ABSTRACT

SYSTEMS ANALYSIS AND SIMULATION STUDY OF NIGERIAN FORESTRY SECTOR: WOOD CONSUMPTION COMPONENT

By

Felix Izu Nweke

The current high world market prices for petroleum products and high rate of drilling for petroleum in Nigeria have generated rates of growth of income higher than anyone could have predicted a few years ago. The governments of Nigeria are investing this income in the education, agriculture, transportation, health, etc. sectors. These changes, if sustained, will result in an increased pace of modernization which will have important consequences for wood consumption.

The various Nigerian governments and other public bodies who own forest lands are currently investing heavily in forest plantations in their attempts to convert some of the natural forest reserves into forest plantations. It does not seem likely that forest land can be extended beyond the present forest reserves because of increasing demand for land from other sectors particularly agriculture, industrialization, urbanization, modern road construction, etc. Under such circumstances the supply of forest products can be increased only by intensive methods.

An insight into the future markets for the products is needed for decisions about heavy investments in forestry industries which

mature with long time lags. Such an insight involves descriptive knowledge of the time paths of wood consumption in the presence of rapidly changing income and government actions. Some of the objectives of this study were to formulate a generalized simulation model of the wood consumption component of the Nigerian forestry sector which can always be updated and used to estimate the annual consumption of wood products; to track annual consumption of wood products for Nigeria in the past from 1965 to 1974 and to project the same into the future from 1975 to 1990; and, to help provide a basis for prescribing actions which would lead to the attainment of the forestry sector objectives of providing the needs of the country in timber and other objectives. This thesis will hopefully contribute both descriptive knowledge for public and private investment decisions in the forestry sector as well as analytical tools that may subsequently be employed in prescriptive and predictive analysis.

The model of the entire forestry sector is specified in a general form but not formulated in detail. The model of the wood consumption component is formulated in detail and used to make projections of annual wood consumption from 1965 to 1990. The various wood products consumed in Nigeria are aggregated into unprocessed wood, processed wood, building board woodpulp, paper pulp, and fuelwood. Wood using subsectors are also aggregated into residential housing construction, non-residential building construction, farm construction, casket manufacture, bridge and vehicle construction, paper consumption, and fuelwood consumption subsectors. The variables which determine the consumption of those wood products in these uses are identified as rural-urban location, income, and educational attainment of individuals;

availability and relative prices of substitutes and complements for wood products in various uses; and public investments in education, agriculture, and other key sectors. The Nigerian population as well as some of the wood using subsectors are disaggregated into traditional, semi-traditional, and non-traditional groups and estimates of wood consumption made separately for each group to account for the differences in wood consumption due to rural-urban location, income, and educational attainment of individuals.

Historical projections of annual consumption of various wood products are made for the period 1965-1974. These backward projections are based on the actual recorded values of GDP, government investments, etc. Three sets of projections based on three assumed alternative rates of growth of GDP are made for annual consumption of the various wood products in the future of the period 1975-1990. Two consequences, one immediate and the other lagged, of changes in income and government spending on wood consumption are apparent from the projections. Wood consumption in residential housing construction subsector is particularly sensitive to the lagged consequences. The model was validated in an iterative manner on the basis of the objective tests of clarity, coherence, logical consistency, and workability of the information and concepts employed in or gained from the study. The projections generated with the model were also tested for consistency with available projections from other studies as well as with recorded experience in Nigeria and in some other parts of the world. These tests are not final as the passage of time will reveal further inconsistencies and information that we are not aware of at present.

A SYSTEMS ANALYSIS AND SIMULATION STUDY OF NIGERIAN FORESTRY SECTOR: WOOD CONSUMPTION COMPONENT

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To Warren H. Vincent and his family and to Anita Mackie: they provided hope when I had none and turned that hope into reality.

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CHAPTER I

BACKGROUND, DESCRIPTION OF STUDY, AND RELATED METHODOLOGICAL ISSUES

Background

We shall start by presenting some background information which will enhance the understanding by readers who may not be familiar with Nigeria of the model to be developed in this dissertation. This information includes size (land area), geographical location, vegetation, political divisions, population, and the culture of Nigeria. We shall also describe the national economy and the role of forestry in it. All these are important in studying wood consumption in Nigeria although not all of them are considered explicitly in this study.

General Information

1. Size and Location: Nigeria has an area of 923,774 square kilometers which is unevenly divided into north, southwest, and southeast by the rivers Niger and Benue. The greatest length of Nigeria from east to west is about 1,148 kilometers, and from north to south about 1,066 kilometers (47).

Bounded on the south by the Gulf of Guinea Nigeria extends to the subSahalien border on the north. It is bounded on the west and north by the Republic of Dahomey and Niger, and on the east by the

Republic of Cameroun. Entirely within the tropical zone, Nigeria lies between parallels 4° and 14° north and longitudes 3° and 15° east (47).

2. Vegetation: The vegetation of Nigeria can be divided into four easily recognizable belts. The southern most part consists of swamp forests which in some areas stretch up to 100 kilometers into the interior. The characteristic vegetation is mangrove trees which furnish mostly roundwood for local building construction.

The rain forest lies to the north of the swamp forests, forming a belt of 150 kilometers. The rain forest provides the most valuable timber species which include mahogany (Khaya ivorensis), sapele-wood (Entandrophragina cylindricum), iroko (Chlorophora excelsa), African walnut (Lovea klaineana), guarea (Guarea thompsonii), opepe (Sarcocephalus diderrichii), agba (Gossweilerodendron balsamiferum), obeche (Triplochiton scheroxylon), etc.

North of the rain forest is the savannah which forms a belt of some 500 kilometers. The savannah is a region of wide grasslands dotted with trees. North of the savannah is the sub-Sahel zone. The vegetation of the sub-Sahel consists of dwarfed bushes (47).

3. Nigeria has a military government and is divided into twelve states. The twelve states vary from 3,577 to 272,015 square kilometers in land area, and from 1.443 million to 9.428 million in population (1963 census). Each state has an internal self-government which has powers of internal self-government. These powers are determined by the Military Council which appoints the governors for each state.

4. People: In 1963 a population census showed that Nigeria had about 56 million people. In 1973 another census indicated that the

population has risen to 79 million. Many people including some Nigerians believe that the 1973 census involves statistical and other errors which resulted in the inflation of the figures. Up to this time the 1973 census is controversial in Nigeria and is unacceptable to some Nigerian state governments.

The Nigerian population is made of nearly 248 language groups (5). The populations of these groups vary considerably ranging from a few hundred to several million. The three major groups are Hausa, Yoruba, and Ibo accounting for 11.65, 11.32, and 9.50 percent respectively of the total population in 1963 (47). The Hausas are based mainly in the north, the Yorubas in the southwest and the Ibos in the southeast. In the absence of a single common language English has been adopted as the official and commercial language.

The three major religious groups are Muslem, Christian, and animism accounting for 47.2, 34.5, and 18.3 percent respectively of total population in 1963 (47). Muslems are based mainly in the north among Hausas and other language groups. The number of Muslems among the Ibos and other language groups in the southeastern region is negligible, the religious adherence being shared approximately equally between Christianity and animism. Among the Yorubas and other language groups in the southwestern region, Muslem has an edge over Christianity and animism (38).

National Economy

Nigeria is predominantly a primary producer of agricultural and mineral products. About 80 percent of total working males are engaged in crop production, wood production, animal husbandry, and fishing.

These activities contributed some 49 percent of national income in 1969-70 (26). Food production is based on grains, pulses, sugar cane, and cattle in the northern region, and root crops (yams and cassava) and fruits in the southwestern and southeastern regions.

Each of the three regions derives its wealth from one of Nigeria's agriculture export crops. These are palm oil and kernel in the southeast, cocoa in the southwest, and peanuts in the north. The country is a major world source for these crops accounting for as much as 50 percent of the world supply of palm kernels, 30 percent of palm oil, and 13 percent of cocoa (47). The crops are grown in small holdings by Nigerian farmers and sold through semi-governmental marketing boards.

Mining plays an important role in Nigeria's economy. Among the minerals are tin, columbite, limestone, and petroleum. Nigeria ranks sixth (43) in tin and has a virtual world monopoly in columbite. Uranium bearing rocks, extensive areas of iron-ore deposits and lignite have been located. Nigeria ranks eighth in petroleum production. The relative importance of petroleum rose sharply in 1973 because of high world prices of petroleum products and increased drilling in Nigeria. In 1973 the export of crude petroleum accounted for about 90 percent of the total foreign exchange earning (6). Since then this relative importance of petroleum has risen steadily.

Although the Nigerian economy remains predominantly agricultural, there has been progress in industrial development. Traditional crafts have always played an important part in the life of the people with modern factory type industry a recent development. In the early 1950s the contribution of all manufacturing including handicrafts to total output was less than 3 percent; by 1970 this had risen to more than 8 percent (26). Some of the main industries operating in Nigeria today are cement, cigarette, soap, oil refining, tyre, leather, shoes, sugar, textiles, aluminum products, glass, plastics, sawmilling (including plywood and veneer), canning and food processing.

Major developments in industrialization are expected soon when the planned additional oil refineries (two), pulp mills (four) using Nigerian wood, an integrated iron and steel complex using Nigerian ore, limestone, coal and electric power, and three car assembly plants are set up. A wide range of indigenous raw materials is available. With a population of nearly 80 million, Nigeria offers potentially the largest single market in Africa.

The Nigerian economy exemplifies a dualistic system in which poor masses coexist with fairly well-to-do few in the same economy. In a paper published in 1972, Aboyade (1) observed that 90 percent of Nigerian families earn less than ₦300 (₦1≈$US1.60) per family per year and 0.8 percent of families earn more than ₦1,750 per family per year. Educational and agricultural opportunities are equally unevenly distributed. By 1971 approximately 27 percent of children of primary school age were in school (7). At the secondary level approximately 3.4 percent of school age youth were in school (7). In agriculture which contributed about 50 percent of gross domestic product and employed about 70 percent of the labor force in 1970, 83 percent of farming households farmed two hectares of food crop or less, or one hectare or less of tree crops per family (35).

The rate of rural to urban migration has grown from 1.1 percent in 1961 to 7.5 percent in 1971. It was observed to be positively correlated with rural-urban income differential and varied from 85.5 percent among people between the ages of 11 and 20 to 0.0 percent among people older than 40 (33). None of the families studied reported a returning migrant implying that the rural-urban migration is one way. This trend will probably continue unless the rural-urban income gap is narrowed substantially.

On the aggregate the economy has grown. We have mentioned the increasing importance of petroleum in the economy. This accounts for most of the economic growth. The gross domestic product has grown from ₦3,144 million in 1964-65 (26) to ₦24,235 million in 1974-75 (7). Public and private investments in various types of construction--residential housing, schools, hospitals, commercial centers, roads, etc.--have grown at comparable rates. During the second national development plan which ended in March 1975, ₦630 million was spent on roads. The capital allocation to education was ₦360 million. The total enrollment in primary schools rose from 3.5 million in 1970 to 4.5 million in 1973 and university enrollment rose from 14,500 in 1970-71 to 20,000 in 1974-75 (7). In the Third Five Year Development Plan which started in April 1975, ₦3,400 million is allocated to road construction, and ₦2,000 million to education. Primary school enrollment is expected to rise to 7.5 million in 1976 and to 11.5 million by 1980. It is planned to increase university enrollment from the present 20,000 to 53,000 by 1980 by expanding the existing six universities and by building four additional ones (7).

Private investment is expected to grow at similar rates. It is expected that average annual private investment in the five year period beginning April 1975 will be about ₦2,000 million in contrast to pre-1975 rate of ₦1,000 million (7).

<u>Forestry in the National Economy</u>

The concept of forestry as an organized sector in Nigeria was started after 1861 when Nigeria became a formal colony of England. The colonial government set aside specific natural forest areas as forest reserves. The aims were to conserve forest resources for the benefit of the local communities owning the land, to oppose the wholesale exploitation of those resources, to impress the native with the economic value of the forests as a source of present and continual revenue for himself and his children, to prevent destruction through indiscriminate farming operations and bushfires, and to prevent the felling of immature trees (38).

There are about 96,000 square kilometers of such forest lands today in Nigeria out of 980,000 square kilometers of total surface area (21). There seems to be no potentials for expansion of forest lands beyond the present area because of increasing demands on land for agriculture, urbanization, industrialization, and road construction. Natural forests are gradually being converted into forest plantations to increase the production of forest products by intensive techniques.

The relative importance of forestry in the national economy in terms of its contribution to GDP and foreign exchange earnings seems to be declining. In 1959-60 forestry including activities related to the production, processing and distribution of wood and minor forest products, the conservation of soil, watershed and wildlife and those related with recreational activities contributed 6.5 percent of the gross domestic product, by 1969-70 this proportion has fallen to 2.3

percent (26). In 1962 export of wood products contributed ₦17.2 million in foreign exchange; by 1972 this contribution has fallen to ₦6.3 million (21).

The decline in the relative importance of forestry in the gross domestic product could be due to increasing importance of petroleum. The decline in the contribution of forestry in foreign exchange earning is certainly due to increased domestic consumption resulting in a cut-back on the exportation of wood products. Records of domestic consumption of wood products do not exist but one estimate (15) suggests that domestic consumption of wood including sawlongs, veneer logs, and woodpulp was 610 cubic meters (roundwood equivalent) in 1960-61 and 1,360 cubic meters in 1973-74. This suggests that with respect to domestic consumption of forest products the importance of forestry in the economy is increasing.

Description of Study

The Scope of the Study

The forestry sector can be defined to include activities related to the production, processing and distribution of wood and minor forest products, the conservation of soil, watershed and wildlife, and those related with tourism and other recreational activities. The general model of the forestry sector will be concerned with activities related to only the production, processing, and distribution of wood products. In the present study we shall merely specify the general model of the forestry sector such that later it can form the basis for the construction of the model itself. We shall concentrate our efforts on modeling the consumption component, use it to track annual consumption of

different wood products in the past from 1965 to 1974 and in the future from 1975 to 1990.

The construction of the general model for the entire sector including production, processing, and consumption components would involve resources that are not available to us at present. We concentrate on a component of the sector which will logically come first and which we can formulate with the scanty resources we have at present. We shall formulate it in such a way that, eventually, it can be easily integrated with the models of the other sub-components. The consumption component comes first because to plan production investments in an industry where investments mature with long time lags one needs an insight into the future for the availability of the market for the products.

Without the model of the whole sector, however, we shall not be able to make serious analysis and draw conclusions about the consequences of decisions and actions being taken in the forestry sector. Such analysis and conclusions should be broadly based on the information yielded by the model of the entire sector.

Some Existing Generalized Models of Forestry

A few simulation models of forestry sector are available for different countries but we will describe only two of them briefly because of their different approaches. One of these is Simulation Studies of Forest Sector Development Alternatives in West Malaysia (17) prepared by FAO in 1972. This is a simulation model used to analyze a total of twenty-eight forestry policy alternatives on the basis of major national objectives. The simulation model which is computerized is used for Malaysia to make variations in data on forest resource flows, wood based industries and market information for wood products. The effects on employment, income, foreign exchange earnings, capital requirements and return on investments of different forestry management practices and of converting forest land to other uses would be evaluated on the basis of the information yielded by the model. This formed background material from which the Malaysian government could choose that forest development strategy most compatible with their overall strategy for national growth and development.

The second general model of forestry sector which we want to describe is that developed for the forestry sector of Trinidad in 1969 by M. Gane (23). Gane defines consumption as the ultimate economic goal and treats it as if it were an interpersonally valid welfare measure. Maximum consumption is set as the sole forestry policy objective and all input and performance variables of the forestry sector are reduced to consumption gains and losses. He employs "Feldstein Multiplier" to calculate the social opportunity cost and social benefit of public investments in forestry. Net social benefit is defined as the value at the time of the decision-making of the net addition to future consumption that would result from undertaking the project. The desire to consume now as against in the future is social time preference which is assigned an arbitrary value.

Consumption gains and losses based on an arbitrarily chosen social time preference is certainly not interpersonally valid because people have different time preferences. The concept of social time preference is not well understood at present. The calculation of Feldstein Multiplier requires such parameters as marginal propensity to consume, marginal propensity to consume from imported goods, marginal propensity to invest, net output per acre, etc. Underdeveloped countries may not have the necessary data for the estimation of such parameters. Since forestry competes for resources with agriculture, the analysis must be done for all competing crops before the social opportunity cost and social net benefit of a resource in forestry as defined by Gane can be calculated. Such analysis will be enormous.

Some Available Wood Consumption Estimates

The works of FAO like European Timber Trends and Prospects (16) published in 1953, and World Demand for Paper to 1975 (19), published in 1960 and the work of Stanford Research Institute, America's Demand for Wood (54), published in 1954 are some of the works done in the general area of demand/consumption forecast for wood products in other parts of the world. The objective of European Timber Trends and Prospects is to estimate what the European demand for wood and its products were likely to be in 1960--a period of ten years. Two sets of assumptions were made, one for a low and a high level of economic growth and the other for a high and low level of prices for wood products in the year 1960. Four sets of figures for demand in 1960 are presented, each of the alternative assumptions about economic development being combined with each of the alternative assumptions about relative price movements.

In America's Demand for Wood the objectives include an estimate of the consumption of each of the major timber products in 1952 and a projection of these estimates for the target years 1960, 1965, 1970, and 1975 using regression equations of the form,

$Y = a+bx$ where Y = dependent variable

a,b = constants

x = independent variable

In all cases economic estimates are made for all the factors that influence demand for wood products such as population, gross national products and in some cases economic trends.

FAO in World Demand for Paper to 1975 used the log normal distribution function of the form:

$$Y = S_{\infty} \int_{-\infty}^{t} 1/\sqrt{2\pi}\ \text{exponent}_{-t^2/2}\ dt$$

where Y = dependent variable

$t = (\ln x - m)/g$

S_{∞} = Saturation value in kg/capita

x = independent variable

m and g = constants

and cross-sectional data of national income and paper consumption from different countries to estimate a demand curve for paper. This form is realistically used when the dependent variable will approach a saturation value as the independent variable increases and when the dependent variable will rise according to the sigmoid represented by the integral of the log normal distribution. The elasticity coefficient decreases as the independent variable increases. The saturation value for the dependent variable is not a fixed value but may change with time. It is simply a tool for the design of a suitable mathematical formula to fit the statistical data. The log normal demand function offers little advantage over the straight line function when making projections over a

limited range in the independent variable. Its usefulness lies mainly in its being applicable over a wide range of the independent variable.

With respect to Nigeria specifically there are two estimates to which references can be made. One of these, Forecasting Potential Consumption Requirements for Nigerian Forest Products, by E. E. Enabor (46) covers estimates of annual consumption of fuelwood, other roundwood, sawnwood, wood panels, paper and paperboard for up to 1985 but assumes that the current per capita consumption level of different wood products will always remain the same and that population change is the only variable that determines wood consumption. This allows the consumption of all the wood products to grow at the same rate of 2.5 percent per annum or the assumed rate of growth of total population. The other estimate of wood consumption for Nigeria is contained in FAO, Agricultural Development in Nigeria 1965-1980 (15) but the report is not detailed enough to indicate the assumptions made in arriving at the estimates.

The Objectives of the Study

The survey of the estimates of annual consumption of wood for Nigeria presented above indicates that the available consumption information is not adequate to form a basis for decisions concerning expanding investments in Nigerian forestry industries. The duration of the estimates are not long enough for an industry where investments mature with long time lags. Some of the available estimates have also ignored important variables that determine consumption of wood, such as changes in the level and distribution of income, urbanization, public investments, etc.

The present study based on a national wood consumption survey considers not only changes in population levels as determinants of demand for wood but also changes in level and distribution of income, educational opportunities, urbanization, public policies, and distribution of population. The specific objectives of the study are:

1. to specify a general model for the forestry sector in preparation for the formulation of a specific wood consumption model.

2. to formulate a specific simulation model of the wood consumption component which can always be updated and used to estimate annual consumption of wood products when necessary data are available and when desired.

3. to use the model of the wood consumption component to estimate annual consumption of wood products for Nigeria from 1965 to 1974 and project future consumption from 1975 to 1990.

4. to make limited prescriptions for actions that would lead to the attainment of the forestry sector objective of providing the needs of the country in timber.

5. to identify aspects of the forestry sector where further economic studies are necessary.

It is particularly intended that information provided by the study will be useful for long range planning of public and private investments in forestry industries in Nigeria.

The Approach of the Study

The approach employed in this study is the General Systems Analysis and Simulation Approach (GSASA). The GSASA model which we shall construct for the wood consumption component of the Nigerian forestry sector is general with respect to techniques, kinds of data and information used in formulating and operating it, and with respect to its philosophic orientation.

Multidisciplinary Nature of the Approach

The model of wood consumption is general with respect to sources of data and techniques. It accepts data and information from many sources including time series, survey data, normative and non-normative judgements of informed people, etc., and uses many specialized techniques including mathematics, econometrics, statistics, input-output, systems science, simulation, etc.

The general systems analysis and simulation approach recognizes that various specialized techniques are often too limited in scope and by their assumptions to be used alone to solve problems involving change in technology, institutions, and people. For example, if we restrict our definition of economics to that which considers technology, tastes, income distribution, population, institutions, perfect knowledge, etc., as given, the problem under investigation here will virtually disappear because wood consumption is a function of changes in those variables. Economists who define economics this way often prescribe the right action as that which maximizes the difference between the sum of _goods_ and the sum of _bads_. Well trained economists and the general systems analysts recognize that such prescriptions are based on certain assumptions which are often not met for problems involving change and uncertainty with respect to technology, institutions, and people. These assumptions are that a normative common denominator is available which permits different _bads_ to be added together, different _goods_ to be added together, and the subtraction of the total _bads_ from the total _goods_; that the normative common denominator is interpersonally valid; that actions can be ranked in the order of decreasing net advantage per unit of sacrificed good or incurred bad; and that the rule of defining the right action is simply one of subtracting the sum of the bads from the sum of the goods and adopting that which maximizes the difference. Many problems which involve change and uncertainty do not meet these assumptions.

When generalized systems analysis and simulation investigators encounter problems in which the above preconditions for maximization are not met, they try to approximate them by designing a general model which utilizes normative and non-normative information from various sources including interaction with experienced persons, by iteratively making adjustments in the relevant variables and by tracing the consequences of the changes in the relevant variables through time. It is the ability to trace the consequences through time that makes such a model a simulation model. It can do this with minimum cost in personnel, time, and other resources because it is computerizable.

The wood consumption model is also a systems model because the wood consumption component is viewed as a system made up of subsystems, but itself is also a subsystem of a still larger system, the Nigerian forestry sector. When the general systems simulation model of the forestry sector is developed the wood consumption model will be a submodel of it and it will then be easier to study the interactions among the components of the forestry sector including the wood consumption component and between the forestry sector and the other sectors of the national economy.

In summary, systems analysis and simulation studies offer a multidisciplinary approach for interrelating the different aspects of complex problems involving change and uncertainty to see the consequences through time of alternative choices of actions. Its projections are objective estimations of the consequences through time of alternative choices in terms of attaining several relevant goods and incurring several relevant bads for which there may be no common denominator for evaluation.

Philosophic Position of the Approach

The model is also general with respect to philosophic orientation. It recognizes that practical problems involve change in technology, institutions, and people. Such problems require normative as well as non-normative knowledge to reach prescriptions for their solutions. Undue adherence to any one or unthoughtout combinations of philosophic positions such as normativism, positivism, pragmatism, etc. may not lead to adequate definitions and solutions of practical problems.

The normativists are sometimes able to define and arrive at solutions to practical problems when they hold that objective knowledge both abstract and prescriptive of goodness and badness is possible because prescriptive knowledge about what is right and wrong depends on both normative and non-normative knowledge. But when certain forms of normativism hold that non-normative knowledge is impossible they lose that part of rational prescriptive power which depends on non-normative information and lack adequate non-normative knowledge to work on the practical problems.

Outright non-normativism prevents the attainment of objective prescriptive knowledge since prescription requires both objective normative as well as objective non-normative knowledge. Adherence to outright non-normativism precludes problem definition as well as prescriptive solutions to problems and it is an inadequate philosophic position for practical problems.

Pragmatism is based on the presumption that normative and non-normative knowledge are interdependent in the context of the problem they are being used to solve. Its strength lies on its focus on the problems of society. Pragmatists attach importance on tests of workability in solving problems while, perhaps, underestimating the importance of the hard descriptive and abstract normative and non-normative knowledge of the traditional academic disciplines. This makes problem solving techniques more important than knowledge. For more complete discussion of philosophic position, see Johnson (29).

Before we summarize the philosophic position of GSASA we shall stop to define some terms like practical problems, objectivity, and goodness and badness which we have used sloppily. The words good and bad are primitive undefined terms like weight and distance on the non-normative side which we either do or do not know their meanings from experience and which are hence, basically undefinable.

Objectivity is used to qualify both an investigator and his investigation. An investigator is objective if he does not identify himself and his prestige with some particular concept so that in the absence of pride or humiliation which follows self-identification with a concept the investigator will be willing to subject any relevant concept to certain tests and is willing to revise a concept that may fail any of those tests. In the same way we use objectivity to qualify a concept and define as objective those concepts that would pass those tests established by practicing economists such as the tests of consistency, clarity, and workability.

The test of consistency is both an internal and an external one. The internal test requires that a set of concepts must bear logical relationships to each other whether they pertain to the past, the present, or to the future. The test of external consistency is a test of experience. An existing concept is compared with concepts based upon new experience. The text of clarity requires that a concept has a clear and specifiable meaning. A concept is clear if it can be understood and communicated from one person to another who has the relevant knowledge. The test of workability is a pragmatic test. Concepts are often used to solve problems; for instance, they are often used to predict certain outcomes. If that outcome fails to materialize the concept used in predicting it has flunked the test of workability.

Objectivity is not limited to the physical or biological sciences; it is also applicable to social sciences. It is not confined to non-normative as contrasted to normative concepts. Both may pass or flunk any of the tests of objectivity.

A practical problem as contrasted with a theoretical one is that which decision makers have to live with. Even when they decide not to solve it a decision is, in effect, made to live with it and its consequences. In contrast a theoretical problem is a problem of belief about whether alternative normative and non-normative concepts describe or might describe reality. Such a problem may exist for years in an academic discipline without pressing for a solution.

We can summarize the philosophic positions of the generalized systems analysis and simulation approach by saying that its investigators show a willingness to estimate the future consequences of actions without being constrained by the economists' tendency to maximize unless the preconditions for maximization are met. If not met, before they maximize the generalized systems analysis and simulation investigators first approximate those conditions by building a general model which can utilize both normative and non-normative information, can make adjustments in relevant variables by iterative methods and trace the consequences of those adjustments through time. Generalized systems analysis and simulation investigators also show a willingness to work objectively with the normative as well as the non-normative concepts. The process of systems analysis and simulation involves team work among interdisciplinary researchers and policy-makers thus making the policy-makers a part of an objective research team.

Application of the Approach

The approach is a flexible iterative process involving (1) problem formulation, (2) mathematical and computer modeling, and (3) testing and validation of the model as presented in Figure 1.

1. Problem Formulation: An early step in problem formulation is the recognition of what normative and non-normative knowledge are relevant to the problem under study. The intent is to identify the major questions which will be put to the model after it is formulated such as what will be the consequence on annual consumption of various wood products if national income grows at a different rate or if the public sector changes its investment priorities, etc. During the problem definition and subsequent stages of model formulation, improvements are made in both the normative and non-normative information which

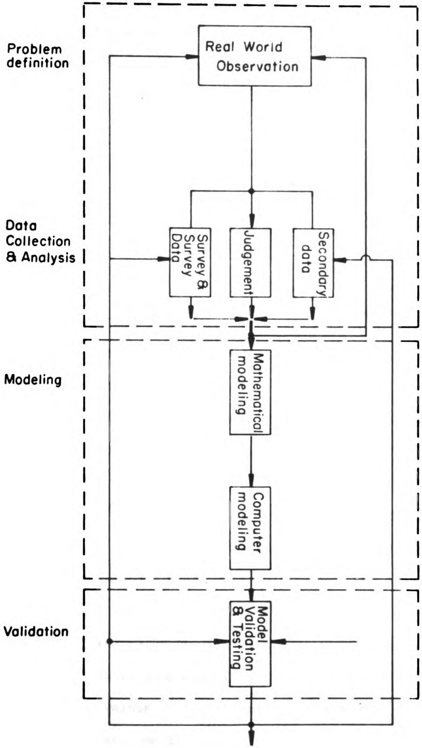


FIGURE I: APPLICATION OF GENERALIZED SYSTEMS ANALYSIS AND SIMULATION APPROACH TO WOOD CONSUMPTION MODEL.

contribute to the model. The process of problem formulation includes, in addition to a wood consumption survey to collect both normative and non-normative data on wood consumption behavior of people, a series of interactions in formal and informal meetings with decision makers, and businessmen in the forestry sector, consumers of various wood products in Nigeria and with professors and graduate students at Michigan State University who have experience in Nigerian economy and in the systems analysis and simulation approach. The major policy questions and variables which determine wood consumption behaviors and the interrelationships between them were isolated more easily than they might have been without such interactions.

2. Modeling: Mathematical modeling involves specifying in mathematical symbols the relationships between state variables involving the level of a variable at a given time, a set of parameters that defines the structure of the system like elasticity coefficients, a set of exogenous variables that influence the system behavior, and a set of variables which can be controlled to alter the systems performance in various directions. The mathematical model also specifies a set of intermediate output variables which measure how well the system model corresponds to reality and a set of output variables. In general the mathematical model illustrates how the variables which define the state of the simulated system in time period t + 1 is a function of the state of the system and the values of the parameters, exogenous variables, and the control variables at time t.

For programming the computer version the entire model is provided both in mathematical form and in detailed flow diagrams using variable names compatible with the programming language of the CDC 6500 computer at Michigan State University, but in such a way that it is transferable to some other computers like the CDC 3600. Both the mathematical and flow diagram forms of the model of the wood consumption component are presented in Chapter IV.

3. Model Testing and Validation: One problem of general models is the need for testing and validating them and their projections. Unlike specialized models using data from controlled sources general models use data from different sources including judgement, time series, etc., brought together from many different sources and with different degrees of validity. This implies that several kinds of information with unknown levels of validity are being used to forecast the attainment of a wide variety of goods and avoidance of a similarly wide variety of bads. The consequences of making wrong decisions on the basis of the projections provided by a general model will be incurrence of a wide variety of bads or attainment of a wide variety of goods if the decisions are right. The rate of wood consumption depends a great deal on the rate of growth of national income. The national income estimates available do not go far enough into the future and are of uncertain accuracy. But we want to be sure that the future rate of wood consumption which we estimate is the rate that will actually prevail if we can avoid the consequences of wrong decisions.

The theory of statistics is not adequate at its present level of advancement for establishing appropriate confidence intervals for the various kinds of data used in a general model. It is not adequate for making choices between more than two alternatives, particularly when the alternatives involve utilization of several kinds and sources of data or if the alternatives are possible prescriptions to solve more than one problem each of which may result in the attainment of multiple goods and avoidance of multiple bads for which a common denominator may not be found.

The need for validation is intensified by the fact that machine rather than man is used to put together the many different parts of the model and to make the complex computations involved in a large model. As long as the programming rules are met the coumputer will provide mathematical solutions even though the procedure may be illogical. If a model is large a programming error can elude a good programmer but can be detected by appropriate validation and verification tests.

In general, the more rigorous statistical and econometric methods of verification and validation involve the application of tests of coherence with observed and recorded experience, logical internal consistency of the concepts, interpersonal transmissability of the concepts between persons equipped with relevant knowledge, and workability when applied to problems. The predictions which our model has reached can be accepted or rejected as false according to the same tests. These tests have been repeatedly applied at different degrees of rigor in bringing our model to its present stage. They were applied in assembling data, modifying and developing model components, and in combining various components of the model. Later in Chapter VII they will be applied in evaluating model output. In that chapter we also introduce more information about the inaccuracies by changing some of the parameters used by the model to obtain an indication of the consequences of possible variations and errors in the data. This process of testing the sensitivity of the projections yielded by the model to possible errors in the data is helpful in finding out how much poor information is generated by a wide variety of unvalidated data which are used in making the projections. Model testing never stops; it takes place each time a new use is made of the model.

The normative content of the model deals with goodness and badness of things, situations, and conditions or with the questions of value. Both the normative and the non-normative content are verifiable according to the procedures described above. The factual elements of the earlier versions of the wood consumption model which have not met these tests were replaced. Those elements still retained in the model are those which have not yet failed the tests. In testing the normative concepts, reliance was placed on experienced Nigerians to verify the validity of weights attached to such things, conditions and situations as wood versus non-wood in various parts of buildings, wood versus alternative sources of fuel, rural-urban distribution of population, etc., in the future. We want to stress the fact that the normative and the non-normative concepts, information, estimates and forecasts of this model are only tentatively true even if they survive the four tests described above. Time will reveal inaccuracies in both the normative and non-normative information used in reaching these estimates and predictions. Time will also reveal relevant normative and non-normative information not conceived at present.

Complexity of the Approach

Some object to generalized systems analysis and simulation studies because they are complex and not easily described. They involve a wide variety of techniques and model components. Attempts to make the models conceptualizable by means of flow diagrams scarcely improve clarity. The diagrams are replete with boxes, lines, and arrows but still messy.

The analysis of a problem involving technological, human, and institutional changes is difficult to describe in terms of any one discipline be it mathematics, economic theory or any other. Also, the closer to reality a model approximates, the more techniques and submodels it necessarily involves and the more complex it is likely to become. This truth is not unfortunate because the policy makers do not have to construct the general models by themselves. The situation is comparable to our transportation needs. We do not build the cars we drive; further, most of us do not understand how the engine works yet we drive our car and meet our daily transportation needs. We do this by simply specifying our transportation needs in terms, for instance, of size, reliability, safety, economy, comfort, speed and so on and rely on automobile engineers to provide them. Similarly if general systems models are complex and messy because they approximate real world situations and if approximation of real world is desirable, then systems analysts should be furnished with information about systems needs and be relied upon to construct and interpret general systems models.

Organization of the Thesis

The thesis is organized in such a way as to provide general information on Nigeria in Chapter I for the reader who is not familiar with that country. In the same chapter we also present the coverage and the specific objectives of the study as well as the general approach to studies employed by the thesis. In Chapter II, we present a framework for a general systems analysis and simulation model for the Nigerian forestry sector. We do not formulate this model in this study because it would be too large for a thesis and because doing so requires more resources than are available for the present study.

Chapters III to VII concentrate specifically on the wood consumption component. In Chapter III we describe some of the terms we shall use in developing and operating the model of the wood consumption component. We shall also discuss in the same chapter the important variables in the model. The discussions in this chapter will facilitate the reader's understanding of the aggregations we have made in wood products and in wood using subsectors to simplify the analysis, and make it easier for the reader to follow the structure of the model.

The model of the wood consumption component is presented in Chapter IV in three different versions; a general non-quantitative conceptualization, the mathematical model, and the computer models. Depending on his quantitative background and interest, the reader can conceptualize what the model is about by reading only the first and/or the second version or all three versions. In Chapter V, we present and discuss data used to operate the model so that anyone wanting to make use of the projections provided by it should be aware of the strengths and weaknesses of the data on which those projections are based.

Projections generated with the model are summarized in Chapter VI. Some of the validation tests discussed in Chapter I are applied to the model output in Chapter VII. In Chapter VIII, the last chapter, we summarize the thesis, make suggestions for actions to achieve the goals of the forestry sector, and conclude by identifying important aspects of the sector that need further study.

CHAPTER II

SPECIFICATION OF A SIMULATION MODEL FOR THE FORESTRY SECTOR

Introduction

We mentioned in Chapter I in the section on the scope of the study that the emphasis of the study will be on the consumption component. Due to lack of time, research resources, and the "normal" size of a doctoral dissertation, we shall merely specify the model of the whole sector and develop only the consumption component in detail leaving to later and, perhaps, others the task of creating the whole model. Thus, in this chapter we shall specify the whole sector model to provide the setting for our detailed work in later chapters on the consumption component.

This will involve discussions of (1) background of the forestry sector including a definition of the sector, the extent of the forest resources of Nigeria and the ownership of forestry industries in Nigeria, (2) interrelationships among the various components of the sector and between the sector and other sectors including description of the various components of the sector, and (3) decision making in the forestry sector including public decisions with some examples and also private decisions. We shall summarize the chapter by pointing out the importance of developing the whole model before we can make a serious analysis of the consequences of decisions made and actions taken in the sector.

Background on the Forestry Sector

What is Included as the Forestry Sector

The forestry sector in Nigeria includes the industries related to the production, processing, and distribution of wood and minor forest products; the conservation of wildlife, soil, and watersheds; and the development of tourism and other recreational facilities. In this study we shall be concerned with only those industries related to production, processing, distribution, and the consumption of wood products.

Forest Resources of Nigeria

There are about 96,000 square kilometers of natural forest reserves (21). Virtually all of these are secondary-growth forests. About 22 percent of the natural forest reserves is located in the high rainforest zone and produces about 90 percent of total sawlogs. Seventy-eight percent is located in the savannah and subsahahel zones and produces mainly fuelwood and building poles (40). In addition to this, in 1972 there was about 74,000 hectares of forest plantations growing mainly teak, Gmelina, and a range of indigenous species in the rain-forest areas and eucalyptus, neem, and acacias in the savannas. Wood is also supplied from various non-forest sources including homesteads and farm lots. It was estimated in 1964 that this source supplied up to 50 percent of all sawlogs processed in Nigeria (48).

Nigerian forests contain a wide variety of timber species, perhaps as many as 600. Only twenty-four (48) of those including mahogany

(Khaya ivorensis), sapele-wood (Entandrophragina cylindricum), iroko (Chlorophora exdelsa), African walnut (Lovea klaineana), guarea (Guarea thompsonii), opepe (Sarcocephalus diderrichii), agba (Gossweilerodendron balsamiferum), obeche (Triplochiton scleroxylon), etc. are being extensively utilized at present. It is estimated that up to 100 of them are utilizable but they are unknown in the world market and wood industries are generally conservative with respect to accepting new species.

Felling of trees is regulated in the reserves and it is the policy of the government that steps be taken to assure that timber yields from them is sustained. But felling of trees in the non-forest reserves is not controlled and no efforts are made to replace the trees once felled. As sawlog trees from the non-forest sources become exhausted, production will have to be expanded in forest reserves.

Domestic consumption of wood is growing very fast as a result of increasing population, changing characteristics of the population, and high rate of spending on construction industries in recent years. The rate of felling has, as a result, been such that there is now a scarcity of sawlogs. Immature and lower grade logs are now being harvested. Replacement efforts are no longer keeping pace with removals in the forest reserves. In the Western State, for example, which supplies most of the sawlogs from forest reserve sources only 57 out of 85 square kilometers exploited annually receive limited regeneration treatments consisting of enrichment planting and periodical opening of the canopy and cleaning of undergrowth. Ironically, in spite of these shortages usable trees are felled and burnt or abandoned during farming operations in the rainforest zones. Because of limited transportation and processing facilities and because of lack of information about availability of markets for wood in other parts of the country, it is not worth the efforts of the farmers to salvage wood for utilization.

It is asserted that the present forest lands cannot sustain the growing domestic need for sawlongs (48). Because of the expanding population, urbanization, industrial estates, modern road systems, and agricultural tree crop plantations, there is little hope of increasing the area of forest land. The natural forests are gradually being converted into forest plantations in the effort to increase wood production by intensive methods. The annual rate of expansion of forest plantations has grown from 1,700 hectares in 1960 to over 6,000 hectares in 1970. It is proposed by the various state governments owning forest reserves that the annual rate of conversion of natural forest reserves into forest plantations should be as much as 20,000 hectares by 1985.

Research in various tropical countries including Malaysia has, however, shown that there is a limit to which wood production per hectare of forest land can be increased by intensive methods (3). This limit is imposed by maximum attainable limits in the number of species, basal area, and crown size per stand observed in the tropical rainforests for most of the species. The extent of these limits has not been verified for Nigeria. If they exist it means that the potential for domestic production of wood by extensive methods is limited by land area and the potential for domestic production by intensive methods is limited by ecological conditions. Under such conditions Nigeria must consider the possibility of looking beyond her borders for some of her future consumption needs.

Wood processing going on in Nigeria includes conversion of sawlogs into lumber, plywood and veneer, conversion of wood into charcoal, conversion of pulp into various products including paper and building boards, and wood seasoning. Conversion of wood into pulp will start soon when the four pulp mills planned by the Federal Government are set up. The lumber industry is diverse with respect to both the size and technology of operation. It varies from a few very large mills like those of the African Timber and Plywood Company to small one or two-man operated mills. The technology varies from the most modern techniques employed by large mills to the traditional techniques employed by pitsawyers. For example, in 1970, there were 171 wood processing mills which employed more than ten people per mill. Four of these produced 90 percent of all processed wood exported from Nigeria the same year (45).

Ownership of Forestry Industries

All forest reserves and forest plantations are publicly owned by state and local governments. Exploitation is controlled by the state governments which also are responsible for various forest maintenance practices. The Federal Government assists the state governments in major investment projects with financial and personnel aids. The local governments receive a share of the revenue accruing from the forest products even though their contributions towards investment costs are minimal. This is partly because the land belongs to the local community and partly because the cooperation of the local governments facilitates forest protection from illegal removal of sawlogs, purposeful forest fires for hunting purposes, and encroachment by farmers on forest lands.

Non-forest sources of wood are privately owned and controlled. Privately owned forest lands are limited although it is a written objective of the public forestry sector to encourage the establishment of private forests (46). Private investments in forest plantations are beginning in the wood scarce states of the north. The reasons for limited private forest lands are not well known. One of them may be the traditional land tenure system. Land is owned by the community and allocation and use is controlled by emirs, chiefs and elders who act as trustees for the community. The plots worked by the individual farmers are small and scattered. This has been a deterrent to the investment of private capital on land and to the establishment of plantations.

Another reason may be that individuals are reluctant to invest their land in forest trees because of low growth and high interest rates. Although fast growing species of trees are being introduced both from outside and by research in Nigeria, forest trees are generally long-range, low return investments. Some will not mature in the life time of the investor. In addition, forestry generates many externalities which have no monetary values. The private entrepreneur will base his decision to put his land into forest on his valuation of risks that go with long range investments, the importance he attaches to who may inherit the investment, and also the many external benefits of the investment which have no monetary values. Such valuations often result in the land being more valuable to the individual in other than forest uses.

If the private sector cannot be relied upon to provide the forest products including wood products, the conservation of wildlife, soil, and watershed, etc., which the society needs, it may be right for the public sector to provide them. We should not, however, ignore some of the problems which public ownership of productive resources may create. Frequent occurrences of overexploitation, illegal removal of trees, purposeful forest fires, and overgrazing of forest lands are traceable to public ownership of forest lands.

Local authorities to whom forest revenue accrue and who have overhead cost in terms of land but zero marginal cost, will likely press for overexploitation if left uncontrolled since they do not bear the cost of regenerating the forests. Similarly, a hunter once sure that he will not be caught will burn public forest land to catch an animal as the burning has a zero cost to him. If held responsible for regrowing the forest, he will not burn it down in order to catch an animal. Similar reasoning can be used to explain the overgrazing of forest lands by nomadic herdsmen whose activities are uncontrolled.

Since public ownership of forest reserves is desirable, more serious efforts are needed to control abuses of public forest lands by the private sector. There are at present forest ordinances enacted against such abuses as illegal removal of trees from forest reserves, etc., but most of the cases brought against violators are lost in the courts. The forestry departments have to secure lawyers to plead their cases from the justice departments. These lawyers lack forestry backgrounds and cannot realistically argue the case for forestry. Many bureaucratic procedures are involved in transferring services from one government department to another and this often results in loss of time. In addition, these government lawyers are civil servants who receive their pay whether the case is lost or not. Two alternatives can be recommended, the forestry departments should train their own lawyers and provide them with background in forestry or they should be free to hire private lawyers so that they can get the most competent to argue their cases.

Anybody who is benefiting directly from the forest products should where possible be made to pay for at least part of what he gets. If nomadic herdsmen are to graze their cattle in the forest reserves, they should be taxed before they can do so. Before this can be done, however, the forest reserves boundaries should be well defined. The potential of the land for pasture and the number of cattle it can support should be ascertained. This would involve extensive investigations and capital losses to some people. The situation is serious and calls for hard decisions and actions from policy makers.

The processing industries, unlike other forest industries, are privately owned, partly be foreign investors and partly by Nigerians. In the very large concerns, a Nigerian government may be a shareholder. However, in general the large concerns are owned by foreign investors. In 1970 the four mills which produced 90 percent of wood exported in processed form and which owned 80 percent of logging licenses were foreign owned (45). In that year there were 124 mills owned by Nigerians, 44 owned by foreigners, and 3 owned together by both Nigerians and foreigners (45).

