techniques

This section is included here to provide background information to the techniques employed in the design and programming of survey packages. Appendix D to this paper details a number of "Do's and Don'ts" that should be followed when using the microcomputers. Although designed specifically for use at APMEPU, they are reproduced here as a guide to the style of approach we have found necessary to achieve an effective system of operation.

In designing the various survey systems, considerable emphasis has been placed on the interaction between the programs and the user. All programs are designed to "communicate" with the user, so that a typical computer session involves the program issuing instructions to the user and accepting information back from the user. Specimen screen prints for the Agronomic Analysis data entry program are included in Appendix C and discussed in the following section.*

As the data are keyed, each code is "translated" into a meaningful description, thus allowing the user to gain an understanding of the data entered. A complete set of checks are carried out as each field is entered, thus ensuring that the data are at least free from the majority of possible errors. It is believed in APMEPU that it is better to spend time entering and correcting the data at the point of source rather than later when the data have been transferred onto the minicomputer system and the original data forms are still stored at the ADP's headquarters. Similarly, in designing the systems, the actual data analysis time is not considered as an overly important factor and certainly not a factor that should affect the ability to access and update information easily and quickly. In other words, emphasis is placed on ease of use rather than disk space or processing time.

Programs are supplied in BASIC on 5 1/4-inch diskettes. It was decided in the early stages that BASIC should constitute the main programming language for software on the microcomputing systems, even though all of the programming personnel at APMEPU have Fortran experience. The reasons for this choice may be summarized as follow:

1. The considerable flexibility of BASIC's data entry screen handling software (VTAB, HTAB, INVERSE, NORMAL, etc.) has no comparison in either Fortran or Pascal.
2. BASIC allowed for rapid program development, especially when several available software development "tools" were purchased.
3. Debugging is fast and easy in BASIC.
4. Character handling using the BASIC string manipulation functions (MID$, LEFT$, RIGHT$, and string concatenation "+") is excellent.
5. The advantage of Fortran for faster execution speed and code security could be easily matched by using a standard BASIC compiler.

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*Appendices A, B, and C of the original paper are not reproduced here.

Considerable use is made of string manipulation functions since information relating to record keys is held in string format. The main reason for this is the significant reduction of diskette space allocated for these plus the greater programming ease when scanning long lists of codes to determine, for example, if a specific village, household, period, and record type has been entered previously.

A further use of string manipulation occurs when formatting the report printout. The version of BASIC used does not allow a PRINT USING command and therefore all output is converted to a character string for easier manipulation prior to printing.

The Agronomic Survey

The agronomic survey, which is conducted annually, forms a fundamental part of the data collection and analysis work undertaken by the ADPs. The survey is designed to record information about crop areas, production, agronomic practices, and use of purchased inputs on a farmer's plot of land. It is normally conducted on a large sample of 250 or more households, each of which cultivate between 5 and 7 plots on average. The survey form, which has developed through several stages (culminating in the version as included in Appendix A to this paper), enables coding to be included on the same form as data collection.

It was stated in the introductory section of this paper that a significant backlog of data awaited both data preparation and analysis at the time of introduction of microcomputers at APMEPU. Starting data entry on the microcomputer-based systems in October 1981, the survey data for seven projects (Ayangba, Bida, Lafia, Ilorin, Gombe, Bauchi, and Funtua) were entered and available for analysis before February 1982. This work, plus the survey data entry for the 1981/82 season, which has been conducted at the various ADP headquarters, has not only considerably relieved the pressure on the APMEPU computing department but also enabled the data to be reported much earlier and easier than in previous years.

Although the first microcomputer system was not received at APMEPU until August 1981, the first agronomic data set (Gombe 1980/81) was keyed during October 1981. The total design, programming, and implementation period required for the system was approximately nine man-months. A significant contribution was also provided by the various evaluation departments, especially those of Ayangba, Bida, and Ilorin, which not only assisted in specifying the basic system but also contributed a wide range of ideas for improvement and modification based on actual "field" use.

