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MICROCOMPUTERS IN THE GAMBIAN MIXED FARMING PROJECT

by

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Introduction

The Gambian Mixed Farming and Resource Management Project, funded by the United States Agency for International Development from 1981-1986, required a wide range of computer capabilities to support field team activities in research and administration.

Computer based activities included a wide range of statistical functions used in analyzing research data, data base management in handling range inventory data, word processing, computer graphics for enhancing reports and project accounting and financial management.

Initially the project sought to provide computer services for data analysis from its home base at Colorado State University. Results were unsatisfactory for several reasons discussed in a subsequent section. An evaluation of this experience led to the recommendation that computer processing be shifted to microcomputers in The Gambia so it could better support the field program.

Short-term consultant services were used to design an appropriate hardware and software mix for project needs.(1) After purchasing and testing the equipment, a second consultant brought it to Banjul, set up an operational computer facility and provided initial training to key team members.(3)

The Mixed Farming Project (MFP) computer facility in The Gambia had two objectives. First, it was to serve MFP needs during the remaining life of the project. Second, it was to result in trained Gambian personnel and an equipment complement, both of which could be transferred to the Government of The Gambia (GOTG) at the project's end.

This paper evaluates MFP's experience in operating a computer facility within the context of a development project. The capacity of microcomputers to serve project needs is examined first, followed by an evaluation of the computer training program and, finally, the institutional transfer of personnel and equipment. The tripartite division of MFP computer activities into project utilization, training and institutional transfer is rather artificial and ignores inter-relationships between the three endeavors. These inter-relationships are more fully examined when some conclusions and recommendations for future development projects are made.

Statistics used in this paper are derived from questionnaires which were distributed as personnel neared the end of their tours. Responses to questionnaires came from 10 senior staff (Gambian and Expatriate), five secretarial staff and three computer room personnel. The questionnaire was divided into two sections, research and training. Not all respondents participated in all types of computer activities. Eight respondents completed the research questionnaire, while 12 responded to the training questionnaire. Some respondents did not answer all questions.

Description of the Facility

Three microcomputers were stationed at project headquarters. Two IBM machines with 512KB of memory each were available, one a PC and the other a PC-XT. A COMPAQ micro was also available with 256KB of memory. The portable COMPAQ proved useful as many computer demonstrations were given at various locations throughout The Gambia. Two printers accompanied the micros, one a dot-matrix (Epson FX-80) printer and the other a Qume Sprint 9/45 letter-quality printer. The Epsom printer was used as a portable item when necessary.

Several software packages were acquired; among them STATPAC, MSTAT, LINDO, LOTUS 1-2-3, FinalWord and PeachText. The BASIC programming language was also used extensively. Evaluation of software adequacy appears below.

A single room, 10' x 12', was identified as the computer facility. Windows were sealed with plastic sheeting and an air conditioner installed. A 2.5 KV gasoline driven generator was available as a backup power supply.

Meeting Project Needs

Utilization of the Facility

At one time or another all project staff, Gambian and expatriate, used the computer facility. When additional computer time was available, access was granted to various agencies of the GOTG and other foreign donor agencies. Towards project termination, utilization of the facility was over 100% as the competing demands of data analysis and word processing forced much work to

be done off-hours. This caused a number of time allocation problems which are discussed below.

Of project staff answering the questionnaire, 87% used the machines for data analysis, 75% for word processing and 12% for accounting. Table 1 shows respondent perceptions of the extent of their utilization of the computer facility in various types of work.

Table 1. Degree of Computer Utilization for Research by MFP Senior Staff

	Minimal	Moderate	Extensive
Data Analysis	44%	28%	28%
Word Processing	17%	83%	0%
Other (2)	0%	50%	50%

(2) Accounting and analysis using MFP developed software.

While Table 1 is useful in gauging staff perceptions of computer utilization, it gives no indication of the magnitude of conflicting demands for computer time which plagued the project during its final year. While few staff members thought they used the computers extensively, nearly all of the senior staff complained about lack of access to the over-taxed facility with its three machines. Particularly acute was the conflict between word processing and data analysis, both priority areas. Meetings with staff to map out priority areas and allocate computer time were held, but schedules were often over-ridden by rush, high-priority jobs. Scheduling and enforcement, or lack thereof, was a major problem cited by many staff members.