There are no conditions for entry into the industry by Nigerian investors. The only obstacle is access to sawlogs which is not a problem to small scale millers who do not have high overhead costs since they can operate when they can get sawlogs and close down when sawlogs are not available without incurring large capital losses. The relatively free entry into the wood processing industries coupled with the excess profit which was observed in the industry by Okigbo (48) has attracted many entrants over a wide range of scale and technique of operation into the industry. They include small owner-managed mills who employ traditional techniques such as pitsawing as well as very large integrated mills which employ the most modern techniques available to produce not only lumber but also plywood, veneer and other wood panels. The owner-managers according to Okigbo (48) more often than not possess neither the technical knowledge nor previous experience necessary for the success of the mill. They are able to make profit because their overhead costs are minimal.

The consequence of this condition of the industry is much wastage of wood at the processing stage. The average saw mill conversion factor for the country is 50 percent. The social cost of waste of this magnitude in a country which is facing a shortage of wood products is high enough to inspire action from the public sector. Such actions can be minimum levels of training and capital investment requirements for entry into the industry. It can be the use of tax policy to remove some of the excess profit so that only efficient producers can stay in the industry.

At the present time Nigeria is insisting on exporting processed rather than unprocessed wood so that the value added in processing will be internalized. It is possible that the foreign companies which bought Nigerian wood as sawlogs would now want to process them in Nigeria to maintain the quality for their home consumers. They should be encouraged to stay because they are likely to be more efficient than their domestic counterparts as they have the necessary capital to take advantage of scale and are more likely to have the necessary training and experience. In so doing, care should be exercised to assure that non-monetary goals (e.g., increased employment, redistribution of population, utilization of by-products, utilization of lesser known species, etc.), which a profit motivated private entrepreneur is likely to ignore, are not lost to society.

Foreign investors assume more risks than their domestic counterparts. An example of this is the indigenization policy which politicians in some countries sometimes use to please their constituencies even when there are no other basis for such actions. Examples also exist in recent years where foreigners were expelled from some countries. Such policies usually involve capital losses by the foreign investors which should be borne in mind when specifying the conditions for their entry.

The problems of ownership of resources in the forestry sector both in the forest industries and in the wood processing industries are serious but not enough is known about them. Detailed investigations are needed in this area to determine the extent of cost to society involved and what the solutions can be.

How the Forestry Sector Interacts with Other Sectors

The Components of the Forestry Sector

Before we discuss the interrelationships among the various components of the forestry sector, we shall first describe the components. They include unprocessed wood supply, wood processing, wood distribution and consumption, forest education, forest research, and foreign trade in forest products. Each of these can be modeled independently as a submodel of the forestry sector model.

1. Unprocessed Wood Supply: The sources of supply of raw wood can be grouped into forest reserve sources, non-forest reserve sources, and possible foreign market sources. The forest reserve sources can further be grouped into unmanaged natural forests, managed natural forests and plantation forests. Non-reserve sources can also be further grouped into plantation forests and non-forest sources of wood (see Figure 2). Non-forest sources of wood include home- and farm-stead trees. As pointed out in the previous section, the possibility of expanding forest lands beyond the present 96,000 square kilometers is limited because of other demands on land.

2. Wood Processing Component: Wood processing includes conversion of sawlog into lumber, plywood and veneer; conversion of wood into charcoal, and wood seasoning. Conversion of wood into pulp will start soon in Nigeria when the proposed four pulp mills are set up. The lumber industry is diverse with respect to both the size and technology of operation. It varies from a few very large mills like those of the African Timber and Plywood Company to small one- or two-man operated mills. Technology varies from the most modern technique employed in large mills to traditional techniques employed by pitsawyers. The greatest problem of small mills is the seasonal shortages of sawlogs. Small mills have been able to get by because they can shut down at off seasons because of their low capital investments. The very large mills have integrated both logging at one end and more advanced processing like veneer and plywood manufacture at the other end. There are potentials for further integrations. Forward integration reduces wastage which is currently as high as 50 percent in small mills. Mills integrated with final product factories such as furniture factories,

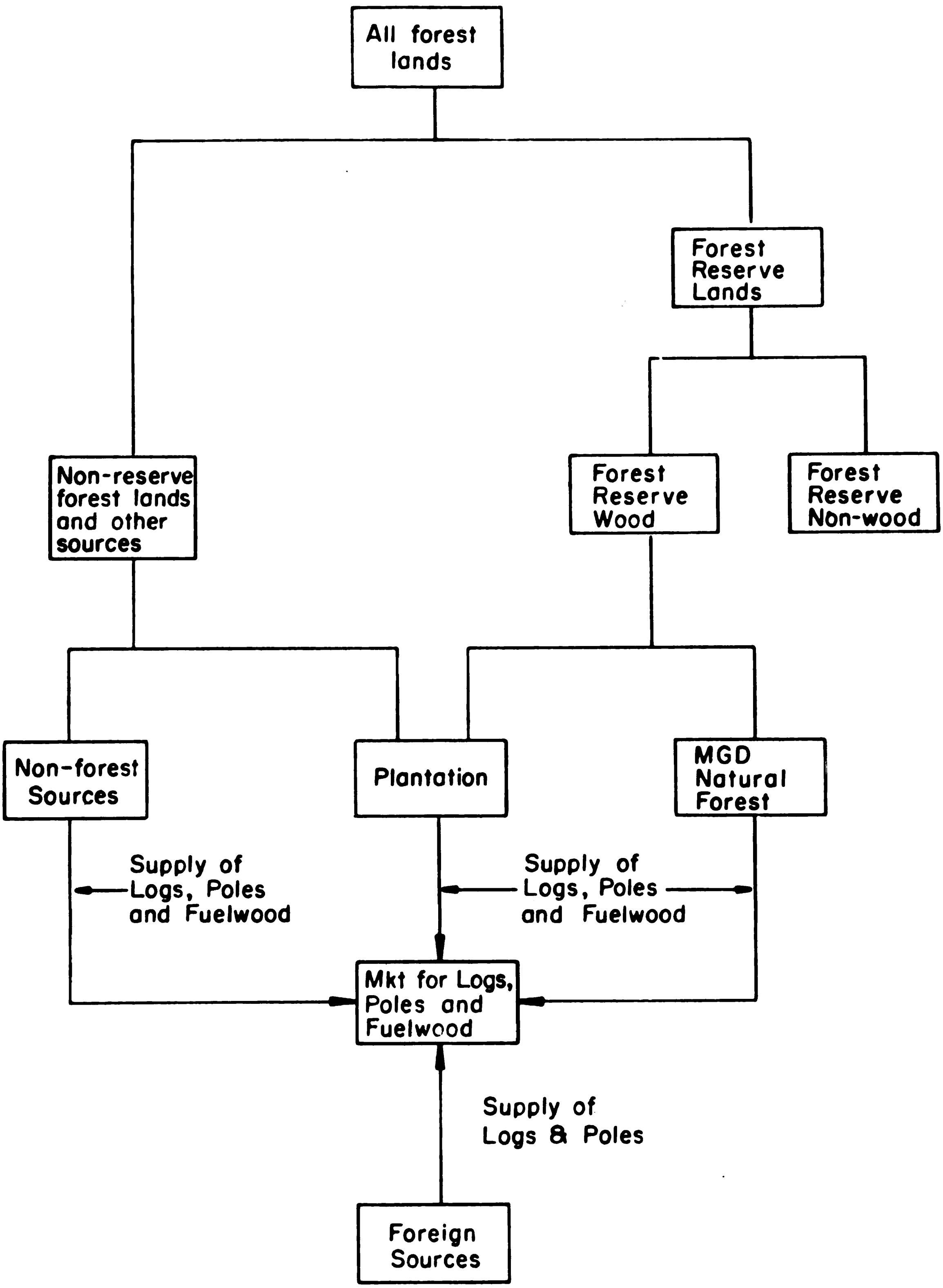


FIGURE 2: SOURCES OF UNPROCESSED WOOD.

building construction, charcoal manufacture or with a pulp factory can utilize additional volumes of slabs, edgings, and sawdust.

3. Wood Distribution and Consumption: Wood is consumed as unprocessed wood, sawnwood, plywood and veneer, paperboards, charcoal and paper pulp in various residential housing, non-residential building, road and vehicle construction, casket manufacture, paper, etc., subsectors and as fuelwood. Wood products are distributed to the various wood-using subsectors for final consumption both directly from the forest and indirectly through the market.

A high proportion of the wood is used in the raw form mainly in the traditional sectors. Wood used in this form goes directly from the forest to the market or from the forest to the user if the user owns the forest. Wood used in processed form goes from the forest to the processing mill if the exploiter owns the mill. Sometimes logs reach the factory through the market when factory owners do not own exploitation concessions but buy their logs from those who own concessions.

All processed wood is distributed through the market. Wood from the very large mills is distributed through company licensed distributors who sell both to the final product producers as well as to a large number of small retailers in market sheds. Smaller mills sell both directly to final product producers and through many small retailers. More highly processed wood like plywood, veneer, paper boards, and wood panels is distributed through larger scale retailers who can provide more adequate storage.

Most savannah and sub-savannah states are self-sufficient in fuelwood but depend on the rainforest zones for sawnwood. Consequently, there is extensive internal trade in lumber, plywood and veneer. Wood product prices vary widely between wood surplus and wood deficient zones. For example, by the end of 1974, the price of fuelwood was about four times in Enugu and eight times in Sokoto what it was in Ibadan.

4. Forest Education and Training: Professional training in forest education is carried out at a university department of forestry. Courses are available up to bachelors degree in forest production, wildlife, and wood technology. For specialization beyond the bachelors degree, students are sent to more advanced countries.

Two year intermediate training program and some vocational training programs for forest attendants in forest production, sawmilling and wood technology are available in the three schools of forestry located in Benin, Ibadan, and Jos. These schools also offer short refresher courses and special courses.

5. Forest Research: Forest research is conducted in the areas of silviculture, mensuration, tree improvement, forest product utilization among other areas. The major problem of forest research in Nigeria is the non-availability of trained research manpower. By November 1974, out of some 116 research officers only 20 held research degrees. Eighteen held masters degrees and 2 held doctorate degrees. Public service in Nigeria is not attractive to people with the competence and type of training needed for research in the forestry sector. Generally seniority is more important than productivity in pay and promotion. Opportunity for advancement is limited in the hierarchy where only a few will ever hope to attain the principal officer position.

6. Trade with Other Countries: Nigeria exports sawlogs, lumber, and plywood mainly to Western European countries. The volume of logs exported has, however, declined from 470,183 cubic meters in 1962 to

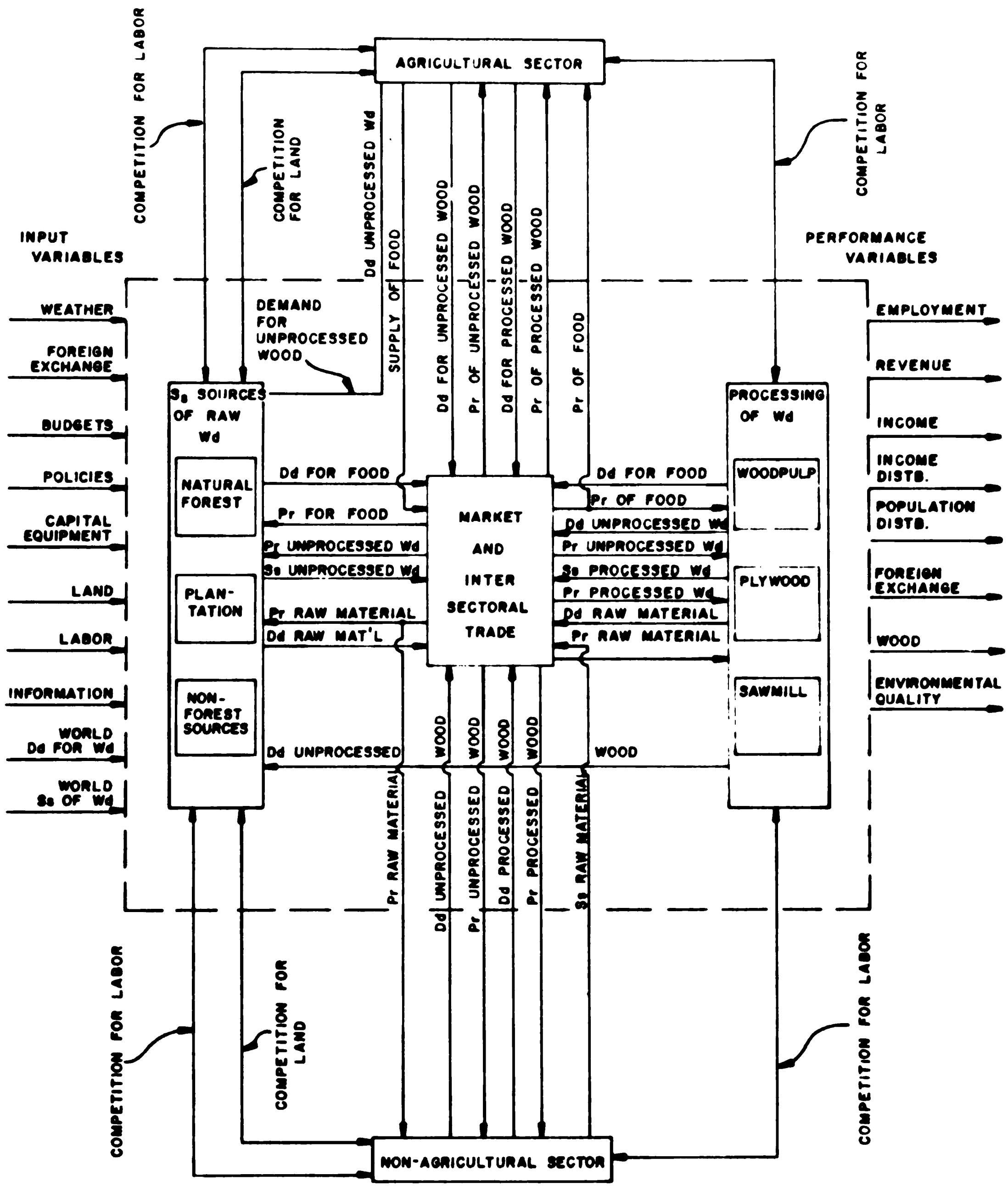
161,847 cubic meters in 1972 (21). The volume of lumber exported has also declined from 67,776 cubic meters in 1962 to 54,593 cubic meters in 1972 (21), while the value of plywood and veneer exported increased from ₦1.56 million in 1967 to ₦1.89 million in 1971 (10). Increased demand at home and government policy of more home processing are responsible for these changes in export trade in wood.

Interactions Among the Components and Between the Sector and Other Sectors

A conceptual block diagram of the wood forestry sector showing interdependences among various components of the sector and between the sector and other sectors of the economy is presented in Figure 3.

The forestry sector receives as input, revenue allocation in form of education, training, research and forest regeneration budgets, land, labor, and foreign exchange for purchase of capital equipment. It yields as outputs wood, minor forest products, environmental quality (soil conservation, watershed conservation, forest fire, recreation), employment, population distribution, income and income distribution, tax revenue, foreign exchange, etc.

The wood supply component provides unprocessed wood directly to the agriculture and other sectors when farmers and other private owners of sources of supply obtain their wood directly from the forest and to the processing component through large sawmills who own logging concessions, and through losses by theft. Apart from these the center of interaction among the different components of the sector and between the forestry sector and other sectors of the economy is the box labelled "Market and Intersectoral Trade." The unprocessed wood supply component provides unprocessed wood to the market and it is bought by smaller mills



<u>KEY</u>

Dd = DEMAND
DISTB = DISTRIBUTION
MATL = MATERIAL
Pr = PRICE
Ss = SUPPLY
Wd = WOOD

FIGURE 3: INTERACTIONS AMONG THE COMPONENTS AND BETWEEN THE FORESTRY SECTOR AND OTHER SECTORS.

which do not own log concessions and cannot obtain their sawlogs directly from the forest.

The processing component provides processed wood to the market which is bought by residential housing; non-residential building; farm, road, and vehicle construction; and other wood using subsectors. The agricultural sector supplies food to the market and the food is bought by the forestry and the other sectors. The other sectors supply raw materials like fertilizers, vehicles, machines, parts, etc. through the market to the forestry sector and to the agricultural sector. Prices of wood products, food stuff, and input raw materials are determined in the market. Information about supplies of products, inputs, and price levels are generated and disseminated.

The forestry, agricultural, and other sectors compete for land and labor among other resources. The rainforest zone, which contains only 22 percent of the forest reserves but supplies 90 percent of the sawlogs also supplies all the agricultural tree crops (such as cocoa, oil palm, and rubber) and much of the root food crops--cassava and yams. The agricultural tree crops also yield soil conservation, watershed conservation, employment, and income, as do the forestry trees and more tax revenue and foreign exchange than the forestry trees.

For example, in 1967, forestry yielded ₦8.64 million in foreign exchange and contributed 4.1 percent of gross domestic product (10). In the same year cocoa, oil palm, and rubber together yielded ₦140.18 million in foreign exchange (10) and agriculture (excluding forestry, livestock, and fishing) contributed 43.0 percent of gorss domestic product. In 1970 forestry yielded ₦8.1 million in foreign exchange earning and contributed 2.3 percent of gross domestic product. In the

same year cocoa, oil palm, and rubber together yielded ₦173.7 million in foreign exchange (10) and agriculture (excluding forestry, livestock, and fishing) contributed 38.7 percent of gross domestic product (26).

If foreign exchange, tax revenue, income, employment or any other commonly supplied product is presented as the major objective of the forestry sector, it is possible that the forestry sector will lose resources to non-forestry tree crops. There are some forest products, like wood, which all sectors need but which no other sector can supply. The production of these exclusively forestry products have been more advantageously presented by the policy makers in the forestry sector as the major objectives of the sector (46).

Decision Making in the Forestry Sector

The purpose of decision is to choose the right course or a right set of courses of action to achieve the desired goals. The Nigerian government has stated the provision of the country's needs in wood as the number one goal (46) of the forestry sector. The need is the difference between estimated annual supply and consumption.

Some courses of action open for choice include annual rates of exploitation of standing forests; annual rate of replanting of exploited forests; how much land, if any, shall be put into or taken out of forestry; how much wood should be imported or exported; how much processing should be done and how much foreign capital investment should be involved; and to what extent, if any, should consumption be controlled. The choice of course of action depends on the magnitude of the need and available resources. Some decisions are made by the public sector and others are made by the private sector. We shall discuss the decisions made in both the public and private forestry subsectors, but first we shall describe briefly how the public forestry sector is organized.

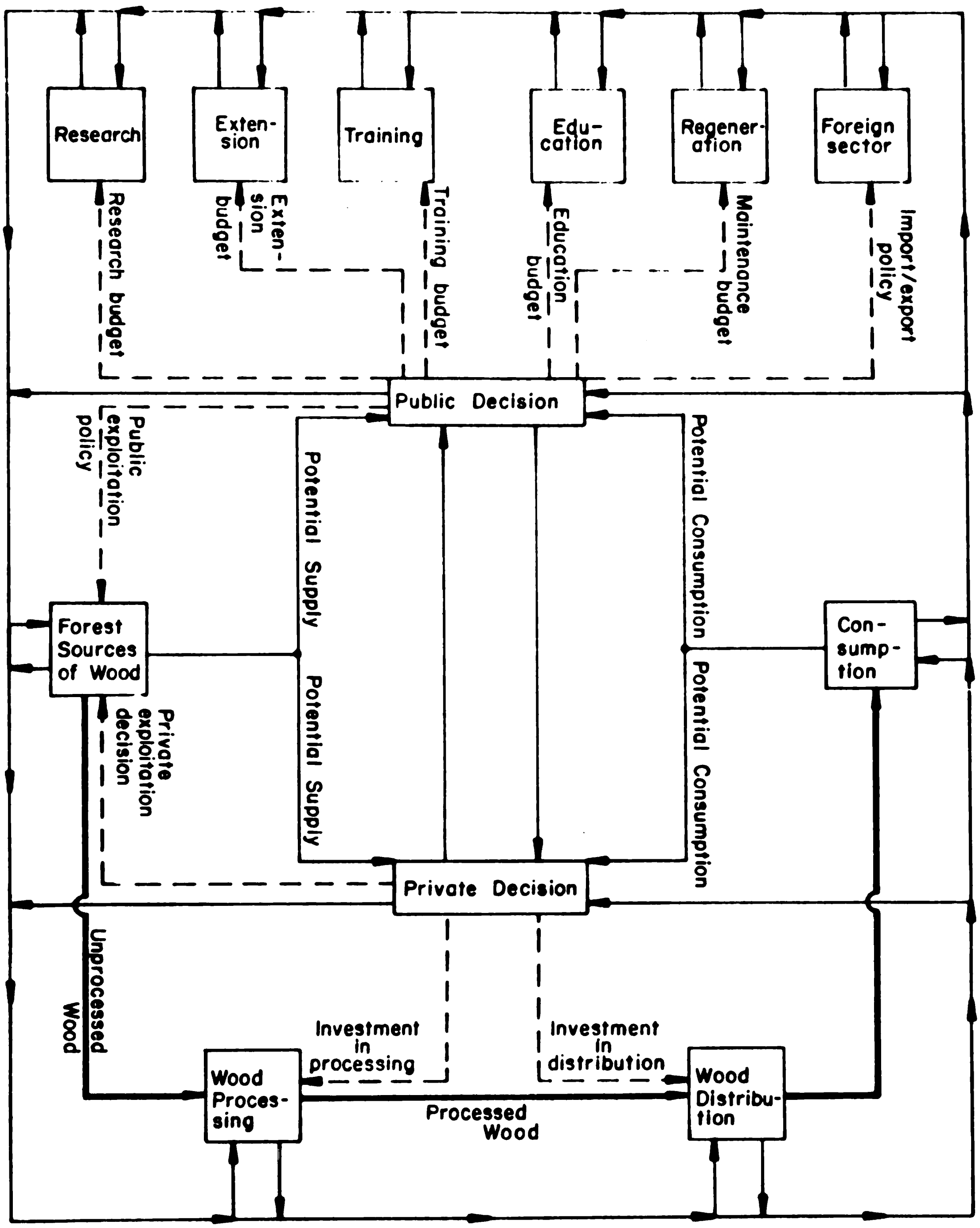
Organization and Functions of the Public Departments of Forestry

We pointed out in Chapter I that Nigeria is at present divided into twelve states each with a government. Forestry is a division of an appropriate ministry in each state. The state divisions of forestry control the forestry resource of the states. The Federal Government has two departments of forestry, namely, the Federal Department of Forestry and the Federal Department of Forest Research both in the Federal Ministry of Agriculture and Natural Resources. These do not own or control forests. State and local but not the federal government own forests.

The functions of the Federal Department of Forestry are "to advise the Federal Government on Forest Development throughout the country, to act as an advisory and liason body to the Nigerian States and to provide development services at Federal and interstate levels" (21). The Federal Department of Forest Research is responsible for forest and forest product research and forest education and training.

Public Decisions

Since most forest lands are publicly owned, most decisions relating to annual rates of cutting and replanting are made by the public sector in the box labelled "Public Decision" in Figure 4. State governments which own forest lands decide the annual rate of cut and how much land will be put into forest uses. The Federal Government



KEY

Investment/policy flow

Information flow

Wood flow

FIGURE 4: DECISION MAKING IN THE FORESTRY SECTOR.

decides how much resources will be invested in forest research, education, and training.

Although most wood processing industries are privately owned, the public sector has a control function over the private sector. When it becomes necessary the public sector can use its control power to eliminate inefficient operators in the processing industries and save some of the wood that is lost by poor processing techniques. Such controls can be the use of tax policy to remove excessive profit, establishment of minimum training requirements and minimum capital requirements for entry into the industries. These will be decided in the box labelled "Public Decision" in Figure 4. The public sector will also make the decisions on whether or not wood will be imported or exported and whether foreign capital will be used in the various forest based industries.

The right course of action will depend not only on non-normative information about the magnitude of the need and on the available resources but also on the priorities between conflicting needs. Any chosen course of action which has desirable normative consequences for the forestry sector may have undesirable normative consequences for other sectors of the economy. We pointed out that land is needed in the agriculture sector for tree and food crops and in the construction sectors for urbanization, industrialization, and road construction as well as in the forestry sector for producing more wood for increased consumption.

Any decision to transfer land from one sector to another implies a judgement that one sector is more important than the other. Such decisions present problems because they cannot be easily made on

the basis of the calculus commonly used by economists to prescribe the right actions as that which maximizes the difference between the sum of the goods and the sum of the bads. This is because it is difficult to establish a common denominator which will permit the summation of the goods, the summation of the bads and the subtraction of the sum of the bads from the sum of the goods. Even if there were such common denominators they may not be intersectorally valid and they should not be used to subtract bads imposed on one sector from the goods imposed on another.

Some Examples of Public Decisions

The Western State contributes over 50 percent of all sawlogs from public forest lands. In 1974, around 85 square kilometers of forest land were exploited and natural regeneration was supplemented with limited silvicultural operations consisting of enrichment planting, undergrowth cleaning, and climber cutting through the fourth year. Research, has however shown that for maximum yield undergrowth cleaning and climber cutting should continue through the tenth year (3). Exploitation was by licensed logging contractors.

Fees charged to the log contractors in 1974 varied from ₦1.04 per cubic meter for low grade species such as *Berlinia*, *Canariium*, and *Daniellia*, to ₦15.52 per cubic meter of such choice species as *Tectona grandis*. Seventeen percent of the revenue generated was paid directly as royalty to local government authorities, 58 percent was used to pay for forest administration, regeneration and replanting, and other recurrent costs. The balance over this type of costs is returned to local government authorities as further royalty. Twenty-five percent was put in trust funds not used for forestry services or payments.

We have pointed out that excess profit generated in the processing industries has attracted many inefficient operators because entry into the industry is relatively free. This implies that the public decision with respect to inefficiency in the industry is to let it continue. Inaction when a practical problem exists implies a decision to live with the problem.

Nigeria exports both sawlogs and processed wood but the volume of logs exported from Nigeria declined from 470,183 cubic meters in 1962 to 161,847 cubic meters in 1972 (21) while the value of plywood and veneer exported increased from ₦1.56 million in 1967 to ₦1,893 million in 1971 (10). Goals of more employment opportunities and more even distribution of population between rural and urban areas which are attained by processing wood in Nigeria for export are more important than the goal of additional foreign exchange which may be earned by exporting sawlogs. This is so probably because sufficient foreign exchange is currently being earned from petroleum. Priorities will likely be redefined when petroleum ceases to earn as much foreign exchange as it does at present.

Private Decisions

In so far as non-forest sources of wood are privately owned and controlled, how much to use this source is determined in the box labelled "Private Decision" in Figure 4. These decisions will probably be based on information on domestic and foreign market prices of wood, public decisions on importation and exportation of wood, and the rate of exploitation of public sources. Similarly, the amount of private land to be converted to forest plantations will be determined in the "Private Decision" box in Figure 4. This would probably be based on present government forestry extension efforts and public investments in forest research, education, and training. It will also depend on expected public import/export policy on wood products, and expected domestic and foreign market prices of wood products, i.e., on private conception of the marginal productivity of land in forest trees relative to marginal productivity of land in other uses.

Most of the wood processing industries, with the exception of the four pulp mills which are about to be established, are privately owned but publicly controlled to the extent that the public sector controls a high proportion of the raw wood supply, import/export of processed wood products, and importation of machinery and foreign capital. Foreign capital is important in the establishment of large plants. In 1970, four processing plants accounting for 90 percent of all processed wood exports and owning 80 percent (45) of logging concessions were foreign owned. There are numerous plants owned by Nigerians, but they are small scale. Private decisions, however, determine the amount of wood processed within limits of constraints set by the public sector and private decision makers are free to decide the degree of processing to be done on the basis of information on consumer taste and market prices.

Reaching private decisions also involves non-normative as well as normative concepts of good and bad. Private decisions differ from public decisions in that if there is a common denominator on the basis of which the goods and the bads can be evaluated, the problem of interpersonal validity of the common denominator may not be as serious in private decision as in public decision. Public decisions are made for more people and affect larger sectors.

Summary of Chapter

We have in this chapter specified on a very broad basis some aspects of what will have to be considered when constructing a general model of the Nigerian forestry sector. The sections on interrelations among the components of the sector and between the sector and other sectors and the section dealing with decision making in the forestry sectors are not independent parts but aspects of each other. The rate of interaction among components and with other sectors will be influenced by the decisions and actions taken in the sector. A decision can be with respect to any of the components specified above, and the decision can be made by either the public or the private sector.

Efforts in the forestry sector are to satisfy the goals of the sector, the foremost of which is the provision of wood to satisfy the increasing demand. The consumption estimates which the consumption model will yield will serve as feedback into the other components and will influence decisions and actions that will be taken with respect to them. We have discussed some of the decisions and actions that are being taken in the sector to realize the stated goals and other needs without tracing the time paths of their consequences. We cannot do this without constructing the model of the sector. And until we trace their time paths we cannot really say too much about them.

We shall devote the rest of this study to organizing the concepts of the consumption component, constructing the model, making the projections of future consumption, and to discussing the consequences of the consumption estimates as much as we can without the entire sector model.

CHAPTER III

A MORE DETAILED DESCRIPTION OF THE WOOD CONSUMPTION COMPONENT

Introduction

In Chapter II we stated that although we shall specify a simulation model for the entire forestry sector, the major emphasis of this study will be on the model of the consumption component.

The specification of the entire forestry sector was presented in the previous chapter. The rest of the study henceforth will be concerned with the consumption component. We shall develop the model of the consumption component in Chapter IV and discuss some of the inputs in Chapter V. In Chapter VI we shall present the projection estimates made with the model and apply some of the validation tests discussed in Chapter I to those model projections in Chapter VII.

Before we do those things we shall describe in more detail in this chapter some of the wood products with which we shall be concerned. We shall describe the various subsectors where wood is used in Nigeria, the factors which shape the wood consumption characteristics of individuals and how the model deals with them. We shall also discuss in this chapter some of the public actions affecting the rate of wood consumption and some other public actions which could be used if desired to further control the annual consumption of wood.

Nigerian Wood Products

A wood product here means wood that is ready to be put in its end use. In this sense wood products in Nigeria include wood not processed at all, wood sawn into lumber, veneer and plywood, wood panels, paperboard, fiberboard, soft board, paper pulp, charcoal, fuelwood, and so on all of which are used in Nigeria. For the purpose of the present study these wood products will be aggregated into five categories: namely unprocessed wood, processed wood, building board wood pulp, fuelwood, and paper wood pulp.

Unprocessed Wood

Unprocessed wood will here include wood cut and used directly in the farm for farm construction; round wood used in permanent positions in various housing construction mainly in the rural areas but also in limited amounts in urban areas. We shall also include as unprocessed wood, wood used in carving household utensils like pounding mortars and pestles, and wood used for carving various farm hand tools like handles for hoes, axes, matchets, etc., used in the traditional sectors.

Most of these wood products are not obtained from the "forest" but from the "bush" or the "farm." Also most of them are not distributed through the market but are cut from the so called "bush" and used directly on the farm. We have considered it necessary to include a crude estimate of consumption of them because if they were not available from those sources, the forestry or another sector would be required to supply them or alternatives to them. Not all unprocessed wood by our classification is from non-forest and non-market sources.

Round wood used as scaffolds during construction of urban buildings or as props in mines, and round wood used in permanent positions in some rural and some urban buildings are supplied from the forestry sector and are distributed through the market. We shall include these in the aggregate we want to consider as unprocessed wood even though some of them may have undergone limited processing like trimming and seasoning.

Processed Wood

We pointed out in Chapter II that the wood processing going on in Nigeria includes the conversion of logs into lumber both by pit-sawing technique and by modern mill technique, manufacture of veneer, plywood, and wood panels. Imported wood pulp is also converted into paper boards for building constructions. We shall classify wood used for paperboards and other pulp products used for building construction separately as building board wood pulp later. We group here as processed wood only lumber, veneer, plywood, and other wood panels.

Most of the processed wood products are distributed through the market. Most of the trees from which wood is cut for processing are grown specifically for wood even though as much as 50 percent (48) of sawlogs converted into lumber may not have come from forest reserves and forest plantations.

Building Board Woodpulp

The woodpulp used in making all woodpulp products like fiber boards, particle boards, hard boards, and soft boards which are used for various building construction purposes are aggregated and referred to in this study as building board woodpulp. At present all pulp and pulp products consumed in Nigeria are imported and distributed through the market.

Paper Woodpulp

Woodpulp used in making all newsprint, writing, and printing paper products are grouped as paper woodpulp. Some of these, like building board woodpulp, are imported as finished products and some are imported as pulp and converted into paper in Nigeria. All paper woodpulp products are distributed through the market. Four woodpulp mills are being established in Nigeria at present to produce woodpulp both for building boards and for paper.

Fuelwood

Although most of the fuelwood is consumed as unprocessed wood, some wood is converted into charcoal before it is burnt for fuel. Charcoal is more commonly used in urban areas than in the rural areas both for domestic cooking and for some industrial heating like blacksmithing, goldsmithing, and welding.

Some of the fuelwood is obtained from trees grown specifically for fuelwood particularly in northern forest reserves but by and large most of the fuelwood comes from various salvage sources including bush fallow farming, logging, wood processing, building construction, wood works and other activities.

All of the fuelwood supplied from forest reserves in some northern states and some of the fuelwood from some salvage sources are distributed through the market. But fuelwood not distributed through the market forms the greater proportion of total consumption.

Units of Measurement

Unprocessed wood, and processed wood are measured in cubic meters and converted into round wood equivalence. Woods used for all types of building paper boards and for all writing, and printing papers and for newsprints are converted into wood pulp equivalence and measured in kilograms. Charcoal is converted into round wood and measured along with other fuelwood in cubic meters.

Factors Which Shape the Wood Consumption Habits of Individuals

The wood consumption habits of an individual are determined by the type of wood product the individual consumes most often, how sparingly or unsparingly he uses the wood, and by the use to which he puts it. Observation in Nigeria shows that these characteristics differ with people depending on whether they live in the rural or in the urban areas or on how close they are to the forest source of wood; on the ability of individuals to afford different types of wood products; on the price of wood products relative to prices of substitutes for wood and also prices of other materials which complement wood in various uses; and on the previous exposures of individuals to alternative living conditions. In summary, an individual's wood consumption behavior is shaped by some factors which approximately correspond to his location with respect to rural and urban areas, his income, availability and relative prices of substitutes and complements for wood in various uses, and the level of education attained by the individual.

Rural-Urban Location of Individuals

Most of the forest and non-forest sources of wood are located in the rural areas. Rural people are more frequently associated with occupations like farming, logging, and forest tending which give them access to wood. Because of availability of wood, rural based people tend to consume proportionally more wood than their urban counterparts. They obtain most of their wood directly from the forest and use it in unprocessed form for both building and fuel.

Individual's Income

We discussed the economic dualism of Nigeria in Chapter I and pointed out that a great majority of Nigerians are very poor while a few who though may not be considered very rich by developed world standards are fairly well to do. The wood consumption characteristics of Nigerians have followed this dualism. Among the poor, particularly rural poor, dirt and farm salvage materials especially cork stock, stems of palm leaves, and livestock skins and droppings have substituted for wood extensively in various uses including farm construction, housing construction, furniture, and fuel. To the extent that wood is used, it is used in unprocessed form and is generally obtained directly from the forest or farm.

In contrast, among the higher income classes, except temporary wood used during construction and sometimes in permanent positons in buildings for decorative purposes, wood is almost always used in processed form and is obtained through the market. When it is desirable to substitute other materials for wood which may be because wood with desired qualities including well formed grains is not available or because weather conditions would not permit the use of wood in some outside parts of buildings, the substitutes are metal, concrete, glass, and asbestos.

Adeyoju believes that "the fortunes of the cash crops with which most consumers' income is tied underlie the absolute demand for wood. . . . in periods of high producer prices for primary produce, there is a corresponding high demand for sawnwood as was the case for 1954-55, and in periods of market depression for primary produce as in 1958-59 a fall in demand is also recorded" (2).

Availability of Substitutes and Complements for Wood

All the building engineers and architects we interviewed during the wood consumption survey (carried out as part of this study and discussed in Chapter V) explained that the place of wood in a building is very elastic depending on availability of the right type of wood, availability of alternative materials and their relative prices. This statement implies that substitutability and complementarity between wood and other materials in buildings are imperfect. If substitution were perfect then either wood is used if it is cheaper or its alternative is used if wood is more expensive. Conversely, if complementarity were perfect between wood and other materials, then the building is built with the required amount of wood or it would not be built. Under perfect complementarity, building technology would determine exactly how much of each material must be used.

In the case of imperfect complementarity and substitutability which we face in the use of wood in a building a wide range of proportions is possible, the optimum proportion depending partly on building technology, cost of labor and general construction convenience, relative prices of the building materials, and the tastes of the individual owners of the buildings. Further, we note that if either wood or complements for wood in buildings become cheap more buildings will be set up and more wood will be required simply because of increased number of buildings. Conversely, if wood or its complements become expensive enough fewer buildings will be set up and less wood will be required. Also, if substitutes become more expensive than wood it is likely that more wood and fewer wood substitutes will be used, but if substitutes become less expensive than wood, less wood will be used.

In recent years plastic products have substituted for wood in household utensils and in parts of household and non-household furniture because plastic industries established in Nigeria in recent years mass produced these products and made them cheaper than their wood alternatives. More wood will likely be displaced in buildings, utensils, and furniture when the integrated iron and steel mills which are planned in Nigeria start operating. The Federal Government plans to harness the natural gas associated with petroleum drilling which is presently wasted (7). Natural gas is more than a perfect substitute for wood as a source of fuel. If it becomes cheap enough when the initial cost involved in its use is considered, it will displace a large proportion of wood in the fuel consumption subsector.

Educational Attainments of Individuals

The process of formal education is not the only way individuals get exposed to alternative living conditions. Nigerians who have travelled to the countries of Western Europe and North America have been known to try to live like people in those countries. We use educational attainment only as index of exposure to different living conditions. Although college graduates would spend some time with their folks who may live in mud huts with thatched roofs, it is doubtful if any college trained individual would like to live permanently in any of those huts even if such people do not have jobs and hence incomes befitting their training. We did not come across any one among the college graduates we interviewed during the wood consumption survey mentioned above, who did not live in buildings with concrete walls, including those living and working in rural areas. Nor did they burn wood or charcoal for fuel.

How the Determinants of Wood Consumption Habits of Individuals are Incorporated in the Model

Based on the wood consumption behavior of individuals, Nigerian people can be classified into three groups with fairly distinct wood consumption characteristics. Such grouping will approximately correspond to (1) rural poor; (2) medium income people whether rural or urban, urban poor, and college graduates who for any reason including unemployment may earn lower than average income irrespective of whether they live in the rural or in the urban area; (3) high income people irrespective of their educational attainment, and irrespective of their rural-urban location. We shall refer to these groups as traditional, semi-traditional, and non-traditional wood consumption population groups. Following this grouping of people we shall, where appropriate, subdivide various wood using subsectors which we shall describe in the next section into traditional, semi-traditional, and non-traditional because

of differences in size, and structure of buildings and in the building materials used in the buildings.

Our model will use different parameters like average proportion of building per person, average amount of wood per building, average fuelwood per person per year, and average paper per person per year for each of these groups. This differentiation will account for differences due to rural-urban location, personal income, and educational attainment of individuals. Wood consumption estimates based on these distinctions should be closer to reality than estimates based on averages for all Nigerians.

The model will account for the effect of relative prices of wood and of wood substitutes by estimating average wood per building in the different wood consumption groups as functions of the ratio of the index of price of wood to the index of prices of substitutes for wood. This will allow for substitution of metals, glass, and so on to displace wood as they become more available and relatively cheaper than wood in various uses where those products are substitutes for wood.

Wood Using Subsectors

The wood using subsectors we are considering in this study are grouped into residential housing construction subsector, non-residential building construction subsectors, farm construction subsector, casket manufacturing, vehicle body and bridge construction subsectors, fuel-wood consumption subsector, and paper consumption subsector. Within each subsector, there is a wide range of variation in size, structure, and building materials among products produced. In the following sub-sections we shall describe each of these groups briefly and point out what subsectors are in each group and explain how we want to deal with the variations in the size, structure, and building materials in the products of each subsector.

Residential Housing Construction Subsector

Only dwelling houses are included in residential housing construction except in the business districts of urban centers where some buildings are used partly for dwelling and partly for commercial purposes. Such buildings are included in the residential building subsector. Student dormitories, hospitals, hotels, etc. where people may live but are not homes are not included in the residential housing construction subsector. Dormitories are under school buildings, hospital buildings are under hospital buildings, and hotels are under commercial buildings, all of which are treated as non-residential buildings. The residential housing construction subsector is subdivided into traditional, semi-traditional, and non-traditional subsectors because of variation in the size, structure, and building materials in residential houses.

Non-Residential Building Construction Subsectors

Schools, religious, hospital, and public administration buildings, and commercial buildings like shopping centers, market places, workshops, and so on are grouped under the non-residential subsectors. Elementary schools, high schools, and colleges are treated as three separate subsectors because of the differences in size of buildings and types of building materials used. Elementary schools, commercial, and religious building construction subsectors are further divided into traditional, semi-traditional, and non-traditional. Residential buildings within institutions such as homes for professors on a university campus are considered residential rather than non-residential.

Farm Construction Subsector

Farm crop storage buildings, livestock sheds, farm fences, farm crop staking, and manufacture of farm implements such as hoes, matchets, and axes with wooden handles are grouped in the farm construction subsector. These activities are different for traditional and non-traditional farms. Since the level of transformation from traditional to non-traditional agriculture which has occurred in Nigeria is insignificant, it was difficult to find an adequate definition of a non-traditional farm on which we could base our simulation of non-traditional farming activities, which will likely be expanding in the future. Eventually we classified as a traditional farm any tree crop farm less than one hectare or a food crop farm less than two hectares.

During the wood consumption survey which will be described later in Chapter V, we observed that traditional farms livestock mix with people in living rooms and farm crops are stored until ready for market in the rooms in which people live. Such multi-purpose houses are more conveniently regarded as residential in the study. Estimates of annual wood consumption are made separately for traditional and for non-traditional farms.

Casket Manufacture Vehicle Body and Bridge Construction Subsectors

The containers in which the dead are buried in Nigeria vary with the people, religions and economic conditions. Among some people and religious groups the dead are not buried in any type of container. Even among some people and religious groups where ordinarily the dead will be buried in a standard casket made of processed wood some cannot afford such a casket and are buried in caskets made of other materials. Our estimate here included only caskets made of processed wood and we assume that only about 40 percent (2), of the dead in Nigeria are buried in such caskets.

Some commercial vehicles are imported as chassis and the body is added by local carpenters. Among these are "lorries," "pick-up," "mini-buses," and some "non-luxury" buses. There are also, particularly in urban areas, a number of manually powered carts which are made almost entirely of lumber. "Pick-ups" and "mini-buses" are small vehicles and most of the bodywork is metal. The wood content consists merely of one or two boards of plywood or paperboards used in the roof as insulation material against heat. "Lorries," "non-luxury" buses and manual trucks are included in what is here referred to as "lumber-trucks."

Bridges on modern tarred roads are frequently made of concrete and steel. Formwork materials like props and concrete containers are more often than not metal. On untarred roads, however, bridges or parts of bridges are still made of wood; only the latter type is included here.

Furniture and Utensils

Household furniture includes seats, tables, trunks, beds, shelves (cupboards), and clothing hangers. Household utensils are pounding mortars and pestles, bowls, and spoons. Non-household furniture includes seats, tables, desks, shelves, writing boards and dividing screens. Furniture and utensils are included as parts of the building where used. Wood in a building is therefore wood used in formwork--props, concrete containers--during construction, in permanent positions--shutters, frames, roof--in the building, and in the furniture and utensils used in the building.

Fuelwood Consumption Subsector

We mentioned under the section above dealing with wood products that some of the wood burnt for fuel is in the form of charcoal and some is round wood. We also mentioned that some of the fuelwood is distributed through the market but that most consumers of fuelwood obtain their supplies directly from various salvage sources. There are significant differences in per capita consumption of fuelwood between those who obtain their supply of fuelwood through the market and those who obtain theirs from non-market sources. Separate estimates of annual consumption of fuelwood are made for fuelwood obtained from market and non-market sources.

Paper Consumption Subsector

Paper here includes newsprint, printing paper and writing paper. Estimates will be made separately for low income, medium income, high income and student population groups.

Other Uses of Wood

In Nigeria wood is also important in the construction of boats and canoes, and railroad sleepers. Wood is used for power and transmission poles and pit props in coal mines. Some packaging materials are also made of wooden boxes or paper bags. Wood used in these ways is not estimated in this study because of time constraint.