One of the original requirements for the system was that it could be used by staff of various levels and abilities, without the necessity for programmer supervision. The success of this can be seen from the fact that no project entering data for the 1981/82 season has required any direct supervision, although problems linked either to omissions in the system documentation or to diskette corruption have been encountered that have required attention. Our approach has been designed for inexperienced users by the combination of an interactive easy-to-use program design, plus documentation, plus training in the use of the programs. However, it is still desirable for whoever is in charge of the computer operation to have a broader knowledge of both hardware and software to cope with unexpected problems. This is beyond the scope of our own job-related training programs.

A training period of two weeks is recommended for staff who are first-time users. This period allows for enough data to be entered to ensure that sufficient problems are encountered. Staff undergoing training are also instructed on the fundamentals of preventive maintenance.

The system design is based on that of the survey with data being referenced by village, household, field, and plot numbers. Higher-level key information such as project code, survey year, and village stratum code is stored along with other data from the survey but this information does not form part of the main record index.

Using the file access facilities available on the microcomputer system (sequential and random), the storage location of each questionnaire is recorded as the questionnaire is entered. This requires that an index file, referred to throughout the user documentation as a household file, is "maintained" allowing rapid identification of any questionnaire. On obtaining the record number of the required questionnaire, the system transforms this value into a data diskette number and absolute record number on the given data diskette. The data entry clerk is instructed to include the computer-allocated record number on the survey form for any future use such as data correction.

A typical survey consists of approximately 1,200 field/plot records, each of which is allocated 3 sectors of disk space on the data file. This enables the data from 150 questionnaires to be stored on each data diskette.

The size of the index file imposes limits to the number of questionnaires that can be conveniently handled by the system, since it cannot occupy more than one diskette. The index file currently allows a maximum of 400 households, each with a maximum of 31 field/plot records. Some flexibility exists within the system to modify these figures, providing that their multiple does not exceed 400x31.

Data entry is normally undertaken by one member of staff for each survey, although it is possible to divide a large survey between several operators. This should be carried out with care, since it is difficult to analyze data contained and indexed on several sets of data files. Based on the average number of survey questionnaires, data entry and initial reporting require approximately three man-weeks. To accelerate this process, it is recommended that the initial reports for each village are produced as the data entry for that village is completed.

As data entry takes place, an initial validation is performed. Nominal coded values are compared with permitted ranges, logic within the form is monitored (e.g., date of weeding must be after date of planting), and abnormally high values for plot area and crop yield are spotted. The data entry clerk responds by flagging the survey form in error for subsequent edit correction.

On completion of data entry, a wide range of reports can be produced by the user. Two reports, referred to as the "Field/Plot Report" and the "Household Report" which present the major items of the keyed data in a concise format, are generally produced on completion of data input. These reports are designed with two aims in mind. First, to enable an "eyeball" validation of the data to spot irregular entries that escape checks during data entry. Second, they enable swift production of simple reports which can be available within one month of the end-of-data collection. This element of timeliness is particularly important for the needs of project management.

A third style of report presents a full analysis table. The user makes a choice from a number of variable options for cells, rows, and columns, and may impose some selection criteria based both on variables in use and variables not used in the table. An example of each of these reports is included in Appendix B to this paper. The effectiveness of the microcomputer-based approach is indicated from the fact that five projects (Ayangba, Bida, Gombe, Ilorin, and Lafia) have completed their data entry and first-level analysis for the 1981/82 survey.

The Household Survey

The agronomic survey was chosen to be handled first by the microcomputer because of the relatively simple structure of one form per study unit per year. In contrast, the household survey, code-named "Clearline," has a complex structure. The survey records information about household income, expenditures, consumption, and labor utilization on farm and non-farm work. The study households are visited once per week with two interviews being recorded on one form. Current practice is for the survey to be carried out on the same sample of households as the agronomic survey. The survey questionnaire still reflects the use of a card-based data preparation system, but this has been readily adopted by the microcomputer data entry program. Only minor modifications are required to remove all references related to the use of punched cards for data entry.

The Clearline survey is conducted over a period of one year with information being gathered weekly, thus giving a total of 26 survey forms per household for the survey. Based on a typical sample size of 225 (15 villages x 15 households per village), the total number of survey forms handled is therefore 5,850.

