October 1972

DRAFT PROPOSAL FOR AN AGRICULTURAL SECTOR SIMULATION LIBRARY

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Background and Rationale

The agricultural sector simulation team at Michigan State University has developed and applied the generalized system simulation approach to agricultural sector analysis in Nigeria and Korea [1,2]. Computerized simulation models have been built and tested for the investigation of one general problem area in two subsectors of the agricultural sector--the low productivity of agricultural resources, primarily land and labor, in livestock and crop production. In addition, in building these models functional components have been developed which show promise of being generalizable to a broad range of situations. For example, demographic components individually designed to model specific populations of people, trees and cattle may be generalized so that a single component would model any of those three populations as well as any number of others that may be of interest, e.g., tractors, houses, cars, bacteria, insects.

Experience with these models and components has demonstrated the desirability and feasibility of realizing more of the potential of the generalized system simulation approach by broadening its applicability to cover other problems in other subsectors of the agricultural sector in other countries of the developing (or even developed!) world. These would include--in addition to other contributors to agricultural production such as forestry and fisheries--agricultural processing and marketing and non-economic aspects of the agricultural sector such as health and education.

In the long run, applications of the approach may even be expanded further to other sectors of society.

The remainder of this paper proposes a method and organization for servicing such applications: a library of generalized models and components. The next section discusses the kinds of models and components which will stock such a library and the services that can be offered. Succeeding sections describe the management and organization of the proposed library, including its communication with users. Finally, we outline the activities related to setting up and operationalizing the proposed library which can be undertaken under the remaining period of the current contract, AID/csd-2975.

This paper is a draft proposal, so comments, criticisms and ideas are welcome, indeed solicited, from participants, potential users and other interested parties.

Users serviced by the library will include individuals as well as public and private organizations and will fall into two classes. First, individuals and organizations doing teaching or research can use appropriate models and/or components from the library as teaching aids or research tools, both as a part of regular university courses and curricula and in high-level professional training programs conducted by, for example, AID or FAO. The other class of library users includes public and private organizations serving as consultants or contractors to the governments of developing countries and charged to do policy, program and project analyses. The latter class would include, for example, FAO; IBRD; AID; a private company under contract to a foreign government to do an economic and technical feasibility study for the construction of, for example, fertilizer plants in that country; and Oregon State University (recently under contract

to the government of Venezuela to use simulation techniques to investigate cattle production policies).

A centralized library would have many advantages for all such potential users. First, where models or components are needed for a particular application, a central location would simplify the task of finding out whether appropriate models are available or whether it would be necessary to either build them on an ad hoc basis or do without. In this regard, where there is a central repository, duplications of effort in model building can be avoided or at least reduced. Perhaps the largest advantage would derive from a standardization of models and organization. Specifically, models and components can be assured to be linkable with one another as necessary for a particular application, and they will certainly be programmed in the same style and computer language. In addition, the style, format and content of documentation will be standardized as will communication with and distribution to actual and potential users.

With this introduction, let's turn now to a discussion of the scope of the proposed Agricultural Sector Simulation Library: what it will contain and the services it will (or might) offer.

Scope of the Library

The scope of the Agricultural Sector Simulation Library (ASSL) lies in two dimensions: the kinds of models, components and routines it will inventory; and the activities and services it will perform or offer.

Contents of ASSL

The library will stock three categories of computer programs with associated documentations: generalized function-oriented components,

generalized problem-oriented models, and technical routines to assist in building, testing and validating models and components.

Generalized function-oriented components (hereinafter called components) can be defined and developed which would serve in any number of applications. For example, a production component essentially an input/output routine, could be used for the production of fish, livestock, perennial crops, annual crops, industrial goods, and perhaps even public and private services. A single demographic component could model populations of people, cattle, trees, automobiles, and capital goods such as tractors and factories. An accounting component could be designed which would perform industry, sector and national accounting functions. Other components relevant to agricultural sector economic development include processing, marketing, demand, labor migration and resource allocation.