Government Actions Which Affect Wood Consumption

Discussions of wood products, wood using subsectors, and factors influencing wood consumption indicate that certain actions of the governments do affect wood consumption. Government investments in agriculture, education, health, and transportation are some of these actions. Other actions not being taken at present could further control the rate of consumption of wood in Nigeria. These will include pricing of wood products, substitutes, and of complements in various uses and the establishment of building construction codes which specify where and when wood may or may not be used in buildings.

Government Investments

A passage from Adeyoju (2) quoted earlier in this chapter indicates that higher producer prices for agricultural products in 1954-55 stimulated demand for sawnwood. Any public investment in agriculture which will improve the real income of the rural people whether the investment is in the form of higher producer prices or in the form of subsidized input prices will affect the rates at which various wood products are consumed in two ways. First, agricultural activities will be stimulated by the public investment. Then there will be increased consumption of the wood products used in traditional farm construction. This will occur with minimum time lag. After a longer time lag, there will be a shift toward increased consumption of more processed wood, the consumption of which is associated with semi- and non-traditional wood consumption groups. This will happen because increased investment in agriculture will eventually, result in higher income for rural people, enabling some of the rural poor to enjoy the living conditions of the semi-traditional population groups.

Government investments in education have similar consequences. Investments in education will include expansion of school buildings and furniture which will result in almost immediate increases in wood consumption. A more important consequence of such investment in education will be apparent after the appropriate time lag. When people benefiting from such investments begin to graduate from high schools or colleges and take appropriate jobs, they will acquire the living habits associated with the non-traditional population groups and consume more processed wood.

If investments in the various sectors are sustained, the lagged consequences will continue. The increased rates of consumption of various wood products which are being experienced at present in Nigeria are merely some of the unlagged consequences of the government investments in various sectors including agriculture, education, health, and transportation which began with the "oil boom." If such heavy public investments are sustained, the lagged consequences for wood consumption will be large. Decision makers for the forestry industries should only anticipate them and plan for their consequences.

The model of the wood consumption component is structured to take government investments into consideration. The annual changes of the various wood consumption population groups are estimated by the model partly as functions of projected government investments in different sectors. The numbers of students who go to high schools and colleges annually and who will eventually be classified in the semi- or non-traditional wood consumption population groups are estimated as functions of government investments in education as well as functions of GDP. Similarly, the number of people who will be reclassified from traditional to semi-traditional population groups because of increased personal income are estimated in the model as a function of public investments in agriculture as well as of agriculture's contribution to GDP.

Other Public Actions

Other public actions which can be used to control wood consumption include artificial pricing of wood products, substitutes, and complements, and the establishment of building codes which will specify the use for wood in buildings.

We pointed out earlier that since the substitutes for wood are imperfect, an increase in the price of wood relative to the price of the substitutes will result in the substitutes displacing some but not all wood in some uses. Thus, the government can use this relationship to encourage or discourage wood consumption if desired. Wood prices can be controlled by various tax measures including producer or consumer tax. Producer tax is convenient in Nigeria at the logging stage. Since the various state governments are the owners of forest sources of wood, they can control the prices of wood products by raising or lowering the fee they charge for logging rights. The Federal Government can control the price of wood by manipulating the importation and exportation of wood into and out of the country. If it is desirable to encourage wood consumption, the Federal Government can relax the conditions for importation and at the same time tighten the conditions necessary for exportation of wood products from Nigeria. This will expand domestic supplies and reduce domestic prices relative to the prices of substitutes for wood.

Administered prices may have undesirable consequences in the long run. Suppose that due to certain reasons, one of which can be shortage of wood products, it is desirable to discourage the consumption of certain wood products and this is done by artificially increasing the price of wood relative to prices of substitutes. Consumers will begin to substitute other materials for wood and producers will begin to invest in forest industries in response to the artificially high prices. Eventually when these investments begin to mature in form of increased supply of wood products, there may be a reduced market for the wood products because people have learned to use other materials in place of wood.

Establishment of building codes which will specify the uses of wood may create complementarity where little exists. If a code specifies that wood must be used in certain positions in a building, either the required amount of wood is used or the building is not built, as under perfect complementarity. Such a measure can also lose markets for wood products which are hard to reestablish if it is later desirable to encourage wood consumption. Because of their undesirable consequences, artificial pricing and building codes should be very carefully considered before used to control the consumption of wood.

CHAPTER IV

THE MODEL OF THE WOOD CONSUMPTION COMPONENT

Introduction

In Chapter I the complex nature of general models was discussed and we pointed out that a generalized systems analysis and simulation model is typically complex and disorderly. We also discussed other characteristics of such studies and pointed out that they proceed from conceptualization to mathematical and then computer modelling. In this chapter we shall discuss the three stages beginning with general conceptualization. This will make it possible for a reader who finds mathematical and computer models complex to conceptualize what the model is about without reading the mathematical and computer versions.

Conceptualization of the Model

We shall discuss the conceptualization in two stages: first, how the model is structured and, second, how it operates through time.

How the Model Is Structured

In Chapter III we discussed various uses of wood products, including construction, fuel, and paper. Some of the construction subsectors considered are residential, school and hospital, housing, bridge, and farm constructions. Estimates of wood consumption in these subsectors are based on the independent adult in the case of residential housing, students for school housing, hospital beds for hospitals, kilometers of road for bridges, and farms for farm construction. For lack of common terminologies, we use "building" to commonly refer to a residential house, school building, hospital building, a bridge, or a farm building and "unit" to refer to an independent adult person, a student, a hospital bed, a kilometer of road, or farm. The general procedure of the building construction submodels is to estimate the rate of setting up new buildings in each subsector as the sum of the rate of replacements of existing buildings and the product of average proportion of building per unit and the rate of change in the number of units in the subsector. Once this is done, average wood per building in the subsector is applied to the number of new buildings to arrive at the rate of wood consumption in that building construction subsector. This is described in Figure 5. Wood can be unprocessed wood, processed wood, or building board woodpulp. If wood is building board woodpulp, the unit is kilograms/year rather than M^3/year. The subsector can be residential housing construction, non-residential housing construction, farm construction, or bridge construction. If we eliminate the component which deals with the replacement of old buildings, the general procedure will also apply to other subsectors namely lumber truck construction, where the structure is not replaced, and in fuelwood consumption and paper consumption subsectors where the wood is used once and for all.

For modeling convenience, the wood consumption model is divided into six submodels corresponding to (1) population; (2) residential housing construction; (3) non-residential housing construction, including school, hospital, commercial, religious, and public

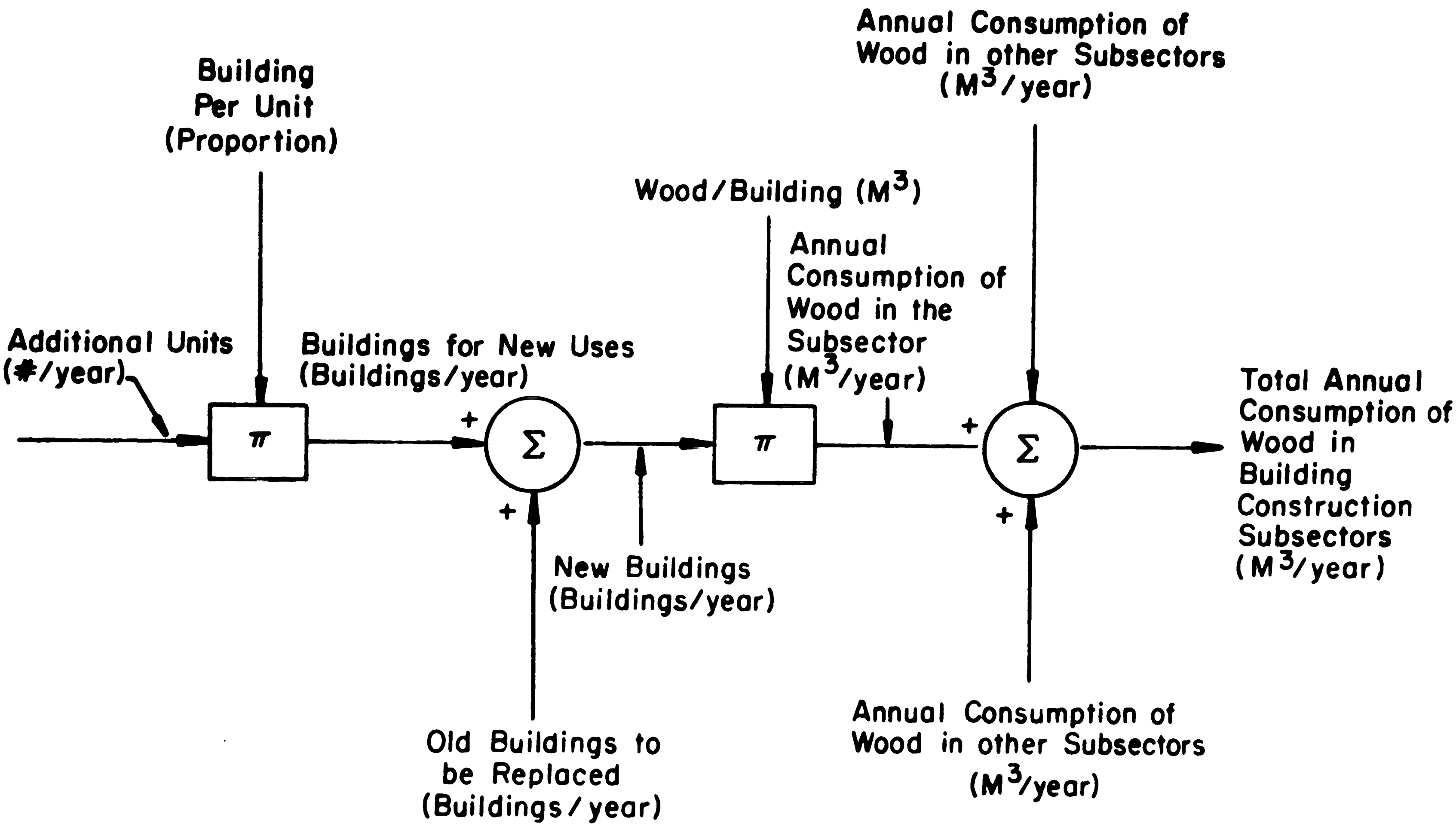


FIGURE 5: GENERAL STRUCTURE OF BUILDING CONSTRUCTION SUBMODELS.

administration building construction; (4) farm construction and fuelwood; (5) other construction and manufactures, including caskets, vehicles, and bridges; and (6) paper subsectors. These submodels are independently modeled, but the outputs of the population submodel are inputs to other submodels.

There is a lag between the time a building is built and replacement. During this lag, losses occur in the total number of buildings due to such random factors as wind or fire which add to the number of buildings to be replaced. Though these losses are stochastic, this model treats them as constants.

The rates at which buildings are set up in the elementary school, commercial, religious, and public administration building construction subsectors are estimated as constant proportions of the rates of construction of residential buildings.

Buildings in some subsectors are classified as traditional, semi-traditional, and non-traditional following the disaggregation of the population into those wood consumption groups as discussed in Chapter III. Residential and elementary school buildings are disaggregated into traditional, semi-traditional, and non-traditional residential and elementary school buildings, depending on whether they are used by traditional, semi-traditional, or non-traditional population groups. Commercial, farm, and religious buildings are classified as either traditional or non-traditional. Buildings in other subsectors (such as hospitals, high schools, and colleges), vehicles, bridges, and caskets, cannot be conveniently classified into any of the three classes. These latter subsectors are considered as nonspecific.

Annual consumption of fuelwood is estimated for fuelwood from market sources and for fuelwood from non-market sources for traditional and semi-traditional wood consumption population groups. We assume that non-traditional wood consumption habits do not include the consumption of fuelwood. The rate of consumption of paper is estimated on the basis of per capita consumption per year for individuals in the low-, medium-, and high-income brackets and for elementary, high-school, and college student population groups. The average annual per capita consumption increases with per capita income in different income groups except in the low-income bracket.

The output of the model includes estimates of annual consumption of five wood products--namely, unprocessed wood, processed wood, building board woodpulp, fuelwood, and paper woodpulp for the three wood consumption population groups. The estimated annual consumption of these wood products will also be classified on the basis of the subsectors where wood is consumed--namely, residential housing construction; non-residential building construction; caskets, lumber trucks, and bridges; farm construction; fuelwood; and paper. It is possible to get estimates of the annual wood consumption in the non-residential building construction separately for each of the subsectors that make up that aggregate from the model. Fuelwood will be classified on market, non-market basis, as well as by traditional and semi-traditional population groups.

The model will generate some demographic information as intermediate outputs. These include the classification of adult population into traditional, semi-traditional, and non-traditional groups approximately corresponding to low, medium, and high income groups

respectively; estimates of annual high school and college enrollments; high school and college graduation rate; and total number of deaths. Other intermediate outputs of the model include estimates of annual number of management level job openings, number of buildings set up each year in different building construction subsectors for different population groups; and the number of trucks added on annually.

How the Model Operates Through Time

In the previous subsection we pointed out that the rate at which buildings are set up in the various subsectors is estimated as the sum of the rate of replacements of old buildings and the product of the rate of change of the number of units in each subsector and the average proportion of buildings per unit. Average proportions of buildings per unit in the subsector are nonvariable parameters in the model. But the rates of replacements of the old buildings and the rates of change of the number of units in each subsector vary with time. These two variables determine the time paths of the rates of consumption of the various wood products. Both variables are endogenously generated in the model. A population submodel generates rates of change in independent adult population and in student population. The inputs of the population submodel are the population of twelve-year-old children, income differential between rural and urban areas, and the rate of growth of the gross domestic product and government investments in education and agriculture. These are some of the variables discussed in Chapter III as the determinants of the annual wood consumption.

A proportion of the twelve-year-old population, depending on the rate of growth of GDP and government expenditure on education, will go

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to high school each year. Similarly, a proportion of high school graduates, also depending on GDP and government investment in education, will proceed to college. These people, after the appropriate time lags, will be classified with the semi-traditional population group if they stop at high school or with the non-traditional population group if they graduate from college and take befitting jobs.

A proportion of the twelve-year-old children who do not go to high school are in urban areas. After some time lag, ranging from nine to twelve years, these people mature into independent adults to be classified with the semi-traditional population group. Similarly, after a period of time between twelve and eighteen years, the proportion of the twelve-year-old children who are in the rural areas mature into independent adults and are classified with the traditional population. Migration from the rural to urban areas takes place during this delay period in response to expected better economic opportunities available in the cities.

The model can reclassify an individual already classified in a group if his personal income improves enough. For example, if the personal income of an individual classified as traditional improves enough, he will be reclassified as semi-traditional, even though he may be living in the rural area. In the same way, if the income of an individual in the semi-traditional population group rises enough, he is reclassified as non-traditional by the model.

The traditional population group consists of the low-income rural people. The semi-traditional population is made up of the urban population who are not in the high income bracket, rural population who are in the medium income bracket, and high school graduates and college

graduates who do not have college-level jobs irrespective of whether they live in the rural or urban areas or whether their income is below average. The non-traditional population consists of all people in the high income brackets irrespective of whether they live in the rural or in the urban area and whether they went to school or not. In Chapter V we shall explain what are meant by low-, medium-, and high-income brackets.

At high rates of growth of GDP and government investments to stimulate economic activities, the number of people who will go to high schools and colleges and eventually be classified as non-traditional will be high. Similarly, the number of individuals in the traditional population groups whose income will rise enough to enable them to be reclassified as non-traditional will be higher at higher rates of economic activities. In response to improvements in economic conditions, the proportion of the traditional population is expected to decline exponentially over time without reaching zero. The proportion of semi-traditional population will first grow, then level off, and eventually decline but never reach zero. The proportion of the non-traditional group is expected to grow exponentially without attaining unity. The time paths of these population groups are represented in Figure 6 as functions of changes in income. In Figure 6 the total population is represented by one while each population group as a proportion of the total is represented by the distance from the horizontal axis to the curve with the corresponding label. If economic conditions deteriorate, the time paths will be reversed in that non-traditional population will be expected to decline as a proportion of total and traditional population to grow proportionally over time.

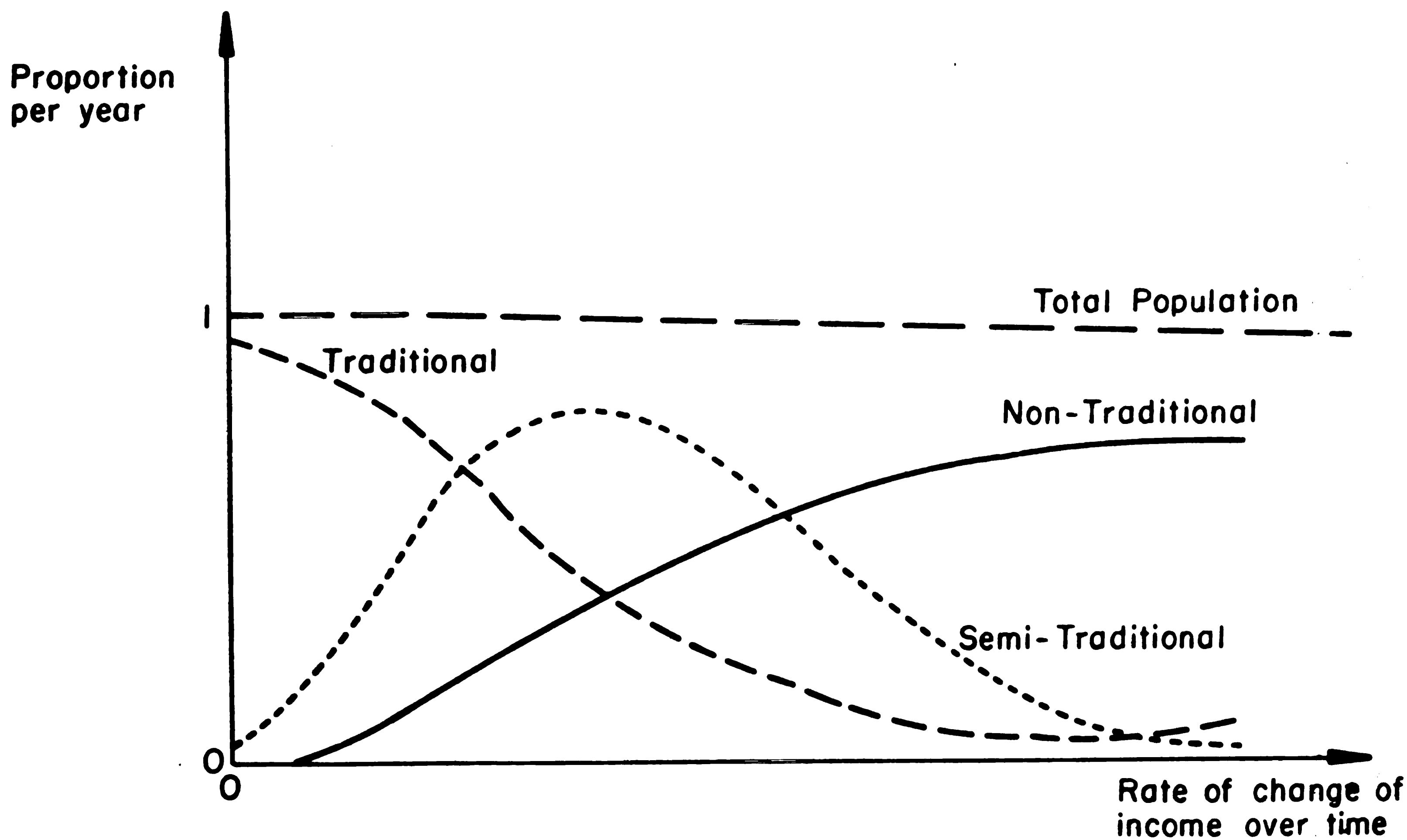

FIGURE 6: TIME PATHS OF VARIOUS POPULATION GROUPS AS FUNCTIONS OF INCOME (PROPORTIONS/YEAR)

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The rates of setting up new buildings in different subsectors will follow comparable time paths. If economic conditions improve over time, the rate of new building construction will be expected to decline because of declining rates of growth of traditional populations. The rates of non-traditional building will be expected to grow with non-traditional population. Lumber trucks will tend to be replaced with modern vehicles, and traditional bridges will be fewer because dirt roads will be converted to modern-tarred roads. Consumption of fuelwood and unprocessed wood both used relatively more in the traditional sectors, will be expected to decline as economic conditions improve. Consumption of processed wood, building board woodpulp, and paper, which are relatively more important in the non-traditional sectors is expected to grow over time.

There are some time lags which elapse before changes in economic conditions are translated into changes in the rates of wood consumption. For instance, by 1976 primary education will be free in Nigeria. It will take at least fifteen years including six years in the primary school, five in high school, and four in college, before the first group of beneficiaries from free primary education can graduate from college, find befitting jobs, and adopt non-traditional wood consumption habits. This is why consumption of fuelwood and unprocessed wood estimated in Chapter VI have not declined substantially in spite of the fact that GDP has grown at relatively accelerated rates in recent years because of availability of petroleum in Nigeria. The duration of our projections, which is only fifteen years, is not long enough for most of the consequences of the present changes in economic activities to be fully felt.

The other variable on which new building depends is the rate of replacement of old buildings. When a building is set up, it deteriorates after a delay period at a rate determined by the rate of extraction of services from that building as well as by environmental conditions.

A group of buildings of the same subsector, type, and vintage will deteriorate over time at different rates depending on the rates of use. The order of deterioration in a group of buildings can be different for different groups of buildings. In one group most buildings may deteriorate early and only a small proportion experience long delays while most buildings in another group may experinece long delays; conversely a small proportion of buildings in a group may experience short delays and deteriorate quickly while another small proportion deteriorates much later, and most of the buildings deteriorate near the mean life for the group. This later order will be likely for buildings with uniform rates of use, building materials and environmental conditions. A graphical representation of the number of buildings which deteriorate in each group as a function of time is shown in Figure 7. If in a group of buildings, the rate of deterioration follows the first order described, the rate of deterioration will follow the time path labelled k = 1 (36) in Figure 7. The model assumes that the rate of deterioration in different buildings will follow the time path labelled k = 10 in which most of the buildings will decay near their mean life. This assumption is realistic because we have disaggregated buildings into groups of uniform characteristics such as purpose (rate of use), building materials, etc. and we use different mean lengths of life for

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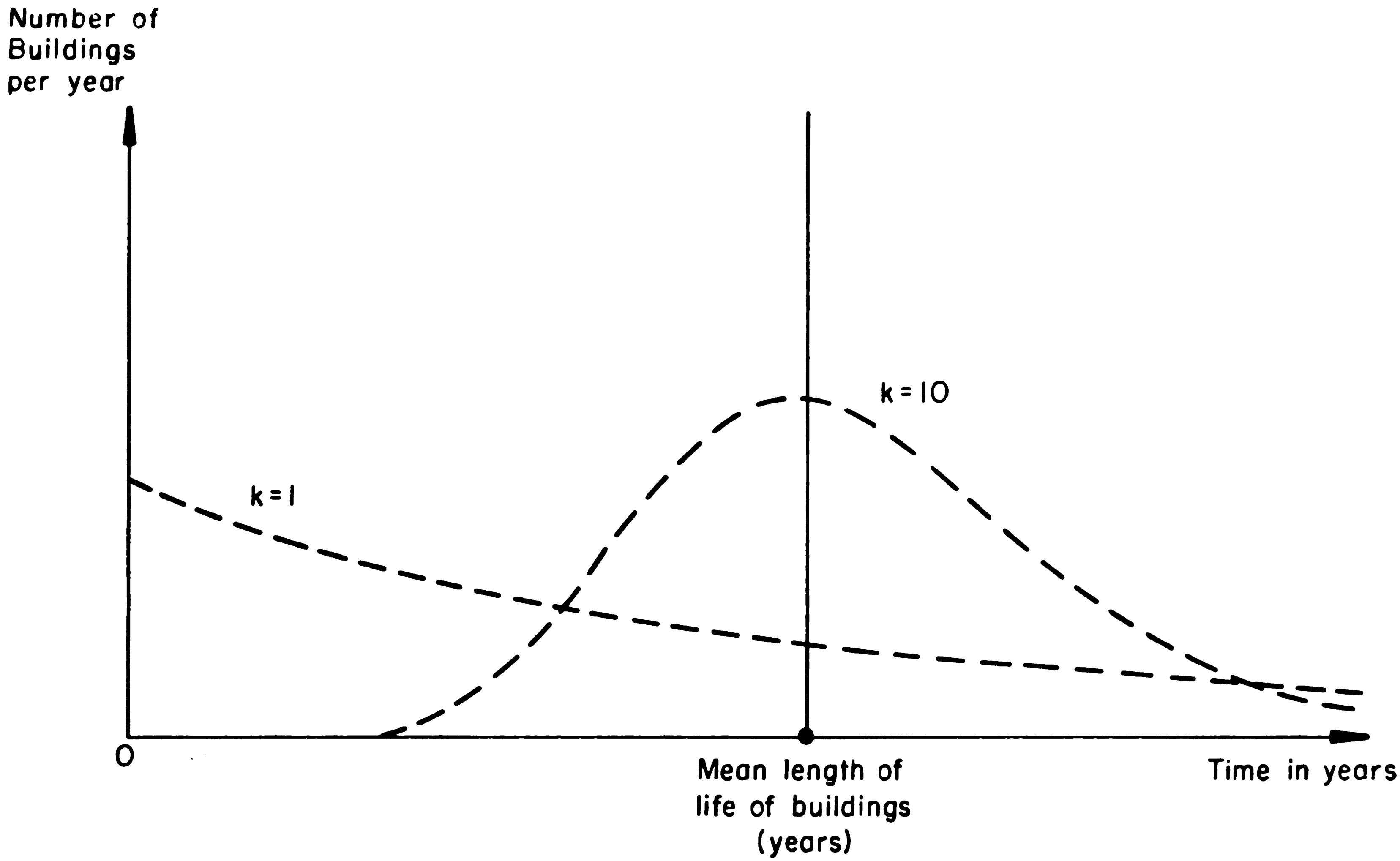

FIGURE 7: TIME PATHS OF THE RATES OF DETERIORATION OF DIFFERENT GROUPS OF BUILDINGS

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buildings in the traditional, semi-traditional, and non-traditional groups.

The Mathematical Model

The details of the mathematical model, a repetition of the last section in a mathematical form, are presented in Appendix A. The model is divided into six submodels, namely (1) population, (2) residential housing construction, (3) non-residential building construction, (4) farm construction and fuelwood, (5) other construction, and (6) paper. Each of these is independently modeled though the outputs of one submodel may be inputs into another.

The population model is a demographic submodel which disaggregates Nigerian population into traditional, semi-traditional, and non-traditional groups according to their wood consumption habits by simulating the rate at which non-educated rural and urban populations mature into adulthood and join the pools of traditional and semi-traditional adult populations. This submodel also simulates the rate at which individuals between the ages of thirteen and thirty migrate from rural to urban areas and the rate at which individuals in the traditional population group move into semi-traditional population group and individuals in the semi-traditional population group move into non-traditional population group as income level grows. The submodel also computes total deaths, high school and college enrollments, and numbers of managerial job openings and high school and college graduates annually. Non-demographic population estimates such as numbers of hospital beds, lumber trucks, and kilometers of dirt road are made in the submodels where needed.

Typically the mathematical model of each building construction subsector involves the simulation of the time delay involved in the deterioration process of buildings to estimate the rate of replacement of standing buildings. The flow of new buildings (buildings/year) is next estimated in an identity equation. Following Euler's Integration methods (36, pp. 9-23 and 9-24), the flow is converted into stock (buildings/unit of time). The total amount of a wood product (in cubic meters or kilograms per unit of time) used in those buildings is estimated in an identity equation as the product of the wood product per building and the total number of new buildings per unit of time in the subsector.

In elementary school, commercial, public administration, and religious building construction subsectors, the flows of new buildings are estimated as proportions of the flow of new buildings in the residential housing construction subsector. As caskets and lumber trucks are not replaced when they deteriorate, the rate of replacements are not simulated in those submodels. In the fuelwood and paper consumption subsectors, wood is used up without time delay; the amounts of wood used in those subsectors per unit of time are estimated as identities.

The outputs of the population submodel are inputs in all the other submodels and some intermediate outputs of the residential housing construction submodel are inputs in the non-residential building construction submodel. Apart from these, the combination of the submodels is structural involving accounting identities. For example, the total amount of wood consumed per unit of time is obtained by summing up t

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up the amounts used per unit of time in the various wood using sub-sectors.

To enhance understanding of the model, we start off the presentation with a general description of the types of delay model employed. Each submodel is presented in two forms: mathematical equations and flow diagrams. This assists in understanding the model as well as simplifies its computer programming.

The Computer Model

The Computer Program

The computer program of the wood consumption model was written by the author. It is presented in Appendix B. The program is divided into seven subroutines; namely, FUN, POP, RESID, NRESD, CAVIB, FAFU, and PEPA. The subroutines POP, RESID, NRESD, CAVIB, FAFU, and PEPA are programs of the population, residential housing, non-residential building construction; other construction; farm construction and fuelwood; and paper submodels discussed in the previous sections. The routine FUN is used to generate the future values for GDP, government investments, per capital incomes, price ratios, migration rates, and so on, which are used in the other subroutines. The past values of those variables are attached as data. When backward projections are needed, the computer skips FUN and reads in the attached data; and when forward projections are needed, it skips the read statement and calls FUN.

Although each subroutine is complete and can print the outputs of its submodel, all the submodels are put together in a main program called PROGRAM MAIN which calls all the subroutines and prints all the outputs. The model makes calculations for every quarter of a year, but res

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results are printed on a one-year basis. Calculations which are made with parameters from more than one subroutine are made in the last subroutine which is PEPA. Common blocks rather than parameter statements are used to transfer parameters from one subroutine to another. Dimension statements are separate from common blocks. The maximum number of characters of the parameters is six, so that the model can be transferred to another computer which may not accept parameters with seven characters.

CLASS Documents Followed

CLASS refers to Computer Library for Agricultural Sector Simulation, temporarily based at Michigan State University. Its purpose is to assemble software from system simulation studies done in various places and make it available to anyone who would use it. Although this study has benefited from its resources, the library is not yet adequately organized because it is still in its early stages of establishment.

The discrete delay model used to model the initial stages of the maturity process of nonschool-going rural and urban youth in the population submodel is borrowed from CLASS. This model, called DEMOGD, Demography with Discrete Age Cohorts (9) is followed to disaggregate the nonschool-going population by age and by rural-urban location. Migration and births are treated as time-varying inputs. Migration is treated as positive losses in the rural areas and as negative losses in the urban areas.

The distributed delay models of the final stages of the maturation process of the rural and urban youth in the population submodel and of the deterioration processes of the buildings in the submodels of various building constructins are also modeled with a distributed delay model borrowed from CLASS. This model, DELLVF, Distributed Delay with Storage Losses and Variable Delay Time (11) treats the k^{th} order differential equation and variable delay time as if it were k first order differential equation modeling a k-stage process where each stage is a first order delay. Other CLASS documents we used include Executive Program (22) which was modified into our PROGRAM MAIN, referred to earlier, and also subroutine PLOT used to plot the model output which will be presented in the following chapter, PLOT is still being developed by the CLASS library.

CHAPTER V

THE INPUTS OF THE MODEL OF THE WOOD CONSUMPTION COMPONENT

Introduction

In Chapter I we pointed out that a general model such as the one presented in Chapter IV requires information from a wide variety of sources because it employs many techniques, has many submodels, and attempts to approximate reality more closely than single technique models. In this chapter we shall discuss the data which our model needs to operate. We shall also present the data we used to run the model for the projections to be presented in Chapter VI and explain how we obtained those data.

The Data Which the Model Needs to Operate

The wood consumption component as a system needs data inputs on population, income, public investments, pricing of wood products, world trade in wood products, and possibly legal wood consumption codes. Some of these variables (domestic prices of wood products, investments in the forestry sector, and possible wood consumption codes) are controllable by decision makers in the forestry sector. Other variables (population, income, public investments in non-forestry sectors, and world trade in wood products) are uncontrollable by the decision makers for the Nigerian forestry sector. The model of wood consumption which is a paper representation of the wood consumption system needs the same data inputs to yield estimates of annual wood consumption. The more accurate the data put into the model, the more accurate the consumption projections will be.

Although world trade in wood products influences the consumption of wood in Nigeria and although wood consumption codes may sometimes be used in Nigeria to influence wood consumption, the model is not structured to use these two inputs because we cannot make reliable predictions and assumptions about them. In the future when more data on them become available, the model can be easily adjusted to make use of such data. The present estimates of the model will be inaccurate to the extent that changes in world trade in wood products influence domestic consumption of wood in Nigeria. The model is structured to use income, public investments, population, and price relationships between wood and wood substitutes and other variables as inputs on the basis of the predictions and assumptions about the future values of those variables. To the extent that these variables influence wood consumption, the accuracy of the projections made with the model will depend on how closely our predictions of and assumptions about their future values approximate reality.

The model is designed to receive average proportion of building per unit, average lengths of life of buildings for buildings in different subsectors, proportional loss rate of buildings to accident and other causes as constant inputs. These proportions have different inputs over time. Take for example, the average proportion of residential building per adult. There are three values for this variable in the model, one for traditional, semi-traditional, and non-traditional, none

of which varies. As economic conditions improve the number of persons being added to the traditional population group declines, the number being added to the non-traditional group increases and the value for average proportion of building per person in the traditional group becomes less important while that for non-traditional population group becomes more important in the model for estimations. In the same way the model structure is used to vary average amounts of wood products per building, average length of life of buildings, etc. over time.

The Data Used to Run the Model

We shall discuss the data used to run the model in four parts (1) constant inputs, (2) estimates of coefficients of variable inputs, (3) sources of the data, and (4) the reliability of the data.

Constant Inputs

In this subsection we shall show in which submodel each of the constant inputs mentioned above are used, explain what they mean and present the values we assigned to some of them.

1. Average Proportion of Building per Unit: The average proportion of building per unit is needed in the residential housing construction, non-residential building construction, farm construction, and bridge construction submodels. The proportion of residential building per adult by traditional, semi-traditional, and non-traditional population groups is the number of houses occupied by a household divided by the number of adults in the household. The proportion of school building per student by high school and college levels is the number of buildings in a school divided by the number of students in the school. The average number of buildings per farm for traditional

and non-traditional farms is the arithmetic mean of the total number of farm buildings in the number of farms shown in Table 1. The proportion of hospital building per hospital bed is the number of buildings in a hospital divided by the number of hospital beds in the hospital. The average proportion of bridges per kilometer of dirt road is the number of bridges on the number of routes shown in Table 1 divided by the length of road in kilometers. This was derived by keeping track of kilometers and number of bridges on the roads as we travelled from Ibadan to Zaria, Zaria to Sokoto, Zaria to Enugu, and Ibadan to Enugu. Average proportion of bridge per kilometer of road varied from region to region depending on how riverine the region is.

2. Average Wood per Building: Although the model is structured to receive average amounts of wood per building as a variable function of the ratio of the index of price of wood to the index of prices of substitutes for wood, only the average amounts of processed wood in residential buildings are treated this way in making the present projections. The average amounts of unprocessed wood, and building board woodpulp for all buildings in addition to the average amounts of processed wood per non-residential building and other construction are treated as constants in making the projections because we do not have enough price and consumption information to estimate the coefficients of the prices of those wood products in various uses. Since in reality the average amounts of different wood products per building are influenced by the relative prices of wood and substitutes for wood, the model is designed to receive them as variable inputs even though at present only processed wood in the residential buildings is varied with prices.

Table 1.--The Average Proportions of Buildings per Unit[1].

Type of Building	Average Proportion of Building per Unit[1]	Number of Observations	Coefficient[2] of Variation
Traditional Residential	0.860	299	1.37
Semi-Traditional Residential	0.310	139	0.29
Non-Traditional Residential	0.510	90	0.34
High school	0.037	36	0.19
College	0.046	1	0.00
Hospital	0.026	44	0.07
Bridge	0.150	6	0.70
Traditional Farm	4.70	89	0.96
Non-traditional Farm	3.89	3	0.77

Note: [1]Chapter IV, Page 2 we specified that we will use the word <u>unit</u> to commonly refer to an independent adult person, a student, a hospital bed, a kilometer of road and to a farm. We use the word <u>building</u> to commonly refer to a residential house, school building, hospital building, a bridge and to a farm building.

[2]Coefficient of variation is calculated as $\sqrt{\left(\sum_{i=1}^{n} (x_i-\bar{X}/n)^2\right)} \Big/ \bar{X}$

X = variable

$\bar{X}$ = mean of X

n = number of observations

The average amounts of unprocessed wood and building board woodpulp are needed in the residential housing construction submodel. The amounts of a wood product in a residential building is calculated as the sum of the amounts of that wood product in the furniture and utensils which are used by the household divided by the proportion of the building which the household occupies, the amount of that wood product used in formwork during the construction of the building, and the amount of it in permanent positions in the building. Arithmetic means for these were found for a number of households and presented in Tables 2 through 2B.

The average amounts of unprocessed wood, processed wood, and building board woodpulp are needed in the non-residential building construction submodel for elementary school, high school, college, commercial, religious, public administration, and hospital building construction subsectors and also for the farm building construction subsectors. A wood product in a non-residential building is calculated as the sum of the wood product in the pieces of furniture which are used by the institution or center divided by the proportion of the building which the institution occupies, that used in formwork during the construction of the building, and in the permanent positions in the building. Arithmetic means for these were found for a number of institutions and commercial centers and presented in Tables 2 through 2B.

The average amounts of processed wood per casket, bridge, and lumber truck are needed in the casket manufacturing, vehicle, and bridge construction submodel. The values assigned to these for making the projections are the arithmetic means of independent estimates by a

Table 2.--Average Amount of Unprocessed Wood Per Building by Type of Building.

Type of Building	Unprocessed Wood (M^3)/Building	Number of Observations	Coefficient[1] of Variation
Traditional Residential	1.440	201	0.33
Semi-Traditional Residential	1.800	119	0.31
Non-Traditional Residential	1.490	89	0.26
Traditional Elementary School	1.980	23	0.37
Semi-Traditional Elementary School	0.071	10	0.22
Non-Traditional Elementary School	0.000	10	0.00
High School	1.550	35	0.34
College	2.470	1	0.00
Traditional Commercial	0.220	25	0.53
Semi-Traditional Commercial	0.079	25	0.80
Traditional Religious	1.340	18	0.36
Semi-Traditional Religious	1.059	24	0.47
Public Administration	1.470	5	0.34
Hospital	1.470	44	0.22
Traditional Farm	8.195	75	0.48
Non-Traditional Farm	4.250	3	0.39

[1]See Note 2, Table 1.

Table 2A.--Average Amount of Processed Wood Per Building by Type of Building.

Type of Building	Processed Wood (M^3)/Building	Number of Observations	Coefficient[1] of Variation
Traditional Elementary	4.78	23	0.39
Semi-Traditional Elementary	7.18	10	0.41
Non-Traditional Elementary	4.11	10	0.46
High School	14.47	35	0.36
College	12.86	1	0.00
Traditional Commercial	0.09	25	0.57
Semi-Traditional Commercial	3.49	25	0.62
Traditional Religious	2.20	18	0.32
Semi-Traditional Religious	17.48	25	0.51
Public Administration	13.75	5	0.40
Hospital	8.08	44	0.27
Bridge	3.08	3	0.36
Vehicle	3.05	3	0.35
Casket	0.00	3	0.41
Traditional Farm	0.00	75	0.49
Non-Traditional Farm	0.19	3	0.16

[1]See Note 2, Table 1.

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Table 2B.--Average Amount of Building Board Woodpulp Per Building by Type of Building.

Type of Building	Building Board Wood Pulp (Kg.)/Building	Number of Observations	Coefficient[1] of Variation
Traditional Residential	0.00	231	1.19
Semi-Traditional Residential	0.60	139	0.44
Non-Traditional Residential	3.30	89	0.23
Traditional Elementary School	0.00	23	0.00
Semi-Traditional Elementary School	1.38	10	0.35
Non-Traditional Elementary School	1.38	10	0.49
High School	4.30	35	0.41
College	5.80	1	0.00
Traditional Commercial	0.00	25	0.00
Semi-Traditional Commercial	2.00	25	0.57
Traditional Religious	0.00	18	0.00
Semi-Traditional Religious	0.66	25	1.01
Public Administration	5.00	5	0.37
Hospital	5.00	44	0.39

[1]See Note 2, Table 1.

number of architects and local builders of caskets, bridges, and vehicles. These values are presented in Table 2A.

3. Mean Delay Periods: A mean delay period refers to the average length of a time lag. Mean delay periods are needed in the population, residential housing construction, non-residential building construction, farm construction, and in bridge construction submodels, where a distributed delay model is used to simulate the time lag involved in the final stages of maturity process of nonschool-going rural and urban population; and in the deterioration processes of various houses, buildings, and bridges. The values assigned to these in our projections are presented in Table 3. They are based on the guess-timates of sixteen knowledgeable individuals we interviewed during the wood consumption survey that will be described later in the chapter.

4. Losses of Buildings During the Processes of Delays: In the time lag that elapses before a group of buildings deteriorates and requires replacements, some losses occur in the number of the buildings so that not all of them are replaced at the end of the delay period. Some are replaced before the time lag elapses, some are not replaced at all. We shall refer to the first type of losses which results in some buildings requiring replacements before the end of the delay period as the replaceable losses and the other type of losses which result in some buildings not being replaced at all as the nonreplaceable losses. The sum of the two is used to calculate the proportional loss rates for buildings in different subsectors during the delays. Values for the replaceable losses are needed in the residential housing construction, non-residential building construction, in the farm construction, and in the bridge construction submodels where time delays are simulated. These

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Table 3.--Mean Delay Periods for Final Stages of Individual Aging Process and Decay of Buildings.

Population Group/ Type of Building	Mean Delay Period (Years)	Number of Observations	Coefficient[1] of Variation
Traditional Population	6	13	0.49
Semi-Traditional Population	3	13	0.44
Traditional Residential Building	15	16	0.36
Semi-Traditional Residential Building	60	16	0.39
Non-Traditional Residential Building	90	12	0.14
High School Building	60	12	0.39
College Building	90	12	0.14
Hospital Building	90	12	0.14
Bridge*	7	12	0.16
Traditional Farm*	2	7	0.15
Non-Traditional Farm*	5	5	0.29

[1]See Note 2, Table 1.

*These structures are usually made of low quality non-durable building materials, hence short delay periods.

losses are due to fire, wind, or other accidental factors. The number of structures demolished this way in different subsectors are added on to the number replaced each year. Such losses are generally random events, and we lack adequate information about their random nature to make realistic assumptions about them at present.

The use of the term "loss" to refer to the events we call non-replaceable losses is questionable. We pointed out in Chapter III that the number of buildings constructed each year in any subsector is the sum of new buildings for new units and old buildings replaced for old units. When new families or other units inherit old buildings, the new buildings that would be set up for them are not required. Such losses can occur in the residential housing construction subsector when independent adults die and residential buildings are turned over to their children. It can also occur in farm buildings, either by the death of the farmer or by his leaving farm business and someone who would otherwise set up new farm buildings inherits the old ones. Similar losses are also possible in bridges when dirt roads are replaced with modern concrete roads, so that bridges on them will no longer be replaced at the expiration of the time lag with the type of bridge we are concerned about. The number of structures lost this way is subtracted from the number to be replaced annually in each subsector.

These losses are calculated as proportions and are presented in Table 4. Both types of losses are automatically accounted for in elementary school, commercial, religious, and public administration building construction subsectors, where the number of buildings per year are calculated as proportions of numbers of residential buildings. No

Table 4.--Numbers of Buildings Lost During Delay Processes as Proportions of Total Numbers of Buildings in the Delay Processes by Type of Building.

Type of Building	Replaceable Loss (Prop./Yr.)	Non-Replaceable Loss (Prop./Yr.)	Proportional Loss Rate (Prop./Yr.)	Number of Observations	Coefficient of Variation[1]
Traditional Residential	0.027	0.033	0.060	14	0.44
Semi-Traditional Residential	0.006	0.024	0.030	16	0.22
Non-Traditional Residential	0.001	0.019	0.020	15	0.35
High School	0.006	0.000	0.006	12	0.22
College	0.001	0.000	0.001	12	0.35
Hospital	0.006	0.000	0.006	12	0.35
Bridge	0.027	0.133	0.160	12	0.07
Traditional Farm	0.150	0.040	0.190	7	0.27
Non-Traditional Farm	0.090	0.080	0.170	5	0.33

[1] See Note 2, Table 1.

reasons are discernible at present to expect nonreplaceable losses in school and hospital buildings.