During most of the project life, data entry and analysis occupied the majority of time allocated. Word processing became

proportionally more significant during the last three months as data analysis came to a close and report writing increased. It must be remembered that microcomputers were only available for the last 2 1/2 years of the project. Table 2 displays the types of analyses performed by MFP senior staff. The types of analyses done on MFP computers were determined by two factors; one, the adequacy of the software and two, the level of expertise and degree of understanding by computer personnel.

Table 2. Types of Statistical Analyses Utilized by MFP Staff (Percent of staff by type of analysis)

Descriptive Statistics	75%
Correlation, Simple Regression	63%
Multiple Regression	37%
ANOVA	50%
Data Base Analyses	37%
Other	12%

Adequacy of Software

The ability of the software to meet project analytical needs varied with the type of analysis desired. Where "canned" software packages were inadequate, attempts were made to design BASIC programs to provide needed analyses. While 100% of the respondents were completely satisfied with MFP word processing capability, only 58% were completely satisfied with the ability to analyze research data. According to 14% of the research staff, the software was adequate to handle most of their data needs while 28% said that the available software was not at all adequate.

Project agronomists were among the most disappointed of research staff, even after the acquisition of the specialized agronomic program MSTAT. It was stated that the ANOVA components of the available statistical packages were not sophisticated enough for the field experiments conducted. In part this reflects the fact that researchers did not familiarize themselves with software capabilities before designing their experiments. MFP emphasized agronomic trials in two of its three core areas of research. It is suggested that any project with a similar emphasis should be equipped with the most powerful software available for the analysis of agronomic trials. This action, together with the recommendation below of close coordination and consultation between research and computer staff, should eliminate problems of designing experiments without having the analytical capability at hand.

Project agronomists were not the only research staff whose desired analyses could not be fully accommodated with existing software packages. MFP efforts in the fields of range inventory and farm management required specialized output In these instances, computer personnel were able to write BASIC programs which satisfied the demands of the principal researchers. This experience, however, emphasizes the need for programming skills to handle unusual computational requirements.

Major programming efforts were mounted in analysis of range inventory and farm management data. Range inventory analyses required data base management capabilities which were not available at the time. As of this writing (9/86) there are several excellent programs available for these functions.

The attempt to utilize MFP microcomputing capability for the analysis of farm management data resulted in development of the Gambian Agricultural Data System (GADS).(4) GADS is a complete farm management data collection and analysis system in

which all field coded data can be entered, verified, corrected and analyzed using an on-site microcomputing facility. GADS, specifically designed for Gambia but adaptable to other West African farming systems, has been continued by the Ministry of Agriculture under their Gambian Agricultural Research and Diversification (GARD) project. The inherent flexibility of this field designed and tested system makes it readily adaptable to a wide variety of research needs. Because the programming of GADS is relatively simple and straight forward, a programmer of relatively modest experience is capable of modifying the programs to suit individual needs.

While GADS was being developed, computer staff realized that it was relatively simple to write "user-friendly" data entry programs requiring little expertise to operate. These programs included "error traps" designed to catch invalid data entries, thus cutting down on the number of corrections necessary to validate the resulting data set. Data could be stored in a format compatible with the type of analysis for which the data were intended. Consequently, when data were presented to computer personnel for entry, the set was evaluated in terms of quantity, format, content and intended analysis. A decision was then made whether to utilize existing software or to develop a program to handle the data entry requirements of that particular job. BASIC programming capability is clearly needed at present to augment commercial software.

Skills

Only 25% of the staff said that computer personnel were always able to understand their research needs, 37% said they encountered no unusual problems, while the remainder indicated that there were some misunderstandings that required discussion before personnel were able to understand their requirements. On

the output side, 63% of project staff said that the computer personnel adequately met all of their research needs while 37% said that only some of their needs were met. Once again, the factors behind the failure to meet some research needs lay with the degree of understanding on the part of both computer and research personnel and on the sophistication of the available software.

The computer staff consisted of a Gambian supervisor and a Peace Corps Volunteer counterpart, along with three data entry personnel. All Gambian staff had secondary school diplomas, while the PCV had an M.S. degree in agricultural economics. The host country nationals on the computer staff possessed few of the mathematical/statistical skills necessary to coordinate the level of analysis demanded by senior staff. At the same time, few of the expatriate staff possessed the computer skills necessary to operate the software. While the addition of the Peace Corps Volunteer certainly helped narrow the skills gap between researchers and computer personnel, a gulf still remained. The following are a number of recommendations which the authors feel would eliminate the analytical gap between computer personnel and research staff:

1. Placement and/or training of an Host Country National with statistical/biometrical and computing skills on the computer staff.