In keeping with the building block approach [1, Chapter 3], such generalized components can be combined to form any number of larger models for use in the investigation of a wide spectrum of specific problems. For example, to look at the problem of low productivity of agricultural resources, we would build a model using a production component, a resource allocation component, an accounting component and a demand component, all linked together with an overall executive program which would generate policy inputs and displays results. In this way, problem-oriented models (hereinafter called models) can be built to examine a wide range of problems in the agricultural sector (or any other sector, for that matter, if so desired).

Problem areas of concern to agricultural sector development may be distinguished in three fields: economic--including resource allocation,

resource productivity, inflation, income distribution, etc.; social--including health care, population, education, housing, law enforcement, etc.; and physical--including power systems, communication systems, public works, etc. These fields are related and, indeed, overlapping, and analysis of a particular problem may require components and models from all of them.

Components may be generalized for wide application or specialized for a particular use. For example, it may be desirable to modify a generalized demographic component ~~model~~ by including special features and deleting others in order to make it more efficient and relevant for modeling a human population, say. In the same way, a model general enough to be applicable to the study of a particular problem almost anywhere in the developing world may be specialized for use in a specific country or region.

So far, then, we have defined four libraries for ASSL: libraries of generalized and specialized components and libraries of generalized and specialized models. Of course, as new and improved components and models become available, they will join the appropriate libraries, perhaps replacing units already there. Furthermore, as old problems cease to be of concern, certain problem-oriented models may fall into disuse and be retired from the active library, to be replaced by new models designed for new problems. Function-oriented components, on the other hand, wouldn't be subject to this kind of obsolescence.

There is one more library ASSL will contain: a library of technical routines (hereinafter called routines). In building, modifying, testing and validating models and components, there are a number of necessary activities which could be simplified with the aid of computerized routines. For example, routines could conduct sensitivity tests and/or Monte Carlo

analyses on model parameters, perform spectral analyses of simulation-generated data, track the model against recorded time series, and do regression analyses on time series data, where available, to estimate model parameters. Such routines will be useful to users in modifying and specializing library components and models for particular applications, and to model builders in developing new models or updating and testing old ones.

Activities and Services of ASSL

The primary charge of the Agricultural Sector Simulation Library will be the stocking, maintenance and distribution of the libraries of components, models and routines. In performing these functions, ASSL will be responsible for acquiring and testing potential library elements, documenting them and distributing documentations and elements upon request. Distribution procedures and the formats of various kinds of documentations will be discussed later in this paper.

In general, there will be two sources of library components, models and routines (hereinafter collectively called library elements). These sources can best be described relative to the institution housing the library, so let's assume for concreteness that ASSL is located at Michigan State University (MSU). First, library elements may be acquired from outside sources, i.e., in the literature or directly from people in other universities, institutions or agencies who have developed models in support of their own research, teaching and/or applied work in agricultural sector development. Secondly, library elements may originate from people doing similar work inside MSU. The difference will be that, while ASSL will be conceptually a distinct unit at MSU, library elements may be built and tested expressly

in direct support of ASSL using other resources of the university or other contractual sources. For example, graduate students in agricultural economics development courses and in applied systems science and simulation courses may elect, as class projects, to fill gaps in the library or to improve upon elements already in the library. Or, funds either from the same contract as ASSL's or from a separate one may be made available specifically to support professional and/or graduate assistant work in developing elements for the library.

In acquiring elements for a particular slot in the library--e.g., a resource allocation component or a validation routine--it will be desirable to actively search out and test alternative candidates from both inside and outside sources. One or more will then be chosen to become part of the library, the appropriate set of documentations will be written, and users will be notified of the changes in, deletions from or additions to the library. Of course, elements entering the library must meet ASSL's criteria for inclusion, discussed in the next section.

The other side of ASSL activities will be servicing users with library elements as requested. As a bare minimum, ASSL will publicize and distribute elements and associated documentations and will keep a file of users' feedback, i.e., reports, results and specialized models and components.