5. Other Constant Inputs: The ratios of number of buildings in the elementary school, commercial, religious, and public administration building construction subsectors to number of buildings in the residential housing construction subsector in the base year (1974) are needed in the non-residential building construction submodel. The number of buildings set up each year in the commercial, religious, and public administration subsectors are estimated as proportions of the number of buildings set up each year in the residential housing construction subsector. Our estimates of those ratios are based on the enumeration of all buildings in Ibadan province by Ibadan City Council in 1974. The relative proportions of numbers of different buildings in Ibadan are not representative for all of Nigeria. A more realistic ratio would be based on the average of those ratios from the other parts of Nigeria. The number of buildings at the base year are also needed in residential housing constructions, non-residential building construction, farm construction, and bridge construction submodels, where time delays are simulated. They are used to estimate the number of buildings that are at their various stages of deterioration in the different building construction subsectors. The number of buildings in each subsector at the base year is calculated as the product of number of units and the average proportion of buildings per unit in the subsector.

The average amount of fuelwood from nonmarket sources per adult per year is the fuelwood from nonmarket sources as a proportion of the total amount of fuelwood consumed by the household which obtained all or part of its total consumption from nonmarket sources divided by the number of adults in the household. The mean of this for a number of households is used to estimate the total amount of fuelwood obtained from market sources.

Income per adult for low-, medium-, and high-income groups were adapted from Aboyade (1). Aboyade's observed average income per family was divided by our observed average number of adults per family.

Individuals in the low-income group earn less than ₦400.00, individuals in the medium-income group earn between ₦400.00 and ₦2,000.00, and individuals in the high-income group earn more than ₦2,000.00 per adult per year. It is assumed that the rate of growth of per capita income for the high-income group will lead gross domestic product by 5 percent, while that for medium-income group will lag the GDP by 2 percent. The per capita income for the low-income group will not change significantly as GDP grows.

Estimation of Regression Parameters

Ordinary least squares techniques were employed to estimate the regression parameters for some of the equations. Some of our data, particularly the time series data, may not meet most of the assumptions of ordinary least squares technique. Time series data in Nigeria are often incomplete and of short duration. There is a reasonable chance that a high degree of measurement and other statistical errors were involved in collecting, analyzing, and presenting them. Also, a civil war disturbed economic activities in many parts of the country between 1967 and 1970.

The range of the time series data are not wide enough to determine the functional form by plotting the data. We have substituted a linear approximation to a functional form which is consistent with our assumptions (see page 77). We deemphasized these problems because the regression equations serve predictive purposes. We retained variables at moderate levels of significance and coefficients of determination (R^2's) where other experiences and judgements have given us strong reasons to believe that such variables are important determinants of the dependent variables.

1. Parameters of Processed Wood Per Building as Function of Prices: The average amounts of processed wood in residential buildings were estimated as variable functions of the ratio of the price index of processed wood to the index of prices of substitutes for processed wood in various uses. The cross-sectional data on processed wood used for the regression analysis were derived by grouping residential buildings enumerated during the wood consumption survey according to the years they were built. Arithmetic means of amounts of processed wood per building (defined as processed wood in furniture and utensils used in the building, in formwork during construction and in permanent positions in the building) were found for the buildings in each group. These means are presented for traditional, semi-traditional, and non-traditional residential housing construction subsectors in Tables 5 through 5B. Price information is derived from the import and export values of processed wood products, and non-wood products which are used in the various building construction.

We present the results of the regression analyses below in Table 6. For each equation the standard errors of the estimates and the levels of significance of the variables are in parentheses. R^2 and DW stand for coefficient of determination and Dubin-Watson statistics.

Table 5.--Average Amount of Processed Wood Per Traditional Residential Building by Year(s) of Construction.

Year(s) of Construction	Average Amounts of Processed Wood/Building (Cubic Meters)	Number of Observations	Coefficient of Variation[1]
1952 and earlier	1.80	20	0.52
1953 - 1956	1.01	27	0.52
1957 - 1960	1.58	17	0.87
1961 - 1962	1.55	33	0.64
1963 - 1964	1.65	38	0.65
1965 - 1966	1.61	15	0.49
1967 - 1968	1.77	21	0.53
1969 - 1970	1.68	24	1.27
1970 - 1974	1.42	31	0.29

[1]See Note 2, Table 1.

Table 5A.--Average Amount of Processed Wood Per Semi-Traditional Residential Building by Year(s) of Construction.

Year(s) of Construction	Average Amounts of Processed Wood/Building (Cubic Meters)	Number of Observations	Coefficient of Variation[1]
1949 and earlier	6.20	15	.43
1950 - 1956	4.58	9	.50
1957 - 1959	4.61	16	.43
1960	3.81	11	.71
1961	3.62	18	.59
1962	4.15	24	.48
1963	6.10	11	.06
1964 - 1966	6.42	14	.20
1967 - 1972	5.03	18	.53

[1]See Note 2, Table 1.

Table 5B.--Average Amount of Processed Wood Per Non-Traditional Residential Building by Year(s) of Construction

Year(s) of Construction	Average Amounts of Processed Wood/Building (Cubic Meters)	Number of Observations	Coefficient of Variation[1]
1949 and earlier	4.57	8	.30
1950 - 1956	3.26	6	.29
1957 - 1959	3.69	8	.28
1960	3.30	11	.38
1961	3.85	17	.44
1962 - 1963	4.89	10	.59
1964 - 1965	5.32	5	.31
1966 - 1969	5.61	16	.74
1970 - 1974	5.67	8	.16

[1]See Note 2, Table 1.

Table 6.--Parameters of Processed Wood Consumption in the Construction of Residential Buildings as Function of Prices.

EQ. 1	PR_{12}	=	1.83	-	0.94 · P_2	R^2 = .50
	(0.11)		(0.34)		(0.36)	DW = 1.75
			(.01>L>0)		(.03)	
EQ. 2	PR_{22}	=	11.40	-	7.45 · PSI	R^2 = .63
	(6.69)		(2.07)		(2.17)	DW = 1.73
			(.01>L>0)		(.01)	
EQ. 3	PR_{32}	=	8.48	-	4.28 · PSI	R^2 = .24
	(0.90)		(2.69)		(2.84)	DW = 1.69
			(.02)		(.18)	

L = level of significance

PR_{i2}, i = 1, . . ., 3 are the average amounts of processed wood in cubic meters per traditional, semi-traditional, and non-traditional residential building respectively. P_2 is the price index of processed wood at 1956 level and PSI is the ratio of the price index of processed wood to the price index of substitutes for processed wood in various uses.

The price index of processed wood rather than the ratio of the price index of processed wood to the price index of substitutes for wood is used to estimate the parameters in EQ. 1 in the above table because substitutes for wood in the traditional residential building construction as pointed out in Chapter III are mainly dirt, and farm salvage materials which are not usually obtained from the market. The low R^2 in these equations may be explained by the fact that not only prices but also other variables including personal income and tastes of individuals for wood and non-wood in various parts of buildings and furniture determine how much wood is used in a piece of construction. Prices are significant at 18 percent level in the non-traditional, at 3 percent level in traditional and only at 1 percent level in the semi-traditional residential buildings. The level of substitution for wood for other materials is least in the semi-traditional residential construction and highest in the non-traditional sectors where concrete, steel, asbestos, glass, etc. are used in place of wood in parts of buildings, furniture, and utensils.

2. Parameters of Market Supplied Fuelwood as Function of Fuelwood Price: Some households obtain part or the whole of their fuelwood supply from the market. For each of these households the quantity bought was divided by the number of adults in the household and converted

to annual quantities in cubic meters. The households were grouped according to their local market sources of fuelwood and the arithmetic means of the market supplied fuelwood per adult per year were calculated. These means are presented in Table 7. They were regressed on the local market prices to obtain the average amount of fuelwood from market sources per adult per year separately for the traditional and the semi-traditional population groups. These equations are presented in Table 8.

Table 7.--Average Amount of Fuelwood Per Adult Per Year by Local Market Area.

Local Market Price (₦/m^3) (Aug. - Dec. 1974)	Average Amount of Fuelwood/Adult/ Year (Cubic Meters)	Number of Observations	Coefficient[1] of Variation
8.62	7.30	35	0.57
7.75	10.59	25	0.21
6.89	10.95	28	0.35
6.03	8.03	27	0.58
5.69	9.86	15	0.47
5.17	15.33	18	1.27
4.31	14.24	27	0.64
3.96	13.14	30	0.81
3.45	14.97	14	0.82
2.86	14.60	17	0.76
1.03	15.33	8	1.76

[1]See Note 2, Table 1.

PF_i, i = 1 or 2 is the average amount of fuelwood in cubic meters from market sources per adult per year in the traditional or semi-traditional wood consumption population group who obtained part or the whole of his

Table 8.--Parameters of Market Supplied Fuelwood Consumption as Function of Fuelwood Price.

EQ. 1	PF_1	=	2.9	$- 0.18 \cdot P_4$	R^2 = .66
	(1.84)		(1.42)	(0.05)	DW = 1.88
			(.01>L>0)	(.01>L>0)	
EQ. 2	PF_2	=	2.1	$= 0.12 \cdot P_4$	R^2 = .71
	(0.83)		(1.23)	(0.04)	DW = 1.65
			(.01>L>0)	(.01>L>0)	

L = level of significance

supply from market sources. P_4 is market price of fuelwood (₦/cubic meters).

3. Parameters of Paper Consumption as Function of Per Capita Income: The per capita consumption of paper for the low-, medium-, and high-income population groups are calculated as functions of changes in per capita income in the various income groups. The parameters here are estimated by judgement rather than by regression methods because of insufficient data on per capita consumption of paper. Average annual consumption of paper per adult in the various income brackets in the base year (1974) were estimated by asking the respondents the number of periodicals including newspapers, magazines, and journals they read and how often each was published, and how many printed books and writing books they buy in a year. Respondents in the medium and high income groups were also asked in addition how much toilet paper they buy per month. These were converted to annual quantities. Average amounts of paper in kilograms were found per person in each income group. The averages for the medium and high income groups were doubled assuming that people use as much paper at home as at work. These averages were used as constant parameters.

The same respondents as above were asked how many more magazines and reading and writing books they would buy if their incomes doubled. These were calculated as percentages of periodicals and books now bought. Arithmetic means for these were taken for different income groups and multiplied by 1.5 assuming that the volumes of newspapers and periodicals will probably increase as income increases in the aggregate. These were used as the coefficients of per capita income in the consumption of paper. These estimates are presented below:

$$PAP_1 = .03 + 0.0 \quad (PCI_1 - PCI_1(0))$$

$$PAP_2 = 2.9 + 0.0013 \, (PCI_2 - PCI_2(0))$$

$$PAP_3 = 31.0 + 0.0023 \, (PCI_3 - PCI_3(0))$$

PAP_i is per capita consumption of paper in kilograms in the income group i, PCI_i is the per capita income (₦/year) in the income group at time t, and $PCI_i(0)$ is the per capita income (₦/year) at the base year. i = 1, 2, 3 represents low-, medium-, and high-income brackets respectively. The coefficient of change in income for the low-income group is zero. If the income of anyone in this group changes enough, he is classified in the medium-income group. Because of lack of information we assume that changes in per capita consumption of paper for high school and college students will be proportional to changes in medium and high per capita incomes respectively.

4. Other Parameters Estimated: In Table 9 the results of the regression estimates of other parameters are shown:

Table 9.--Estimates of Other Parameters.

EQ. 1	HST	=	-31721	+	36.02·GDP	+	283.87·EB	R^2 = .57
	(15810)		(1312)		(16)		(309)	DW = 1.69
			(.39)		(.05)		(.38)	
EQ. 2	CST	=	-88	+	10.420·EB	+	55.912·THG	R^2 = .85
	(69)		(35)		(19)		(17.319)	DW = 1.54
			(.32)		(.17)		(.08)	
EQ. 3	JOB	=	2863	+	9.09·GDP	+	5.31·SB	R^2 = .82
	(1737)		(7812)		(4.85)		(15.34)	DW = 2.43
			(.12)		(.11)		(.74)	
EQ. 4	RSI	=	327	+	0.07·AGP	+	5.19·AB	R^2 = .96
	(173)		(54)		(0.02)		(7.25)	DW = 2.02
EQ. 5	SNI	=	-41776	+	0.23·GDP	+	1.96·SB	R^2 = .87
	(2771)		(21546)		(0.07)		(0.20)	DW = 2.12
			(.02)		(.04)		(.34)	
EQ. 6	BED	=	106	+	0.04·GDP	+	188.92·HB	R^2 = .72
	(101)		(48)		(0.01)		(6.17)	DW = 1.83
			(.26)		(.76)		(.02)	
EQ. 7	PRD	=	333	+	0.15·GDP	+	2.32·TB	R^2 = .84
	(214)		(139)		(0.07)		(0.59)	DW = 1.69
			(.05)		(.07)		(.69)	
EQ. 8	ETA_1	=	0.97	-	0.02·AB	+	226.74·PD	R^2 = .92
	(.01)		(.01)		(.01>E>0)		(.01>E>0)	DW = 2.57
			(0>.01)		(.01>L>0)		(.15)	
EQ. 9	ETA_2	=	0.02	+	0.02·AB	-	16.63·PD	R^2 = .93
	(.01)		(.01)		(.01>E>0)		(.01>E>0)	DW = 2.54
			(.06)		(.01>L>0)		(.09)	
EQ. 10	TMT	=	37	+	4.03·BLN			R^2 = .91
	(12)		(73)		(.69)			DW = 1.37
			(.62)		(.01>L>0)			
EQ. 11	RIG	=	.19	-	0.00099·PDF			R^2 = .72
	(.02)		(.04)		(.01>E>0)			DW = 2.41
			(.01)		(.03)			

E = Standard error of coefficient

L = Level of significance

HST = Number of incoming high school students (people/year)

Table 9.--Continued.

CST =	Number of incoming college students (people/year)
JOB =	Number of management level job openings (jobs/year)
RSI =	Number of people in the traditional population group reclassified as semi-traditional (people/year)
SNI -	Number of people in the semi-traditional population group reclassified as non-traditional (people/year)
BED =	Number of additional hospital beds (beds/year)
PRD =	Additional kilometers of dirt road (kilometers/year)
ETA_1 =	Proportional rate at which people enter traditional agriculture (proportion/year)
ETA_2 =	Proportional rate at which people enter non-traditional agriculture (proportion/year)
TMT =	Number of new lumber trucks (trucks/year)
RIG =	Proportional rate of rural to urban migration (proportion/year)
GDP =	Gross domestic product (₦million/year)
EB =	Government education expenditure (₦million/year)
THG =	Number of fresh high school graduates (thousand people/year)
SB =	Total government fiscal expenditure (₦million /year)
AGP =	Agriculture's contribution to GDP (₦million/year)
AB =	Government expenditure on agriculture (₦million/year)
HB =	Government health expenditure (₦million/year)
TB =	Government transportation expenditure (₦million/year)
PD =	Population density (people/square kilometer)
BLN =	Commercial bank loans for transportation and communication industries (₦million/year)
PDF =	Rural-urban income differential (₦/year)

All the parameters except those of EQ. 11 were estimated on the basis of time series data. The parameters in EQ. 11 were based on cross-sectional data provided by Mabawonku (33).

Sources of the Data

Data presented above came from both primary and secondary sources. The primary sources are the national wood consumption surveys carried out between July and December 1974 cooperatively with the Federal Department of Forestry and Food and Agriculture Organization working on the High Forest Development Project in Nigeria. The secondary sources are published and unpublished sources of government departments, commercial banks, the Central Bank, and so on.

The National Wood Consumption Survey

The objective of the survey was to observe how much of different wood products are used in the residential housing construction, non-residential building construction, casket manufacturing, vehicle body and bridge construction, fuelwood consumption, and paper subsectors. The survey was conducted at the point of consumption or at the household, institution, etc., levels, i.e., we observed the wood that is already in use. We could have as well observed the wood at the production point or at the distribution level at a point in time and derive estimates of consumption. This would be probably easier but it would not provide sufficient insight into the use to which the wood products are put. Ideally, observation should be made at the three points and comparison made but we could not do this because we were limited by resources.

1. Some Problems Encountered in the Survey: The enumeration included both counting of pieces of wooden items, taking measurements and photographs of them as well as of buildings to be later presented to building architects and engineers for the estimates of amounts of wood involved. We could not trust that hired enumerators would do these as carefully as required, so the investigator with an assistant carried out all the interviews and completed all the questionnaires personally. This practice limited the sample size but it makes us aware of all the measurement errors and other biases that are involved in the field work.

Four provinces approximately representing four natural forest zones, namely, Ibadan (rain forest), Enugu (derived savannah), Zaria (savannah), and Sokoto (subsahelian) were surveyed. The original arrangement was to include Port-Harcourt, Calaber, and Jos provinces. The bureaucratic processes in the Federal Government resulted in loss of time. Vehicles were available but government drivers were in short supply and they alone can drive government vehicles. Travelling advances were approved for the assistant who went out with me on the field trips but never made available in time. One or the other person who would sign the voucher would not be "on seat." The FAO project director tried to help out by providing the travel advance on loan for the assistant but when the loans were not refunded, he ceased. When we were able to go out, we were not able to work long hours as we would have wanted since our time was limited and since we would meet more people at home in the evenings. Civil servants were reluctant to work outside office hours. A guide and interpreter was provided in each province by the arrangement of the Federal Department of Forestry. The guides who were all forest guards were very useful.

It was our intention to take measurements of buildings and furniture and observe their wooden parts personally. We could not always do this in the provinces surveyed in the north because of religious restrictions. In those areas we relied on the respondents for the measurements. In the same areas too, we were required to get permit from the chief and the sub-chief before we carried out any interviews in each village. The permit was never refused once we could locate the appropriate chief but further time was lost in locating him.

Except in the Ibadan province where some interviewees were reluctant, most of our respondents were quite polite although some of them believed that through our study they could get scarce wood products cheaper. We tried to explain that through our study wood products may become cheaper but not right away. For this reason we suspect that some of the price information we got, particularly in Enugu province, was exaggerated. We avoided questions on the sensitive area of personal income and tried to classify people in income groups on the basis of type of house in which they lived.

Except in a few cases where the date the residential buildings were set up was carved on the wall in front of the buildings, the ages of buildings were often guessed. There were no other written records and memories were short.

Measurements of houses and furniture presented problems, especially in the rural areas where there was absence of regularity in size and design of buildings. In the non-residential buildings, too, the sizes of buildings varied widely from single-floor to multi-floor buildings. In such cases, it becomes unrealistic to count number of houses.

2. Sampling Procedures: Rural household surveys were limited to villages located between ten and thirty kilometers from the outskirts of the major city in each province included. We selected five routes leading out of the city, including branch routes, and making sure that they were as far as possible in different directions around the city. Starting at the tenth kilometer from where by judgement we considered the city limit on the route we chose and enumerated the first five, ten, or fifteen households (see Table 10) on the right-hand side of the road. It will be relatively easy to recognize and repeat or avoid the same households if another survey is desired.

In the urban residential wood consumption survey the major city in each province, namely, Ibadan, Enugu, Zaria, and Sokoto, were included. Each city was stratified into high and low income neighborhoods which were distinct and easy to recognize. The high income neighborhoods were not many, in most cases one or two. From a list of streets obtained from the city council office, one street was selected by a random method in one high income and in one low income neighborhood. Any twenty households in the selected street in the high income neighborhood and any thirty households in the street selected in the low income neighborhood were enumerated. Very frequently people were not available at home by the time we visitied so we continued until we got enough households where we could find respondents.

The survey in the non-residential building construction subsectors included hospitals, elementary schools, high schools, religious, commercial, and public administration centers. These were also surveyed in the same provinces as were the residential constructions. Lists of elementary schools, high schools, hospitals, public administration

Table 10.--Locations of Households Included in the Rural Residential Wood Consumption Sample Survey.

Province	Route	Distance From Outskirts of City (Kilometers)	Number of Households Included
Zaria	Samaru - Hunkui	15	10
	Slika - Tandama	18	15
	Zaria - Kaduna	21	10
	Zaria - Soba	21	10
	Kuolan - Roga	15	5
	Total		50
Sokoto	Sokoto - Kware	18	15
	Kware - Gande	18	10
	Sokoto - Bodinga	13	5
	Sokoto - Gusau	21	10
	Sokoto - Gorougo	20	10
	Total		50
Ibadan	Ibadan - Imaw	11	5
	Ibadan - Ijebu - Igbo	14	10
	Ibadan - Apomu	13	15
	Ibadan - Moniya	11	15
	Ibadan - Oshielo	15	5
	Total		50
Enugu	Enugu - Olo	17	10
	Ninth Mile - Nsukka	5	15
	Enugu - Okbokubono	21	10
	Emene - Abakaliki	10	10
	Oji River - Awgu	7	5
	Total		50
	Grand Total		200

centers, and churches in both rural and urban areas and mosques in the urban areas were available in the various offices of the ministries, city councils, church headquarters, etc., if one searched hard enough. Rural mosques were often open grounds. From the various lists, ten elementary schools, three from the urban low income neighborhood, two from the urban high income neighborhood and five from the rural area were selected by a random method in each province.

Five high schools in each province were selected from the list. Effort was made to include one of secondary grammar, secondary modern, secondary commercial, vocational, and teacher training schools if available.

Five hospitals were selected from the list in each province. Where available at least one public or quasi-public, and one private hospital, one "health center" and one maternity home were included. Ten religious centers, five in the rural and five in the urban areas, were selected in each province. They included at least one church, one mosque, and one shrine where these were available. The religious centers included were only those with erected buildings and where more than one household worshipped. Actually no religious center was enumerated in the rural areas of the two provinces in the north because none were found.

One public administration center in each province was included. Besides differences in size of buildings they were fairly uniform in terms of furniture in the buildings and the building materials. Commercial centers in rural areas are market places. We included one of these in each province. In the urban areas, we included at least one retail shop, one workshop, and one factory if they were available.

3. Estimating the Amount of Wood in an Item: At the end of the enumerations we went to the senior architect in the Western State Ministry of Works and Housing in Ibadan, a foreign building contractor who has worked in Nigeria for twenty-six years, and to a building engineer in Enugu with our photographs and measurements of buildings and the records of parts of them made of wood. These people made independent estimates of the average amounts of different wood products in each group of houses, furniture, and utensils as well as in caskets, lumber trucks and bridges. We calculated the arithmetic means of the estimates by the three people and used them in our model.

Sources of Time Series Data

Government expenditures for agriculture (AB), education (EB), transportation (TB), economic services (SB), and commercial bank loans (BLN) for transport and communication were obtained from various issues of the Standard Bank Group, Annual Economic Review, Nigeria (53), Central Bank of Nigeria, Economic and Financial Review (4), and from John W. Hanson et al., Report on the Supply of Secondary Level Teachers in English-Speaking Africa (28). AB and EB are recurrent expenditures. TB which is transport and communication and SB which includes education, health, agriculture, construction, transport and communication and other economic services expenditures are both capital and recurrent expenditures.

Gross domestic product (GDP) and agricultural gross product (AGP) were obtained from Gross Domestic Product of Nigeria, 1958-59 to 1969-70, Federal Office of Statistics (26), and from various issues of the Standard Bank Group, Annual Economic Review, Nigeria (53).

Number of new timber trucks, additional kilometers of dirt road per year and price indexes at 1960 level were obtained from various issues of Digest of Statistics, Federal Office of Statistics (10). New lumber trucks are new registrations of commercial vehicles excepting trailers, cars, and light trucks. Additional kilometers of dirt roads are the sum of tarred and gravel or earth road in year one minus the same in year zero assuming that every road starts as dirt road.

First-year high school and college students respectively were obtained from various issues of Statistics of Education in Nigeria (55). High school includes secondary grammar, secondary commercial, secondary modern, vocational schools, and teacher training. College includes universities, polytechnics, schools of arts, science and technology, and advanced teacher training colleges.

The proportion of farms that are traditional and the proportion that are non-traditional are derived from Rural Economic Survey of Nigeria, Consolidated Results of Crop Estimation Surveys, 1968-69, 1969-70, and 1970-71 (52). A commercial farm is a farm household farming two hectares or more of food crops or one hectare or more of tree crops.

The numbers of new college-level jobs were estimated from various issues of Digest of Statistics (10), Statistics of Education in Nigeria (55), and Investment in Education, the Report of the Commission on Post-School Certificate and High Education in Nigeria. College-level jobs were defined to include managerial and professional positions and positions for teachers with Nigerian Certificate of Education and higher qualifications. The sectors included are government services, manufacturing, construction, electricity, transport, and teaching.

The rural-urban income differential (PDF) and the proportional rate of rural-urban migration were adapted from Mabawonku, Impact of Rural-Urban Migration on the Agricultural Economy in Western Nigeria (33). PDF is government minimum wage rate in 1971-72 minus average cash earnings per head of rural household in the same year in the selected communities. Proportional rate of rural-urban migration is the rate of rural-urban migration in the selected communities in 1970-71.

Reliability of the Data: The accuracy of the projections yielded by the model will depend partly on the assumptions we make about the relationships between variables and the values we assign to the various variables and constant inputs. We have regretted that the average amounts of some wood products in some uses could not be varied as functions of prices in the present projections. We are, however, more concerned about the accuracy of the values we assigned to them and to other inputs which the model receives as constants.

The major source of this concern is the size of the sample covered in the national wood consumption survey from which most of those constant inputs were derived. The differences in the living conditions in Nigeria with such variations in vegetation, economic conditions, educational backgrounds, etc., described in Chapter I cannot be observed in four provinces.

We have three main reservations about the variable inputs, GDP, government investments, and others. One major reservation is about the assumptions we have made about their future values. The economic conditions in Nigeria are so unstable and the information base so scanty that it is very difficult to make dependable assumptions about income and expenditure for any extended lengths of time. We shall discuss this reservation further in Chapter VII.

The second source of concern about variable inputs is the time series data used to estimate most of the coefficients. We have pointed out that they are generally incomplete, of short duration and are likely to have high degrees of errors. We attempted to make up for some of the incompleteness by trying to assemble some data from unanalyzed information in the files of the Federal Office of Statistics. We discovered many empty cells in the questionnaires. Because of the short duration of most of the time series, our degrees of freedom in the regression analysis presented above were between seven and ten. The next reservation is the simple nature of the equations. In some of the equations we wanted to use exponential functional forms which will be more consistent with our basic assumptions but we needed more and better data to do so. Since we are using these equations for the purpose of predicting the time paths of modernization processes, we are not as much concerned with the functional form and the numbers of degrees of freedom as we are with the accuracy of the data. We recommend that when the model is rerun with a new set of data to make fresh projections some coefficients should be reestimated with cross-sectional data and that the sample size be extended in the next survey to cover various geographical, vegetational, and economic backgrounds in Nigeria which we could not cover.

CHAPTER VI

SUMMARY OF BASE RUN ESTIMATES AND PROJECTIONS

Introduction

In Chapter I it was stated that an objective of the present study was to develop a computerized simulation model which could be used to estimate wood consumption levels for Nigeria whenever the necessary data are available. In Chapters IV and V this model was developed and computerized. On the basis of data presently available, the model was used to estimate the annual wood consumption in various wood-using subsectors in the past from 1965 to 1974 and to make three sets of projections of those estimates into the future up to the year 1990. Projections were also made for each of the population groups, high school and college enrollments, management level employment opportunities and other intermediate outputs.

One set of projections, called the base run projections, is based on projected GDP for the period 1975 to 1980 made by the Federal Government of Nigeria. Estimates and projections are also made on the basis of two alternative assumed rates of growth of GDP. We shall present the base run estimates and projections in this chapter and present the projections under alternative assumptions in the next chapter.

Assumptions About Variables

GDP and Government Investments

In the Fourteenth Independence Anniversary broadcast General Gowon said that during the period 1975-80 the gross domestic product of Nigeria is expected to grow from ₦13,962 million in 1974-75 to ₦24,235 million in 1979-80, indicating an average compound rate of growth of 11.7 percent per annum (7). In the same broadcast General Gowon summarized the highlights including government expenditures of the Second National Development Plan ending in March 1975 and of the Third National Development Plan beginning in April 1975. These government estimates form the basis for the base run projections made with the model.

We assumed that the gross domestic product will continue to grow at 11.7 percent per annum between 1975 and 1990. But the base figures of ₦13,962 million for 1970 and ₦24,235 million for 1975 were reduced to their values at 1960 price levels. It is also assumed that government expenditures will continue to grow at the governmentally projected rates of the period 1975-80. Expenditures at the final year of each five year period are assumed to be 25 percent higher than expenditure for the first year of the same five year period. General Gowon stated in the broadcast cited above that "by 1973 about ₦315 million (out of the 1970-75 plan transportation budget) had been spent by the governments of the Federation on the various transport modes. By March 31, 1975, it is expected that expenditure (on the various transport modes) will be at least twice that figure" (7). Frequently a greater proportion of budgets for various National Development Plans are spent towards the end of the plan period. The assumptions about the gross domestic products, and government expenditures for agriculture, education, and transportation for the base run are summarized in Table 11.

Table 11.--Annual Values (at Five Yearly Intervals) of GDP and Government Expenditures Assumed for the Base Run (₦ million/year), 1965-1990.

Year	GDP	Agriculture Budget	Education Budget	Transportation Budget
1965	2,990	30.0	26.1	1.7
1970	3,700	43.1	56.1	10.5
1975	10,254	226.0	380.0	784.0
1980	16.840	372.8	610.0	1,098.0
1985	26.120	515.4	852.6	1,516.0
1990	37.920	786.4	10.446.0	2,306.0

Other Variables

Some of the other variables about which assumptions were made are agriculture's contribution to GDP, the ratio of price index of wood to the price index of substitutes for wood, average per capita incomes for the medium and for the high income brackets, and the loans provided for the transportation industry by commercial banks. Agriculture's contribution to GDP is assumed to continue to grow at its 1958-74 average rate of 3 percent per annum.

Projections of Intermediate Variables

Some of the intermediate variables projected by the model are population of adult persons by traditional, semi-traditional, and non-traditional population groups corresponding approximately to low income rural population, medium income and urban low income population, and high income population groups. Projections were also made for high school and college enrollments, deaths, management level job opportunities, numbers of lumber trucks and hospital beds, and annual rates of construction of buildings in the various wood using subsectors. The projections of these intermediate variables are based on various definitions and assumptions which are adequate for estimation and projection of wood consumption, but may not always be adequate for the estimation and projection of the intermediate variables because the estimation and projection of the intermediate variables are not the primary objectives of the study. We shall summarize the projections of some of these intermediate variables.

Population

Population projections are needed and made for the total and for the annual growth of traditional, semi-traditional, and non-traditional wood consumption population groups. Projections are also made for totals and changes in high school and college enrollments and for total deaths. The projections of the population component of "A Generalized Simulation Approach to Agricultural Sector Analysis with Special Reference to Nigeria (GSAASA)" (35) form the basis of our projections of traditional, semi-traditional, and non-traditional wood consumption population groups. The GSAASA estimates of the total population are lower than the results of 1973 population census in Nigeria by 7.6 percent. But as pointed out in Chapter I above some of the unexpected increase in the Nigerian population from less than 56 million in 1963 to over 79 million in 1973 can be attributed to statistical errors. The 1973 population results are still controversial and not completely accepted in Nigeria. The resort of the present study to GSAASA for population projections is not due to a confidence in its accuracy. It is rather because it is the most up-to-date population estimate that we could find for Nigeria. Population projections of our model are presented in Appendix C and summarized in Table 12 and Figure 8.

Table 12.--Summary of Some of the Population Estimates and Projections, 1965-1990.

Year	High School Students (Total)	College Students (Total)	Traditional Population (Rate/Year)	Semi-traditional Population (Rate/Year)	Non-traditional Population (Rate/Year)
1965	251,424	7,750	355,380	181,171	7,380
1970	352,059	11,501	278,920	181,912	9,909
1975	960,574	21,546	256,644	198,972	24,201
1980	2,001,755	55,408	232,955	356,753	41,365
1985	3,210,549	102,128	240,227	509,278	68,790
1990	4,827,840	153,868	249,760	702,165	104,475

Building Construction Rate

Estimates and projections are made of rates of construction for residential, school, farm, commercial, religious, public administration, and hospital buildings; bridges; and lumber trucks. These are presented

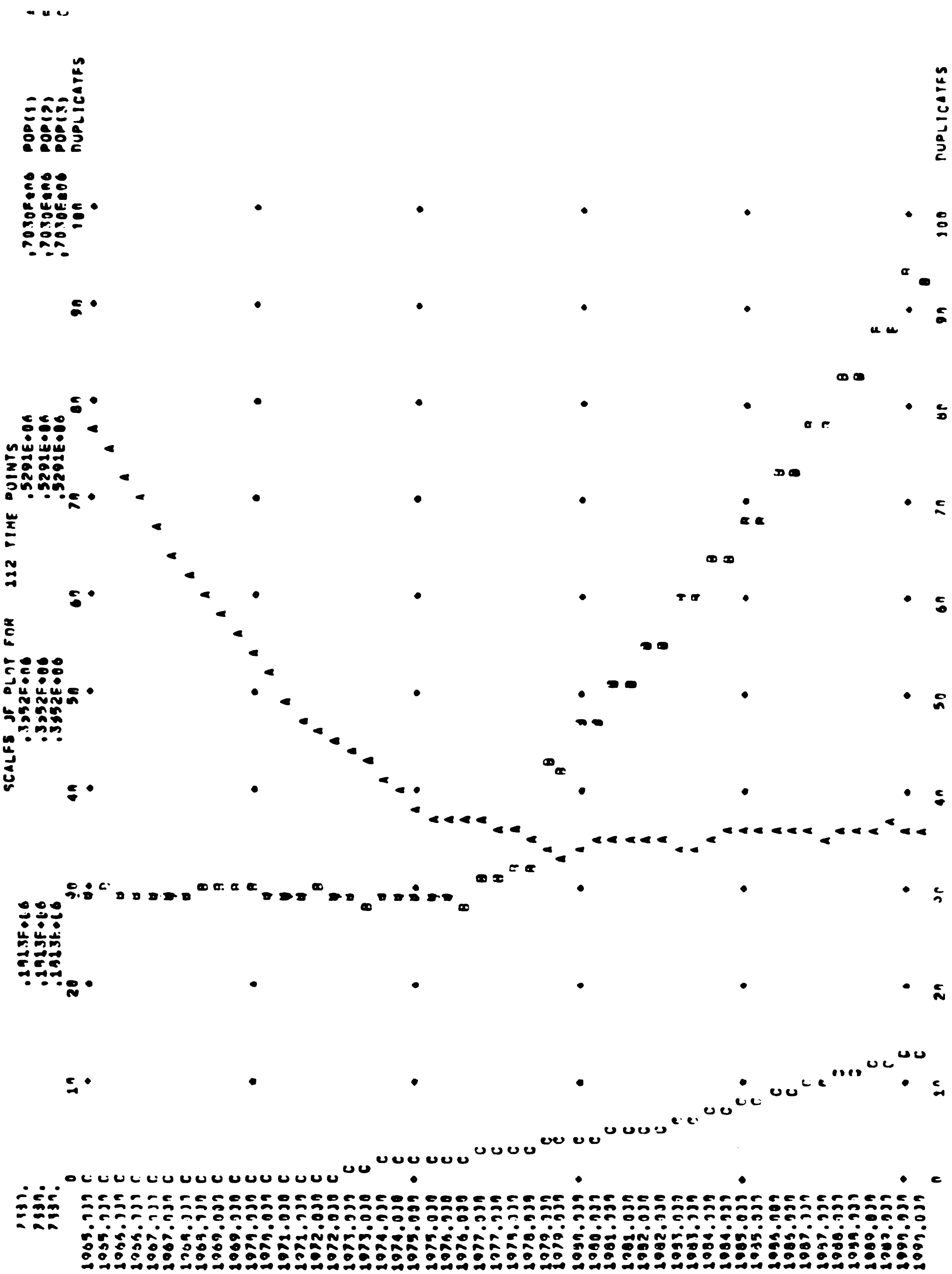

Figure 8: Base Run Projections of Annual Growth of Traditional (A), Semi-Traditional (B), and Non-Traditional (C) Population Groups (people/year), 1965-1990.

in Appendix C. These estimates are subject to the same errors and follow similar time paths as the estimates and projections of the rates of wood consumption.

The rates of construction of residential, farm, school, and hospital buildings and bridges is not exactly proportional to the rates of growth of independent adult populations, farm populations, student populations, hospital bed, and road kilometers. Replacement of decayed buildings after losses resulting from deaths, leaving farm business, conversion of dirt roads to modern ones and losses of buildings by accident are considered.

The rates of construction of commercial, religious, public administration, and elementary school buildings are proportional to the rates of construction of residential buildings for the traditional, semi-traditional, and non-traditional population groups because they are estimated as constant proportions of residential buildings. These projections are presented in Appendix C.

Other Intermediate Variables

The projections of other intermediate variables namely management level job openings, deaths, numbers of lumber trucks and hospital beds, and the rate of rural-urban migration, are presented in Appendix C.

Projections of Annual Wood Consumption

The wood using subsectors discussed in Chapter III are residential housing construction, non-residential (school, religious, commercial, public administration, and hospital buildings) building construction, farm construction, casket manufacture, bridges and vehicle construction, fuelwood, and paper. Estimates of the past annual wood consumption made for these subsectors are based on actual levels of GDP, government expenditures, and other variable inputs of the model in the past. Projections of annual wood consumption in the future in the subsectors are made on the basis of assumed levels of GDP, public investments, and other variables and on model projected levels of population and other intermediate outputs.

The projections of annual consumption of unprocessed wood, processed wood, building board woodpulp, fuelwood, and paper woodpulp in the aggregate are presented in the Appendix D and summarized in Table 13 and Figures 9, 10, and 11.

Table 13.--Summary, Base Run Projections of Overall Annual Consumption of Different Wood Product, 1965-1990.

Year	Fuelwood $(000M^3)$	Unprocessed Wood $(000M^3)$	Processed Wood $(000M^3)$	Building Board Woodpulp (000 kg)	Paperpulp (million kg)
1965	39,876	3,738	700	239	147
1970	57,822	2,972	640	245	175
1975	65,693	2,744	801	382	1,761
1980	70,804	2,666	942	548	3,518
1985	75,565	2,897	1,168	771	7,949
1990	79,740	3,290	1,501	1,055	16,876

We shall next discuss these estimates of annual wood consumption made for the base run in more details under the following subtitles: (1) wood for construction and manufacturing purposes, (2) fuelwood, (3) wood consumption requirements by wood consumption population groups, and (4) wood for paper.

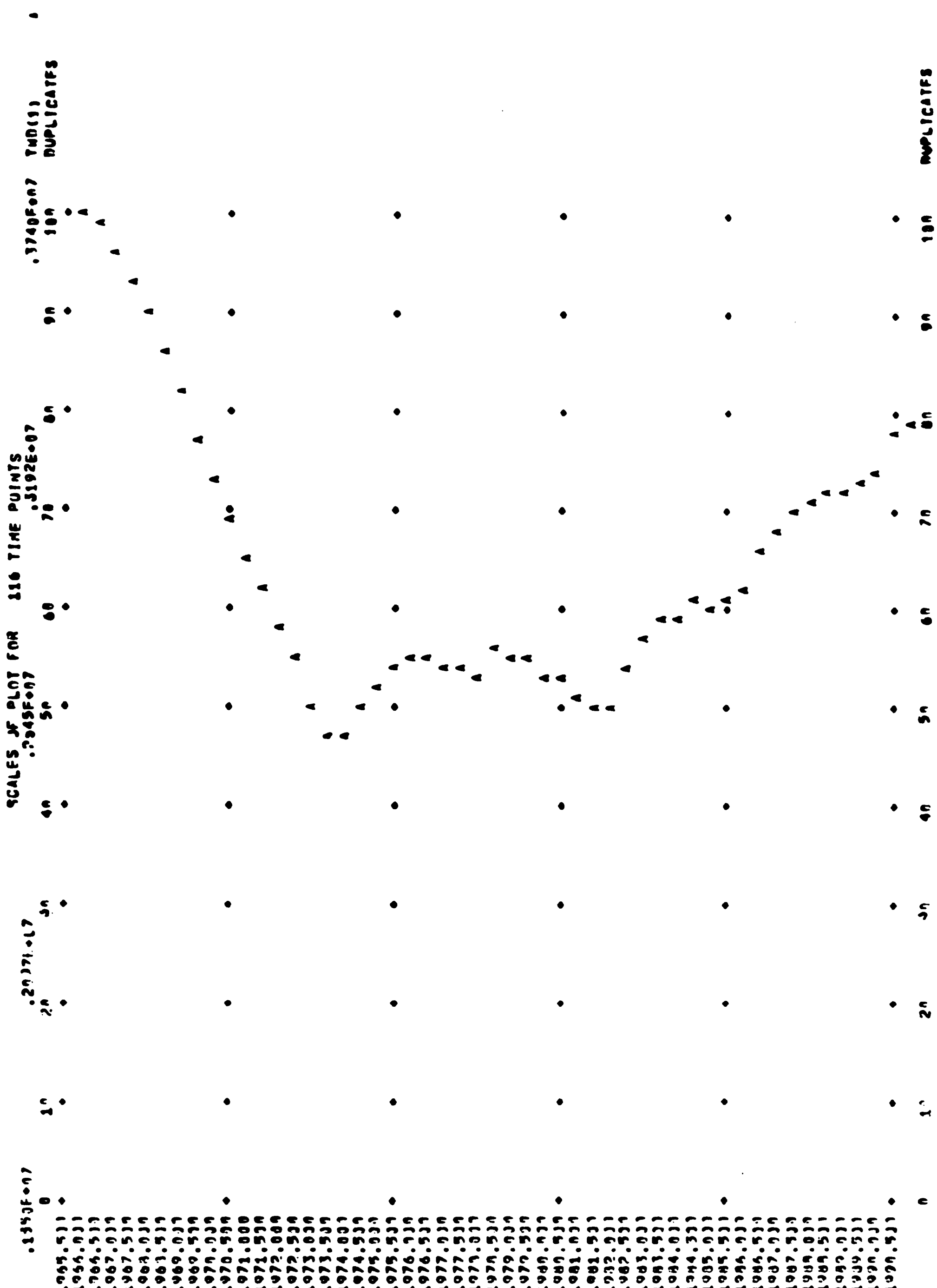

Figure 9: Base Run Projections of Annual Consumption of Unprocessed Wood, 1965-1990.

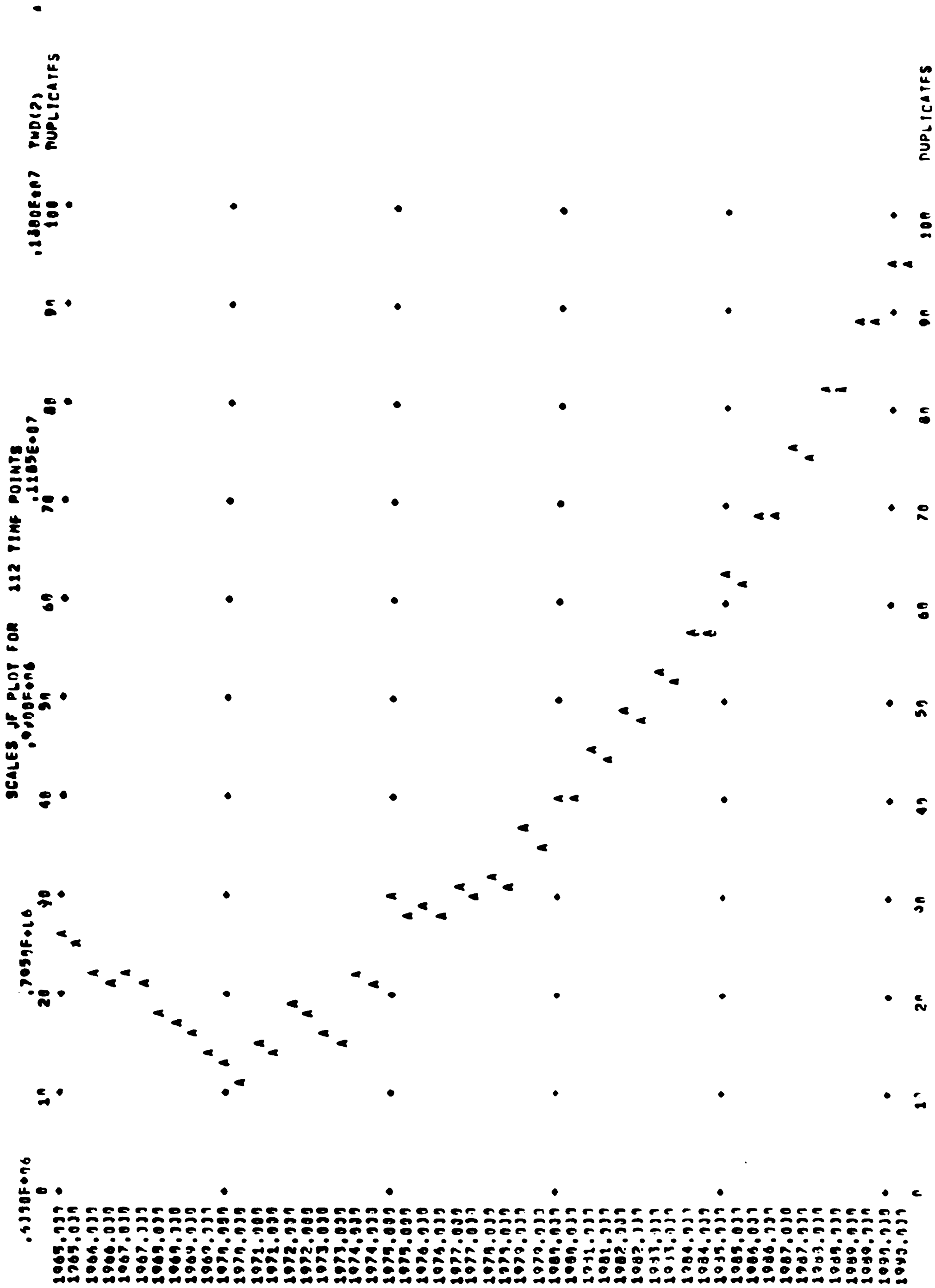

Figure 10: Base Run Projections of Annual Consumption of Processed Wood, 1965-1990.