2. Train research personnel in relevant software packages. The training need not be designed to make them experts, but instead acquaint them with the capabilities, limitations and data requirements of the available soft ware.

3. Closer coordination and consultation between research staff and computer personnel at all stages of a research effort including, but not limited to,

a. identification of a clearly defined goal and the data necessary to achieve that goal,

b. design of a data collection instrument satisfactory to both researchers and computer personnel,

c. monitoring of data collection,

d. scheduling of data entry,

e. analysis.

Another skill which proved useful is some degree of programming expertise to augment commercial software. Given the often unique data requirements of a development effort, the capability to design customized analytical software can be important. Because data entry operators may not have the training to operate the data entry portions of some software, and given the need for constant validation of entered data, user designed data entry programs are flexible enough to meet the constraints of a given situation. It should be noted that the level of programming expertise needed is not great. Both of MFP's principal programmers had only six credit hours of computer programming. What is needed is knowledge of the fundamentals of programming and one or two programming references for the machines being used. It is also fair to note that as better software emerges, this need will subside.

If the above recommendations are instituted, an on-site computing facility should be capable of handling all necessary analysis, with the possible exception of those research efforts requiring massive data sets. With close consultation between research and computer staff, the common pitfall of conducting an

experiment demanding analytical capability far beyond that of the available software will be avoided.

Advantages of On-Site Computing

Some of the advantages of an on-site computing facility are obvious while others are not so obvious. The most evident advantage was the role of computers in the production of project reports. With the acquisition of a letter quality printer, technical reports were sent to Colorado State University in "camera ready" condition, i.e., the report could be sent directly to reproduction with little or no additional editing or preparation. If adequate reproduction facilities had been available in The Gambia, reports could have been issued there. Should it be necessary to reproduce reports out of country, it is easier to send disks than printed reports.

The computers gave researchers greater flexibility in designing their research projects and in receiving the results. The GADS programs developed for project microcomputers were modeled after the FAO Farm Management Data Collection and Analysis System (2) which was used earlier in the project. When using FMDCAS, data were coded onto code sheets in the field. The information was then brought to project headquarters where all data were transferred to 80-column code sheets before being sent to CSU for key-punching. After key- punching, data validation and analysis using the CSU mainframe computer, final printouts were returned to The Gambia. The total turn-around time using this procedure approached 18 months following completion of data collection. Using the GADS programs, crop budgets were completed 6-8 weeks after harvest while livestock budgets required less than 4 weeks after completion of data collection. Whole farm budgets required an additional week. When one recognizes the degree of control that the researcher has over the complete data

collection, verification and analysis procedure, the value of on-site analytical capability becomes evident. To quantify this statement, of all parcel/fields for which data were collected, only about 40% were "acceptable" on the first run while the balance required additional followup and data editing. By simply checking with field enumerators, original data sheets and the data file on disk, the acceptable rate was increased to 80%. The on-site computing facility allowed complete control of the research effort and swift turnaround time for analysis.

Lastly, the availability of an on-site facility allows researchers to undertake research efforts which would have been difficult or otherwise impractical without the machines. A prime example of this was the study of girth:weight relationships in N'Dama cattle (5). The study involved collection of data from nearly 3000 head of cattle. Calculation of common statistical measures and subsequent regression analysis would have been severely hampered, if not impossible, had no computing capability been available. The only alternative would have been to send the data set to CSU for processing. Because this type of analysis demands intensive management by the researcher as the complex relationships in a given equation are studied for significance, having "instant feedback" greatly facilitates the process. The logistical problems of directing an analytical effort from a distance of 5000 miles would have caused the principal researcher to drop the effort.

While most research endeavors by MFP staff would have continued with or without on-site computing capability, the use of "conventional" methods of analysis would have resulted in slower, less thorough output. However, given the analytical and word processing capabilities of microcomputers and the accompanying control over data sets and swift turn-around time, the benefits of on-site computing capability are clear.

Disadvantages of On-Site Facility

While the use of microcomputers in a developing country resulted in some inefficiencies in terms of data and documents lost due to power outages and disk errors, most of the disadvantages of operating a facility are administrative in nature.

Obtaining computer supplies such as ribbons and paper sometimes proved difficult. Initially, all supplies were brought from the U.S. Dakar, Senegal, like most major cities in Africa, was, by 1986, beginning to have available supplies for computers and printers as well as some repair capability. With the proximity of Dakar to The Gambia, it eventually became a source for most supplies. U.S. sized paper remained a problem but it should be noted that nearly all word processing programs and/or printers can be reset to accommodate page sizes other than 8 1/2 x 11 inches.