The approach used for the previous versions of Clearline as regards data preparation required that the survey be completed before card punching could take place. In addition, since the survey year for each project ran, approximately, over the same time period (May to April), the data preparation department had to meet the almost impossible demand of key punching and verifying the data for several projects competing for the very limited resources available at that time.

It can be seen from the above that even with the introduction of the microcomputer-based system with data being prepared on a regular basis by project evaluation personnel, a survey of this size (90,000 card images) still represents a major use of project personnel and equipment resources.

Systems design of the Clearline survey closely follows that of the questionnaire with data being stored and retrieved by village, household, and interview period. For each village, household, and interview period, a maximum of 50 records may be entered. A record represents one line of data from the questionnaire. Data are stored in "card-image" format with each record being identified by its data element code and "card" number. By assigning a record length of 80 bytes, a data diskette is capable of holding 1,400 records. Based on observations of the Bida ADP 1980/81 Clearline survey, four diskettes are required to store and index the data for the set of questionnaires representing two weekly interviews. The complete data set will therefore approximately occupy a total of 100 diskettes. The large size of this data set necessitates that reports are produced on a period-by-period basis.

Other Surveys

Programs have been written to handle a number of other surveys, but in terms of size, complexity, and design difficulties, they all fall within the range of solutions adopted for the agronomic and household surveys. They are not discussed further here.

The Use of Purchased Software

It was recognized at the outset that no micro-based computer system would enable its user to produce the exceptionally wide variety of reports possible from the information available. The purpose, therefore, of any microcomputer-based system designed by APMEPU, is that it be capable of entering, validating, and storing information which would then be available for subsequent analysis. In the design of the Agronomic Analysis system, two reports were included which have given the system users the capability of hand-extracting in an easy and accurate manner information for the various required tables. The actual preparation of these tables is done using Visicalc.

Visicalc and its derivatives allow the user to enter and manipulate data in a tabular format. The format itself makes the produced tables suitable for direct inclusion in reports, thus avoiding the tedious and error-prone job of typing such information. The transfer of data from Visicalc to Visiplot enables the user to represent data graphically. This is of particular use for the market price surveys that are conducted over a long period of time. It is possible using graphical techniques to examine market trends, seasonal price variations, and between market comparisons rapidly and easily.

A considerable portion of the total microcomputer cost is due to the inclusion of the CP/M-based word processing package Wordstar. The justification behind this expense rests on the fact that the work of the evaluation units in Nigeria involves a considerable amount of report writing for both internal and external use and the use of Wordstar considerably simplifies the preparation of such reports. The original selection of Wordstar as the word processing package for use by APMEPU and the various ADPs was made by the Federal Agricultural Co-ordinating Unit (FACU). This organization has four computers that are dedicated almost exclusively to word processing.

Training

With the number of microcomputers installed within the agricultural sector in Nigeria rising, the requirement for well-trained staff becomes more important. At the present time, the APMEPU computing department conducts training courses in a wide range of software packages with particular emphasis on Visicalc and Wordstar. Training for in-house developed systems, including all of the surveys discussed in this paper, is generally conducted at the site office of the project using the survey.

A typical training session for the Agronomic Analysis program lasts about two weeks during which time personnel are instructed on how to use the microcomputer system, enter data, and produce the required reports. These sessions are usually conducted by a member of APMEPU's data preparation department who has extensive experience in using the particular system.

All specialized training is undertaken by the two members of the computing department responsible for the introduction and application of microcomputer systems. To date, some 25 people have been trained in one or more of the following:

1. Visicalc - 3 days
2. Visiplot/Apple plot - 1 day
3. Wordstar - 5 days

and a further twenty (20) people have been trained to use the survey packages developed by APMEPU.

It has been observed over the last nine months that the use of microcomputers has been readily accepted by the personnel involved. Training, of any form, is seen as a means of improving job status and of achieving promotion. Therefore, staff who previously have not been considered industrious suddenly change their work habits, at least during the training periods. The issuing of certificates of attendance for training courses has generally not been adopted, although certain personnel may be given a certificate if they demonstrate a complete understanding of the work involved and where the issue of a certificate may enable them to advance in their job.