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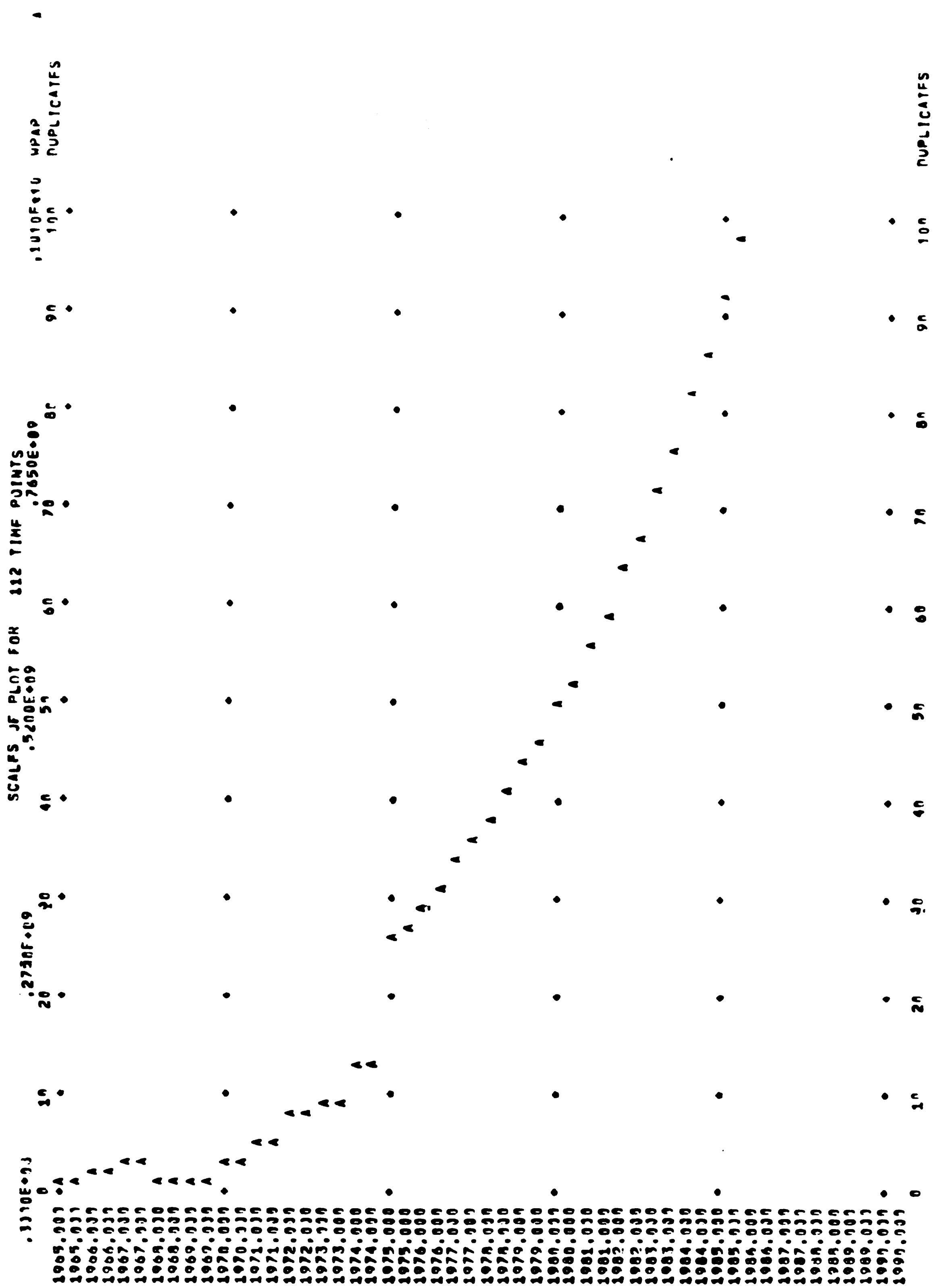

Figure 11: Base Run Projections of Annual Consumption of Paper Wood Pulp, 1965-1990.

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Wood for Construction and Manufacturing

Residential housing construction, non-residential building construction, and casket manufacturing, lumber trucks and bridge construction are the construction and manufacturing subsectors for which annual wood consumption are projected. Projections of annual wood consumption in the residential housing construction subsector both in absolute amounts and as proportions of overall annual wood consumption are summarized in Table 14 and Figure 12 and presented in Appendix D.

The absolute amount and the relative proportion of unprocessed wood required in the residential housing construction subsector increases with increasing income. The relative proportions of processed wood and building board woodpulp decline while their absolute amounts increase with improving economic conditions, implying that other subsectors using processed wood are expanding faster than residential housing construction subsectors.

We have asserted in the previous chapters that most of the projected increases in the annual consumption of various wood products up to 1990 are only the partially lagged consequences of the present high rates of public spending. The governments are currently spending money in building hospitals, roads, schools, etc. and wood is being used in increasing proportions for those purposes. Some lagged consequences of large expenditures on wood consumption will appear later as increased proportions of processed wood in residential housing and furniture construction when the consequences of the current high rate of spending on people materialize. This will happen when the people who are currently benefiting from the present high public spending on education

Table 14.--Summary, Base Run Projections of Annual Wood Consum
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Table 14.--Summary, Base Run Projections of Annual Wood Consumption in Residential Housing: Absolute Amounts and as Proportions of Aggregate Consumption, 1965-1990.

Year	Unprocessed Wood		Processed Wood		Building Board Woodpulp	
	Absolute Amount ($000M^3$/yr)	Relative Proportion (Prop./yr)	Absolute Amount ($000M^3$/yr)	Relative Proportion (Prop./yr)	Absolute Amount (000 kg/yr)	Relative Proportion (Prop./yr)
1965	948	.2536	484	.6910	180	.7547
1970	831	.2798	461	.7188	184	.7489
1975	782	.2851	512	.6396	222	.5803
1980	836	.3136	571	.6053	350	.6389
1985	949	.3276	661	.5654	506	.6563
1990	1,113	.3384	786	.5234	711	.6732

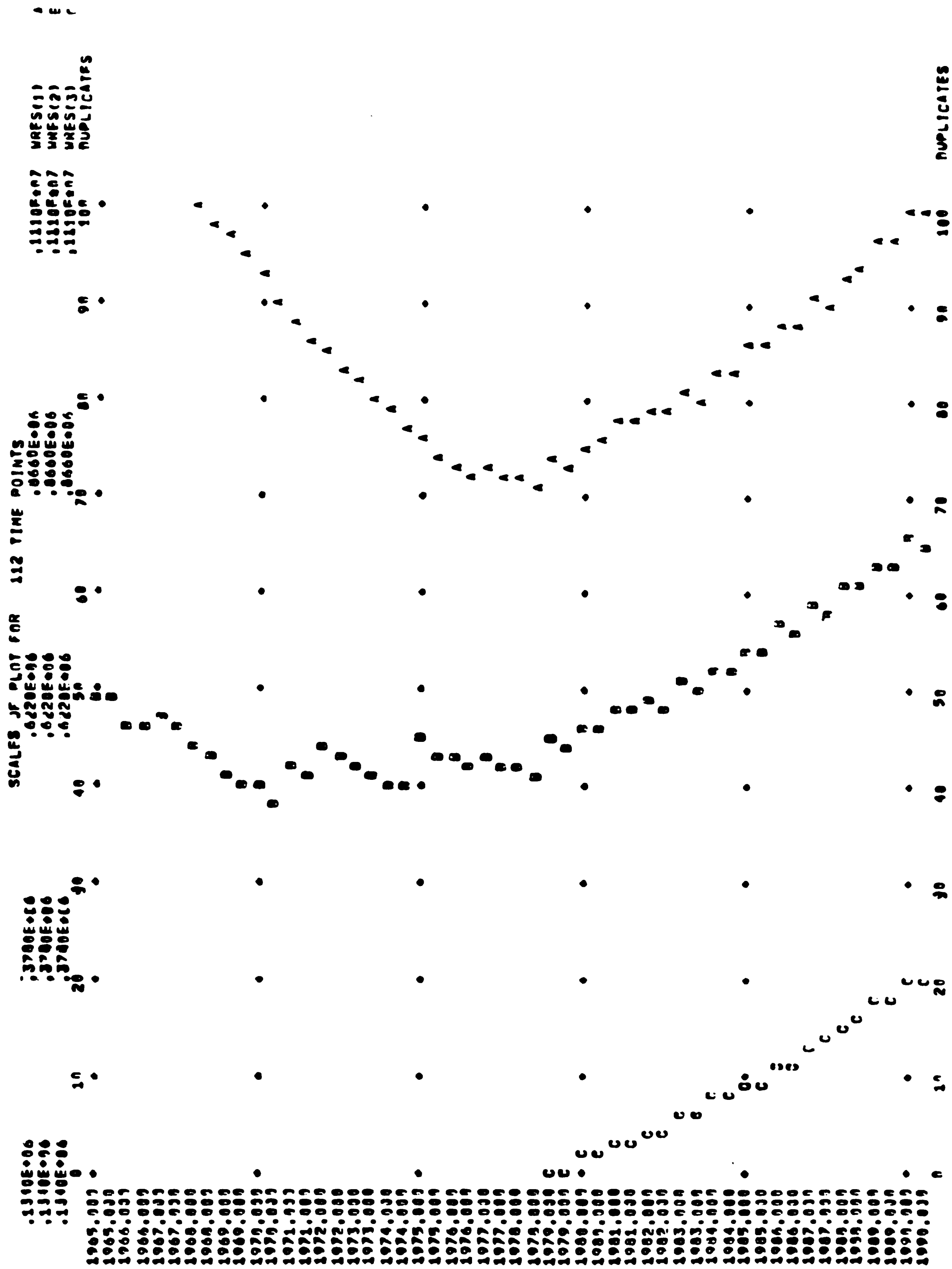

Figure 12: Base Run Projections of Annual Consumption of Unprocessed Wood (A), Processed Wood (B) and Building Board Wood Pulp (C) in Residential Housing Construction, 1965-1990.

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graduate from high schools and colleges and adopt non-traditional living standards for housing and other consumption goods.

Projections of annual wood consumption in the non-residential housing construction (school, religious, hospital, commercial, and public administration buildings) are presented in Appendix D and summarized in Table 15 and in Figure 13. The absolute amounts of building board woodpulp increases while its relative proportion declines. The absolute amounts and relative proportions of processed wood and unprocessed wood in the non-residential housing construction increase with improving economic conditions for the same reasons that those proportions decline in the residential housing construction. The model can supply the information on absolute rates and proportional rates of wood consumption separately if desired for each of these subsectors aggregated together under non-residential housing constructions.

Table 16 and Figure 14 summarize the estimates of annual consumption of processed wood in casket manufacturing, lumber truck, and bridge construction subsectors. These estimates are presented in detail in Appendix D. Assumption was made that these subsectors do not utilize unprocessed wood and building board woodpulp in significant amounts. The rate of wood consumption in casket construction increases at decreasing rate in absolute amounts and decreases in relative proportions as economic conditions get better. This results from declining death rates which will be expected as population shifts from traditional to non-traditional groups as economic conditions improve. Bridge and lumber truck construction subsectors individually do not consume significant proportions of processed wood.

--Summary, Base Run

Table 15.--Summary, Base Run Projections of Annual Wood Consumption in Non-Residential Building: Absolute Amounts and as Proportions of Overall Consumption, 1965-1990.

Year	Unprocessed Wood		Processed Wood		Building Board Woodpulp	
	Absolute Amount ($000M^3$/yr)	Relative Proportion (Prop./yr)	Absolute Amount ($000M^3$/yr)	Relative Proportion (Prop./yr)	Absolute Amount (kg/yr)	Relative Proportion (Prop./yr)
1965	29,707	.0079	135,828	.2081	39,563	.3679
1970	26,421	.0089	133,353	.2149	40,255	.3584
1975	35,836	.0131	239,805	.3053	73,685	.4245
1980	37,879	.0142	298,833	.3276	97,246	.3759
1985	44,667	.0154	396,009	.3563	131,279	.3502
1990	53,168	.0162	514,362	.3734	173,298	.3301

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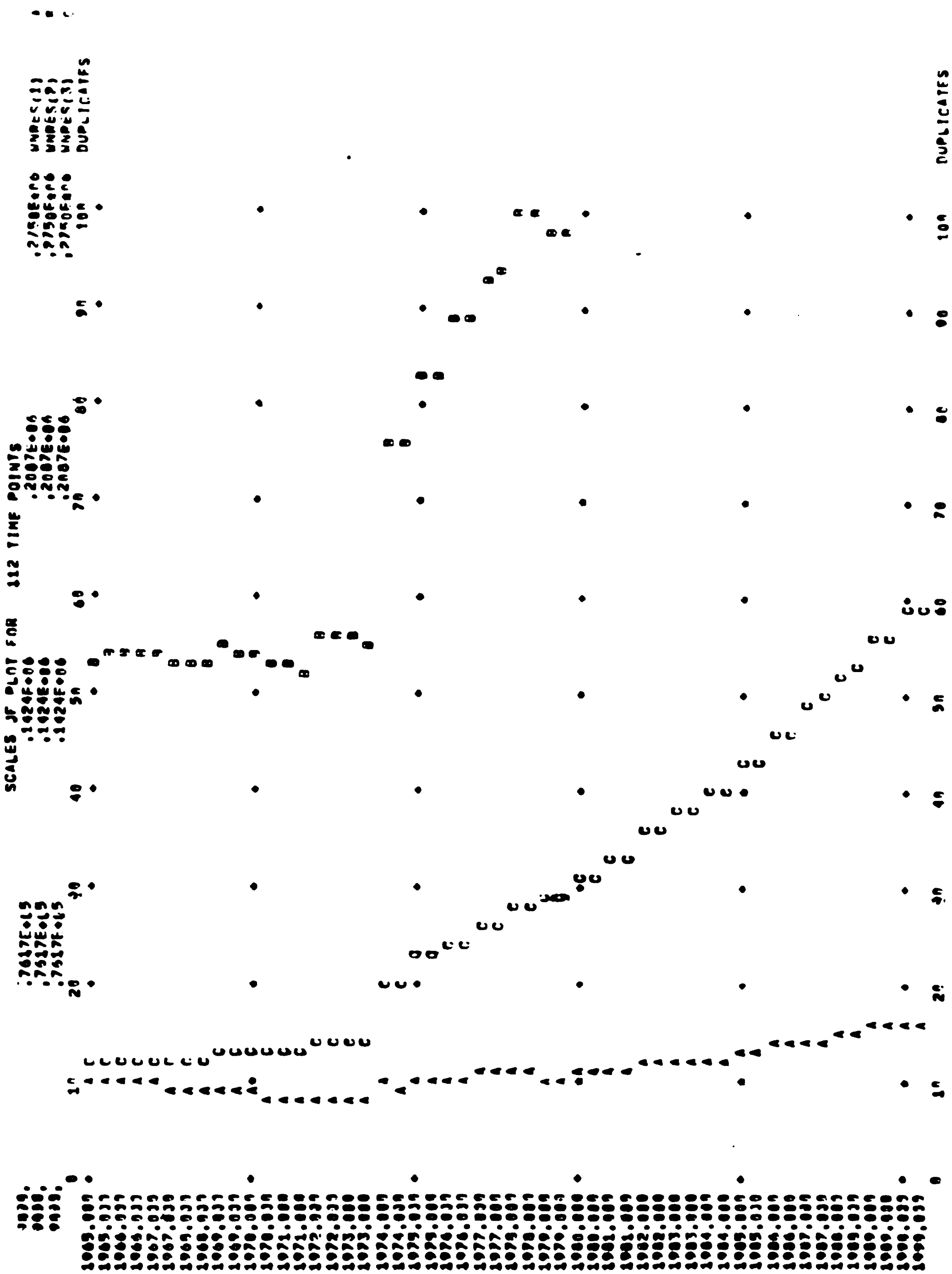

Figure 13: Base Run Projections of Annual Consumption of Unprocessed Wood (A), Processed Wood (B), and Building Board Wood Pulp (C) in the Non-Residential Building Construction Subsectors, 1965-1990.

Table 16.--Summary, Base Run Projections of Annual Consumption of Processed Wood in Caskets, Lumber Truck: Absolute Amounts and as Proportions of Overall Processed Wood Consumption, 1965-1990.

Year	Processed Wood for Casket Manufacture		Processed Wood for Lumber Truck Construction		Processed Wood for Bridge Construction	
	Absolute Amount (M^3/yr)	Relative Proportion (Prop./yr)	Absolute Amount (M^3/yr)	Relative Proportion (Prop./yr)	Absolute Amount (M^3/yr)	Relative Proportion (Prop./yr)
1965	20,315	.0311	1,886	.0029	1,589	.0024
1970	20,859	.0336	1,367	.0022	1,036	.0017
1975	22,151	.0282	5,887	.0075	2,504	.0032
1980	24,031	.0263	9,157	.0100	3,839	.0042
1985	24,579	.0221	14,108	.0127	5,385	.0048
1990	24,987	.0181	20,879	.0152	8,062	.0052

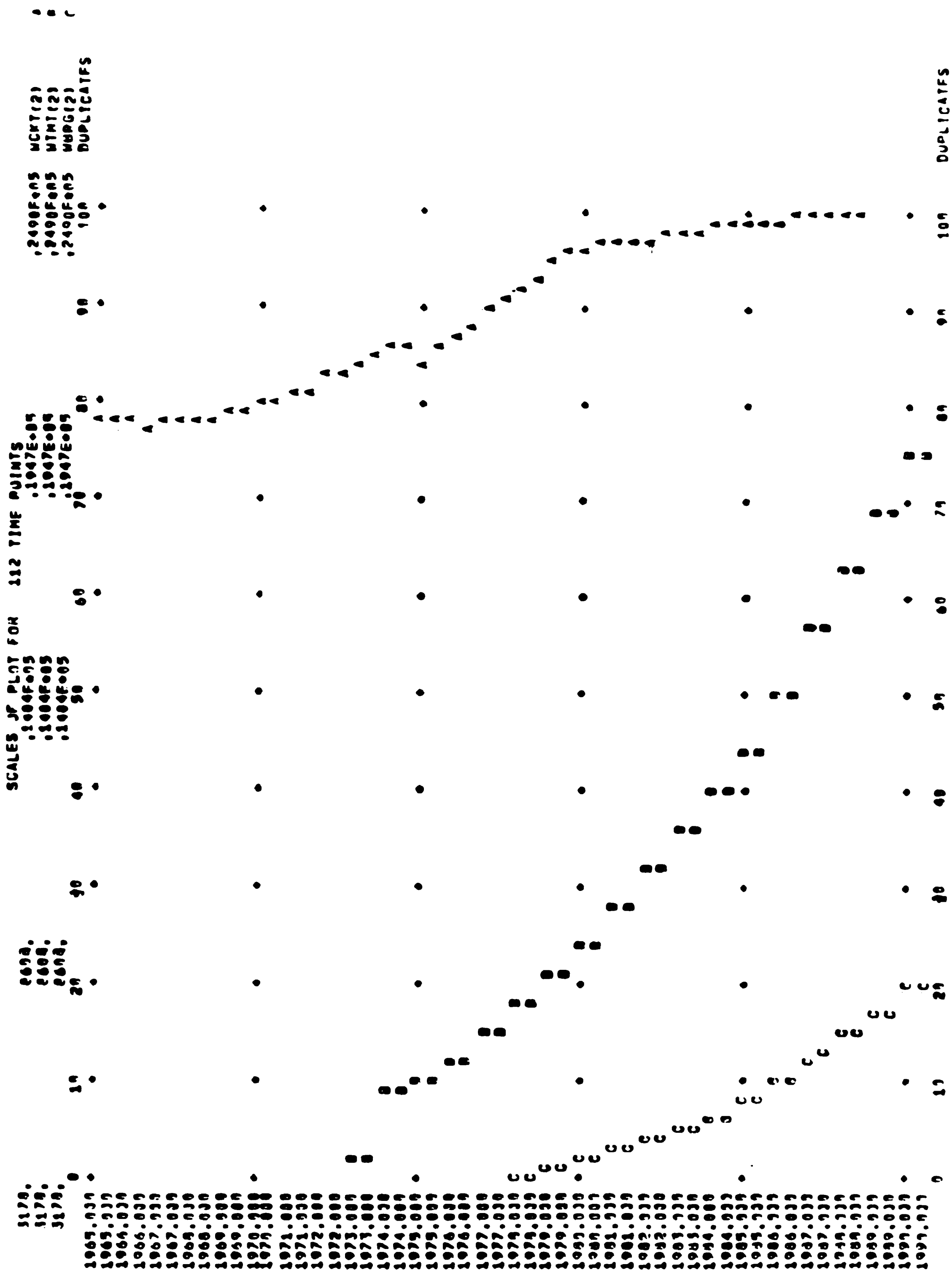

Figure 14: Base Run Projections of Annual Consumption of Processed Wood in Casket Manufacture (A), Lumber Truck (B), and Bridge Construction, 1965-1990.

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Table 17 summarizes the projections of annual wood consumption in the farm construction subsector. The projections are presented in detail in Appendix D. The farm construction subsector consumes a slowly declining large proportion of overall unprocessed wood consumption. The proportion of processed wood used in the farm construction subsector is insignificant. This proportion tends to increase as non-traditional agriculture expands with income and increased public spending in agriculture.

Table 17.--Summary, Base Run Projections of Annual Wood Consumption in the Farm Construction: Absolute Amounts and as Proportions of Overall Consumption, 1965-1990.

Year	Unprocessed Wood		Processed Wood	
	Absolute Amount ($000M^3$/yr)	Relative Proportion (Prop./yr)	Absolute Amount ($000M^3$/yr)	Relative Proportion (Prop./yr)
1965	2,761	.7384	57	.0139
1970	2,114	.7114	23	.0060
1975	1,926	.7007	18	.0037
1980	1,792	.6722	36	.0063
1985	1,903	.6570	68	.0097
1990	2,123	.6454	147	.0171

Fuelwood

Estimates are made for the annual consumption of fuelwood in the traditional and the semi-traditional wood consumption population groups. It was assumed that the non-traditional wood consumption population group does not burn wood for fuel in significant amounts.

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Estimates are also made for the annual consumption of fuelwood from market and from non-market sources. We shall discuss the estimates of the annual fuelwood consumption by traditional and semi-traditional population groups under the next subtitle. The estimates of the annual consumption of fuelwood by market and non-market sources are summarized in Table 18 and Figure 15 and presented in detail in Appendix D. The large proportion of fuelwood coming from non-market sources declines with changing economic conditions implying that in future more reliance will be made on the market for the supply of fuelwood. Market sources do not necessarily mean non-salvage sources of fuelwood. Some of the wood sold in the market in the form of wood or charcoal are salvages from various activities including farming, wood processing, and construction industries.

Table 18.--Summary, Base Run Projections of Annual Fuelwood Consumption by Market and Non-Market Sources: Absolute Amounts and as Proportions of Overall Fuelwood Consumption, 1965-1990.

Year	Fuelwood from Market Sources		Fuelwood from Non-Market Sources	
	Absolute Amount ($000M^3$/yr)	Relative Amount (Prop./yr)	Absolute Amount ($000M^3$/yr)	Relative Amount (Prop./yr)
1965	17,977	.1871	78,101	.8129
1970	19,183	.1957	78,834	.8043
1975	19,096	.1971	77,714	.8029
1980	19,479	.2024	76,765	.7976
1985	20,420	.2122	75,812	.7878
1990	21,902	.2252	75,359	.7748

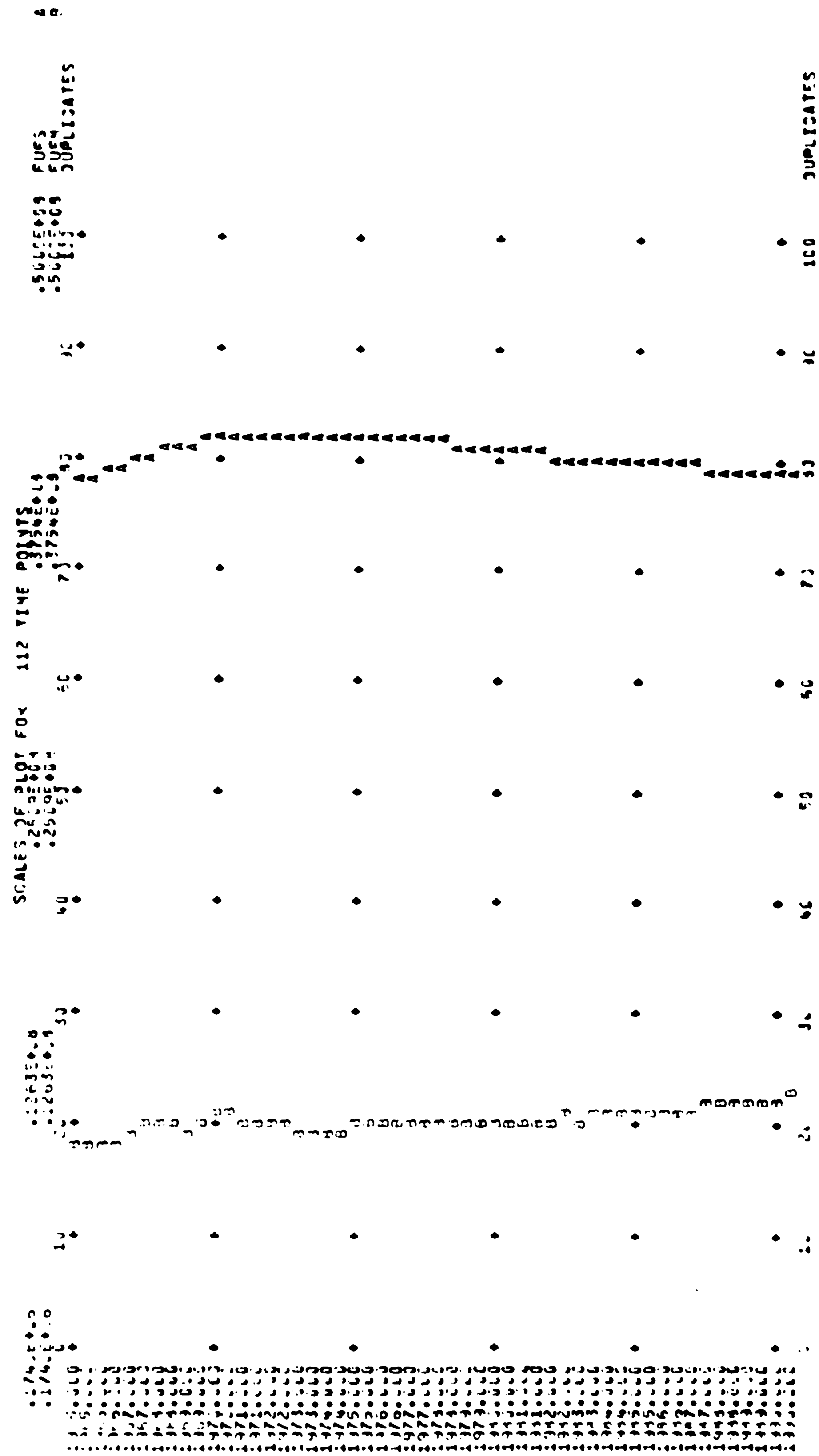

Figure 15: **Base Run Projections of Annual Consumption of Fuelwood from Non-Market (A) and Market Sources (B), 1965-1990.**

Wood Consumption Projections by Wood Consumption Population Groups

In Chapter III the adult population was disaggregated into traditional, semi-traditional, and non-traditional groups on the basis of observed wood consumption habits of individuals in the groups. Activities in some of the wood using subsectors were also disaggregated into traditional, semi-traditional, and non-traditional activities according to the population group engaged in them. Some of the subsectors like hospital, high school and college building construction, casket manufacturing, vehicle and bridge construction subsectors could not be easily classified as traditional, semi-traditional, or non-traditional. These subsectors are considered as non-specific subsectors. Other subsectors like commercial, and religious building construction, farm construction, and fuelwood consumption subsectors were classified into traditional and semi-traditional only. Except for fuelwood consumption, which is not observed in the non-traditional group, the disaggregation of these subsectors into only traditional and semi-traditional does not mean that they will disappear if all Nigerian population became non-traditional. These disaggregations are convenient and adequate at present time.

Estimates of the annual consumption of the three wood products required for various construction purposes by different wood consumption groups and in the non-specific subsectors are summarized in Tables 19 to 21 and in Figures 16, 17, and 18, and presented in details in Appendix E. The traditional group accounts for a large proportion of unprocessed and processed wood but this declines rapidly both in relative proportions and in absolute amounts with increasing income. The proportions of

Table 19.--Summary, Base Run Projections of Annual Consumption of Unprocessed Wood: Absolute Amounts and as Proportions of Overall Unprocessed Wood Consumption by Wood Consumption Groups, 1965-1990.

Year	Unprocessed Wood Required by Traditional Population		Unprocessed Wood Required by Semi-Traditional Population		Unprocessed Wood Required by Non-Traditional Population		Unprocessed Wood Required in Non-Specific Activities	
	Absolute Amount (000M^3/yr)	Relative Prop.	Absolute Amount (000M^3/yr)	Relative Prop.	Absolute Amount (M^3/yr)	Relative Prop.	Absolute Amount (M^3/yr)	Relative Prop.
1965	3,408	.9115	322	.0862	5,846	.0016	2,828	.0008
1970	2,731	.9185	230	.0773	8,050	.0027	3,251	.0011
1975	2,484	.9051	226	.0825	19,353	.0071	14,719	.0054
1980	2,249	.8434	367	.1377	33,375	.0125	17,079	.0064
1985	2,269	.7831	550	.1898	55,818	.0193	22,683	.0078
1990	2,285	.6947	890	.2750	85,527	.0260	29,130	.0089

Table 20.--Summary, Base Run Projections of Annual Consumption of Processed Wood: Absolute Amounts (000 M^3) and as Proportions of Overall Processed Wood Consumption by Wood Consumption Groups, 1965-1990.

Year	Processed Wood Required by Traditional Population		Processed Wood Required by Semi-Traditional Population		Processed Wood Required by Non-Traditional Population		Processed Wood Required in Non-Specific Activities	
	Absolute Amount	Relative Prop.	Absolute Amount	Relative Prop.	Absolute Amount	Relative Prop.	Absolute Amount.	Relative Prop.
1965	359	.5509	236	.0175	11	.0175	46	.0702
1970	314	.5065	241	.0261	16	.0261	50	.0973
1975	299	.3801	283	.0527	41	.0527	162	.2066
1980	260	.2848	397	.0746	68	.0746	188	.2057
1985	248	.2227	508	.0986	109	.0986	247	.2219
1990	244	.1770	656	.1183	163	.1183	315	.2286

Table 21.--Summary, Base Run Projections of Consumption of Building Board Woodpulp: Absolute Amounts (000kg/yr) and as Proportions of Overall Consumption by Wood Consumption Groups, 1965-1990.

Year	Building Board Woodpulp Required by Traditional Population		Building Board Woodpulp Required by Semi-Traditional Population		Building Board Woodpulp Required by Non-Traditional Population		Building Board Woodpulp Required in Non-Specific Activities	
	Absolute Amount	Relative Prop.	Absolute Amount	Relative Prop.	Absolute Amount	Relative Prop.	Absolute Amount	Relative Prop.
1965	0	0	200	.8381	16	.0647	23	.0973
1970	0	0	197	.8045	21	.0867	27	.1088
1975	0	0	208	.5433	51	.1339	123	.3228
1980	0	0	319	.5817	88	.1611	141	.2572
1985	0	0	437	.5664	148	.1914	187	.2422
1990	0	0	591	.5595	226	.2141	239	.2263

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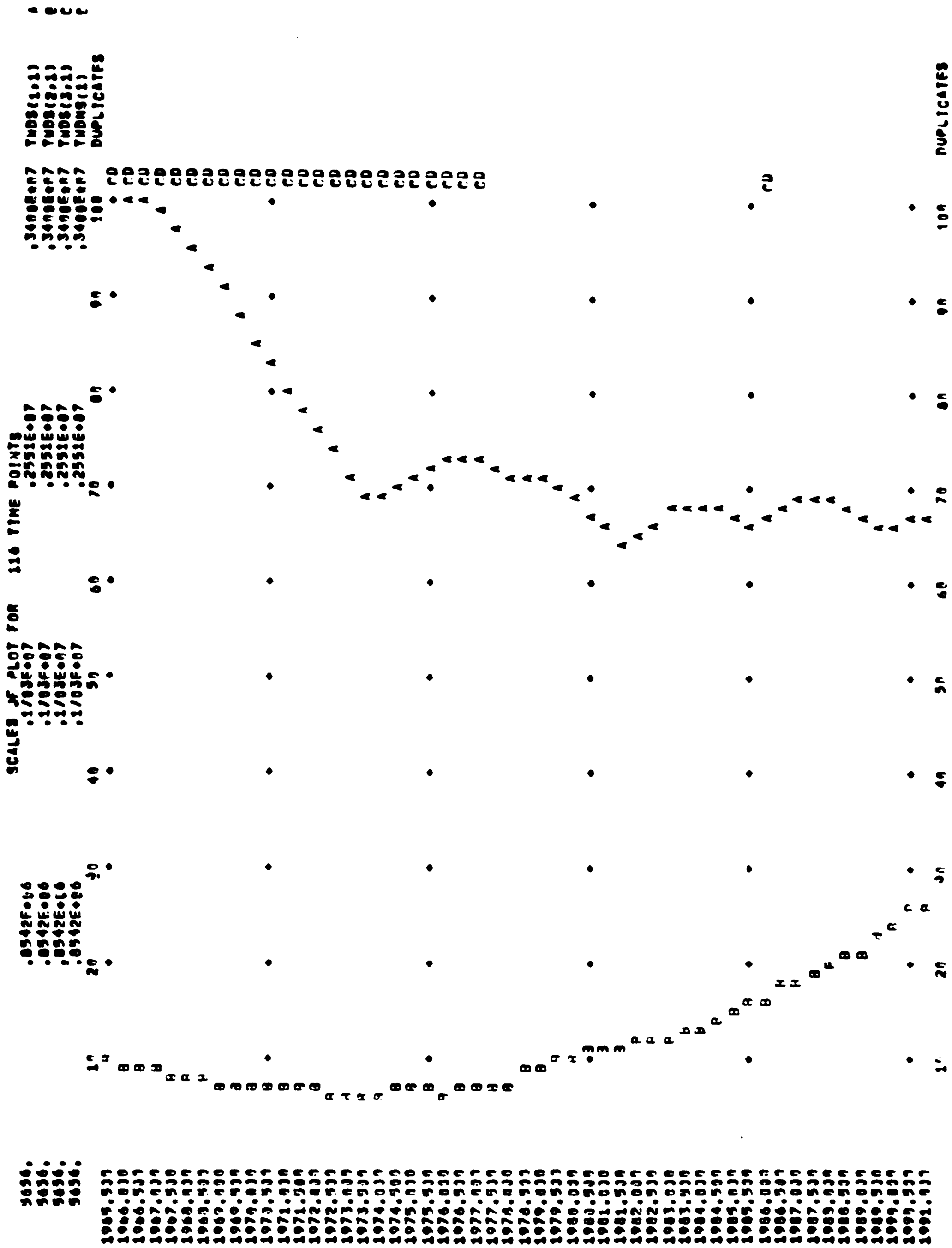

Figure 16: Base Run Projections of Annual Consumption of Unprocessed Wood in the Traditional (A), and Semi-Traditional (B) Sectors, 1965-1990.

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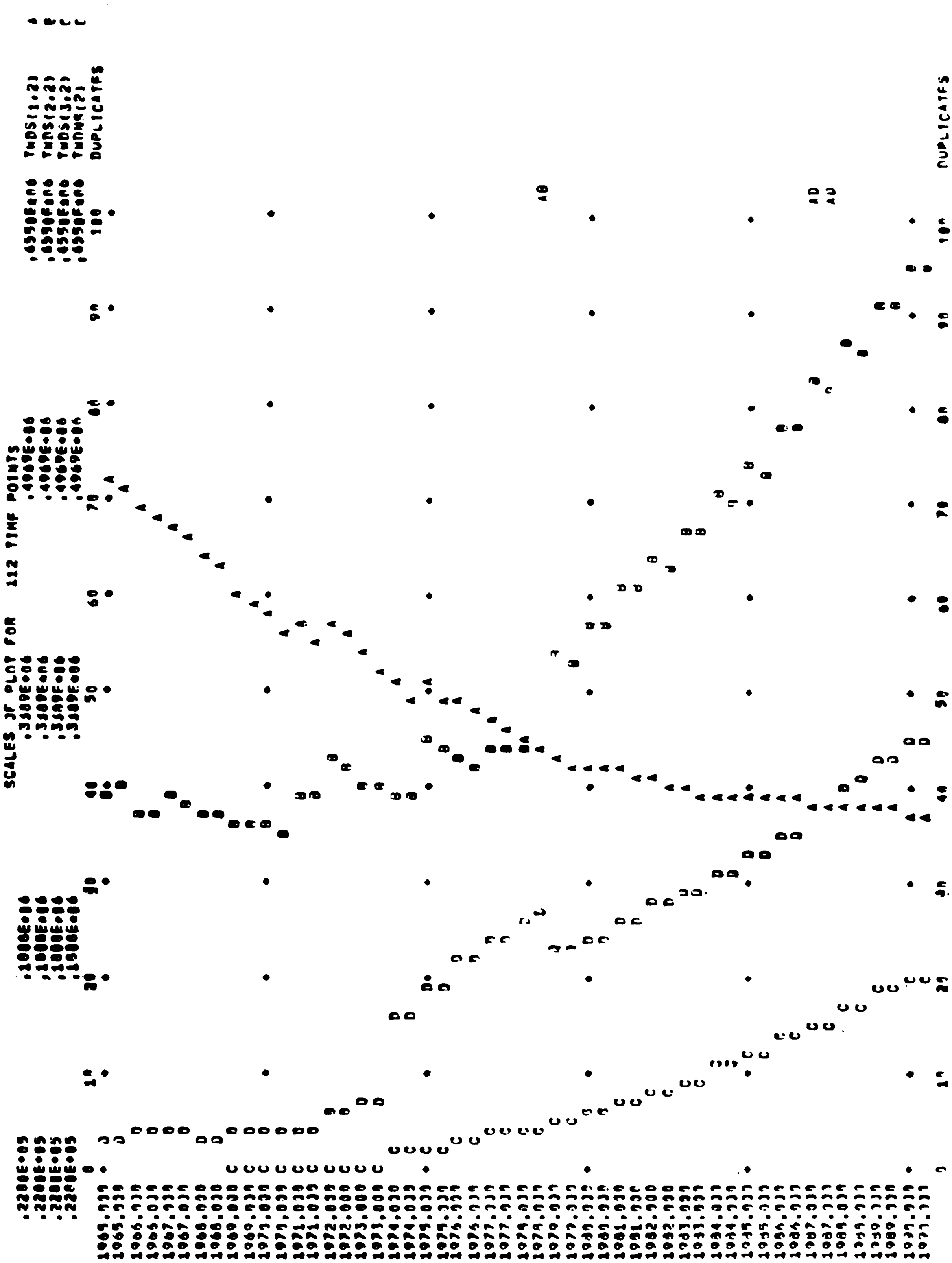

Figure 17: Base Run Projections of Annual Consumption of Processed Wood in the Traditional (A), Semi-Traditional (B), Non-Traditional (C), and in the Non-Specific (D) Sectors, 1965-1990.

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SCALES OF PLOT FOR 112 TIME

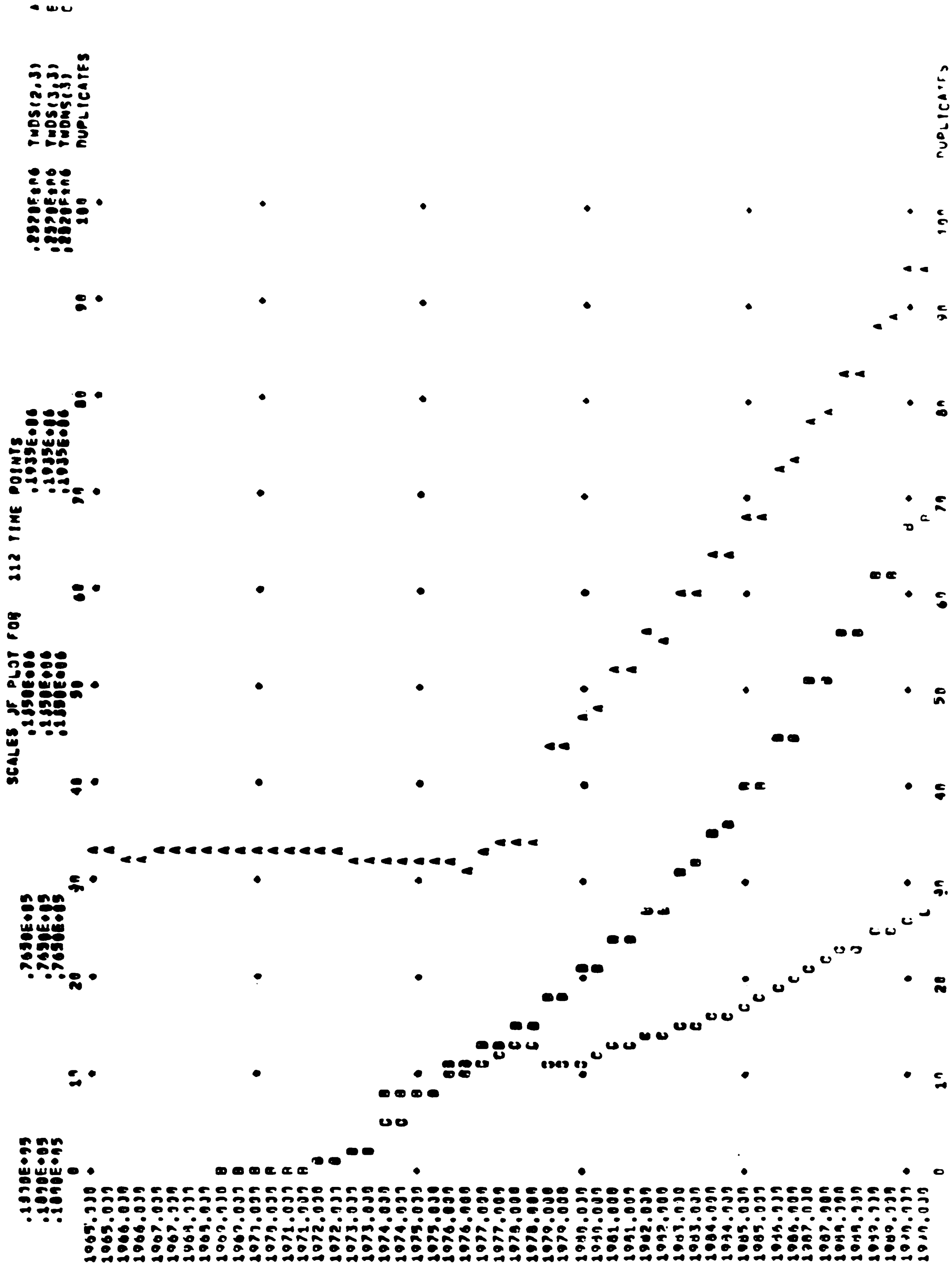

Figure 18: Base Run Projections of Annual Consumption of Building Board Wood Pulp in the Semi-Traditional (A), Non-Traditional (B) and in the Non-Specific (C) Sectors, 1965-1990.

unprocessed and processed wood required by other wood consumption population groups as well as in the non-specific subsectors increase both in absolute amounts and in relative proportions as economic conditions improve. Building board woodpulp consumption was not observed in significant amounts in the traditional sectors. The proportions of this product required in the semi-traditional population group and in the non-specific subsectors are increasing in absolute amounts but slowly declining in relative proportions. These declining relative proportions are absorbed by the non-traditional group where building board woodpulp needs are increasing both in absolute amounts and in relative proportions.