The other major disadvantage of the on-site computer facility was in the allocation of computer time between word processing and analysis. The conflict demanded administrative effort in allocating time and ironing out differences between competing parties.

Training Programs

Five formal training programs were offered by MFP after the facility became operational. These courses included BASIC (12 weeks, 7 students) and LOTUS 1-2-3 (8 weeks, 8 students) for computer operators and senior staff; two word processing courses were offered to secretarial staff (3 weeks and 3 students each); STATPAC was offered to computer operators (1 week, 3 students).

Additionally, informal training in MSTAT was provided to the two project agronomists and two computer room personnel.

A total of 20 individuals participated in at least one of the training programs , with a few participating in two or three courses. Two major goals were stated at the outset of the training program. First, the training effort was to develop a cadre of trained personnel which could be turned over to GOTG upon project completion. This team would form the core of computing expertise within the Ministry of Agriculture. Second, it was desired to introduce Gambian senior staff to microcomputing - what computers can and cannot do - and to encourage incorporation of computing into their research plans.

Table 3 shows the breakdown of course participants by type of staff. Of these participants, 80% had no prior computing experience.

Table 3. Participants by Type of Staff
Percent of Participants

	No.	Row Pct.
Gambian Senior Staff	7	35%
Expatriate Senior Staff	2	10%
Secretarial Staff	5	25%
Computer Personnel	6	30%
Of total		
Gambian	18	90%
Expatriate	2	10%

BASIC and LOTUS courses were structured along the lines of a university course - two 75 minute lectures and an assigned homework each week. Computer time was allocated for completion

of assignments. Due to the smaller size of the word processing and STATPAC courses, a more informal approach was adopted. Secretarial staff were encouraged to bring work to class and all skills were demonstrated on the machines using a "real" document. Each STATPAC participant was given an actual data set for which they were responsible for data entry, correction, analysis and any additional followup required by the principal researcher. These classes were also conducted at the computer.

Upon completion of each course, each participant was subjectively judged by the instructor on the student's demonstrated ability to utilize the skills covered in the course. Table 4 shows the percent of course participants with the degree of skills acquisition.

Table 4. Demonstrated Skill Levels
Percent of Course Participants

	No.	Poor	Fair	Good	Excellent
BASIC	7	14%	14%	57%	14%
LOTUS	8	12%	25%	25%	38%
Word Processing	6	-	17%	33%	50%
STATPAC	3	-	-	67%	33%

Upon examination of Table 4, one will notice the greater degree of demonstrated skill in the word processing and statistical courses as compared to the other courses. It is believed that this is due to the design of those courses. In both the word processing and statistical courses, students were taught skills at the computer using real work. Participants tended to be more highly motivated as they were able to combine work with training. The BASIC and LOTUS courses, however, were primarily conducted in a classroom setting. Homework assignments were

designed around MFP data and activities, but the data had either already been analyzed or was fabricated for use in homework assignments. It is felt that if a development project is planning to engage in a training program, the program should be designed and timed to permit a researcher to complete both analysis and training simultaneously. This would have the dual effect of letting the researcher know the capabilities and limitations of the software being covered and give him/her a better idea on how to incorporate computing into research efforts.

When participants were asked to rate their own skills acquisition, all but one of the BASIC participants indicated that they would have trouble even with a manual available. A majority of students participating in the remaining courses, however, felt that if a manual were available they would have little difficulty in exercising the skills acquired.

While all students in the word processing and statistical courses were able to complete the training courses, 50% of the LOTUS participants and 43% of the BASIC participants withdrew before completion of the program. Of persons who withdrew from the courses, 71% were senior staff members.

Senior staff members unanimously explained that current research and other job requirements demanded too much of their time. Some thought the courses poorly timed with regard to job requirements, and most indicated that courses were too "spread out" over time. An almost universally suggested solution was to offer intensive courses of perhaps two to three weeks, during which the researcher could devote nearly 100% of his/her time to learning the capabilities and limitations of the software covered. The goal of these programs would not be to make the researcher a master of software skills, but instead give the researcher a solid base of knowledge regarding software capabil-

ity and to encourage and aid the researcher in incorporation of computing into research efforts.

While most senior staff were forced to withdraw from training programs, all indicated that the time spent in the classroom and on the machines was worthwhile. The exposure to computers and increased understanding of computer applications and operations was seen to be valuable.