With the number of microcomputer-based systems in Nigeria increasing rapidly, training will assume even greater importance and it is hoped that Video-based training courses for the standard applications packages will be available before the end of the year.

The Supply of Microcomputer Equipment in Nigeria

Local purchases are handled by an authorized Apple dealer which is based in Lagos with poor communications to most of the projects. This dealer has not, as yet, been able to meet the steadily increasing demand for computer systems; therefore supplies are somewhat erratic and are very highly priced. All equipment supplied to APMEPU by the dealer has been installed by APMEPU personnel. This includes having to modify the equipment to install keyboard enhancers, printer interface cards, and numeric key-pads.

It is hoped that as demand continues to increase, more agents will be appointed and both the supply and cost of the equipment will improve.

Hardware Maintenance

In view of the poor communications in Nigeria, it was decided that APMEPU should assume the responsibility for basic hardware maintenance. In order to maintain the microcomputer, a "dealer's kit" was purchased which includes not only a complete set of replacement boards but also spares for each of the "chips." Other peripheral equipment is maintained by reference to the, usually comprehensive, reference manual or by testing individual boards or components of a peripheral by exchange with a similar unit.

Using the spares which are held at APMEPU, the computing department is able to repair and return most of the equipment back to its user quite quickly. Equipment that cannot be repaired is sent back to the U.K. either as a complete item or, if the fault has been localized, as a specific component. A replacement unit is sent to the user from the additional equipment stocks held.

APPENDIX D*

This Appendix contains a list of Do's and Don'ts that should be applied when using microcomputer-based systems.

Recommendations and Considerations

1.1 Introduction

This section outlines a number of rules and guidelines that should be followed when using microcomputer systems. The recommendations and considerations are divided into the areas of:

a. Documentation
b. Hardware
c. Manual
d. Programming
e. Security
f. Transportation
g. Users

1.2 Documentation Considerations

D.1 All diskettes should carry a label that uniquely identifies the diskette. This label should include the following information:

1. System name
2. Diskette title
3. Diskette number
4. Period number
5. Original/Security indicator
6. Comments, etc.

D.2 Diskettes that are used for several files/programs should have a "CATALOG" listing of the diskette contents attached to the sleeve.

D.3 The diskette identification label should be situated in the top right-hand corner of the diskette.

D.4 The diskette sleeve should carry a label, similar to the diskette label, though additional information may be included.

D.5 A block flow-chart should be included, as part of the documentation, for each program.

D.6 A list of all the PEEKs and POKEs should be included, apart from the documentation, for each program.

D.7 A list of all variables used and their associated line-numbers should be included, as part of the documentation, for each program.

D.8 No program should be handed over to user without a complete set of documentation.

*Appendices A, B, and C of the original paper are not reproduced here.

1.3 Hardware Consideration

H.1 If it is necessary to use the printer in any mode, other than default, detailed instructions should be issued to the operator. Similarly, it is expected that the printer should be returned to default condition at the end of the process.

H.2 When not in use, the computer should be switched off with the mains plugs removed and all diskettes filed away. A suitable dust cover should be used to protect the equipment overnight and at weekends.

H.3 Whenever the microcomputer is opened, for the modification or routine maintenance, it should be turned off at the mains.

H.4 Any modification to the microcomputer system should only be performed with the direct permission of the senior programmer. This does not include modification to any printer "bit-settings" provided that the system is returned to its standard state at the end of the process.

H.5 Both the diskette drive and the line printer "leads" should be trapped between the body and lids of the micro-processor. This safeguards the disk and the printer interface cards against accidental damage.

H.6 When removing any "chips" from either the computer or the interface cards, the correct tool should be used and care should be taken to ensure that the connections are not damaged in any way.

H.7 The computer should not be used without the battery backup provided, unless a "clean" power supply, that is one unlikely to be affected by variations in current (caused by switching on and off such items as air-conditioners, etc.), is available.

1.4 Manual Considerations

M.1 None of the computer manuals should be removed from the computer room. Duplicates are available for short-term loan.