The estimates of the annual consumption of fuelwood by wood consumption population groups are summarized in Table 22 and Figure 19 and presented in Appendix E. Changes in the annual fuelwood consumption are rather sluggish as increased consumption of fuelwood, which would follow increased population, is eliminated by substitution of other sources of fuel for fuelwood as income increases. This trend will likely be speeded up resulting in more significant declines in the annual consumption of fuelwood in future when the consequences of current public investments in people through investments in education materialize. The traditional population accounts for most of the fuelwood consumption.

Wood for Paper

Table 23 summarizes the projections of annual consumption of paper pulp by wood consumption population groups. Consumption of paper is highly sensitive to income changes. The rate of consumption of

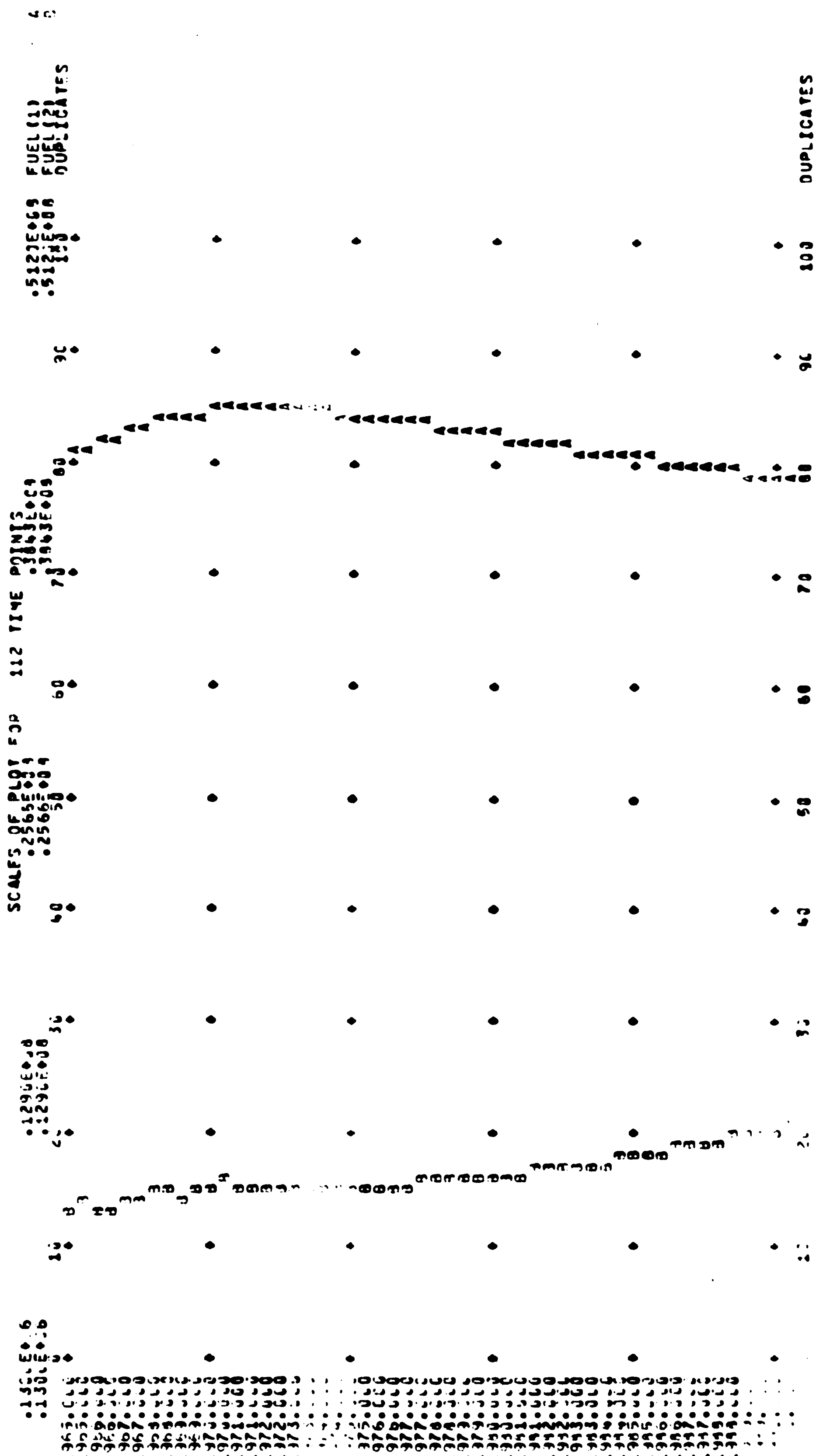

Figure 19: Base Run Projections of Annual Consumption of Fuelwood by Traditional (A) and Semi-Traditional (B) Population Groups, 1965-1990.

Table 22.--Summary, Base Run Projections of Annual Consumption of Fuelwood: Absolute Amounts (000 M^3) and as Proportions of Overall Consumption by Wood Consumption Groups, 1965-1990.

Year	Fuelwood Required by Traditional Population		Fuelwood Required by Semi-Traditional Population	
	Absolute Amount	Relative Amount	Absolute Amount	Relative Amount
1965	82,537	.8591	13,541	.1409
1970	83,224	.8491	14,793	.1509
1975	81,551	.8435	15,259	.1563
1980	79,987	.8311	16,258	.1689
1985	78,130	.8119	18,102	.1881
1990	76,665	.7882	20,596	.2118

paper declines in the traditional population group in response to declining population in that group. The non-traditional and student populations account for most of the paper pulp consumption. The rate of growth of annual consumption of paper in the non-traditional population groups will be stepped up further later when the present high rate of annual college enrollment results in high rate of college graduation and also in high rate of growth of the non-traditional population group. The projections of annual consumption of paper pulp up to the year 1990 are presented in Figure 20.

Summary of Chapter

In discussing the time paths of the annual consumption of various wood products in Chapter IV we pointed out that as the economy grows and as increased public investments are used to stimulate economic activities, the population in the traditional sector and the activities

Table 23.--Summary, Base Run Projections of Annual Consumption of Paper Woodpulp: Absolute Amounts and as Proportions of Overall Consumption by Income Group, 1965-1990.

Year	Paper Pulp for Traditional Population		Paper Pulp for Semi-Traditional Population		Paper Pulp for Non-Traditional Population		Paper Pulp for Student Population	
	Absolute Amount (000 kg/yr)	Relative (Prop./yr)	Absolute Amount (000 kg/yr)	Relative (Prop./yr)	Absolute Amount (000 kg/yr)	Relative (Prop./yr)	Absolute Amount (000 kg/yr)	Relative (Prop./yr)
1965	376	.0117	13,452	.4172	15,965	.4951	2,448	.6759
1970	380	.0104	15,714	.4299	16,968	.4542	3,493	.0956
1975	374	.0018	23,173	.1144	164,001	.8098	14,965	.0739
1980	368	.0009	33,900	.0870	311,190	.7983	44,341	.1133
1985	362	.0004	55,628	.0652	688,784	.8079	107,821	.1265
1990	358	.0001	86,527	.0487	1,474,590	.8293	216,621	.1218

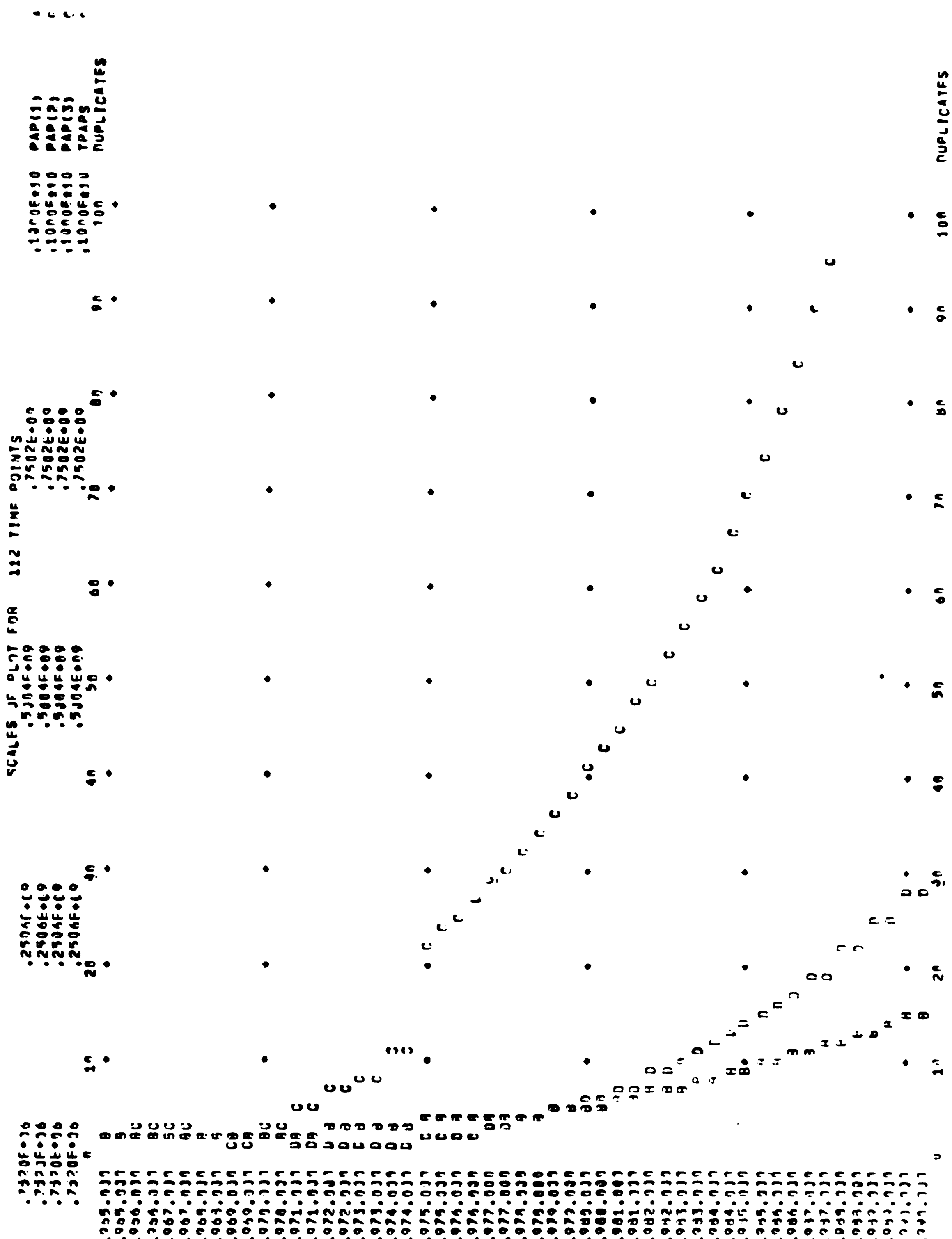

Figure 20: Base Run Projections of Annual Consumption of Paper Wood Pulp by Semi-Traditional (B), Non-Traditional (C), and Student (D) Population Groups, 1965-1990.

classified as traditional will gradually decline while non-traditional population and non-traditional activities will increase. Consumption of unprocessed wood and fuelwood will be expected to decline while the consumption of processed wood and pulp products will be expected to rise. Although the assumed levels of GDP and public investments presented above may appear impressive, they are not high enough to bring about substantial reductions in traditional population and traditional economic activities that will result in observable decline in traditional wood consumption. However, these presentations of the model output indicate that though in absolute terms the amount of wood used in the raw will not fall, its rate of growth will decline.

The projections of annual consumption of various wood products presented here are phenomenal but they do not tell the whole story. We pointed out in Chapter IV that government investments in education, agriculture, and other key sectors have two effects, lagged and unlagged, on wood consumption. Most of the projections up to 1990 are probably the unlagged or direct effects of the present high rates of spending. The duration of these projections which is only fifteen years is long enough to make apparent only the consequences of the present investments on wood consumption; it is not long enough to make apparent the consequences on wood consumption of the present investments on people.

When the government spends money on education it sets up school buildings as well as spends money on the education of the students. The direct effects of this on wood consumption are felt when wood is purchased for this construction. The first students who will benefit from free primary education in 1976 will need at least fifteen years to graduate including six years in the elementary school, five in high school, and four in college. When they get jobs and earn income befitting their training, they will not live in mud huts roofed with corn stocks or stems of palm leaves. The consequences of public spending on wood consumption for non-residential building, vehicle, and bridge construction subsectors are not lagged; those consequences on wood consumption for residential construction, fuelwood and paper consumption subsectors are lagged. The effects of public spending have to materialize on people; then the people adopt different housing, and fuelwood and paper consumption behaviors.

We need to run the model for another fifteen years up to the year 2005 to show the full consequences of the present economic changes, but this will involve very uncertain assumptions about the future levels of GDP and public investment priorities. What we are saying is so logical that we do not need to do this. Our observations are based on the assumption that the high rates of income and spending are sustained so that the modernization process is continuous.

CHAPTER VII

MODEL VALIDATION AND VERIFICATION

Introduction

In Chapter I we discussed the need for validating and verifying economic models in general. The need arises as a result of uncertainty concerning the relationships to be modeled, assumptions about variables, and the likelihood of errors in the estimation of various model parameters. Generalized models employ information from a wide range of sources including survey data, time-series data, judgement of knowledgeable individuals, etc. Data from such a variety of sources will naturally vary in accuracy. This makes the likelihood of errors in parameter estimates higher in generalized models than in single technique or specialized models.

Generalized models are often used to analyze problems which involve changes in people, institutions, and technology. The consequence of such changes is uncertainty about human, institutional, and technological relations and questions about assumptions concerning the model variables. For example, the base run projections presented in the previous chapter were made under the assumptions that GDP will grow at the governmentally estimated annual rate of 11.7 percent and that government investment will be those announced in the Third National Development Plan. After the projections were made, a change of government (institutional change) took place. It is not certain that the new government will follow policies which will result in an 11.7 percent annual rate of growth of GDP or investment programs announced by the previous government.

It is not possible to validate a generalized model on the basis of a single statistic such as confidence interval, coefficient of multiple determination, etc. This is because generalized models are complex with many parameters estimated in many ways and are used to analyze several aspects of problems involving multiple and often competing objectives. In general, knowledge is validated on the basis of the four tests of objectivity discussed in Chapter I; namely the tests of clarity, logical consistency (coherence), historical correspondence, and workability. The present model has been validated and verified on the basis of these tests. In the following sections we shall discuss the application of these tests to the present model and to the projections generated by the model.

Tests of Clarity and Logical Consistency

These two tests were carried out at the various stages of problem definition, modeling (mathematical and computer), and model operation to assure that at all stages the model concepts are logical and clearly specifiable. The tests were carried out in the form of interactions in Nigeria with Nigerian policy makers in the forestry sector, private businessmen in the forestry industries, consumers of various wood products, etc. The tests were also carried out in the form of discussions in formal and informal meetings with professors and graduate students at Michigan State University who are familiar with Nigerian economy.

These tests were continued in an iterative manner until the end of the present study. Their iterative nature made it possible for us at any stage of the study to go back to an earlier stage to make adjustments in the model for inconsistencies in any aspect of the model such as structure, parameter, or computer program. Passing these tests, however, merely makes the model tentatively acceptable because time will likely reveal certain inconsistencies and information not yet perceived.

Tests of Workability

The tests of workability are used to verify whether the model will still work if there are errors in the assumptions about model variables and in the estimation of model parameters. The final test of the workability of a model is in the application of the model concepts in the solution of practical problems. In this section we shall merely carry out limited sensitivity tests on some of our model parameters and variables. We shall (1) adjust some of the model parameter estimates and observe the magnitude of change in the output, (2) make two additional runs of the model on the bases of alternative assumptions about the rate of grwoth of GDP, one lower and the other higher than the assumed rate for the base run. This will indicate the error that can possibly occur in the model output if the base run assumption is wrong.

Sensitivity Tests On Model Parameters

In Chapter V we estimated the various parameters of the model by regression methods and validated them on the basis of certain statistics, namely coefficients of multiple determination, standard errors of coefficients, levels of significance, etc. In this section we shall test the wood consumption estimates generated with the model for sensitivity to errors in the estimates of those parameters. To do this we shall vary a limited number of the parameter estimates by the amount of their standard errors of coefficient, run the model on the basis of the adjusted parameters, and compare the consumption estimates of the affected wood products with their base run estimates.

The parameter estimates adjusted are those of: the price of fuelwood in the consumption of fuelwood from market sources (BF(1), and BF(2) in Table 24), the price of processed wood in the consumption of processed wood in traditional residential construction (BR(1,2) in Table 24), and the ratio of the price index of processed wood to price index of substitutes for processed wood in the consumption of processed wood in semi- and non-traditional residential construction (BR(2,2) and BR(3,2) in Table 24). Although we have tested with only a very limited number of parameter estimates, the model output should be tested for error in the estimates of all the parameters.

The adjustments in the selected parameter estimates and their effects on consumption estimates of the relevant wood products are presented in Table 24. The probabilities of errors in the parameter estimates are fairly high, .32 in fuelwood and .37 in processed wood, but Table 24 shows that the consumption estimates for the wood products are not very sensitive to the errors. An average 30 percent adjustment in the parameter estimates for fuelwood resulted in only an average 12 percent change in the consumption estimates, and an average 45 percent adjustment in the parameter estimates for processed wood

Table 24.--Summary, Results of Sensitivity Tests with Some Parameter Estimates.

Parameter Tested	Estimated Value	Adjusted Value	Wood Product Affected	Estimate of Total Consumption for 1980	
				With Estimated Parameter (000 M^3)	With Adjusted Parameter (000 M^3)
BF(1)	-0.18	-0.13	Fuelwood from Market Sources	9,969.309	10,497.323
BF(2)	-0.12	-0.08	Fuelwood from Market Sources	9,969.309	11,805.948
BR(1,2)	-0.944	-0.584	Processed Wood	912.207	1,085.347
BR(2,2)	-7.453	-5.282	Processed Wood	912.207	1,317.992
BR(3,2)	-4.276	-1.447	Processed Wood	912.207	993.473

resulted in an average 24 percent change in consumption estimate. This means that the structure of the model is good enough to absorb some of the effects of errors in the estimation of the parameters. In Chapter V we pointed out that the regression equations were predictive in purpose, not structural. The errors in parameter estimates which are due in part to poor data and which have high probabilities of occurrence do not greatly affect the consumption predictions.

Summary[1] of Model Runs Under Alternative Assumptions About GDP and Government Investments

The two alternative rates of growth of GDP to the base run rate considered are 6 percent and 15 percent. Public investments in agriculture, education, health, and transportation and the loans made available by commercial banks for the transportation industry are assumed to grow at the same rates as GDP for both alternatives. In making these assumptions, we imply that government investment priorities will remain the same even if national income grows at different rates. This is not necessarily correct--if national income changes, the government may alter its investment priorities.

The rate of growth of average per capita income for the medium income bracket is assumed to lag the rate of growth of GDP by 2 percent per annum and the rate of growth of per capita income for the high income bracket is assumed to lead the rate of growth of GDP by 5 percent per annum. In both alternatives, the rates of population growth, the ratio of price index of wood and price index of substitutes for wood,

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[1]See Appendix F for complete Run results.

agriculture's contribution to GDP, and rural-urban migration are not altered but are assumed to grow at their base run rates. Assumed levels of GDP and public investments in agriculture, education, health, and transportation are summarized in Table 25.

Table 25.--Values (₦ Million/Year) of GDP and Government Investments Under Alternative Assumptions About Rates of Growth of GDP, 1975-1990.

Year	Gross Domestic Product		Government Investments in Sectors: Agriculture		Education		Transportation	
	6% Rate Alt.	15% Rate	6% Rate Alt.	15% Rate	6% Rate Alt.	15% Rate	6% Rate Alt.	15% Rate
1975	10,254	10,254	266	266	380	380	784	784
1980	15,440	16,840	374	392	534	672	1,094	1,154
1985	20,060	29,720	441	576	632	1,178	1,290	1,696
1990	25,460	50,520	522	879	751	1,798	1,540	2,586

Projections of wood required for residential construction under the two alternative rates of growth of GDP are summarized in Table 26. These amounts are also summarized as proportions of aggregate wood requirements under the two alternatives in Table 27. Both the absolute amounts and relative proportions of unprocessed wood are higher under the 15 percent alternative. Absolute amounts of processed wood and building board woodpulp are higher under the 15 percent alternative but the relative proportions of both are lower under the 15 percent alternative indicating that the consumption of both wood products increase faster in the more immediate future in other subsectors where the impact

Table 26.--Summary, Projections of Annual Wood Requirements for Residential Construction Under Alternative Rates of Growth of GDP, 1975-1990.

Year	Unprocessed Wood (000 M^3)		Processed Wood (000 M^3)		Building Board Woodpulp (000 kg.)	
	6% Rate Alt.	15% Rate Alt.	6% Rate Alt.	15% Rate Alt.	6% Rate Alt.	15% Rate Alt.
1975	782	782	512	512	223	223
1980	836	836	569	570	348	350
1985	933	952	637	660	476	516
1990	1029	1165	690	851	586	797

Table 27.--Summary, Projections of Annual Wood Requirements for Residential Construction as Proportions of Overall Wood Requirements Under Alternative Rates of Growth of GDP, 1975-1990.

Year	Unprocessed Wood (Proportion/year)		Processed Wood (Proportion/year)		Building Board Woodpulp (Proportion/year)	
	6% Rate Alt.	15% Rate Alt.	6% Rate Alt.	15% Rate Alt.	6% Rate Alt.	15% Rate Alt.
1975	.2851	.2851	.6521	.6521	.5803	.5803
1980	.3138	.3135	.6387	.6226	.6581	.6341
1985	.3256	.3269	.6396	.5660	.7187	.6164
1990	.3311	.3414	.6190	.5148	.7258	.6024

of public spending on wood consumption is felt without time lags. In the more distant future, this situation will likely be reversed, the proportion of processed wood consumed in residential housing construction will be increasing faster if GDP and public spending are growing at 15 percent per year at present than if they are growing at 6 percent per year. The effects of public investment on wood consumption for residential purposes are lagged depending on the time it takes investments in people to affect their housing and living standards.

Projections of wood required for farm construction are summarized in Table 28. These amounts as proportions of aggregate wood requirements under the two alternative rates of growth of GDP are summarized in Table 29. Unprocessed wood required for farm construction will be higher in absolute amounts at higher rates of growth of income but its relative proportion will be lower. Processed wood requirements are higher at higher rates of GDP and public investments both in the absolute amounts and in relative proportions. Both of these observations are probably due to the expansion of non-traditional agriculture which will be expected at higher levels of income and public investments in agriculture.

The estimates of amounts of wood required for non-residential housing construction (including school, hospital, commercial, religious, and public administration buildings) under the two alternatives are summarized in Table 30. These values, as proportions of aggregate wood requirements under the two alternatives, are summarized in Table 31. The absolute amounts and the relative proportions of all wood products required for these purposes are higher for the 15 than for the 6 percent alternative.

Table 28.--Summary, Projections of Annual Wood Requirements for Farm Construction Under Alternative Rates of Growth of GDP, 1975-1990.

Year	Unprocessed Wood (000 M^3/year)		Processed Wood (000 M^3/year)	
	6% Rate Alt.	15% Rate Alt.	6% Rate Alt.	15% Rate Alt.
1975	1,926	1,926	2,935	2,935
1980	1,793	1,792	5,813	5,920
1985	1,899	1,908	9,526	11,596
1990	2,039	2,174	1,403	27,940

Table 29.--Summary, Projections of Annual Wood Requirements for Farm Construction as Proportions of Overall Wood Requirements Under Alternative Rates of Growth of GDP, 1975-1990.

Year	Unprocessed Wood (Proportion/year)		Processed Wood (Proportion/year)	
	6% Rate Alt.	15% Rate Alt.	6% Rate Alt.	15% Rate Alt.
1975	.7018	.7018	.0037	.0037
1980	.6728	.6721	.0065	.0065
1985	.6621	.6554	.0099	.0108
1990	.6562	.6368	.0128	.0169

Table 30.--Summary, Projections of Annual Wood Requirements for Non-Residential Housing Construction Under Alternative Rates of Growth of GDP, 1975-1990.

Year	Unprocessed Wood (M^3/year)		Processed Wood (M^3/year)		Building Board Wood-pulp (kg.)	
	6% Rate Alt.	15% Rate Alt.	6% Rate Alt.	15% Rate Alt.	6% Rate Alt.	15% Rate Alt.
1975	35,836	35,836	239,805	239,805	73,685	73,685
1980	35,761	38,373	279,669	303,186	91,565	98,577
1985	35,432	51,345	308,424	457,136	104,536	149,695
1990	39,240	74,274	364,717	718,973	124,596	236,673

Table 31.--Summary, Projections of Annual Wood Requirements for Non-Residential Housing Construction as Proportions of Overall Wood Requirements Under Alternative Rates of Growth of GDP, 1975-1990.

Year	Unprocessed Wood (Proportion/year)		Processed Wood (Proportion/year)		Building Board Wood-pulp (Proportion/year)	
	6% Rate Alt.	15% Rate Alt.	6% Rate Alt.	15% Rate Alt.	6% Rate Alt.	15% Rate Alt.
1975	.0131	.0131	.3053	.3053	.4245	.4245
1980	.0134	.0144	.3138	.3309	.3655	.3789
1985	.0124	.0176	.3096	.3874	.3202	.3721
1990	.0126	.0178	.3273	.4351	.3081	.3674

Table 32 summarizes the projections for processed wood consumed in casket manufacturing, and lumber truck and bridge construction under alternative rates of growth of GDP. These amounts are also summarized as proportions of overall processed wood consumption under the two alternatives in Table 33. The amount of wood that will be needed for the manufacture of caskets declines indicating declining death rates under improved economic conditions. Wood required for the construction of lumber trucks is higher in absolute amount but lower in relative proportion under 15 percent alternative indicating declining relative importance of lumber trucks that would be expected at higher levels of income. Wood needed for construction of bridges is higher both in absolute amounts and in relative proportions under the 15 percent than under the 6 percent alternative.

Table 32.--Summary, Projections of Annual Processed Wood Requirements for Casket, Lumber Trucks, and Bridges Under Alternative Rates of Growth of GDP, 1975-1990.

Year	Processed Wood for Casket (M^3/year)		Processed Wood for Trucks (M^3/year)		Processed Wood for Bridges (M^3/year)	
	6% Rate Alt.	15% Rate Alt.	6% Rate Alt.	15% Rate Alt.	6% Rate Alt.	15% Rate Alt.
1975	22,151	22.151	5,887	5,886	2,504	2,504
1980	24,045	24,024	8,680	8,731	3,751	3,892
1985	24,776	24,507	11,295	12,689	4,638	5,870
1990	25,446	24,469	14,444	20,600	5,717	9,691

Table 33.--Summary, Projections of Annual Processed Wood Requirements for Casket, Lumber Trucks, and Bridge Construction as Proportions of Overall Requirements of Processed Wood Under Alternative Rates of Growth of GDP, 1975-1990.

Year	Processed Wood for Casket (Prop./year)		Processed Wood for Trucks (Prop./year)		Processed Wood for Bridges (Prop./year)	
	6% Rate Alt.	15% Rate Alt.	6% Rate Alt.	15% Rate Alt.	6% Rate Alt.	15% Rate Alt.
1975	.0282	.0282	.0075	.0075	.0032	.0032
1980	.0270	.0262	.0095	.0095	.0042	.0042
1985	.0249	.0208	.0113	.0108	.0047	.0050
1990	.0228	.0148	.0130	.0125	.0051	.0059

The projections for annual consumption of fuelwood from market and non-market sources under alternative rates of GDP are summarized in Table 34. The rates of fuelwood consumption are not very different between the two alternative rates of growth of GDP because the substitution of other materials for fuelwood which will follow increased income is partially eliminated by population growth. Besides this, the effect of income and public spending on fuelwood consumption is lagged. This implies that the annual consumption of fuelwood will decline faster later.

Projections of annual consumption of paper woodpulp under alternative rates of growth of GDP are summarized in Table 35. The annual consumption is higher under 15 percent of GDP as expected than under 6 percent rate.

A summary of aggregate requirements of unprocessed wood, processed wood, building board woodpulp, paper woodpulp, and fuelwood under

Table 34.--Summary, Projections of Annual Consumption of Fuelwood from Market and Non-Market Sources: Absolute Amounts and as Proportions of Overall Consumption Under Alternative Rates of Growth of GDP, 1975-1990.

Year	Fuelwood from Non-Market Sources				Fuelwood from Market Sources			
	6% Rate Alt.		15% Rate Alt.		6% Rate Alt.		15% Rate Alt.	
	Absolute Amount (000 M^3/yr.)	Relative Prop./yr.	Absolute Amount (000 M^3/yr.)	Relative Prop./yr.	Absolute Amount (000 M^3/yr.)	Relative Prop./yr.	Absolute Amount (000 M^3/yr.)	Relative Prop./yr.
1975	77,174	.8027	77,714	.8027	19,096	.1973	19,096	.1973
1980	76,766	.7976	76,765	.7976	19,485	.2024	19,478	.2024
1985	75,815	.7877	75,805	.7879	20,467	.2123	20,409	.2121
1990	75,319	.7793	75,356	.7739	21,327	.2207	22,009	.2261

Table 35.--Summary, Projections of Annual Consumption of Paper Woodpulp Under Alternative Rates of Growth of GDP, 1975-1990.

Year	6 Percent Alternative Rate of Growth of GDP (Million kg/year)	15 Percent Alternative Rate of Growth of GDP (Million kg/year)
1975	1,761	1,761
1980	3,503	3,521
1985	7,570	8,072
1990	14,809	18,428

alternative rates of growth of GDP is presented in Table 36. The amounts of unprocessed wood and fuelwood required are not very different for the two alternatives. This is because the total population in traditional group which accounts for most of the consumption of those wood products does not change substantially under either alternative. On the other hand the amounts of processed wood, building board woodpulp, and paper woodpulp required are substantially higher under 15 percent than under 6 percent rate of growth of GDP.

These numerical analyses indicate that while the consumption of fuelwood and unprocessed wood do not appear to be very sensitive to changes in income, the consumption of processed wood, building board woodpulp, and paper woodpulp are quite sensitive to changes in income. The implication of this is that errors of up to 50 percent in the assumed annual rate of growth of GDP will not cause up to 50 percent error in the predictions of annual consumption of fuelwood and unprocessed wood. Such an error will, however, likely cause more than 50 percent error in the prediction of annual consumption of processed wood, building board woodpulp, and paper woodpulp.

Table 36.--Summary, Projections of Aggregate Annual Wood Requirements Under Alternative Rates of Growth of GDP, 1975-1990.

Year	Unprocessed Wood (000 M^3/year)		Processed Wood (000 M^3/year)		Building Board Woodpulp (000 kg./year)		Fuelwood (000 M^3/year)		Paper Wood-pulp (Million kg./yr.)	
	6% Alt. Rate	15% Alt. Rate	6% Alt. Rate	15% Alt. Rate	6% Alt. Rate	15% Alt. Rate	6% Alt. Rate	15% Alt. Rate	6% Alt. Rate	15% Alt. Rate
1975	2,743	2,744	786	786	382	382	48,572	48,572	1,761	1,761
1980	2,665	2,666	891	916	528	552	48,338	48,335	3,503	3,521
1985	2,867	2,913	996	1,180	662	837	48,427	48,408	7,570	8,072
1990	3,107	3,4129	1,115	1,652	807	1,322	48,742	49,118	14,809	18,478

Projections generated under the assumption that GDP will grow at the rate of 6 percent imply further that even if GDP and government investments grow at 6 percent rather than at 11.7 percent annually, the future wood needs of Nigeria will still be high. Policy makers in the Nigerian forestry sector should therefore do something to increase the supply of wood products even if lower rates of growth of GDP and public investments are projected by a new government.

The income trend in Nigeria has been that of a steady growth (26). The government projected a growth rate of 6.1 percent in GDP for the five year period ending in March 1975 but the realized growth rate was 10.2 percent (6)--much higher than projected because domestic supply and world market prices for petroleum went up during the period. The future levels of both domestic supply and world prices for petroleum are uncertain, but the revenue currently being derived from the export of large quantities of petroleum at high prices is being invested in industrialization, road construction, education, agriculture, etc. and very soon such investments will begin to generate multiplier effects on income. These considerations seem to indicate that a growth rate of GDP between 11.7 percent and 15 percent is more probable than one between 6 percent and 11.7 percent. This implies that the projections of wood consumption under 15 percent alternative are more likely than those under 6 percent. The base run projections could be underestimated rather than overestimated.

Further Tests of Objectivity

The model was subjected to further tests of objectivity by comparing its outputs with estimates by other people and with recorded experience for correspondence and consistency. These comparisons are discussed below.

Comparisons of Model Estimates with Estimates by Other People

Estimates by FAO (15) for processed wood for the years 1974 and 1980 are available. Estimates for fuelwood, unprocessed wood, and processed wood by Enabor (46) for 1970 and 1985 are also available. A comparison of these estimates and estimates by our model are presented in Tables 37 and 38. Our estimates of consumption of processed wood are not too far from FAO estimates, but they diverge from estimates by Enabor. While our model projects an increase of about 79 percent in the annual consumption of processed wood between 1970 and 1985, Enabor projects an increase of only 31 percent within the same period or about 2 percent per year. Probably Enabor based his estimate of 2 percent annual rate of growth of consumption of processed wood on the growth of population. In addition to population growth, however, annual consumption of processed wood is also responsive to other variables such as growth in income. Adeyoju (2) has observed that the consumption of processed wood has historically responded to changes in income. Income has recently been increasing in Nigeria as does population (7). One should therefore expect that annual consumption of processed wood would grow at a faster rate than population.

Experience in Japan, a country that underwent the modernization process we anticipate for Nigeria, indicates that annual consumption of processed wood will grow at a faster pace than population if income is also growing. Table 39 compares changes in total national population, annual consumption of timber, and national income in Japan between 1953

Table 37.--Comparison of Estimates of Consumption of Processed Wood by FAO with Model Estimates.

Year	Estimated by FAO (M^3/year)	Estimated by Model (M^3/year)
1974	752,000	777,558
1980	1,050,000	912,207

Table 38.--Comparison of Estimates of Rates of Consumption of Wood by Enabor with Model Estimates.

Wood Product	Year/Estimates			
	1970		1985	
	Estimates by Enabor	Estimates by Model	Estimates by Enabor	Estimates by Model
Fuelwood (Million M^3/year)	46.8	49.3	65.1	48.4
Unprocessed Wood (000 M^3/year)	1,275	2,972	1,680	2,897
Processed Wood (000 M^3/year)	581	620	840	1,112

Table 39.--Population, Lumber Consumption, and National Income Trends in Japan, 1953-1963.

	1953	1963	% Change
Population (Million)	87	96	10
Lumber Consumption (Million M^3)	19	65	240
National Income (Y 000 Billion)	5.8	22.5	291

Sources: Economic Survey of Japan, 1963-64
Economic Survey of Japan, 1954-56
Japan Economic Year Book, 1965
Japan Economic Year Book, 1959

and 1963. While population increased by only 10 percent, wood consumption increased by 240 percent consistent with the increase of 291 percent in national income.

Our projections of consumption of unprocessed wood are more than 72 percent higher than projections by Enabor. We are not sure what wood using subsectors are included in his estimates, but Table 17 indicates that farm construction (which includes crop staking, farm fencing, livestock sheds, and storage spaces) accounts for about 70 percent of total unprocessed wood consumption estimates by our model. We pointed out in Chapter III that we considered it necessary to include those uses because if their needs cease to be met from non-forest sources, the forestry sector will need to satisfy them.

Enabor's estimates indicate an increase of 38 percent and our estimates a decline of 1.8 percent in the consumption of fuelwood between 1970 and 1985. There is no logical reason other than population growth to expect that the consumption of fuelwood will grow. But while population is expected to grow the characteristics of the population with respect to wood consumption is also expected to change if economic conditions are changing. It is likely that the proportion of urban population will be higher in 1985 than in 1970. Urban population buy more of their fuelwood than rural population and therefore consume less per head. As economic conditions improve, it will be expected that people will substitute electricity, natural gas, etc. for fuelwood.

Comparison of Model Estimates with Past Consumption in Nigeria

The model was used to track the past consumption of the various wood products. The backward projections of annual consumption of pulp products were compared with the past consumption of the pulp products derived from foreign trade statistics of Nigeria. All paper, paperboard, and similar products are until now imported either as finished products or as pulp. There are no pulp mills in Nigeria at present. Table 40 indicates that our model has tracked rather closely the past consumption of pulp products. There are no records of annual consumption of other wood products in the past for Nigeria.

Our historical data were generated by running the model backwards to track the past. The adequacy of this test depends on the availability of a sufficient number of degrees of freedom and of historical record with which to compare the tracked data. In our case there are no recorded data on the consumption of the various wood products except woodpulp in Nigeria, hence our reference to experience

Table 40.--Comparison of Model Estimates of Annual Consumption of Pulp Products with Consumption Data Derived from Statistics of Import of Pulp Products.

Year	Model Estimates (000 kg./year)	Derived Consumption Data (000 kg./year)
1965	50,506	46,482
1966	59,972	66,853
1967	42,677	38,354
1968	38,710	36,169
1969	59,924	61,516
1970	80,686	89,509
1971	108,397	113,610
1972	115,135	114,401

in Japan. The number of degrees of freedom available in a generalized model is difficult to count because sometimes personal judgements are employed. However, we believe that there were degrees of freedom adequate for realistic prediction of the past.

We conclude from these comparisons that it is both logically consistent as well as consistent with recorded experience to expect that as economic conditions improve the annual consumption of fuelwood will decline and the annual consumption of processed wood will grow at a faster pace than population. Our projections may not be accurate to the last figure, but they are likely to be right in pointing at the general direction of future trends in the consumption of various wood products.

Summary of Validation and Verification Tests

The model concepts seem to be clear and easily transmitted between people with relevant knowledge as was done in various discussions of the concepts at the various stages of the study. But the test of clarity is a continuous test; the model is tested whenever anyone with relevant knowledge reads this thesis.

Although the probabilities of errors in the parameter estimates were found to be fairly high, the sensitivity tests on a limited number of parameter estimates indicate that the model outputs are not very sensitive to such errors. The consumption of some wood products--processed, building board woodpulp, and paper woodpulp--was found to be sensitive to changes in the rate of growth of GDP and some other variables while the consumption of others--fuelwood and unprocessed wood--was not. We do not know the probability that GDP will grow at any of the considered rates, but from various considerations discussed under "Summary of Model Runs Under Alternate Assumptions About GDP and Government Investments" an annual rate of growth of 15 percent seems to be the most likely of the three rates considered. If this is true the base run projections of consumption of fuelwood and unprocessed wood may still be expected but those of processed wood, building board woodpulp, and paper woodpulp are likely to be underestimates. These tests of the model concepts for workability in case of errors in parameter estimates or in input variable assumptions are merely tentative. The final test of the workability of the concepts will be in their application to real problems.

The model concepts were found to be consistent with experience in other parts of the world, notably Japan, where the modernization process similar to that we anticipate for Nigeria took place recently. The concepts are also consistent with projections by other people except in the case where some of the important determining variables were omitted in making the projections, therefore making such projections logically inconsistent.

The historical consumption of woodpulp products tracked with the model corresponds closely with recorded consumption of the wood product assuming that we had sufficient number of degrees of freedom as we believe. We cannot count our degrees of freedom because we employed many techniques and derived our data from a variety of sources including judgements.

Passing these tests does not make the model indefinitely acceptable. Time will reveal further information and inconsistencies of which we are not presently aware. But in the mean time our tests indicate that the concepts of the model are quite consistent, fairly easily understood when discussed with knowledgeable people, and are likely to work when applied to real world problems.

CHAPTER VIII

CONCLUSION

Summary

In this thesis we specified a general model for the Nigerian forestry sector without constructing it. However, we constructed a model of its wood consumption component and operated it to make projections of annual consumption of various wood products for Nigeria from 1965-1990. We shall summarize these under (1) the structure of the model, (2) data used in operating the model, and (3) projections by the model.

The Structure of the Model

The various wood products consumed in Nigeria were aggregated into unprocessed wood, processed wood, building board woodpulp, paper woodpulp, and fuelwood. The wood using subsectors were also aggregated into residential housing construction, non-residential building construction (schools, hospitals, religious, commercial, public administration, etc. buildings), casket manufacture and vehicle and bridge construction, farm construction, fuelwood consumption, and paper consumption subsectors. The variables which determine the consumption of those wood products in these uses were identified as rural-urban location, income and educational attainment of individuals, availability and relative prices of substitutes and complements for various wood products in various uses, and public investment in education, agriculture, and other key sectors of the national economy. These variables were incorporated into the structure of the model by classifying Nigerian people into traditional, semi-traditional, and non-traditional wood consumption population groups on the basis of rural-urban location, income, and education attainment of the people. Some of the wood using subsectors were also classified into traditional, semi-traditional, and non-traditional depending on which population group is engaged in them. Each group had a different set of parameters such as average residential building per person, average amount of various wood products per building, average life span of buildings, etc. Variables which may be used to control annual consumption of various wood products, if it ever becomes necessary, were identified as domestic pricing of wood products, and establishment of housing codes. These may, however, lead to undesirable cycles in the production and consumption of wood products.

The annual consumption of a wood product in a construction subsector (residential housing, non-residential, farm, vehicle, or bridge construction) was estimated as the product of the average amount of that wood product in cubic meters per building and the number of buildings set up in the sector each year. The average amount of the wood product per building in each subsector was estimated as a function of the ratio of the price index of the wood product to the price index of substitutes for the wood product. The number of buildings set up in a subsector each year is the sum of new buildings for incoming individuals and old buildings being replaced. An individual may be an independent adult person in residential housing construction, a student in school construction, a hospital bed in hospital construction, or a kilometer of road in bridge construction subsector.

The time path of the model is determined by changes in the number of individuals and the order of deterioration of buildings in each subsector. The order of deterioration of buildings in each building construction subsector is determined by the rate of use of the buildings, the environmental conditions, and the building materials. The annual rate of change of school (high schools and colleges) populations (students/year) are determined as functions of GDP and public investment in education. The annual rates of maturity by rural and urban non-school going youths into traditional and semi-traditional independent adult population groups are determined as lagged functions of time. School going youths will, on graduation and on taking appropriate jobs, be classified as semi-traditional if they stop at high school and as non-traditional if they obtain college degrees. If the personal incomes of some people already classified in the traditional groups improve enough they are reclassified in the non-traditional groups.

This time path is a modernization time path such that as economic conditions improve the traditional population declines and the non-traditional population grows in an exponential fashion. The modernization process which depends on income and government investments in education and other key sectors occurs with considerable time lag to which wood consumption particularly in residential housing construction subsector is very sensitive.

Separate estimates are made for fuelwood from market and non-market sources for rural and urban population groups. Fuelwood from non-market sources is the fuelwood obtained and used directly by the consumer from various own sources like the farm, etc. Annual consumption of fuelwood from each source is computed as a product of average amount of fuelwood from that source per adult per year and the number of adults. The average amount of fuelwood from the market sources per adult per year is estimated as a function of the prices of fuelwood. Annual consumption of paper is estimated as a function of changes in per capita income separately for traditional, semi-traditional, non-traditional, and student population groups. The number of caskets manufactured annually is estimated as a constant proportion of number of deaths each year. Some people are not buried in caskets, others are buried in caskets made of materials other than wood for various reasons including religious prescriptions, inability to afford a wooden casket, etc. Our estimates are for only those made of wood.

Data Used in Operating the Model

The data used in the model were assembled from a national wood consumption survey, published and unpublished secondary sources, and from the judgement of knowledgeable individuals. The model is designed to receive some of the data as constants and other as variables. The fact that some data are fed into the model as constants does not mean that the variables which they are functions of are not varied in making the projections if they are real world variables. For instance, the model receives average proportions of residential building per person as constants. In reality this varies with time because as income improves, people want to live in less crowded houses. There are three values of average proportion of residential building per person in the model for traditional, semi-traditional, and non-traditional residential buildings respectively. Each one is a constant but as economic conditions improve, the value for non-traditional buildings is used more frequently and the value for traditional buildings is used less frequently in making the projections. Thus, the average proportion of residential building per person is varied in the model hopefully as in reality.