More broadly, however, ASSL could offer consultancy and training services both in support of and supported by its distribution activities. Consultants could be supplied in conjunction with the use of library elements. For example if FAO was investigating agricultural marketing in India, say, a professional (or a team) from ASSL would participate on site in performing, first, a system and problem definition study. He would then

identify components and/or models available from the library which would apply, as well as necessary components the library might not have and would have to be built. The ASSL consultant would assist in modifying, specializing and merging the generalized elements to operate in the particular context of agricultural marketing in India. This would involve model testing and validation using, where available, routines from the library. Finally, he would help define and run policy alternatives and interpret the simulated results. Any given application would require any, all or none of the above consultancy services, depending on the available manpower within FAO (in this case) itself.

If FAO, AID, or the governments of developing countries wished to develop that manpower, ASSL could perform or participate in a training role. For example, if AID wishes to train either its own personnel or, as part of a high-level extension program, foreign nationals, ASSL in conjunction with appropriate academic departments at MSU--e.g., agricultural economics and systems science--could supply its models, components and routines as applied teaching tools. In return, the library could benefit from class projects arising out of the training program (as discussed above in regards to the acquisition of models).

Further discussion of the consultancy and training functions will be discussed as part of the next section on the organization and management of ASSL, to which we now turn. The final section of the paper will suggest the activities in furtherance of the proposed library that may be undertaken under the current contract AID/csd-2975.

Library Management and Organization

The Agricultural Sector Simulation Library (ASSL) will perform a function

similar to that of a book library. It will acquire, store, catalog and provide access to the computer programs which constitute the components, models and routines (collectively called elements) making up the library. The library will neither produce nor use its elements, although it may be closely associated with those who do (as at present at Michigan State University) depending on where it is eventually located.

It is recommended that a standing advisory board be set up to supervise both policy and technical matters. This board would be made up of representatives of individuals and organizations using the library and those producing elements for it. It would make policy regarding the acquisition of models and library use and management. In addition it would oversee the technical procedures of model testing, storage and distribution, and documentation.

In what follows, we shall discuss the management and organization of ASSL in relation to: (1) the criteria for inclusion of elements; (2) the physical storage and distribution of library elements; (3) communication with users, including various types of documentation; and (4) the supporting facilities, activities and associated personnel necessary for the operation of ASSL.

Criteria for Inclusion of Elements

As mentioned in the last section, models, components and routines acquired by ASSL must meet or be modified to meet certain standards before they may be included in the library, documented and distributed to users. The advisory board proposed above may set or assist in setting the specific criteria for inclusion. The standards will relate to language, generality, compatability, validity, and user orientation.

One standard programming language will be employed--FORTRAN. Primarily, FORTRAN is the most universally used language for research purposes. Furthermore, almost any computer in the world has a FORTRAN compiler, whereas more specialized languages have relatively limited world-wide distribution.

Library elements will also be expected to be applicable to the developing world in general rather than designed for a particular region or country. As the library is used, it will be expanded to include elements originally obtained from it which have been modified for particular applications and then fed back to ASSL from users.

Since models and components will be combined in a variety of ways as required for a given application, these elements--which may have originally been developed independently--will have to be compatible with one another. Compatibility will be facilitated by the use of a common language (discussed above), a standard programming style, clearly specified and compatible inputs and outputs, and documentation explaining how combinations may be made.

Generalized models and components cannot be validated to the extent of faithfully representing a real-world system; that would have to await specific applications. Rather, they are idealized representations of reality whose validity can only be determined with respect to internal logical consistency and conformity with social and economic theory. Representative data, e.g., from FAO's proposed international agricultural data bank, can be used to conduct such tests and validity checks.

Finally, if ASSL is to be used extensively and successfully, its elements and associated documentations must be user oriented; that is, they must be both comprehensible and easy to use. The various forms of

documentation (see below) and the computer program coding must be understandable to the technical or professional level of their respective audiences. Coding should be extensively "commented," variable names should be defined, and the element itself should be complex enough to do its job yet simple enough to be described both verbally and mathematically. Necessary data--initial conditions and system parameters--must be clearly specified and input formats easy to use. Finally, documentations must show how models and components may be combined and used in policy contexts. In particular, the policy maker's access to the model--including policy input and output formats--must be quick and uncomplicated, possibly even allowing man-machine simulations where policies may be changed during the course of a simulation run.

