AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

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BATCH #14

1. SUBJECT CLASSIFICATION	A. PRIMARY: Agriculture	AA00-0000-G214
	B. SECONDARY: General--Nigeria	

2. TITLE AND SUBTITLE
Simulating the Nigerian agricultural economy,a library of models

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4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1972	7p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Mich.State

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

9. ABSTRACT

10. CONTROL NUMBER PN-RAA-744	11. PRICE OF DOCUMENT
12. DESCRIPTORS Models Nigeria Simulation	13. PROJECT NUMBER
	14. CONTRACT NUMBER CSD-2975 Res.
	15. TYPE OF DOCUMENT

AID 590-1 (4-74)

Simulating the Nigerian Agricultural Economy: A Library of Models

Implementation of the simulation model[1] of Nigeria's agricultural economy [1] could effectively focus upon, as a long term objective, the development and use of a "library of models" [2]. Figure 1 is a hierarchical diagram of how such a library might be organized. After a discussion of the library's organization and use, we shall see how the library could provide a focus for research and application of simulation in the context of agricultural--and, more generally, economic--development planning and policy making in Nigeria and, indeed, elsewhere.

Library Organization and Use

The hierarchy depicted in Figure 1 is not the usual hierarchy of an organizational structure; that is, lower levels are not subordinate to higher levels; nor does it even represent a system model, where lower levels would necessarily be components and subcomponents of higher levels, *i.e.*, of larger systems. Rather, in this figure, lower levels represent increasing disaggregation of analysis, while higher levels represent increasing aggregation. Mesarovic, *et al.* [3] define this type of hierarchy as a "stratified" hierarchy, and the levels are called "strata."

In this way, each box in Figure 1 would be a model unto itself, a member of the library. For example, the annuals and perennials models are not components of a larger crops model but are disaggregated models which could be used *in place* of the more aggregated crops model. This might be

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[1] Developed at Michigan State University under United States Agency for International Development contracts AID/csd-1557 and AID/csd-2975.

done, say, if it were necessary to investigate some problem in more detail than could be done with the more aggregated model. The crops model, however, should represent the same behavior, in the aggregate, which occurs in the more disaggregated models.

This is not to say, however, that for any particular simulation experiment several models from various levels might not be drawn from the library and combined to make up one simulation model. For example, if we wanted to investigate a problem in detail involving cattle production decisions, we might use the following models:

1) the production model of the cattle industry, as our basic unit of interest;
2) the cattle processing and marketing models, to consider interactions with the other activities of the cattle industry; since all cattle activity models are already used, we would not include the cattle industry model;
3) the other livestock industry model, to consider aggregate interactions between cattle and other livestock; since both industry models would be used, we would not use the livestock subsector model;
4) the crops, forestry and fisheries subsector models, to consider aggregate interactions between cattle and other subsectors of the agricultural sector; disaggregate models below the subsector level would not be needed, nor would the aggregate agriculture model;

5) the nonagriculture model, to consider agriculture - nonagriculture interactions; since sector models would be used, we would not use the macro economy model.

Two points are to be noted from the above example. The first concerns requirements upon the supremal[2] models. The basic requirement is that a supremal model be capable of simulating the aggregate behavior of all the infimal[2] models below it. In the example, the crops model was called upon to represent all the industries and activities under it (infimal to it). Secondly, if any infimal model below a particular supremal model is used, all other models on the same stratum and below the same supremal are also used, and the supremal is not used. In the example, the cattle industry was represented by models infimal to it, and the other livestock industry model was also used; therefore, the aggregate livestock subsector model was not used.

It will be noted that six levels of aggregation (or disaggregation) are specified in Figure 1. This by no means represents the only conceivable organization for the library. Some of these levels may be replaced by more meaningful ones, or additional ones may be created. For example, the industry level might be replaced, if desired, by a commodity level: instead of an aggregate perennials model, there might be separate models of each perennial commodity; instead of an aggregate salt water fisheries model, there could be separate models for distant water and coastal waters

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[2]"Supremal" and "infimal" refer to "more aggregated" and "less aggregated" models, respectively, according to Mesarovic's terminology [3].

fishing. Or, instead of replacing the industry level, the more disaggregated models might form a new, commodity level inserted between the industry and activity levels. Another level might also be useful between either the sector and subsector levels or the subsector and industry levels: this would be a region level, where there would be a regional disaggregation, such as the north-south division in the current model [1, Chapter 2].