The coefficients of the variables are estimated in a total of nineteen equations. Sixteen of these are simple linear regression equations. Exponential forms of equations would be consistent with our assumptions but the range and the durations of time-series data available (the maximum of which is twelve years) were not sufficient to estimate the coefficients of exponential equations. The simple form of the regression equations does not concern us greatly because they are used as predictive equations. The coefficients in the other three equations which are those of changes in per capita incomes in the per capita consumption of paper by the low, medium, and the high income population groups were estimated by judgement because we could not gather enough data to estimate them by regression techniques.

Projections from the Model

The model is operated to make historical projections of annual consumption of the various wood products for the period 1965-1974. This was based on the actual values of the various variables like GDP, government spending, etc. Three sets of projections based on three alternative rates of growth of GDP were made for annual consumption of the various wood products in the future for the period 1975-1990. The rate of growth of GDP assumed for the base run of the model is 11.7 percent per annum which is that estimated by the Federal Government for the Third National Development plan. The other two rates which are alternatives to the base run are 6 and 15 percent respectively. Government spending in the various sectors was assumed to grow at the same rate as GDP in each alternative run although we recognize that public investment priorities will vary if national income changes.

We pointed out that changes in income and public spending have two consequences for wood consumption, one is in the near future and the other more lagged. The duration of our future projections is not long enough to cover that lag and we cannot extend it without making undue assumptions about future levels of income and public investment priorities. One should therefore note that the future projections presented in the previous chapters do not tell the whole story. Wood consumption in the residential housing construction is particularly sensitive to the lagged consequences. We pointed out that Tables 14, 15, 27, and 31 show that the proportion of processed wood consumed in the residential housing construction subsector is declining while that of non-residential building construction subsectors is increasing as income and government spending increase. This is because while the consequences of increasing income and government spending take effect instantaneously in the non-residential building construction subsectors, they are delayed in the residential housing construction subsector. When we consider that 70 percent of overall processed wood consumption is in the residential housing construction subsector, we realize that the lagged consequences of the current high public investments on wood consumption which are unobservable in our projections will be substantial. This is based on the assumption that the high rates of spending are sustained over time so that the modernization process is continuous.

The projected annual consumption of various wood products indicates that future wood consumption in Nigeria will be phenomenal. If the production challenge is not met, it will result in high domestic prices for wood products to ration the available supply. One of the consequences of domestic prices higher than world market prices for wood would be pressure to import wood products into Nigeria and for exports of wood from Nigeria to decrease. This would result in loss of foreign exchange contribution from the forestry sector. If it happens when Nigeria will no longer be able to export petroleum in large quantities and at high prices, this consequence will be regrettable.

High domestic prices for wood products would also encourage overexploitation of the existing forests. This would conflict with other forestry sector objectives such as environmental quality control. The undesirable effects of overexploitation of forest lands for various purposes including farming, logging, etc. are already apparent in many parts of Nigeria. Examples of these adverse effects are the southward movement of the desert and the water erosion areas in many parts of East Central state. Overexploitation of forests today will lead to more acute shortages in future and to higher prices and so on.

Another consequence of high domestic prices for wood products would be the introduction of substitutes for wood in various uses. Some of the materials that are extensively substituted for wood in many countries are plastics made from petroleum products, steel, concrete, and glass. Nigeria is blessed with an abundant supply of natural resources from which these materials are made. But these natural resources are exhaustible and cannot be relied upon forever. Wood on the other hand is a renewable natural resource.

High prices for wood products would encourage investments in the forestry industries at the same time as other materials are being substituted for wood in various uses. Investments in some forestry industries mature with long time lags. It is possible that when they mature, there may be reduced markets for wood products as people may have learned to use wood substitutes. This could lead to cycles in the production and consumption of forestry products.

The likely situation of high annual consumption of wood products in future should be of concern to Nigerian policy makers in the forestry sector. The sensitivity analyses presented in the previous chapter indicate that even if our estimates are high by as much as 50 percent, which is unlikely, the expected change is still phenomenal. It is unlikely that the potentials of Nigerian forests will be able to meet such requirements or that more land will be put into forestry because of other demands on land consequent on increasing income such as increasing industrialization, urbanization, roading, and demand for food.

Prescriptions

The first goal of the forestry sector is to "provide for the needs of the country in timber and other forest produce adequate for the requirements of the community under a fully developed national economy and to provide the greatest possible surplus of those products for export markets" (46, p. 2). The projections of annual wood consumption from our model just summarized show that the need of the country for timber is high and will likely be higher. In this section we summarize some of the actions we believe would help in meeting that need as follows:

1. A continuation of the current efforts being made to increase the supply of forestry products by intensive cultural methods. These efforts include: (a) gradual conversion of natural forest reserves to forest plantations. This process is important not only because it results in higher yield of wood of desired species per acre, but also because of the uniform characteristics of plantations, logging operations are more convenient and less expensive than in natural forests. The tendency of the private sector to regard forests as "god given" resulting in such abuses as stealing of forest products, forest fires, etc., will likely be less in forest plantations which are man-made than in the natural forests. The rate of conversion of forest lands to agricultural lands may be reduced when natural forests are converted into forest plantations.

Additional problems associated with man-made forests should be borne in mind. Man-made forests need more silvicultural care and are more susceptible to diseases than natural forests. The high cost of conversion is reduced by the "taungya" method which permits the farmer to clear the forest land and grow his food crops for the first few years thus transferring the costs of clearance and initial maintenance to the farmer. In addition to the problem of maintenance, man-made forests will yield wood the quality of which will differ from that yielded by natural forests. (b) More intensive management of natural forests. Barnard (3) has shown that maintenance practices in the Western Nigerian natural forest reserves are sub-optimum and that such will result in low yield. In view of the rapidly expanding demand for wood, it is necessary that maintenance practices in the natural forests be stepped up. The additional cost of this should be financed by increasing the proportion of forest revenues reinvested in the industry. (c) The practice of multiple use of forest lands for agriculture, recreation, etc., as well as for tree growing should be pursued more vigorously. This practice will reduce the cost of forest maintenance for the forestry sector as well as help bring some agricultural land into forestry.

2. Modernization of processing facilities including equipment and management and encouragement of horizontal and vertical integration of wood processing with final product industries. Inefficiency resulting in 50 percent conversion rate for the country has been observed in the wood processing industry (48). The slabs, edgings, and sawdust which make up the other 50 percent are not entirely wasted since some of them are utilized in various other ways including fuelwood and those not utilized at all return to the soil to enrich it. Yet in view of the phenomenal increase in demand for wood for construction and paper, it is necessary that some of those byproducts should be salvaged for direct utilization.

The efficiency of the industry can be improved in various ways including requiring a minimum capital and training for entrance into the industry. Minimum capital requirement will encourage horizontal integration among the small mills to take advantage of economy of scale which is high in the industry. The school of wood technology should be expanded to accommodate prospective private wood processing industrialists.

Vertical integration of wood processing with final product industries will internalize some of the so called wastes and encourage their direct utilization. For example, integration of the manufacture of matches or of charcoal with wood processing will utilize most of the slabs and edgings which result from sawmilling. Some of these actions will likely have some adverse effects on some people currently employed in the industry. The plans of action should include alternative arrangements for the compensation of such people.

3. Encouragement of substitution of other materials for wood in various uses where such is possible to reduce the amount of wood per unit of structure. Since steel, concrete, and plastics are acceptable substitutes for wood in certain uses, the establishment of iron and steel mills, cement factories, and oil refineries which are planned for the country will likely increase the degree of substitution of these products for wood in certain uses. The net social advantage of such substitution may be high. For example, the proportion of the cost of fuelwood in the household budget is substantial in some parts of the country such as Sokoto province. One way to make fuelwood less expensive for the individual is to grow more trees for fuelwood in the forest reserves. The social opportunity cost of the land and other resources put into growing such trees is high because of the long time lags required to grow trees. Alternative sources of fuel like electricity, natural gas, solar energy, etc. are likely to be eventually cheaper both for the individual and for the society.

Some of the sources of substitutes for wood such as iron ore and petroleum deposits are, however, exhaustible and cannot be relied upon indefinitely. Therefore, the use of substituties should not be regarded as a permanent solution for the wood shortage problem. In addition, any iron ore or petroleum product used in Nigeria cannot be exported; the social advantage of substituting them for wood should be weighed against the social opportunity cost in terms of foregone foreign exchange earnings.

These recommendations are arrived at from the analyses of the projections of annual wood consumption presented in the last two chapters. While in Nigeria gathering information for the model and projections of wood consumption, the author discussed the organization, problems, and other general aspects of the forestry sector with various people including public employees of the sectors as well as some people privately engaged in forestry industries. Based on these discussions as well as on readings of materials (published and unpublished) about the sector we have arrived at additional recommendations. These recommendations should be investigated further before they are considered for implementation because they are not based on an objective study. They are as follows:

1. The present set-up in which public bodies own forest lands should be maintained because forests yield socially important externalities which are not of direct interest to the private entrepreneur. But the protective power of the public bodies responsible for public forests should be strengthened against abuses of such forest lands from the private sector. In Chapter II we pointed out that there are forest ordinances in Nigeria enacted against such abuses but most of the cases brought against the violators are lost in the courts. The forestry departments have to secure from the justice departments lawyers who lack forestry backgrounds and who cannot realistically argue the case for forestry. Bureaucratic red tape involved in transferring services from one government department to another generally result in loss of time.

Forest production divisions in the various departments of forestry should be reorganized to include legal subdivisions whose staff should consist of legal men with forestry backgrounds. In the absence of this, forest protection divisions should be empowered to hire private lawyers when they need them so that the best lawyers will be secured at the right moments.

2. The social advantages of the current practice of indiscriminately grazing cattle on public forest lands by nomadic herdsmen should be weighed against the social costs and stopped or the herdsmen made to pay for grazing on forest lands if such a practice proves to be socially disadvantageous.

3. The advisory services of the Federal Department of Forestry needs to be enhanced. The department is established to advise the Federal Government on forest development including location of federally funded forest projects throughout the country, to act as an advisory and liaison body to the Nigerian states, etc. This function is very important if the Federal resources are to be invested where they are most productive and if unhealthy competition among state departments of forestry is to be avoided. To provide such advisory service, however, the Federal Department of Forestry needs to have adequate information about the supply and productivity of resources in different states. The present capacity of the department to provide this information is heavily on the side of the technical forestry disciplines almost to the neglect of the social science disciplines. An economics division which will be staffed with economists and other social scientists is needed. Such a division would deal with such human problems as land tenure, political problems, etc., and in cooperation with the technical

divisions carry out project appraisals. The information provided by the economics division will be used in the planning division.

4. We pointed out in Chapter II that a problem of the Federal Department of Forest Research (FDFR) is shortage of qualified research officers. The employment policy of the Nigerian governments is at least partially responsible for this. For example, FDFR employs a fresh first degree graduate and after a year or two sends him for a graduate work to study for Master's degree for two years. While in training the individual's training expenses are paid, he is given maintenance allowance in addition to his salary. His promotion is withheld but he maintains his seniority in the civil service. His colleague who is not a government employee pays his own expenses, does not receive any allowance or salary, and gets a doctorate degree after four or five years from first degree. The FDFR offers him a junior officer grade position which is likely to be inferior to that of his colleague who in addition to his training expenses being paid by the government earned his salary and maintenance allowance while in training. This set-up is unattractive to individuals who invested their own time and money to earn higher degrees.

To meet its manpower needs FDFR should step up its training program by increasing the number of employees sent to graduate school each year and by training them up to doctorate degree level because for some of the FEFR research projects Master's degree may not be enough preparation. The cost of this can be reduced by making the department attractive to individuals who have trained themselves up to the doctorate degree level in relevant areas. This can be done by employing such people at least as senior officers to compensate them partially for their efforts to train themselves.

Our recommendations are made on the basis of information generated by an incomplete model--the wood consumption component is only a part of the entire forestry sector model--because we believe that no recommendation will ever be made if we have to wait until we have a complete model. Even a national economy model is incomplete because a national economy interacts with economies of other countries. The only complete economic model will be a world economy model. However, in the next section entitled "unfinished work" we shall discuss the need for the complete forestry sector model and summarize some other aspects of the sector where investigation will be of importance.

Unfinished Work

Need for a Generalized Model of the Entire Forestry Sector

We presented a general model for the Nigeria forestry sector without formulating the model specifically because we lacked the necessary resources (time, information, and money) to do so. The model of the wood consumption component needs to be used in conjunction with models of the other components with which it interacts in the forestry sector system. This has left it open ended without a feedback loop. This loop is needed before we can make any meaningful analysis of policy alternatives. For example, we have merely mentioned that artificial pricing of wood products may lead to undesirable cycles in the production and consumption of wood products. If we had the model of the production component we would generate the equilibrium prices endogenously by equating production with consumption. We could generate those cycles specifically for different pricing policy alternatives by changing the prices from their equilibrium levels.

Similarly, with a complete model of the sector we can analyze the consequences of alternative public and private decisions on the forestry and national objectives. Specifically for example, we can analyze the consequences of alternative forestry management practices (such as natural regeneration, natural regeneration supplemented with limited silvicultural operations, and outright conversion to forest plantations) on the number one objective of the forestry sector, supply of timber (46) as well as on the other national objectives (such as employment, income, revenue, and foreign exchange generation). We would be able to analyze and display on the basis of a complete forestry sector model the consequences over time of alternative uses of land in forestry and in agriculture, of alternative import and export policies for forest products and forest industry inputs, of various profit margins for producers of forest products, etc. on the various forestry sector and national objectives.

A general systems simulation model should make these analyses better than specialized technique models because it can utilize any technique available to handle the full range of relevant normative and non-normative information from a wide range of sources to estimate the consequences through time and over space of alternative actions in terms of various goods and bads. If the necessary preconditions for maximization are not met, a general model can trace the consequences of actions through time and through a series of interactions and generate the necessary normative and non-normative information to approximate the preconditions for maximization. Preconditions for maximization are not generally present for public decisions and actions which involve a multiplicity of goals, people, change and uncertainty.

A model which is generalized with respect to technique, kind, and sources of information, and with respect to philosophic orientation is more likely to provide a multidisciplinary investigation base which no specialized model can provide. This is particularly important in forestry, the components of which including production, processing, distribution, consumption, education and training, land tenure, etc. span a wide range of disciplines such as biology, ecology, engineering, education, and sociology, to mention a few.

Other Areas for Further Research

All through this thesis we have identified portions in the forestry sector where causes and consequences are either not well known or not known at all. These areas need research attention. They include:

1. Constraints on forest land despite the stated public forest sector objective of encouraging private forestry.

2. Wastage of utilizable trees in the forest zones in the presence of markets for them in other parts of the country.

3. Abuses of the public forest lands by the private sector such as overgrazing of forest lands, purposeful forest fires, illegal removal of trees, etc.

4. Adverse consequences on the production of forest products of the present system of distributing investment costs and revenue for the public forests.

5. Inefficiency in the wood processing industries.

6. Alleged excess profit in the wood processing industries.

7. The relative advantages with respect to the national objectives of importing sawlogs for domestic processing for reexport.

8. Need for assembling, analyzing, and publishing for public access of information on prices, production, and domestic consumption of wood products.

Causes and consequences in the areas have always been guessed at but what is needed is objective investigations to determine their extent and magnitude as a first step for reaching prescriptions to solve problems.

APPENDICES

APPENDIX A

MATHEMATICAL MODEL OF THE WOOD CONSUMPTION COMPONENT OF NIGERIAN FORESTRY SECTOR

APPENDIX A

MATHEMATICAL MODEL OF THE WOOD CONSUMPTION COMPONENT OF NIGERIAN FORESTRY SECTOR

Types and Models of Time Lags Encountered

It was pointed out in the section above dealing with the general conceptualization of the model that the response of wood consumption habits to changes in economic conditions involve time lags of different durations. Two types of time lag are encountered in this model. In one of them, described as discrete delay, individuals undergoing the delay process change at a uniform rate. A discrete delay model is used to model the time delays involved in going through high school and college, where most students pass from freshman to sophomore to senior grades and so on at approximately the same rates. Another discrete delay model is used in modeling the time lag involved in the first stages of the aging process of non-school-going rural and urban youth. The young people mature from thirteen to twenty-one years of age in urban areas at the same rate. Similarly, the young people in the rural areas mature from thirteen to twenty-four years of age also at the same rate. In general, a discrete delay model can be represented by (36):

1. $$O(t) = I(t-DT)$$

where:

$O(t)$ is the lagged output of the delay in period t,

$I(t-DT)$ is the input to the delay in period t-DT.

DT is simulation time interval.

A distributed delay model is used to simulate the time lag involved in (1) the final stages of the process of maturity in the non-school-going rural and urban youth, and in (2) deterioration of various buildings as described in the previous sections.

In general a distributed delay is defined as a linear differential equation as follows (36):

$$2. \qquad x(t) = a_k \frac{d^k y(t)}{dt^k} + \frac{d^{k-1} y(t)}{dt^{k-1}} + \ldots + a_1 y(t)$$

where:

$x(t)$ is the unlagged value.

$y(t)$ is the lagged value.

A delay model is defined by its order, k. The order of a delay was described in Figure 7 above. The output $y(t)$ of the delay model represented above is distributed over a number of periods so that it adjusts slowly to changes in input $x(t)$.

<u>Population Submodel</u> (See Figure 21)

Young people who do not proceed to high school generally stay dependent until about twenty-one or twenty-four in the urban and rural areas, respectively, at which ages individuals begin to assume personal responsibilities, such as separate residence, separate business, marriage, etc.

The first thirteen to twenty-one years in the urban areas and thirteen to twenty-four years in the rural areas of this delay are

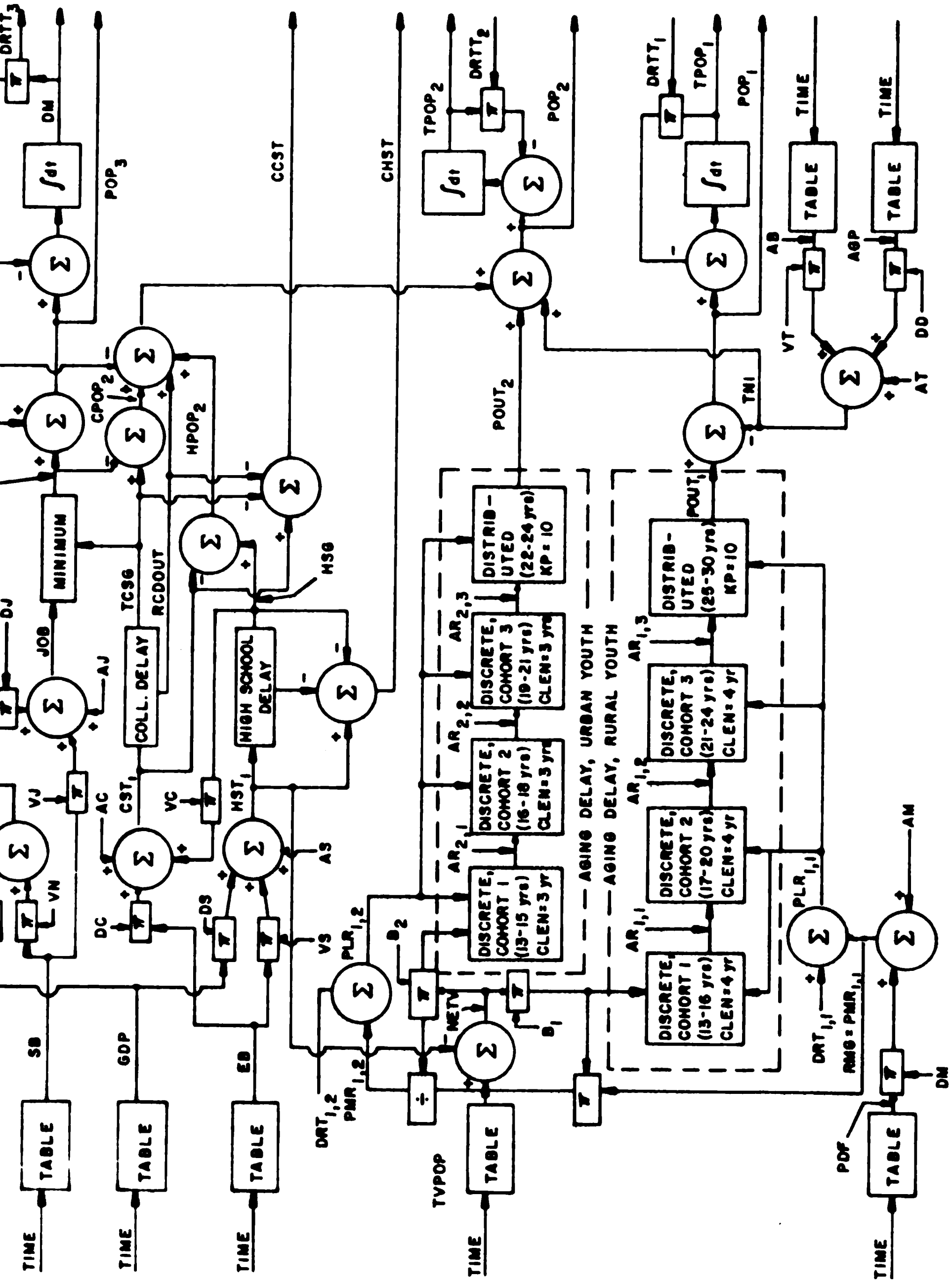

FIGURE 21: FLOW DIAGRAM OF POPULATION SUBCOMPONENT

modeled as discrete delays following a discrete delay model, called DEMOGD (9).

At each time DEMOGD computes population level in cohort j using Euler's integration formula to solve the differential equation:

$$\frac{d\, POP_{ij}}{dt} = -PLR_{ij}(t) \cdot POP_{ij}(t) + AR_{ij-1}(t) - AR_{ij}(t)$$

where:

$j = 1, \ldots NC$ indexes cohorts.

$i = 1, 2$ indexes rural and urban populations, respectively.

$POP_{ij}(t)$ = level of population i in j^{th} people cohort.

$AR_{ij}(t)$ = rate at which population i matures out of cohort j, (people/year).

$PLR_{ij}(t) = RMG_{ij}(t) + DRT_{ij}(t)$ is the proportional rate at which people leave j^{th} cohort for reasons other than age; i.e., deaths and migrations.

where:

$RMG_{ij}(t) = AM + DM \cdot PDF(t)$ is proportional migration rate for population i in j^{th} cohort (proportion).

AM and DM = regression parameters (see Chapter V).

PDF(t) = income earning differential between urban and rural areas.

Migration rates which are positive losses in rural areas are negative losses (gains) in urban areas.

$DRT_{ij}(t)$ = proportional death rate for population i in cohort j.

NC = number of age cohorts.

For: POP_{i1}, $AR_{io}(t) = B_i \cdot NETV(t)$

where:

NETV(t) = 12-year-old population not proceeding to high school at time t (people).

B_i = proportion of NETV made up by population i (proportion).

Every $CLEN_j$ years the maturation rate is computed by:

$$AR_{ij}(t) = POP_{ij}(t)/CLEN_{ij}$$

where:

$CLEN_{ij}$ = the length of j^{th} cohort for population i (year).

At each DT during the simulation, AR_{ij} is adjusted for deaths and migrations occurring during the $CLEN_{ij}$ years:

$$\frac{dAR_{ij}}{dt}(t) = -PLR_{ij}(t) \cdot AR_{ij}(t) \quad t = 0,\ CLEN_{ij},\ 2\ CLEN_{ij}.$$

Deaths during the maturation process are computed for each cohort and summed across cohorts:

$$DTH_{ij}(t) = DRT_{ij}(t) \cdot POP_{ij}(t)$$

$$TDTH_i(t) = \sum_{i=1}^{2} \sum_{j=1}^{3} DTH_{ij}(t)$$

where:

DTH_{ij} = deaths from j^{th} cohort in population i (people/year).

$TDTH_i(t)$ = total deaths (people/year).

The next 22-24 years and 25-30 years of the delay process in the rural and urban areas respectively are modeled following DELLVF (11). STP_{ij} is the storage of population i in the j^{th} stage of delay.

$$STP_{ij}(t) = \frac{DELP_i}{KP} \cdot RP_{ij}(t) \text{ (people)}$$

where:

j = 1,..., KP indexes the delay stages.

$i = 1$ or 2 indexes rural and urban populations respectively.

$RP_{ij}(t)$ = rate of the j^{th} stage for population i (people/year).

KP = order of the delay process for population i.

$DELP_i$ = mean delay period for the population group i.

The rate of change of STP_{ij} is the net flow into the j^{th} stage for population i; Euler's integration formula is used to solve the differential equation:

$$\frac{dSTP_{ij}(t)}{dt} = RP_{i,j+1}(t) - RP_{ij}(t) - PLR_{ij}(t) \cdot STP_{ij}(t)$$

where:

$RP_{i,KP+1}(t) = AR_{i,3}(t)$ or the rate at which people enter the distributed delay from the discrete delay for population i (people/year).

The intermediate rates RP_i are initialized to:

$RP_{ij}(0) = STP_i(0)/DELP$ assuming steady state initial conditions.

$STP_i(0)$ = initial storage for population i in the delay (people).

Educational regulations in Nigeria require a student to spend a minimum of four, five, or six years in college, depending on the program of study, and five years in high school to graduate. Most who do not graduate at the end of the minimum period drop out and take examination as external candidates. Delays involved in this process are modeled following discrete delay developed by Manetsch and Park (36) and modified to account for losses due to dropouts and deaths.

The rate at which students graduate from college is given by:

$$TCSG(t) = \sum_{i=4}^{6} G_i \cdot CST_i(t-1)$$

where:

$i = 1, \ldots, 6$ the student's year in college (freshman, sophomore, etc.)

$G_i = 0$ for $i = 1, 2, 3$.

G_4 = final year of 4-year-program student as a proportion of all 4^{th}-year college students (proportion).

G_5 = final year of 5-year-program students as a proportion of all 5^{th}-year college students (proportion).

G_6 = final year of 6-year-program students as a proportion of all 6^{th} year students ($G_6 = 1$).

$CST_i(t-1)$ = number of students in the i^{th} year of college in the previous time period (students).

Total college students is given by:

$$TCST(t) = \sum_{i=1}^{6} CST_i(t) \text{ students}$$

$$CST_i(t) = CST_{i-1}(t) \cdot [1 - CDOUT(t) - DRTC(t)] \text{ (students)}$$

where:

CDOUT = proportion of all college enrollment who leave college before they graduate (proportion/year).

DRTC(t) = college student deaths as a proportion of college enrollment (proportion/year).

$$CST_1(t) = AC + DC \cdot EB(t) + VC \cdot HSG(t) \text{ (students)}$$

where:

AC, DC, and VC = regression parameters (see Chapter V).

HSG(t) = number of high school graduates (graduates/year).

EB(t) = government education budget divided by price index (₦/year).

College dropout rate is given by:

$$RCDOUT(t) = CDOUT(t) \cdot TCST(t) \text{ (student/year)}$$

College death rate is given by:

$$RCDTH(t) = TCST(t) \cdot DRTC(t) \text{ (deaths/year)}$$

The number of new college-level jobs is given by:

$$JOB(t) = AJ + DJ \cdot GDP(t) + VJ \cdot SB(t) \text{ (job openings/year)}$$

where:

AJ, DJ, and VJ = regression parameters (see Chapter V).

GDP(t) = gross domestic product divided by price index (₦/year).

SB(t) = government economic services budget divided by price index (₦/year).

The rate at which college graduates enter the independent non-traditional adult population is given by:

$$CPOP3(t) = MINIMIZE[JOB(t), TCSG(t)] \text{ (people/year)}$$

The rate at which college graduates enter the independent semi-traditional adult population group is given by the following identity:

$$CPOP2(t) = TCSG(t) - CPOP3(t) \text{ (people/year)}$$

The rate at which students graduate from high school is given by:

$$HSG(t) = HST_{i=5}(t-1) \cdot [1-HDOUT(t)] \text{ (graduates/year)}$$

where:

i=1,..., 5 indexes year of the individual student in high school.

HDOUT(t) = proportion of high school students who leave high school before they graduate.

Total high school student is given by:

$$THST(t) = \sum_{i=1}^{5} HST_i(t) \quad \text{(students)}$$

where:

$HST_i(t) = HST_{i-1}(t) \cdot [1 - HDOUT(t) - DRTH(t)]$ is number of students at their i^{th} year in high school (students).

$HST_1 = AS + DS \cdot GDP(t) + VS \cdot EB(t)$ (freshmen).

where:

AS, DS, and VS = regression parameters (see Chapter V).

GDP(t) = gross domestic product divided by price index (₦/year).

EB(t) = government education budget divided by price index (₦/year).

DRTH(t) = high school student deaths as a proportion of high school enrollment (proportion).

High school death rate is given by:

$$RHDTH(t) = DRTH(t) \cdot THST(t) \quad \text{(deaths/year)}$$

High school dropout rate is given by:

$$RHDOUT(t) = HDOUT(t) \cdot THST(t) \quad \text{(students/year)}$$

The rate at which high school graduates enter the independent semi-traditional population group is given by:

$$HPOP2(t) = HSG(t) - CST_1(t) \quad \text{(people/year)}$$

HPOP2 could be negative because CST_1 can be drawn from working as well as from fresh high school graduates.

The rate at which members of traditional population move into semi-traditional population due to improvement in the level of income is given by:

$$TNI(t) = AT + DD \cdot AGP(t) + VT \cdot AB(t) \text{ (people/year)}$$

where:

AT, DD, and VT = regression parameters (see Chapter V).

AGP(t) = agriculture's contribution to gross domestic product (₦/year).

AB(t) = government agricultural and other rural development budget divided by price index (₦/year).

The rate at which semi-traditional population moves into the non-traditional population due to improvement in income level is given by:

$$SNI(t) = AN + DN \cdot GDP(t) + VN \cdot SB(t) \text{ (people/year)}$$

where:

AN, DN, and VN = regression paramaters (see Chapter V).

GDP(t) = gross domestic product divided by price index.

SB(t) = government general economic services budget divided by price index (₦/year).

The rate at which traditional population grows is given by the following identity:

$$POP_1(t) = POUT_1(t) - TNI(t) \text{ (people/year)}$$

where:

$POUT_1(t)$ = the rate at which members of traditional population mature into adulthood.

The rate at which semi-traditional population grows is given by the following identity:

$$POP_2(t) = POUT_2(t) + TNI(t) + HPOP2(t) + RCDOUT(t) + CPOP2(t) - SNI(t)$$
$$\text{(people/year)}$$

The rate at which non-traditional population grows is given by the following identity:

$$POP_3(t) = CPOP3(t) + SNI(t) \text{ (people/year)}$$

$TPOP_i(t) = TPOP_i(t-DT) + DT(POP_i(t) - DRTT_i \cdot TPOP_i(t-1))$ is the total population of group i.

where:

$DRTT_i$ = proportional death rate for population group i (prop./year).

<u>Residential Construction Submodel</u>
(See Figure 22)

The residential construction component computes the number of new traditional, semi-traditional, and non-traditional residential houses built per unit time and the amount of unprocessed and processed wood in cubic meters, and building board woodpulp in kilograms per unit time used in such construction.

The rate of construction of new residential houses is computed as the sum of replacements of existing houses and a proportional multiple of $POP_i(t)$. The rate of replacements is computed following DELLVF (11) to simulate the time delay involved in the decay process and losses due to accidental demolition of houses and furniture.

STR_{ij} is the storage of houses i in the j^{th} stage of the delay:

$$STR_{ij}(t) = \frac{DELR_i}{KR} \cdot RR_{ij}(t) \text{ (houses)}$$

where:

i = 1, 2, or 3 indexes traditional, semi-traditional, and non-traditional houses.

j = 1,..., KR indexes stage of delay.

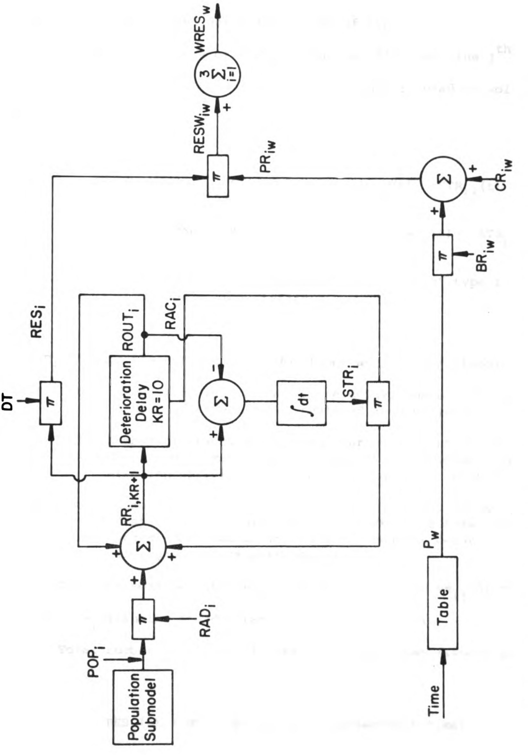

FIGURE 22: FLOW DIAGRAM OF RESIDENTIAL HOUSING CONSTRUCTION SUBCOMPONENT.

$RR_{ij}(t)$ = rate out of the j^{th} stage for house type i (houses/year).

$DELR_i$ = mean delay time for houses of type i (years).

KR = the order of the delay for houses of type i.

The rate of change of STR_{ij} is the net flow into the j^{th} stage for houses of type i; Euler's integration formula is used to solve the differential equation:

$$\frac{dSTR_{ij}(t)}{dt} = RR_{i,j+1}(t) - RR_{ij}(t) - RAC_{ij}(t) \cdot STR_{ij}(t) \cdot$$

$$RR_{i,KR+1}(t) = RAD_i \cdot POP_i(t) + ROUT_i(t) + RAC_i(t) \cdot STR_i(t)$$

is the rate at which new houses of type i are built (houses/year)

where:

RAD_i = proportion of house of type i per adult (proportion).

$ROUT_i(t)$ = $RR_{i1}(t)$ is the output of the delay, number of decayed houses of type i to be replaced (houses/year)

$RAC_i(t)$ = number of standing buildings during the entire delay destroyed prematurely as a proportion of total number of standing buildings for population group i (proportion/year).

$RAC_{ij}(t)$ = number of standing buildings in j^{th} stage of delay destroyed prematurely as a proportion of total number of standing buildings in the same stage of delay for population group i (proportion/year).

The intermediate rates RR_{ij} are initialized to $RR_{ij}(0) = STR_i(0)/DELR_i$ assuming steady state initial conditions.

Total number of houses of type i per unit time (stock) is given by:

$$RES_i(t) = DT \cdot RR_{i,KR+1}(t) \text{ (houses/unit time)}$$

The total amount of wood of type w used in residential house construction per unit time (stock) is given by:

$$WRES_w(t) = \sum_{i=1}^{3} PR_{iw}(t) \cdot RES_i(t)$$

where:

w = 1, 2, or 3 indexes unprocessed wood, processed wood, and building board wood pulp.

$PR_{iw}(t) = CR_{iw} + BR_{iw} \cdot P_w(t)$ is the amount of wood of type w per residential house of type i (PR_{i1} and PR_{i2} in cubic meters, $PR_{i3} = PR_i \cdot PB$ in kilograms).

CR_{iw} and BR_{iw} = regression parameters (see Chapter V).

$P_w(t)$ = index of price of wood, w, to the index of prices of substitutes for wood.

PB = proportion of paperboard that is pulp.

$WRES_w(t)$ as a proportion of total wood w used for all construction purposes is given by:

$$PWRES_w(t) = WRES_w(t)/TWD_w(t)$$

where:

$TWD_w(t)$ = total wood w used for all construction purposes.

<u>Non-residential Housing Construction Submodel</u> (see Figures 23-26)

It was pointed out in earlier sections that the school, hospital, commercial, religious, and public administration building construction subsectors are considered as non-residential building construction subsectors. The rates of setting up elementary school, commercial, religious, and public administration buildings are estimated as constant proportions of building rates for residential buildings. We shall present these first and later present high school and college (as school) and hospital submodels.

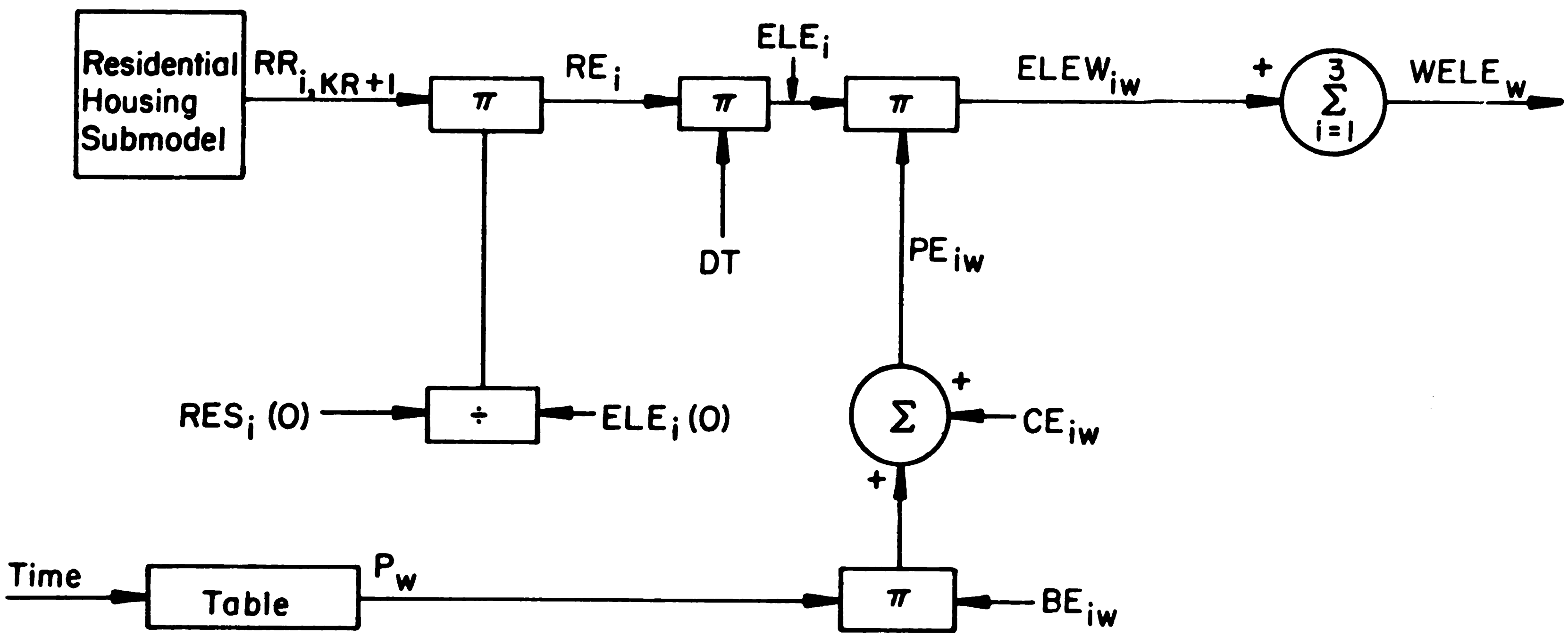

FIGURE 23: FLOW DIAGRAM OF ELEMENTARY SCHOOL BUILDING CONSTRUCTION SUBCOMPONENT.

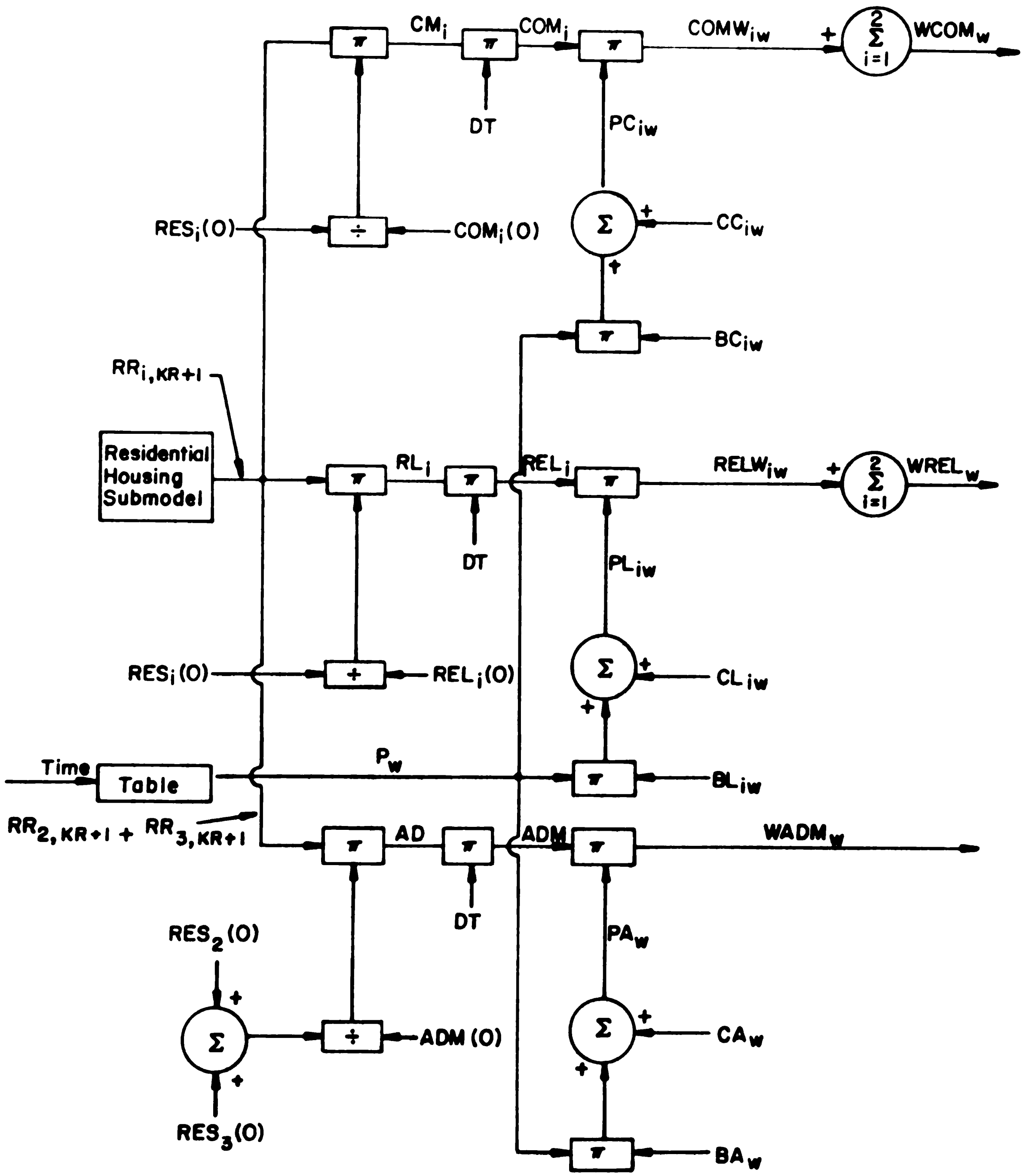

FIGURE 24: FLOW DIAGRAM OF COMMERCIAL, RELIGIOUS, AND PUBLIC ADMINISTRATION BUILDING CONSTRUCTION SUBCOMPONENTS

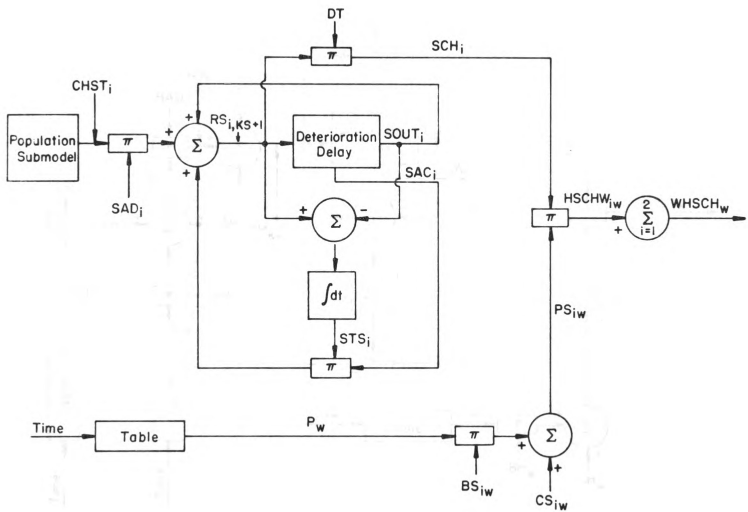

FIGURE 25: FLOW DIAGRAM OF HIGH SCHOOL AND COLLEGE BUILDING CONSTRUCTION SUBCOMPONENT.