Physical Storage and Distribution of Elements

The primary medium for the storage of the computer programs will be magnetic tapes. One set of tapes will constitute the working master source of all elements in the library. It is from the master tapes that changes--additions deletions, updating--will be made. To ensure recovery of the library elements in case of loss or damage to the master tapes, up-to-date backup tapes will be maintained and stored in a different location than the master tapes.

The medium for distributing requested elements will be tapes or cards, depending on the requirements of the user's computer installation. In either case, the desired files will be copied--in source code, not object code--from the master tapes to the distribution medium. It will be necessary to have the ability to create distribution tapes and cards in formats and

codes which are compatible, or can be easily made compatible, with user installations.

In addition to the distribution tapes or cards containing requested elements, a distribution package will consist of a FORTRAN listing of the elements included, the necessary user- and programmer-oriented documentation (see below), and in the case of tape a key to accessing the tape. Such a tape key will provide information on: (1) the number and names of files on the tape; (2) the number of logical records in each file; (3) the names of elements included in each file (if elements and files are not identical); (4) tape label (if any); (5) tape density, parity, blocking factor and number of tracks; and (6) the code used in writing on the tape. (The last item will also be necessary information for punched cards.)

User Communication

Effective communication with users will be essential to the success of ASSL. Three types of communication will be necessary: primary communication to disseminate information on the library's offerings of elements and services; secondary communication to enable users to select and implement library elements and services; and tertiary communication as feedback to ASSL on user experiences and results, including reports and specialized models and components.

Primary communication would consist of a descriptive index of library models, components, routines and services, periodically updated and sent to past, present and potential users. The index could also be published from time to time in appropriate professional journals and newsletters. Included with the index will be a standardized order form for ordering the

various kinds of secondary communication on items described in the index.

Secondary communication will consist of three classes of documentation on each of the elements in the library. A computerized information retrieval system could be implemented which would store, update and print out as needed any of the three classes of documentation for any library element. There are document-producing systems available which use the facilities of a computer and allow instant updating without having to rearrange large amounts of text. This system would produce text in upper and lower case given a file of raw text which consists of the unorganized text with control characters interspersed. Once a competent typist learns the techniques of using the control characters, the raw text can be typed into the computer quite rapidly. Specific documentation procedures and formats will be set by the ASSL advisory board.

For each element, Class I documentation will be a non-technical yet thorough description of that element, including a discussion, with examples, of how it could be combined with other elements to answer particular questions or build particular models. Class I documentation will be intended to inform users--both professional consultants (economists, systems scientists, etc.) and ultimate clients (policy makers and public administrators)--of the capabilities and potential applications of library elements.

Class II documentation, on the other hand, will be directed to professional users. A technical and mathematical description of each element will be given and data input requirements will be specified. Class III documentation will provide technical information needed by a computer programmer to implement the element on a computer, including core requirements, reference maps, subroutine call sequences, etc. Both Class II and Class III documentations will be part of the distribution package for each element

(discussed earlier).

Finally, tertiary communication will involve feedback to ASSL from users. ASSL will solicit comments and suggestions concerning its own operation as well as the usefulness of the models, components and routines themselves. In addition, a file of reports will be kept and a library of specialized models and components will be created from modified versions of its own generalized elements. In this way, deficiencies in current elements as well as the need for new elements can be identified, and later applications may use specialized models and components, where appropriate, which have already been built rather than start from scratch or from generalized models and components.

Supporting Facilities, Activities and Personnel

Physically, ASSL will consist of the elemental models, components and routines and three classes of documentation for each element. The facilities necessary to support this physical core of ASSL will include computer hardware and software and a central office.