Technical Problems and Their Resolution

Hardware and software were purchased in the United States. One hardly expects to have equipment "dead-on-arrival" especially when buying off-the-shelf standard items from the world's most experienced computer firm. Nevertheless, our orders fell in a time period when due to an exceptional backlog of orders, the supplier had partially suspended their quality control. Both the XT and the PC had to be returned for new parts, one of them after having been shipped out to The Gambia. In the latter case, the warrantee period had expired before repairs were made. Further, the Qume printer arrived with an out-of-round platen which had to be returned from Gambia and replaced.

Resolution: Give all hardware a thorough test before shipping. Turn them on and leave them on for 30 days. Make maximum use of the equipment during the 30 days. Run diagnostic routines. Configure for shipment and use original boxes and packing materials.

Each piece of equipment was taken abroad as accompanied baggage by one of the expatriate staff members. No in transit damage occurred. We did not test commercial air freight or other modes of shipment.

Voltage spikes and troughs as well as complete loss of power were a common phenomenon in The Gambia. Our initial solution to irregular voltage was a large voltage regulator which was destroyed shortly after arrival by an extreme spike in the current. The next alternative tried was to trickle-charge automobile batteries and then run the computers off the batteries using a voltage invertor and a DC to AC convertor. The battery arrangement worked well for supporting the computers but the

printers drained them too rapidly. Due to the cost of frequent battery replacements, the practice was discontinued. At the end of the project, the equipment was running off a standard wall outlet with a surge protector and a simple 220v. to 110v. transformer between the outlet and the equipment. Power outages remained a problem.

Resolution: Train all staff well in the use of back-up copies, backing up work or storing files on a frequent (15-20 minute) basis. Use a word processor that automatically stores tests to memory every few lines.

Dust in the computer room was a perennial problem. The facility was at ground level next to an unpaved and actively used parking lot and motor pool. While the windows were well sealed, dust entered under the door and through the panelled ceiling. In West Africa, it may be impossible to completely insulate against the fine dust that fills the air for much of the dry season. "BAD SECTOR" error messages were occasionally received due to dust on floppy disks. At the end of the project, after 30 months of hard use, one hard disk drive and one floppy disk drive quit functioning altogether. Examination at CSU proved dust to be the cause and the drives had to be replaced.

Resolution: Airtight storage containers for floppy disks, plenty of back-up copies of everything, unfailing use of dust covers when equipment is not in use, be excessive in sealing all air entrances to the room (which necessitates air conditioning in West Africa), budget for replacing disk drives every two years.

In the beginning, the project ordered one IBM PC-XT as the main station and a portable COMPAQ (IBM compatible) for use at

multiple sites. An immediate conflict arose between word processing needs and research time. An IBM PC with 256KB RAM was subsequently obtained for word processing. Shortly thereafter the new PC was upgraded to 512KB RAM and a board installed so that it functioned as though it had a hard drive. This permitted the PC to handle large research loads as well.

During the last year of the project, as all the research was being brought to a close, final reports written and analysis being requested by other branches of government and other projects, the facility was in use up to 10 and 12 hours per day. The operational shortage which forced things into overtime was hardware, not people.

Resolution: Err on the high side in the number of machines needed. An extra computer is a small cost compared to an interrupted work program or the management needed to resolve conflicting demands for a scarce resource.

Throughout the project's effective life, the computer facility remained dependent on U.S. supply lines for connecting cables, floppy disks, computer paper, printer ribbons, daisy wheels, etc. Absence of any one of these items can put a piece of equipment out of commission for an extended period if the nearest supply outlet is overseas. None of these items were available in The Gambia. And while some supplies are now available in Dakar, it still involves a major international trip to get them.

Resolution: Include ample spares in the initial purchase and maintain supplies at an adequately high level. Plan well in advance for supply procedures that the host country can use after the facility is transferred.

Institutional Transfer

When the decision to install a microcomputing facility in The Gambia was made, it was also decided that the computer hardware and personnel would ultimately be turned over to the Program Planning and Monitoring Unit (PPMU) of the Gambian government. The PPMU serves two ministries - Agriculture and Water Resources. The MFP experience in the transfer was fraught with frustrations and obstacles. Several of these problems resulted from the fact that the transfer, in this case, involved a change in both location and agency responsible for assuming management of the facility. While a development project seeking to achieve a similar goal will likely encounter a different set of hurdles unique to the institution with which it is working, it is felt that an enumeration of the problems experienced by MFP will be of some use.