The firm level would represent the most micro level of analysis. Here, the internal decisions of individual production/consumption units would be the target for study. An example, under the perennials or annuals production activities, would be the farm/firm as both producer and consumer.

Focus for Research and Application

The dotted lines in Figure 1 roughly enclose the models covered by the current Nigerian simulation model [1]. This is not to say that these models are complete. In fact, if this scheme of a library of models were adopted as the operational objective of an implementation of the system simulation approach, the current models would have to be revised and redefined as unit models in the hierarchy.

The scheme outlined in Figure 1 can easily serve as a focus for research and model building and for practical application of the model. Indeed, some work which has already been done and which is currently under way could contribute to the library. Kellogg's model of a beef distribution system [4] could serve as basis for the market activity model of the cattle industry. O. O. Ladipo, of the University of Ife's Department of Agricultural Economics, is conceptualizing and developing simulation models of Nigeria's fisheries subsector for his Ph.D. dissertation research at Michigan State University.

For the rest, and in general, Nigerian researchers, policy makers and other experts can be involved in the tasks of defining, building, testing and applying models in the process of stocking, maintaining and using the library.[3] This process would thus provide the stimulus and the focus for a great deal of basic behavioral research and data collection and for the development of theoretical models--to be carried out both by government institutions (*e.g.*, N.I.S.E.R., I.A.R.) and research stations and by the staffs and graduate students of university departments.

Strong central coordination would be necessary to insure that comparable work progressed on the various models and that all these models would be able to function together, *i.e.*, that they be compatible with one another. Important considerations here are the assurance that all the models of a given level are defined and constructed to the same degree of disaggregation, and that supremal models truly do simulate the same behavior, albeit in the aggregate, as is simulated by the infimal models below them. Needless to say, such an undertaking would encounter many technical and organizational problems which would have to be overcome.

Finally, let's stress again the importance of *selecting* models, at various levels, from the library as appropriate to perform a particular application. The models should be constructed so that if all the models from a disaggregate level--say the activity level--were combined and run together, the aggregated macro-economic behavior thus simulated would be

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[3]The nonagricultural sector, shown only in the aggregate in Figure 1, would also be disaggregated into appropriate subsectors and lower levels. These could be divided either along ministry and department lines as is the agricultural sector, or by the eight (or more) subsectors defined in [1, Chapter 7], or perhaps following some other scheme of disaggregation.

the same, within tolerance limits, as it would be if an entire aggregate level--say the sector level--were simulated. Although the models should be constructed in this way, in practice an entire disaggregate level such as the activity level would never, *could* never, be run; such a simulation would be both physically impossible due to limitations of computer size and economically inefficient in terms of computer and programmer usage costs (assuming some future gigantic computer could physically handle the whole thing). That is, it wouldn't be economical to run the entire activity level in order to investigate, say, problems of coastal waters fish production when more aggregate models of the rest of the economy would (if constructed properly) give the same results.

References

[1] Manetsch, Thomas J., *et al.*, *A Generalized Simulation Approach to to Agricultural Sector Analysis With Special Reference to Nigeria*, Michigan State University, Nov. 30, 1971.

[2] Clymer, A. Ben, "The Modeling and Simulation of Big Systems," Proceedings of the Pittsburgh Simulation and Modeling Conference, April 1969.

[3] Mesarovic, M. D., D. Macko and Y. Takahara, *Theory of Hierarchical, Multilevel Systems* (New York: Academic Press, 1970).

[4] Kellogg, Earl D. *A Temporal and Spatial Model to Assist in Evaluating Investments in the Nigerian Beef Distribution System*, unpublished Ph.D. dissertation, Michigan State University, 1971.