It will, of course, be essential to have ready access via batch and/or remote terminal to a computer large enough (at least 32,000 words of core) to load likely combinations of library models and components. Since library elements will be stored and manipulated on tapes, tape drives will be necessary. (Cards would be too cumbersome and inefficient; magnetic disks are a possible alternative to tapes.) Also needed will be the capability of creating tapes for distribution to users of any desired density and number of tracks. Software requirements will be: (1) a FORTRAN compiler; (2) an information retrieval system to store, maintain and retrieve the

three classes of documentation for each library element; and (3) utility programs to create, update and otherwise manipulate files on the master tapes, to provide information about those files, and to create distribution tapes.

Office support will include both clerical functions and professional activities. The clerical staff will communicate with and send distribution packages to users, will keep files of such communications, and will prepare and keep files of the library documentations. It will be essential, if ASSL is to remain effective and relevant to users, to keep records of elements users have received from the library, applications and modifications of those elements and reports of user experiences. In addition, as new and improved versions of library elements become available, such records will facilitate sending the new versions to users who have the old ones.

Professional activities will fall into three categories: acquisition of elements, documentation of elements, and performing consultancy and training roles vis-à-vis users.

Although ASSL's functions will not include the initial building and development of models, components and routines, elements will have to be actively sought out and acquired if the library is to remain useful in a changing world. As discussed earlier, acquisitions may come from the literature, from practical work going on elsewhere or, in the case of ASSL's location at MSU, from associated training and applications projects at MSU. The task of ASSL professionals will be to seek out potential elements, test them and (if a decision is made to acquire them) modify them as necessary to meet the library's criteria for inclusion discussed above.

The documentation of library elements will be one of the most important tasks of ASSL professionals. It is only through this medium that elements can be effectively understood, selected and applied by users. Three classes of documentation (discussed above) will be written for each element when it is included in the library, and will be updated as the element is updated.

Finally, ASSL may be given the charge of providing training and consultancy services for users (discussed earlier). These activities aren't essential to the concept of a software library; however, they may be essential for effecti e use of its elements. These functions, if they are to be a part of ASSL, will be performed by professionals--systems scientists, economists, agriculturalists, computer scientists.

Personnel requirements to operate these facilities and carry out these activities will depend somewhat on the level of demand for library services. In any case, library personnel may be classified as managerial, professional and clerical. Figure 1 shows the relationships between staff and library functions.

The library manager--a full-time position--will be responsible for coordinating the library's activities and maintaining quality control over the models, components and routines in the library and their associated documentations. He will identify needed elements or modifications of elements and will oversee (or do) the researching, testing, reprogramming and documenting of them. He will communicate with users and negotiate with them as to the library services they will use, e.g., consulting or training as well as the use of library elements.

The ASSL professional staff will include both high-level personnel, e.g., agricultural economists, systems scientists and computer scientists;