Most of the obstacles stemmed from dealing with the bureaucratic inertia found in all large institutions. When combined with government budget cuts occurring at the time of the transfer, securing civil service positions and budget authority for maintenance of the computer facility proved quite difficult. Initial discussions and planning for the institutional transfer began about 18 months prior to the proposed transfer at the encouragement of MFP expatriate staff. During that time, the following major problems were encountered:

1. Securing capital funds to provide an adequate environment in which to house the hardware at the host institution.

2. Securing recurrent operating funds for supply of computer accessories such as ribbons and paper, as well as covering maintenance costs.

3. Establishment in the civil service of defined jobs and qualifications for the positions of Computer Supervisor and Computer Operator.

4. Commitment on the part of the institution's senior staff to incorporate microcomputing capability into their research programs.

Each of these items will be discussed in turn.

Assuming that the initial hardware will be provided "gratis", the outlay for provision of an adequate environment can be a significant cost. The room should be air-conditioned and dust sealed. Additionally, it should be outfitted with electrical wire of sufficient gauge to handle the heavy load demanded by air conditioners and printers. Voltage regulators and/or transformers should be in place, along with some sort of emergency power supply to deal with the often unreliable public supplies occasionally encountered. PPMU, the agency with which MFP was working, was unable to provide funds from its own budget, but due to its close ties to FAO, support for the transfer was obtained and a site for the hardware was prepared in time for delivery.

The PPMU institutional budget included a line-item for general office supplies, but MFP staff felt that supplies expressly for the computers deserved a separate line item, despite reassurances that the "general" line item would include computer supplies. This problem has been temporarily circumvented because another donor agency has come forward with funding sufficient for two years of supplies.

MFP was notably unsuccessful in their attempts to institutionalize the positions of computer supervisor and computer operators. No civil service graded positions within GOTG have been defined and thus the computer team was employed at PPMU via

indirect methods. Another donor provided one year of funding for employment of a computer supervisor while all computer operators were employed in the position of "Enumerator". The enumerator position pays computer operators the same salary as field data collection personnel and does not provide additional remuneration for the skills possessed by trained operators. In view of the demand by many foreign agencies in The Gambia for trained personnel, and the accompanying willingness of the agencies to pay for the skills, an incentive exists for the supervisor and operators to employ their skills somewhere other than in government service.

Given the climate of uncertainty surrounding the transfer of the facility to PPMU until the last two months of the project, PPMU personnel were understandably reluctant to plan research programs around the uncertain arrival of the machines. By the time the transfer plans had been set, many PPMU staff had already designed and implemented their crop season research programs, plans which often did not include use of the computing capability. Full utilization of the facility will certainly not occur in the first year after transfer.

In summary, the effectiveness of the institutional transfer of computing capability remains in doubt at the time of writing. Budget funds for recurring costs can be guaranteed for only two years while funding for the computer supervisor can be guaranteed for only one year. Operators not compensated for the skills they possess may be enticed to work elsewhere. Lastly, PPMU researchers will not be able to fully utilize the facility during the only year in which it can be guaranteed to be fully operational.

An Integrated Three-Year Plan for Training and Transfer

In view of the MFP experience, the authors propose a three-year plan for the integration of computing capability and

expertise into the research activities of a host institution. This model is designed for a project similar to MFP, i.e., a project primarily involved in research into major topical areas with a secondary objective of the institutionalization of computing capability into an agency of the host government. The plan incorporates all of the recommendations mentioned in the main body of this report. The authors attempt to flesh out a fully integrated training and transfer program which takes into account the interrelationships between the goals of meeting project needs, training of personnel and transfer of equipment and personnel. Four activity areas are mapped - administrative, project utilization of the facility, training and transfer. Also identified are the personnel required to achieve the stated goals. The plan is presented schematically in Figure 1.

During the first six months of the project, much administrative effort will be expended in preparing a proper environment for the hardware, coordinating the arrival of hardware and procurement of software. An expatriate or Host Country National (HCN) with computing skills should be in-country to test the equipment and make sure that hardware and all accompanying software is working properly. Ideally, this person will stay with the project for two to three years as the primary manager of the computer center.

It is not necessary for this person, hereafter known as the principal trainer, to have extensive computer skills on par with a computer scientist. In fact, it is probably better that he/she does not. The individual should be comfortable with microcomputers and familiar with a number of software packages, as well as possessing some programming skills. Since the principal trainer will be in position to liaise between computer staff and research staff, it is desired that the individual have the equivalent of a B.Sc. or an M.Sc. in a field related to one of

the project's major research areas and experience in using microcomputers in actual research analyses.