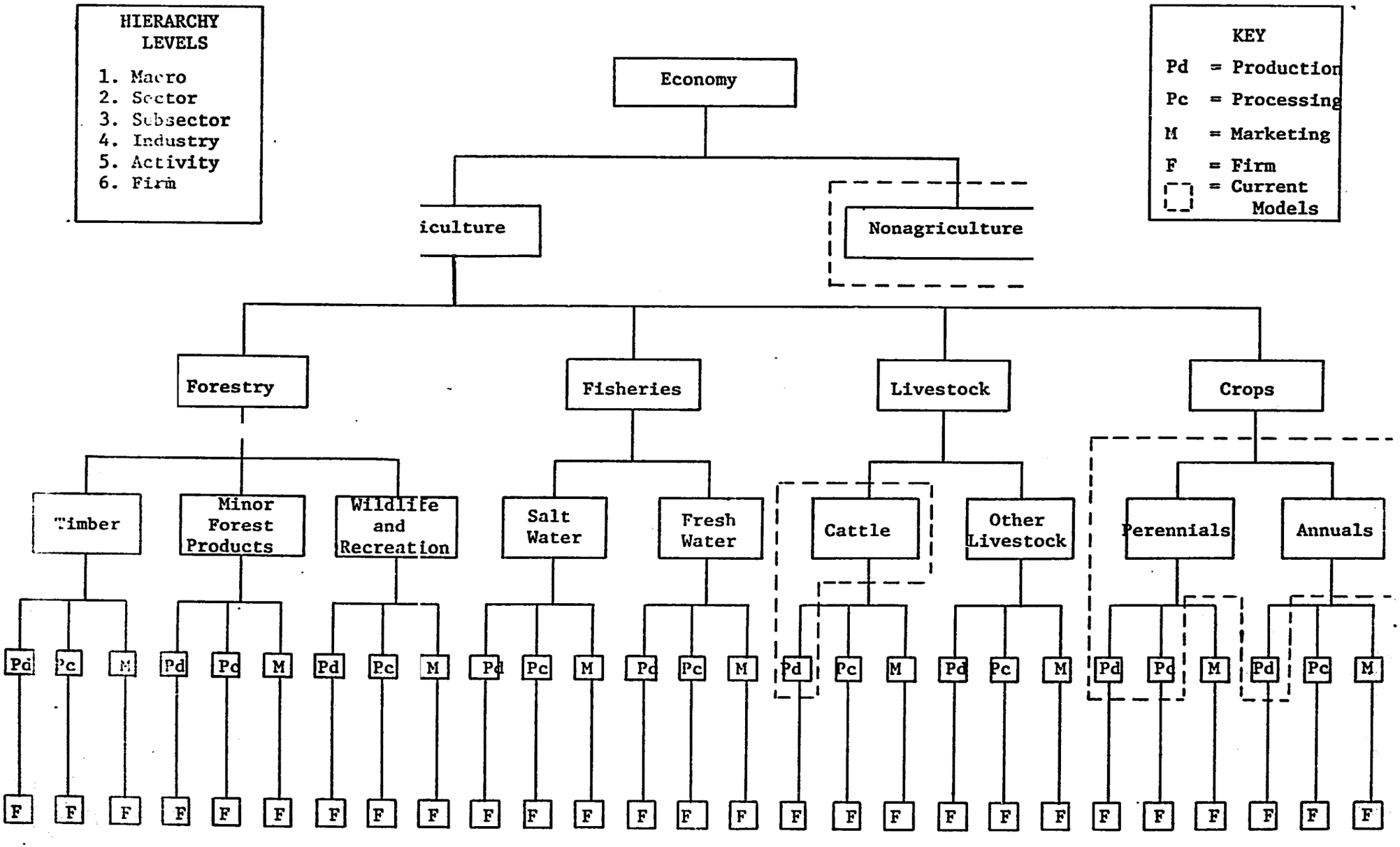

Figure 1

A Library of Models