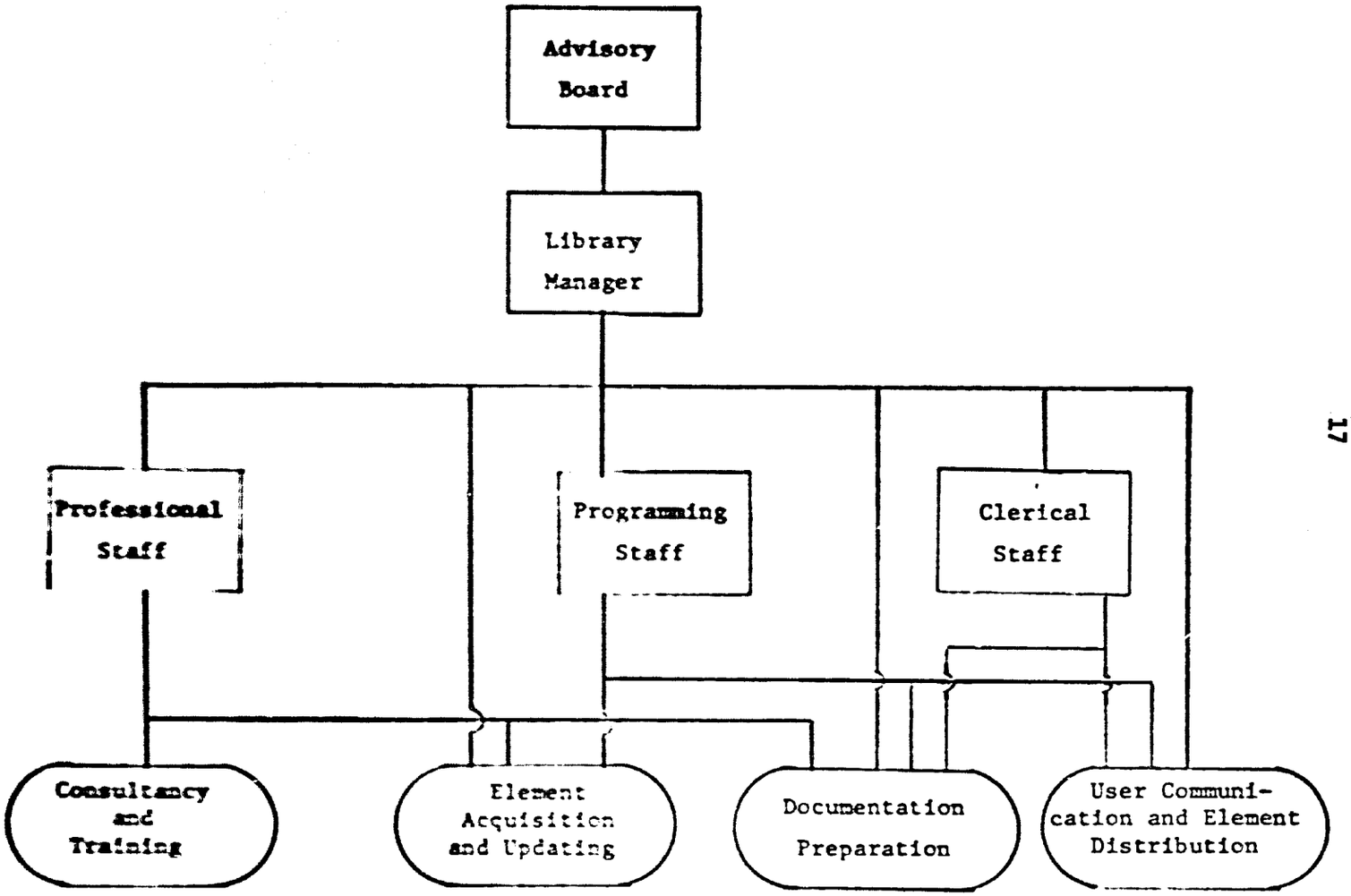

Figure 1. Library personnel and functions.

and middle-level personnel, e.g., computer programmers. High-level professionals will be used on a part-time basis as needed to meet consultancy and training demands and to participate in the researching and testing of elements to be acquired by the library. They will contribute importantly to the Class I and Class II documentation of acquired or updated elements which they have researched and tested. A full-time computer programmer will be required to reprogram acquired elements in the library's standard format, to develop and operate the computerized system of library maintenance and information retrieval, and to prepare distribution packages for users. He will also be expected to write the programmer-oriented Class III documentation. Part-time editorial services may also be desired to review the professionally written documentations and to assure that each class of documentation will be comprehensible to the level of expertise of its intended audience.

As clerical staff, a full-time secretary will be needed to receive user requests for services, to type and send out letters, to type documentations, to send out distribution packages and documentation, and to keep files of communications to and feedback from users.

We have described the ultimate form an Agricultural Sector Simulation Library might take. We turn now to a discussion of how we may get started towards that objective under the remainder of contract AID/csd-2975, i.e., from January 1973 through June 1974.