As soon as the facility has become operational, training programs in accounting and word processing should be conducted. It is the authors' experience that secretarial personnel learn word processing skills quite rapidly. Similarly, project accounts can be maintained on an electronic spreadsheet - another type of program in which skills are rapidly acquired. These training courses, conducted by the principal trainer, should be intensive, informal arrangements with few students. Students will benefit from close personal attention and the project will benefit immediately from the availability of the machines.

Identification of individuals to staff the computer facility should also be a priority during the project's first six to nine months. These individuals may be identified from the short courses discussed above or they may come from host agencies or project staff. Before the first year is out, comprehensive training should be conducted in software appropriate to research being conducted during that year. Training courses should be implemented with clearly defined and articulated skills goals in place. A skills exam should be administered at course completion, with participants successfully demonstrating achievement of the stated skills goals receiving remuneration in the form of a bonus or salary increase. The monetary incentive recognizes that the individual is now more valuable to the project and provides an additional motivating factor for participants. All students should receive a certificate of participation. Upon completion of training, the course graduates will assist in analysis of the project's first year research activities.

Comprehensive training of computing staff should be continued as needed throughout the life of the project. It is likely that one or two individuals will have distinguished themselves by

Figure 1. An Integrated Three-Year Plan for Computer Training and Institutional Transfer

Activity	Year 1	Year 2	Year 3	Subsequent Years
Administrative	Prepare environment Hardware delivery Procure software Scheduling/Allocation ---------->			
	Coordination between research and computer staffs ---------->			
		Transfer activities ---------->		
			HCN facility manager ---------->	
				Complete transfer of management
Project Utilization of Facility	Accounting ---------->			- - - ->
	Word processing ---------->			- - - ->
	Increasing amounts of project data analysis ---------->			- - - ->
		Close coordination between research staff and computer staff ---------->		- - - ->
		Some institutional analysis ---------->		- - - ->
Training Programs	Accounting Word processing			
	Training of computer staff ---------->	(on-going)		
	Research staff training ---------->			
		Training of trainers		
	- - - - - -> (depart)	HCN to advanced training ------- 12-24 months ----------> degree/non-degree	- - - - -> (return)	
				Further training of institution's personnel
Institutional Transfer (Agency Identified)	Identify potential training courses			
	Ident. trainees for computer staff			
		Establish Civil Service computer positions	Budget Civil Service computer positions	
			Project trained staff employed in civil service positions ---------->	
			Establish transfer plan, including timing	
			Site preparation (if necessary)	
			Transfer to new site (if necessary)	
Personnel Requirements	Long-Term Expatriate to coordinate system setup and training programs ---------->		- - - - ->	
			Short-term consultants for staff training and training of trainers	
			HCN with statistical and computer skills	

exhibiting an aptitude and inclination for computer operations. These individuals should be considered the principal trainer's counterparts, and as such they should work closely as a team. Additionally, one (or more) of the individuals will be selected for relevant training at a foreign institution as discussed below.

Second year research activities can be designed with computing capability in mind, but most researchers will not be familiar with the full range of software capability. There should be some consultation between researchers and computer staff (principal trainer), but at this stage of the project, full coordination of research and computing activities is not probable.

Some senior research staff training will also take place at the end of the first year, but will not likely get fully underway until the second year. In-service training of project senior staff is a priority area in year two. Courses should be short, intensive affairs in which the researcher will be able to devote 100% of his/her time to the training. The goal of this training would be to give the researcher an idea of the full range of software capability and to demonstrate the usefulness of computers as a research tool. This training must be timed so that the researcher can combine research analysis with training. For example, training for project agronomists can be scheduled at the time at which collection of all field trial data is complete. Demonstration of a statistical package using the researcher's own data will be more effective because the participant will see an immediate benefit of computer availability. The program should give the researcher an idea of the software's limitations as well as its capabilities. Researchers must be made conversant with the software manual so that they can determine software capabilities relatively independently.

After completion of comprehensive computer staff training and research staff training, all future project research activities should involve close coordination and consultation between the staffs. Research plans should be designed with the limitations of the available software in mind. The design, implementation and analysis of a research activity should be laid out in a clear plan. The goal of the activity and the data necessary to achieve that goal should be clearly stated. Researchers and computer staff should agree on the format in which the data is to be collected with regard to subsequent data entry, verification and analysis procedures. If a research activity which is deemed desirable exceeds the capability of the available software, the method of resolving the problem should be indicated (procure new software, send data to another facility, analyze by hand, etc.).