M.2 Any errors that are detected in the reference manuals should be reported to the senior programmer.

1.5 Programming Considerations

P.1 Data statements with their associated dimension statements should begin at statement number 9000.

P.2 The READ statement, associated with a DATA statement, should immediately follow that statement.

P.3 Interger variables should be used wherever possible.

P.4 The variable A$ should be used as a temporary variable only.

P.5 Statement numbers 1000-1099 should be used for display subroutines.

P.6 Statement numbers 1100-1199, 1200-1299, 1300-1399, etc. should be used for displays 1, 2, 3, etc.

P.7 All GOSUBs should carry a REM statement indicating what the subroutines are used for. For example:

50 GOSUB 500: REM SORT THE DATA.

P.8 D$ should only be used as the direct command indicator.

P.9 The first statement in a program should be a REM statement that defines the program name.

P.10 When using standard routines (e.g., sort, format, display, etc.), care should be taken not to use any of the data names used by those routines.

P.11 All programs that are used by data entry personnel should prompt for diskettes, etc. in the accepted manner.

P.12 Wherever the user is expected to key a data field, the maximum size of that field should be highlighted using an INVERSE/NORMAL sequence.

P.13 Complex data entry programs should allow for a "quiet point," where the data file is closed and re-opened, thus ensuring that the minimum data loss may occur in the event of a system failure.

P.14 Any PEEKs and POKEs used in a program should include a REM statement, on the same line, indicating what action is being performed. For example:

50 POKE 34,10: REM SET THE TOP-OF-SCREEN

P.15 Statement numbers 500-599 are reserved for the SORT software, if required.

P.16 Statement numbers 600-649 are reserved for the line formatting software, if required.

P.17 It should always be assumed that Drive 1 is used for the program diskette. Thus, if a program is run that requires one data-file, Drive 2 should be used. If further diskettes are required, Drive 1 may then be prompted. At the end of the run, the program diskette should be prompted for Drive 1.

P.18 All programs should be initiated from and returned to a system MENU.

P.19 When the data input session is to be terminated from the menu, the screen should be cleared.

P.20 The standard COPY utility should be included as part of each system and the necessary documentation should also be included.

P.21 When using the line-printer for reports, a suitable prompt should be issued for the operator to line up the stationary at "head-of-form."

P.22 When undertaking any long process (sorting, establishing a large data file, etc.), the user should be informed of the current status of the run.

P.23 Whenever possible, one of the standard program routines (sort, merge, format, etc.) should be used in preference to a user written one.

1.6 Security Considerations

S.1 A security copy of every diskette should be kept in the APMEPU tape library.

S.2 On no account should a program diskette be duplicated and passed to a person outside the "unit" without the permission of the Head of the Unit.

S.3 Security copies of diskettes should not be removed from the APMEPU tape library without the permission of the Senior Programmer.

S.4 In the event of a diskette failure that necessitates the security diskette being used, a copy of that diskette should be made and labeled as the original.

1.7 Transportation Considerations

T.1 The microcomputer should always be transported in a suitable packing case if either the distance is greater than 10 km or if the journey is expected to be over "rough" roads.

1.8 User Considerations

U.1 If the possibility of a power failure exists when modifying a program, the program should be saved alternatively using:

SAVE program name A
and SAVE program name B.

This should reduce the possibility of program failure.

U.2 Diskettes should always be handled with the appropriate degree of care. They should never be left exposed but should be placed back into the sleeve when not in use.

U.3 Under no circumstances should food or drink be consumed while working at the microcomputer.

U.4 Care should be taken to ensure that the latest version of software is being used.

U.5 The diskette used to "boot" the system should be placed on Drive 1 before the microcomputer is switched on.

U.6 All faults, whether hardware or software, should be entered into the microcomputer diary with a brief description of the fault.

U.7 The computer should always be used in an air-conditioned, "dust-free" environment.

U.8 Specialized software diskettes for Visicalc, Wordstar, Applesoft Toolkit, Apple, and Plot, etc. are available (with the associated reference manual) from the Senior Programmer.

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