Initial Implementation of ASSL

The discussion up to here has tried to present a broad, general description of the concept and operation of ASSL. The actual organization, activities, size and institutionalization the library will have in the

long run will be dictated by as yet unmade decisions, both those of the advisory board and those of users demanding library services. This section will suggest the organization and activities of ASSL as it may initially be set up at MSU.

While activities in the immediate future will be financed by 2975, long run funding may come from any one or more of a variety of sources, including AID, FAO, IBRD, private foundations such as Rockefeller or Ford, possibly even foreign governments and other ultimate users. Also, although the library will initially be located at MSU, ultimately it may be moved to a national or international agency or perhaps to a private profit or nonprofit organization. The long-run disposition of ASSL--both its organization and activities as described in the previous two sections, and its location and sources of support--should be considered in the design and execution of its initial organization and activities.

Thus, one of the first tasks will be to set up the advisory board which will both oversee the initial operation of ASSL as well as plan for its future. The advisory board will be made up of representatives of: (1) potential users, such as AID, FAO and IBRD; (2) potential eventual supporters, which in some cases may be the same as the users and in others may include foundations such as Rockefeller and Ford; and (3) appropriate disciplines, such as agricultural economics and systems science.

Three ad hoc committees will be created by the advisory board and respectively charged with: (1) designing user communication procedures, i.e., publicizing the library's elements and services via the descriptive index and other means, receiving and processing user requests, and requesting and processing user feedback; (2) designing standardized formats and pro-

cedures for the three classes of documentation; and (3) designing standardized computer programming procedures for, for example, naming variables, defining common blocks, specifying input/output formats, defining subroutines, etc. These committees will be made up of advisory board members and MSU professionals and other personnel; the library manager should be a member of each committee.

Until the committees file their reports and the advisory board acts on them (about two months), work can progress in looking at the current models (Nigeria, Korea and Colombia) and breaking and recombining them into generalized problem-oriented models and function-oriented components, with emphasis on the latter. This will include defining elements by intended function and by inputs and outputs. When documentation and programming standards have been set by the advisory board, these elements can then be reprogrammed, the master tapes created and the three classes of documentation written for each element. This process may take at least eight or nine months, maybe longer if the manager is not full time.

As this process is carried out, other activities can be taking place. First, needed elements for acquisition will be identified, and work may begin on developing some of them as part of MSU's educational curriculum. For example, a systems science student may work on a routine which will perform spectral analyses of simulation data. Also at the same time, office procedures, user communication procedures and procedures for the library's use of the computer will be created and operationalized. One outcome of this will be a document describing in detail ASSL's operations, its activities, its organizations, its procedures and its personnel requirements. This will be primarily an "in-house" document but will be essential

if the library moves elsewhere in the future.

In the final nine or ten months of 2975, then--i.e., through June 1974--the library should be in a position to begin responding to requests from foreign governments, international organizations, individual teachers and researchers and other potential users for library services on terms to be decided by the advisory board. Also, as new elements are acquired by the library and/or old ones modified, the master and backup tapes and documentations will be updated.

The resources necessary for the initial implementation of ASSL will include personnel, office equipment and computer facilities and equipment (tapes, etc.). Going into personnel in more detail, first and foremost will be the library manager to coordinate and take responsibility for the library's operation. While a half-time manager may be sufficient initially, the process of getting the library off the ground may be slowed if he is not full time. Aside from the manager, the present 2975 staff will be sufficient to participate in the initialization of the library. The computer programmer will be needed about half time, and the secretary will have only minimal library-related duties until documentation writing and typing and user communications get under way. Professional (systems scientist and agricultural economist) services to define and test generalized elements can be performed on a part time basis as well--perhaps a half-time equivalent.

Citations

[1] Manetsch, T. J., et al. A Generalized Simulation Approach to Agricultural Sector Analysis With Special Reference to Nigeria. East Lansing: Michigan State University, 1971.

[2] Rossmiller, G. E., et al. Korean Agricultural Sector Analysis and Recommended Development Strategies 1971-1985. Korean Agricultural Sector Study (KASS) Final Report. East Lansing: Michigan State University, 1972.