Getting the research staff and computing staff to work closely is a crucial step in the institutionalization process. As such, project administration plays a vital role in making sure that this coordination takes place. Another administrative activity during the second year is the identification of potential trainees from the staff of the host institution who are not on the project staff.

During the second year, an HCN should be sent to a foreign institution for training. This individual's training will be designed so that upon return he/she will be equipped to liaise between research staff and computer staff. The training should not only include computer applications, but should contain significant exposure to statistical and biometric methods of analysis. A two-year degree should be sufficient to provide the sound base of practical and theoretical skills necessary to serve as the go-between for research staff and computer personnel. It should be noted that a degree program is probably not necessary for the trainee to achieve the skill level from which the project may benefit, but institutional and social realities may deem a

degree program desirable. It is anticipated that this individual will be in charge of the computer facility upon project termination.

By the end of the second year, the project should be self-sufficient in all analytical needs with all research being conducted on project microcomputers. Additionally, some researchers from the host institution who had participated in a training program may desire to have some analysis done on the computers, and this should be scheduled accordingly by the administrator. Work with the host country civil service should have been completed or nearly completed at this point as well. Job titles, qualifications and pay scales for computer supervisors and operators must be in place by project termination.

During the project's third year, the role of the principal trainer will be significantly decreased or eliminated as the computer staff becomes more self-sufficient. Short-term assignments at critical periods during the year may be sufficient. Such consultancies could be planned to provide advice when research plans for the coming year are in development and later when analysis is due to begin. Senior staff training (including staff from the host institution) will be continued, but the training roles should start being assumed by the computer staff itself. A Training of Trainers workshop should be held for computer staff, emphasizing the goals of the research training program and different training techniques.

In year three most training will have been taken over by computer staff. Research staff training will be directed toward staff from the institution to which all hardware and personnel will be transferred. As a result of this training, project administration must expect a number of requests for computer access and schedule computer time accordingly. Administration should also continue work on institutional budgeting and timing

of the transfer, as well as continuing any follow-up in the establishment of civil service positions.

Year three will also see the return of the HCN trained overseas. This person will assume the role of computer supervisor. In addition to coordinating project research plans, he/she will be responsible for training programs involving secretarial staff and research staff from the host institution. The individual will be in position to supervise the physical transfer of the equipment and on-site testing.

It may be desirable to conduct another training of trainers workshop at this time in preparation for the final transfer. During the final year of the project, the computer supervisor and staff should be employed in civil service positions with salaries being paid through the host government.

Summary

Microcomputers offer the opportunity of significantly enhancing the quality and quantity of output from research oriented, technical assistance projects in developing countries. Having a microcomputer facility as part of the project's resources can achieve the following: 1) stimulate the use of more advanced and analytically more powerful research methods, 2) accelerate the research process, particularly those steps occurring after data collection, 3) facilitate report preparation and enhance visual appeal of reports and other project communications, and 4) simplify accounting and reduce the probability of errors. Finally, an on-site computing capability provides for a more intimate relationship between the analyst and the data. The result is that more statistical tests can be run in a shorter time as one searches for relationships. The result should be a better output.

However, developing a microcomputer facility in the Third World is not a simple matter of buying a machine and turning it on. From the perspective of a technical assistance project alone, several issues must be dealt with. First, choices are needed with respect to hardware and software, both quantity and type. Second, the physical plant to house the computers needs attention with respect to power supply, dust control, lighting, and air conditioning, space, layout and security. Third, training will be needed for a number of functions to be handled by computer facility staff: e.g. word processing, data entry, use of analytical software, file management. Fourth, senior scientists and researchers require familiarization with the analytical capabilities so that they can respond, whenever possible, by designing research that is compatible with the software and with staff capabilities. Last, such a facility will require management. This time and responsibility need must be explicitly addressed.

When one adds the additional objective of transferring the facility to the host government, the following additional concerns arise. First, the physical facility must be reestablished in cases where a new location is to be used. Second, there will be additional training needed. Third, creating and funding civil services posts for the computer facility will likely be necessary, as will an assured funding mechanism for supplies, parts, repairs and an occasional software update. In many settings, it will also be necessary to expose senior local staff to the various ways computers can be incorporated into their daily work loads.

Thus, the decision to place microcomputers into a Third World setting is not to be lightly taken. It involves a considerable investment of time, some funds and a great deal of planning. Hopefully, the lessons learned on the Mixed Farming

Project in The Gambia will help others to avoid some of the pitfalls.

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