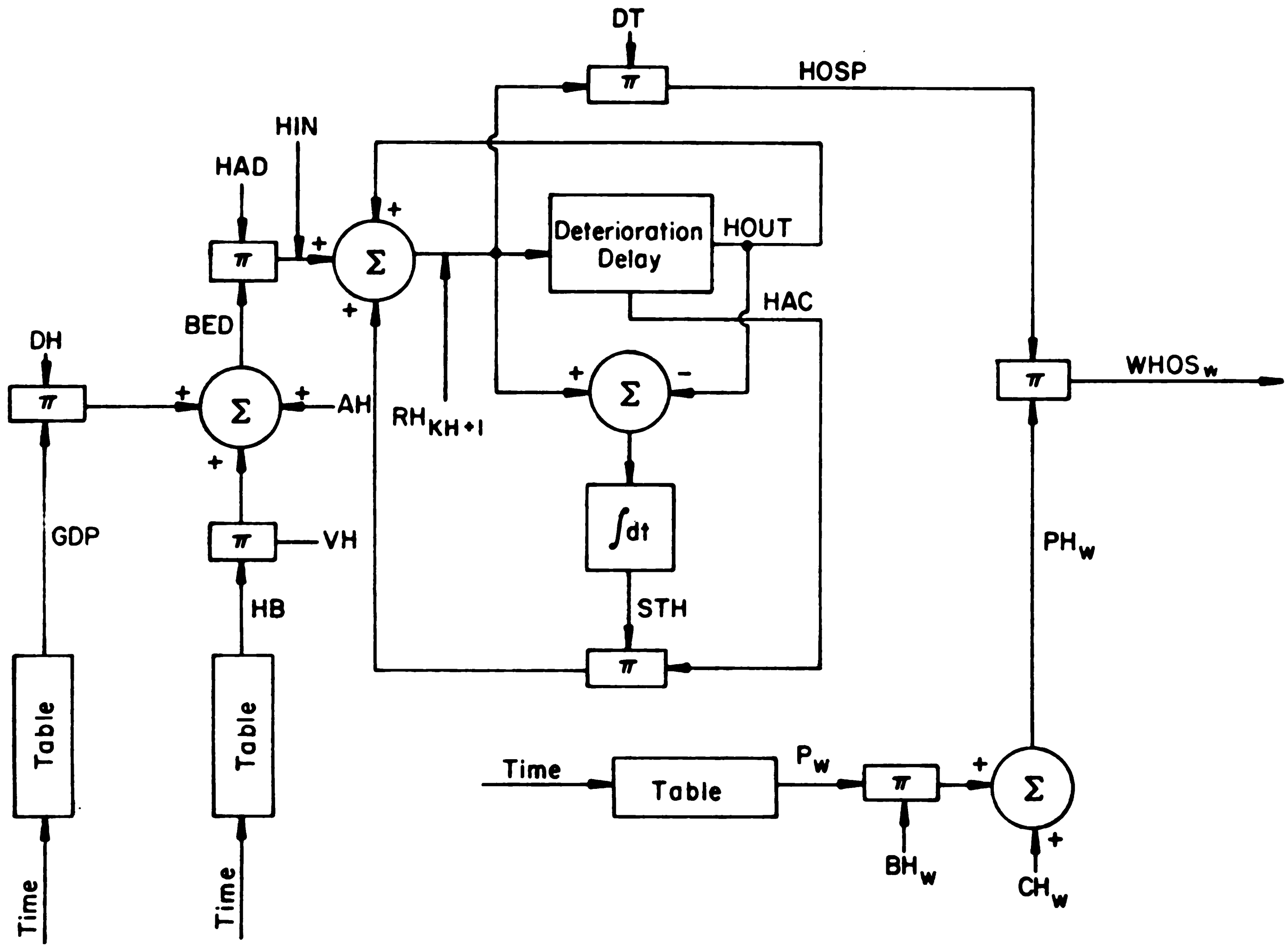

FIGURE 26: FLOW DIAGRAM OF HOSPITAL CONSTRUCTION SUBCOMPONENT.

1. Elementary School (see Figure 23).

The elementary school component computes the number of new houses and furniture set up for elementary schools for traditional, semi-traditional, and non-traditional populations per unit time and the amount of unprocessed wood, processed wood, and building board woodpulp used in this construction.

The rate at which elementary school (of type i) buildings are built is given by:

$$RE_i(t) = \frac{ELE_i(0)}{RES_i(0)} \cdot RR_{i,\ KR+1}(t) \quad \text{(houses/year)}$$

where:

$i = 1, 2,$ or 3 indexes traditional, semi-traditional, and non-traditional respectively.

$RR_{i,KR+1}(t)$ = the rate at which residential houses of type i are set up (houses/year).

$ELE_i(0)$ = total number of elementary school buildings of type i at base time (houses).

$RES_i(0)$ = total number of residential buildings of type i at base time (houses).

Total number of elementary school buildings of type i per unit time (stock) is given by:

$$ELE_i(t) = DT \cdot RE_i(t) \quad \text{(houses/unit time)}$$

Wood of type w used in elementary school housing and furniture per unit of time is given by:

$$WELE_w(t) = \sum_{i=1}^{3} PE_{iw}(t) \cdot ELE_i(t)$$

where:

w = 1, 2, or 3 indexes unprocessed and processed wood, and building board woodpulp respectively.

$WELE_{1,2}$ are in cubic meters, $WELE_3 = WELE_3 \cdot PB$ in kilograms per unit time.

$PE_{iw}(t) = CE_{iw} + BE_{iw} \cdot P_w(t)$ is amount of wood w per elementary school building of type i.

CE_{iw} and BE_{iw} = regression parameters (see Chapter V).

PB = proportion of paperboard that is woodpulp (proportion).

2. Commercial Building Construction (see Figure 24).

This submodel computes the number of new houses and furniture built per unit time for commercial uses by traditional and semi-traditional population groups and the amounts of unprocessed wood and processed wood used (in cubic meters) per unit time and building board woodpulp used (in kilograms) per unit time in this construction.

The rate at which commercial buildings of type i are built is given by:

$$CM_i(t) = \frac{COM_i(0)}{RES_i(0)} \cdot RR_{i,KR+1}(t) \quad \text{(houses/year)}$$

where:

i = 1, or 2 indexes traditional and semi-traditional commercial buildings respectively.

$RR_{i,KR+1}(t)$ = the rate at which residential houses of type i are set up (houses/year).

$COM_i(0)$ = total number of commercial buildings of type i at base time (houses).

$RES_i(0)$ = total number of residential houses of type i at base time (houses).

Number of commercial buildings of type i per unit time (stock) is given by:

$$COM_i(t) = DT \cdot CM_i(t) \text{ (houses/unit time)}$$

Wood of type w used in commercial housing construction is given by:

$$WCOM_w(t) = \sum_{i=1}^{2} PC_{iw}(t) \cdot COM_{iw}(t)$$

where:

w = 1, 2, 3 indexes unprocessed wood, processed wood, and building board woodpulp.

$PC_{iw}(t) = CC_{iw} + BC_{iw} \cdot P_w(t)$ is average amount of wood w per commercial building of type i.

CC_{iw} and BC_{iw} = regression parameters (see Chapter V).

$P_w(t)$ = the ratio of the index of price of wood, w, to the index of prices of substitutes for wood.

PC_{i1} and PC_{i2} are in cubic meters.

$PC_{i3} = PC_{i3} \cdot PB$ is in kilograms.

PB = proportion of paper board that is woodpulp.

3. Religious Building Construction (see Figure 24).

The religious housing construction submodel computes the number of new houses and furniture set up per unit time for religious uses by traditional and semi-traditional population groups and the amounts of unprocessed wood and processed wood in cubic meters per unit time and building board woodpulp in kilograms per unit time used in those constructions.

The rate at which religious buildings of type i are set up is given by:

$$RL_i(t) = \frac{REL_i(0)}{RES_i(0)} \cdot RR_{i,KR+1}(t) \text{ (houses/year)}$$

where:

i = 1, or 2 indexes traditional, and semi-traditional respectively.

$REL_i(0)$ = total number of religious buildings of type i at base time (houses).

Number of religious houses of type i set up per unit time is given by:

$$REL_i(t) = DT \cdot RL_i(t) \text{ (houses/unit time)}$$

Wood of type w used in religious housing construction is given by:

$$WREL_w(t) = \sum_{i=1}^{2} PL_{iw}(t) \cdot REL_{iw}(t)$$

where:

w = 1,..., 3 indexes unprocessed wood, processed wood, and building board woodpulp.

$PL_{iw}(t) = CL_{iw} + BL_{iw} \cdot P_w(t)$ is the average amount of wood, w, per religious building of type i.

CL_{iw} and BL_{iw} = regression parameters (see Chapter V).

$P_w(t)$ = the ratio of the index of price of wood, w, to the index of prices of substitutes for wood.

PL_{i1} and PL_{i2} are in cubic meters.

$PL_{i3} = PL_{i3} \cdot PB$ is in kilograms.

PB = proportion of paper board that is woodpulp.

4. Public Administration Building Construction (See Figure 24).

This submodel computes the number of new houses and furniture built per unit time for public administration uses and the amounts of unprocessed wood and processed wood (in cubic meters per unit of time) and building board woodpulp (in kilograms per unit of time) used in those constructions.

The rate at which public administration buildings are set up is given by:

$$AD(t) = \frac{ADM(0)}{RES_2(0) + RES_3(0)} \cdot (RR_{2,KR+1} + RR_{3,KR+1}) \text{ (houses/year)}$$

where:

$RR_{3,KR+1}(t)$ = the rate at which non-traditional residential houses are set up (houses/year).

$RR_{2,KR+1}(t)$ = the rate at which semi-traditional residential houses are built (houses/year).

$ADM(0)$ = total number of public administration buildings at base time (buildings).

$RES_2(0)$ = total number of semi-traditional residential houses at base time (houses).

$RES_3(0)$ = total number of non-traditional residential houses at base time (houses)

Number of public administration buildings set up per unit of time (stock) is given by:

$$ADM(t) = DT \cdot AD(t) \text{ (houses/unit time)}$$

Wood of type w used in public administration housing construction is given by:

$$WADM_w(t) = PA_w(t) \cdot ADM(t)$$

where:

$w = 1, \ldots, 3$ indexes unprocessed wood, processed wood, and building board woodpulp.

$PA_w(t) = CA_w + BA_w \cdot P_w(t)$ is average amount of wood w per public administration building.

CA_w and BA_w = regression parameters (see Chapter V).

$P_w(t)$ = the ratio of the index of price of wood, w, to the index of prices of substitutes for wood.

PA_1 and PA_2 are in cubic meters.

$PA_3 = PA_3 \cdot PB$ is in kilograms.

PB = proportion of paper board that is woodpulp.

5. School (High School and College) Building Construction (see Figure 25).

This submodel computes the number of new houses and furniture set up per unit of time for school uses by high school and college levels and the amounts of unprocessed wood and processed wood in cubic meters per unit time and building board woodpulp in kilograms per unit of time used in this construction.

The rate at which high school or college buildings are set up is computed as the sum of the rate of replacements of existing ones and a proportional multiple of the increment in the number of students.

The rate of replacements is computed following DELLVF (11) to simulate the time delay involved in the decay process and losses due to accidental demolition of school buildings and furniture as follows:

STS_{ij} is the storage of school house of type i in j^{th} stage of delay:

$$STS_{ij}(t) = \frac{DELS_i}{KS} \cdot RS_{ij}(t) \text{ (houses)}$$

where:

i = 1, 2 indexes high school and college.

j = 1,..., KS indexes stage of delay.

$RS_{ij}(t)$ = rate out of j^{th} stage for school building of type i (houses/year).

$DELS_i$ = mean delay time for school building of type i (years).

KS = order of the delay for school building of type i.

The rate of change of STS_{ij} is the net flow into the j^{th} stage; Euler's integration formula is used to solve the differential equation:

$$\frac{dSTS_{ij}(t)}{dt} = RS_{i,j+1}(t) - RS_{ij}(t) - SAC_{ij}(t) \cdot STS_{ij}(t) \cdot$$

$$RS_{i,KS+1}(t) = SAD_i \cdot CHST_i(t) + SOUT_i(t) + SAC_i(t) \cdot STS_i(t)$$

the rate at which new school buildings of type i are built (houses/year)

where:

$SAC_i(t)$ = number of school buildings of type i destroyed prematurely during the entire delay as a proportion of all school buildings of type i (proportion/year).

$SOUT_i(t)$ = $RS_{i1}(t)$ is the output of the delay, the rate at which school buildings of type i decay (houses/year).

$CHST_i(t)$ = increment in student enrollment for school type i (students).

SAD_i = proportion of school building of type i per student (proportion).

$SAC_{ij}(t)$ = number of school buildings of type i destroyed prematurely during the j^{th} stage of delay as a proportion of school buildings of type i in the j^{th} stage (proportion/year).

Intermediate rates of RS_{ij} are initialized to:

$$RS_{ij}(0) = STS_i(0)/DELS$$

assuming steady state initial conditions.

Total number of school buildings of type i per unit time (stock) is given by:

$$SCH_i(t) = DT \cdot RS_{i,KS+1}(t) \text{ (houses/unit time)}$$

Wood of type w used in school housing construction is given by:

$$WHSCH_w(t) = \sum_{i=1}^{2} PS_{iw}(t) \cdot SCH_i(t)$$

where:

$w = 1, \ldots, 3$ indexes unprocessed wood, processed wood, and building board woodpulp.

$PS_{iw}(t) = CS_{iw} + BS_{iw} \cdot P_w(t)$ is average amount of wood, w, per school building of type i.

CS_{iw} and BS_{iw} = regression parameters (see Chapter V).

$P_w(t)$ = ratio of the index of price of wood to the index of prices of substitutes for wood.

PS_{i1} and PS_{i2} are in cubic meters.

$PS_{i3} = PS_{i3} \cdot PB$ is in kilograms.

PB = proportion of paperboard that is woodpulp.

6. Hospital Building Construction (see Figure 26).

This submodel computes the number of new houses and furniture set up per unit of time for medical uses and the amounts of unprocessed wood and processed wood in cubic meters per unit of time and building board woodpulp in kilograms per unit of time used in this construction.

The rate at which hospital buildings are set up is computed as the sum of the rate of replacement and a proportional multiple of increment in the number of hospital beds. The rate of replacement is computed following DELLVF (11) to simulate the time delay involved in the delay process and losses due to accidental demolition of hospital buildings.

STH_j is the number of hospital buildings in the j^{th} stage of delay:

$$STH_j(t) = \frac{DELH}{KH} \cdot RH_j(t) \text{ (houses)}$$

where:

$RH_j(t)$ = rate out of j^{th} stage (houses).

$j = 1, \ldots, KH$ indexes delay stage.

DELH = mean delay time for hospital buildings (years).

KH = order of delay for hospital buildings.

The rate of change of STH_j being the net flow into the j^{th} stage, Euler's integration formula is used to solve the differential equation:

$$\frac{dSTH_j(t)}{dt} = RH_{j+1}(t) - RH_j(t) - HAC_j(t) \cdot STH_j(t)$$

$RH_{KH+1} = HAD \cdot BED(t) + HOUT(t) + HAC(t) \cdot STH_j(t)$ is the rate at which hospital buildings are set up (houses/year).

where:

HAD = hospital building per hospital bed (proportion).

$BED(t) = AH + DH \cdot GDP(t) + VH \cdot HB(t)$ is increment in number of hospital beds (beds/year).

AH, DH, and VH = regression parameters (see Chapter V).

GDP(t) = gross domestic product divided by price index (₦/year).

HB(t) = government health budget divided by price index (₦/year).

$HOUT(t) = RH_1(t)$ is the output of the delay, worn out hospital buildings (houses/year).

HAC(t) = number of hospital buildings destroyed prematurely during the entire delay as a proportion of the total number of hospital buildings (proportion/year).

$HAC_j(t)$ = number of hospital buildings in the j^{th} stage of delay destroyed prematurely as a proportion of the total number of hospital buildings in the j^{th} stage (proportion/year).

The intermediate rates RH_j are initialized to $RH_j(0) = STH(0)/DELH$ assuming steady state initial conditions.

The number of hospital buildings per unit of time (stock) is given by:

$$HOSP(t) = DT \cdot RH_{KH+1}(t)$$

Wood of type w used in hospital building construction per unit of time is given by:

$$WHOS_w(t) = PH_w(t) \cdot HOSP(t)$$

where:

$w = 1, \ldots, 3$ indexes unprocessed wood, processed wood and building board woodpulp.

$PH_w(t) = CH_w + BH_w \cdot P_w(t)$ is average amount of wood, w, per hospital building.

CH_w and BH_w = regression parameters (see Chapter V).

$P_w(t)$ = ratio of the index of price of wood to the index of prices of substitutes for wood.

PH_1 and PH_2 are in cubic meters.

$PH_3 = PH_3 \cdot PB$ is in kilograms.

PB = proportion of paper board that is woodpulp.

Wood w used in non-residential housing construction per unit of time is given by:

$$WNRES_w(t) = WELE_w(t) + WCOM_w(t) + WREL_w(t) + WADM_w(t) + WHSCH_w(t) + WHOS_w(t)$$

$WNRES_w(t)$ as a proportion of all wood w used for all construction purposes is given by:

$$PWNR(t) = WNRES_w(t)/TWD_w(t)$$

<u>Farm Construction and Fuelwood Submodel</u> (see Figures 27-28)

1. Farm Construction (see Figure 27).

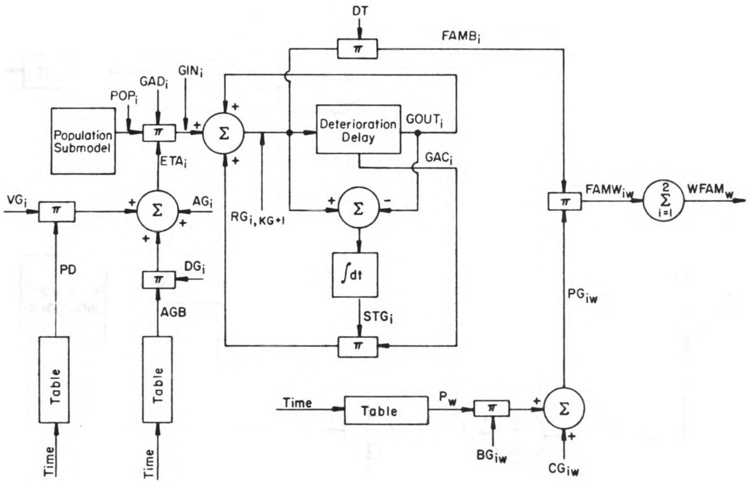

FIGURE 27: FLOW DIAGRAM OF FARM CONSTRUCTIONS SUBCOMPONENT.

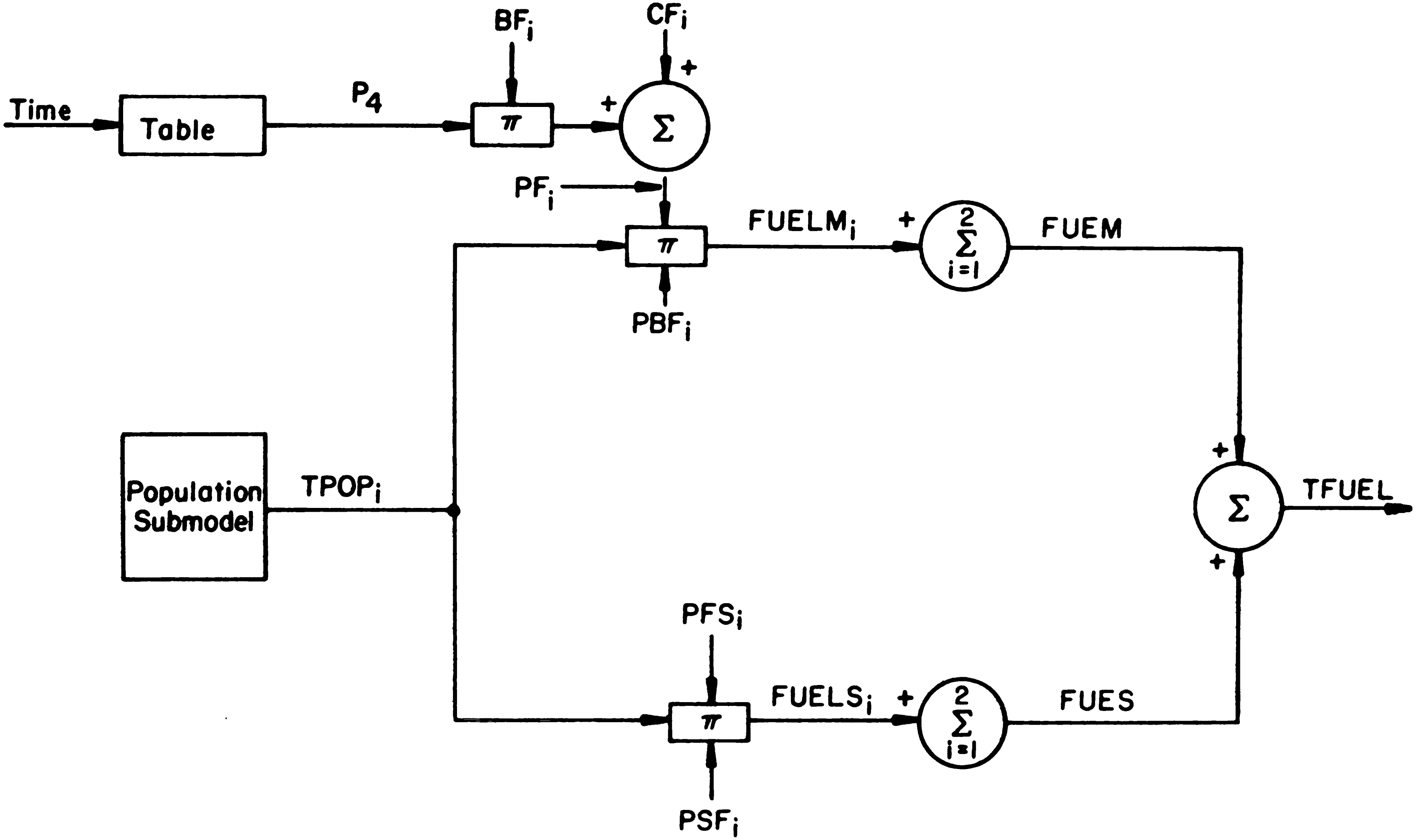

FIGURE 28: FLOW DIAGRAM OF FUELWOOD CONSUMPTION SUBCOMPONENT.

This submodel computes the number of new farms by traditional and non-traditional, the rate at which farm buildings are set up, and the amounts of unprocessed wood and processed wood in cubic meters per unit time used in the farm construction.

The number of new farms per unit time is given by:

$$FAM_i(t) = ETA_i(t) \cdot POP_i(t)$$

where:

$i = 1, \ldots, 2$ indexes traditional and non-traditional.

$POP_i(t)$ = the rate at which population group i grows (people/year).

$ETA_i(t) = AG_i + DG_i \cdot AGB(t) + VG_i \cdot PD(t)$ is the proportion of population group i that are farmers (proportion/year).

AG_i, DG_i, and VG_i = regression parameters (see Chapter V).

AGB(t) = state government's budgets for agriculture (₦/year).

PD(t) = population density by state.

The rate of construction of new farm buildings is computed as the sum of replacements of existing farm buildings and a proportional (buildings per farm) multiple of new farms. The rate of replacements is computed following DELLVF (11) to simulate the time delay involved in the decay process and losses due to accidental demolition of farm buildings.

STG_{ij} is the storage of farm buildings, i, in the j^{th} stage of the delay:

$$STG_{ij}(t) = \frac{DELG_i}{KG} \cdot RG_{ij}(t) \text{ (farm buildings)}$$

where:

$i = 1, 2$ indexes traditional and non-traditional farm buildings respectively.

$j = 1, \ldots, KG$ indexes stage of delay.

RG_{ij} = rate out of the j^{th} stage for farm buildings of type i (farm buildings/year).

$DELG_i$ = mean delay time for farm buildings of type i.

KG = the order of the delay for farm buildings of type i.

The rate of change of STG_{ij} is the flow into the j^{th} stage for farm buildings of type i; Euler's integration formula is used to solve the differential equation:

$$\frac{dSTG_{ij}(t)}{dt} = RG_{i,j+1}(t) - RG_{ij}(t) - GAC_{ij}(t) \cdot STG_{ij}(t)$$

$RG_{i,KG+1}(t) = GAD_i \cdot FAM_i(t) + GOUT_i(t) + GAC_i(t) \cdot STG(t)$ is the rate at which new farm buildings of type i are set up (farm buildings/year)

where:

GAD_i = average number of farm buildings of type i per farm (farm buildings/farm).

$GOUT_i(t) = RG_{i1}(t)$ is the output of the delay, number of decayed farm buildings of type i to be replaced (farm buildings/year).

$GAC_i(t)$ = number of farm buildings of type i destroyed prematurely during the entire delay as a proportion of total number of farm buildings (proportion/year).

$GAC_{ij}(t)$ = number of farm buildings of type i in the j^{th} stage of delay destroyed prematurely as a proportion of total number of farm buildings in the j^{th} stage (proportion/year).

The intermediate rates RG_{ij} are initialized to:

$RG_{ij}(0) = STG_i/DELG_i$ assuming steady state initial conditions.

Total number of new farm buildings of type i per unit time (stock) is given by:

$$FAMB_i(t) = DT \cdot RG_{i,KG+1}(t) \text{ (farm buildings/DT)}$$

Wood, w, used for farm constructions per unit time is given by:

$$WFAM_w(t) = \sum_{i=1}^{2} PG_{iw}(t) \cdot FAMB_i(t)$$

where:

$PG_{iw}(t) = CG_{iw} + BG_{iw} \cdot P_w(t)$ is average amount of wood, w, per farm of type i.

CG_{iw} and BG_{iw} = regression parameters (see Chapter V).

w = 1,..., 2 indexes unprocessed wood and processed wood.

$P_w(t)$ = ratio of the indexes of price of wood to the index of prices of substitutes for wood.

PG_{iw} is in cubic meters.

$WFAM_w(t)$ as a proportion of wood, w, used for all construction purposes is given by:

$$PWFAM_w(t) = WFAM_w(t)/TWD_w(t)$$

where:

w = 1,..., 2 indexes unprocessed wood and processed wood in cubic meters.

$TWD_w(t)$ = wood w used for all construction purposes.

2. Fuelwood Consumption (see Figure 28).

This submodel computes the amounts of fuelwood from market and nonmarket sources in cubic meters per unit time for the traditional and non-traditional population groups.

Fuelwood from market sources is given by:

$$FUEM(t) = \sum_{i=1}^{2} PF_i(t) \cdot PBF_i \cdot TPOP_i(t)$$

where:

$i = 1,\ldots, 2$ indexes traditional and semi-traditional.

$PF_i(t) = CF_i + BF_i \cdot P4(t)$ is average wood in cubic meters per adult in population group i who obtained his fuelwood from the market.

CF_i and BF_i = regression parameters (see Chapter V).

$P4$ = price per cubic meter of fuelwood.

$TPOP_i(t)$ = total adult population in group i.

PBF_i = the proportion of population group i that obtained fuelwood from market sources.

Fuelwood from nonmarket sources is given by:

$$FUES(t) = \sum_{i=1}^{2} PFS_i \cdot PSF_i \cdot TPOP_i(t)$$

where:

$i = 1,\ldots, 2$ indexes traditional and non-traditional.

PFS_i = fuelwood in cubic meters per adult in population group i who obtained their fuelwood from nonmarket sources.

PSF_i = proportion of population group i that obtained fuelwood from nonmarket sources.

Total fuelwood per unit time is given by the following identity:

$$TFUEL(t) = FUEM(t) + FUES(t)$$

Submodel of Other Manufacture and Construction Subsectors (see Figures 29-30)

Casket manufacture and lumber trucks, and bridge construction subsectors are grouped together as other manufacture and construction subsectors. It is assumed that none of these subsectors consumes unprocessed wood and building board woodpulp in significant amounts.

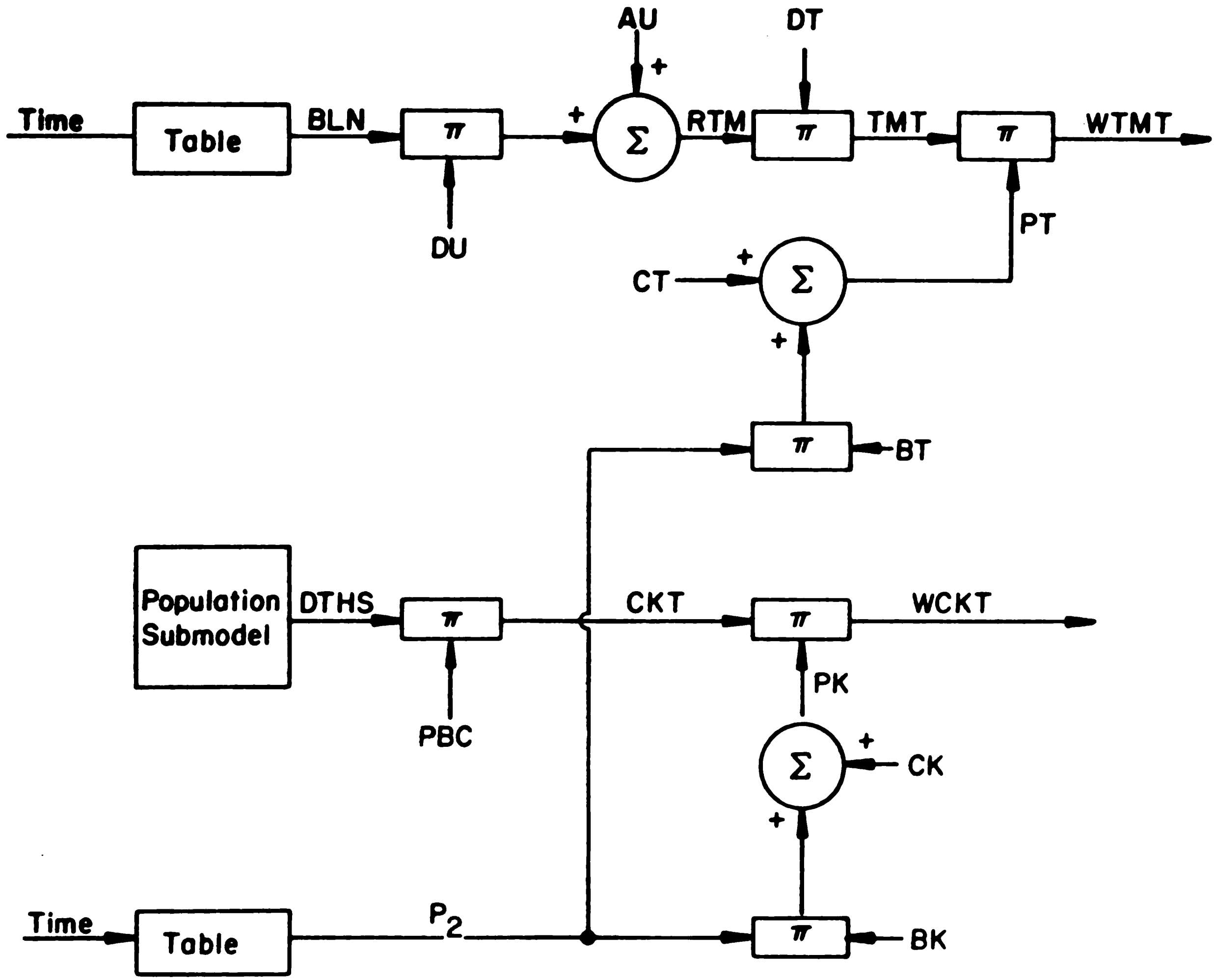

FIGURE 29: FLOW DIAGRAM OF CASKET MANUFACTURE AND LUMBER TRUCK CONSTRUCTION SUBCOMPONENTS.

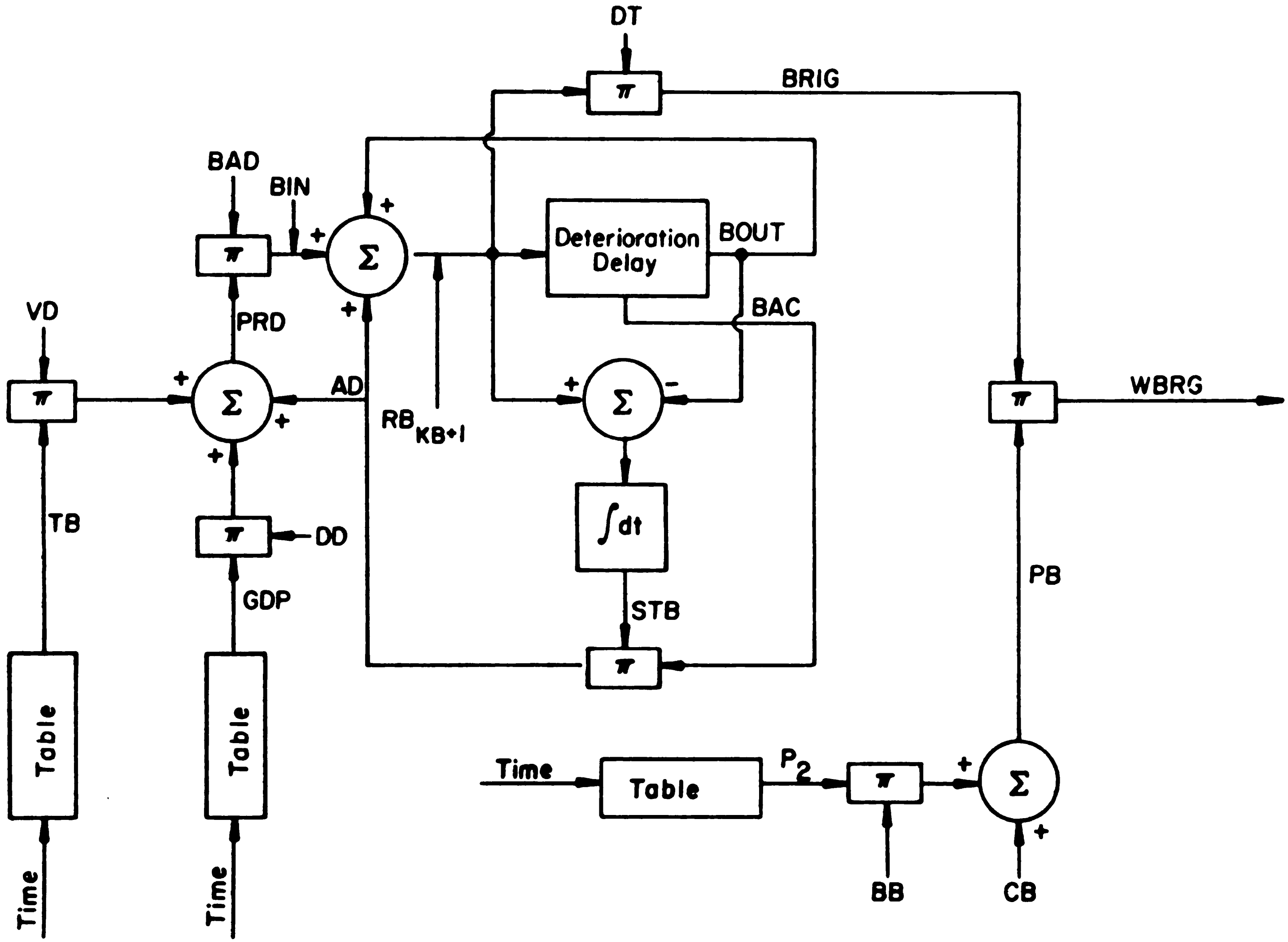

TABLE 30: FLOW DIAGRAM OF BRIDGE CONSTRUCTION SUBCOMPONENT.

1. Casket Manufacture (see Figure 29).

The rate at which caskets are built is given by:

$$CKT(t) = PBC \cdot DTHS(t) \text{ (caskets/year)}$$

where:

PBC = proportion of dead buried in caskets (proportion/year).

DTHS(t) = total number of deaths per unit time.

Processed wood used for casket construction per unit time is given by:

$$WCKT(t) = CKT(t) \cdot PK(t) \text{ (cubic meters/year)}$$

where:

$PK(t) = CK + BK \cdot P_2(t)$ is average amount of processed wood used per casket (cubic meters).

CK and BK = regression parameters (see Chapter V).

$P_2(t)$ = ratio of index of price of processed wood to the index of prices of substitutes for processed wood.

2. Lumber Trucks Construction (see Figure 29).

This submodel computes the number of lumber trucks per unit of time and the amount of processed wood in cubic meters used in the construction of the trucks.

The number of new lumber trucks per year is given by:

$$RTM(t) = AU + DU \cdot BLN(t)$$

where:

AU and DU = regression parameters (see Chapter V).

BLN(t) = commercial bank loan funding available for transportation industry (₦/year).

The number of new lumber trucks per unit of time is given by:

$$WTMT(t) = PT(t) \cdot TMT(t)$$

where:

$PT(t) = CT + BT \cdot P_2(t)$ is average amount of processed wood used for lumber truck (cubic meters).

CT and BT = regression paramters (see Chapter V).

$P_2(t)$ = ratio of index of price of processed wood to the index of prices of substitutes for processed wood.

3. Bridges Construction (see Figure 30).

This submodel computes the number of bridges built on dirt roads per unit time and the amount of processed wood in cubic meters used for the construction of the bridges.

The rate at which bridges are set up is computed as the sum of the rate of replacements and a proportional multiple of additional miles of dirt road each year. The rate of replacements is computed following DELLVF (11) to simulate the time delay involved in the decay process and losses due to accidental demolition as follows:

STB_j is the storage of bridges in the j^{th} stage of decay:

$$STB_j(t) = \frac{DELB}{KB} \cdot RB_j(t)$$

where:

$j = 1, \ldots, KB$ indexes delay stage.

$RB_j(t)$ = rate out of j^{th} stage for bridges (bridges/year).

DELB = mean delay time for bridges (years).

KB = order of the delay for bridges.

The rate of change of STB_j is the net flow into j^{th} stage; Euler's integration formula is used to solve the differential equation:

$$\frac{dSTB_j(t)}{dt} = RB_{j=1}(t) - RB_j(t) - RB_j(t) - BAC_j(t) \cdot STB_j(t)$$

$RB_{KB+1}(t) = BAD \cdot PRD(t) + POUT(t) + BAC(t) \cdot STB(t)$ is the rate at which new bridges are built (bridges/year).

where:

BAD = bridges per mile of road (proportion).

PRD(t) = AD + DD $\cdot$ GDP(t) + VD $\cdot$ TB(t) is additional miles of road (miles of road/year).

AD, DD, and VD = regression parameters (see Chapter V).

GDP(t) = gross domestic product divided by price index (₦/year).

TB(t) = government transportation budget divided by price index (₦/year).

BOUT(t) = $RB_1(t)$ is the output of the delay or worn-out bridges on old roads (bridges/year).

BAC(t) = number of bridges destroyed prematurely during the entire delay as a proportion of the total number of bridges (proportion/year).

$BAC_j(t)$ = number of bridges destroyed prematurely during the j^{th} stage of delay as a proportion of the total number of bridges in the j^{th} stage (proportion/year).

The intermediate rates RB_j are initialized to $RB_j(0) = STB(0)/DELB$ assuming steady state initial conditions.

Number of bridges per unit time (stock) is given by:

$$BRIG(t) = DT \cdot RB_{KB+1}$$

Processed wood used for bridge construction per unit time is given by:

$$WBRG(t) = PB(t) \cdot BRIG(t) \text{ (cubic meters/unit time)}$$

$PB(t) = CB + BB \cdot P_2(t)$ is average amount of processed wood per bridge (cubic meters).

where:

CB and BB = regression parameters (see Chapter V).

$P_2(t)$ = ratio of index of price of processed wood to the index of substitutes for processed wood.

Paper Submodel (see Figure 31).

The paper component computes the amount of paper used by elementary school population, high school population, college population, traditional adult population, semi-traditional adult population and non-traditional population.

Total wood (pulp) used for paper per unit time (stock) is given by:

$$WPAP = \sum_{S=1}^{3} TPAPS_s + \sum_{i=1}^{3} TPAP_i$$

$$TPAP_i(t) = PAP_i(0) \cdot (1 + PB \cdot CP_i(PCI_i(t) - PCI_i(0))) \cdot TPOP_i$$

is per capita consumption of paper by population group i (kg./year)

where:

i = 1, 2, 3 indexes traditional, semi-traditional, and non-traditional population groups respectively.

$PAP_i(0)$ = per capita consumption of paper by population group i at base time (kg./year).

$PCI_i(t)$ = per capita income for population group i (₦/year).

$PCI_i(0)$ = per capita income for population group i at base time (₦/year).

$TPOP_i$ = total adult population in group i (people).

PB = proportion of paper that is woodpulp.

CP_i = proportional increase in per capita consumption of paper per unit increase in per capita income for the income group i.

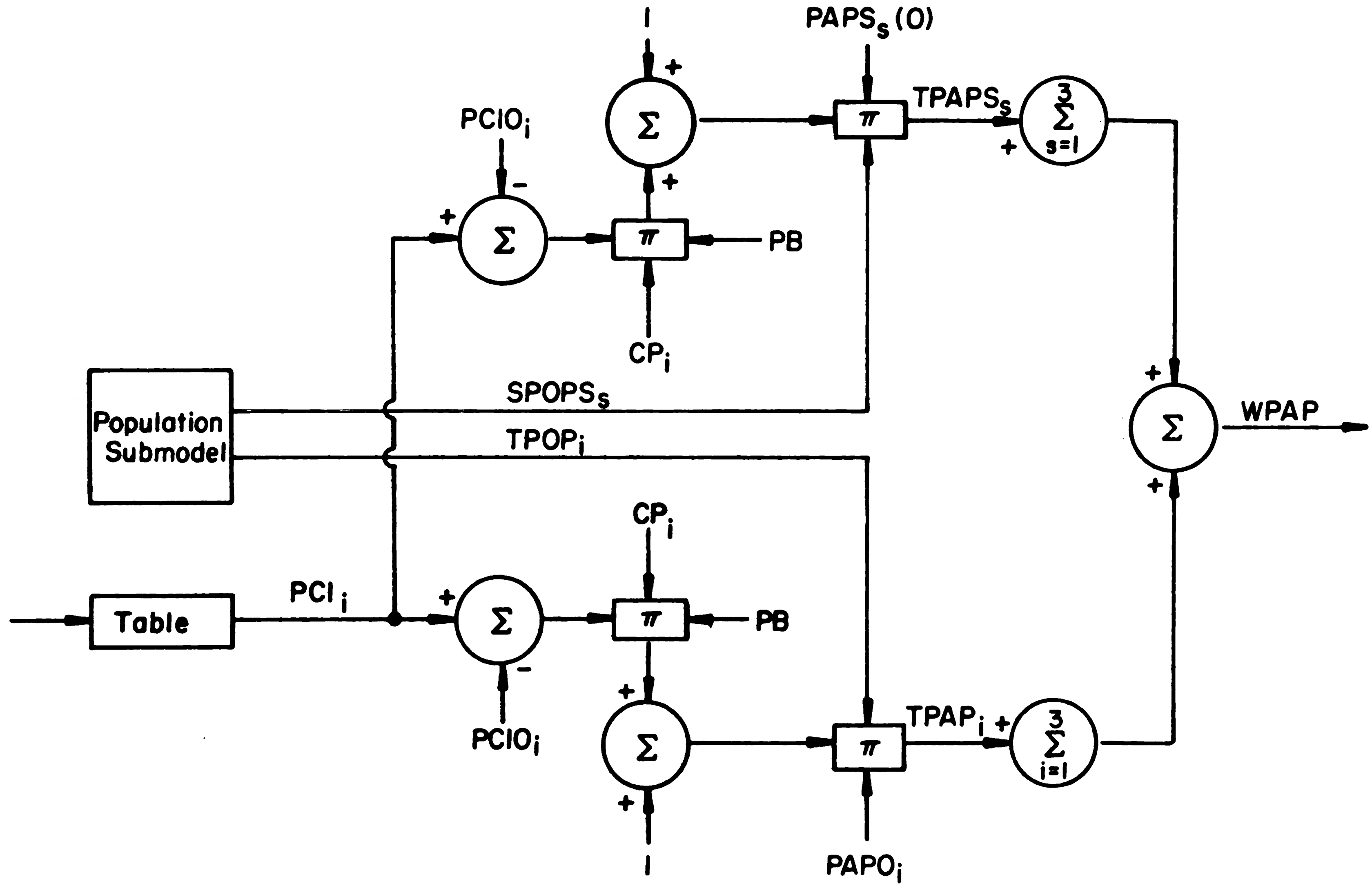

FIGURE 31: FLOW DIAGRAM OF PAPER CONSUMPTION SUBCOMPONENT.

$PCI_1(t) = PCI_1(0)$ by assumption. If the per capita income of an individual classified in the low income group increases enough to make significant difference in his paper consumption habit he is reclassified in the medium income group. Because of lack of adequate information we also assume that changes in per capita consumption of paper for high school and college students will be proportional to changes in medium and high per capita incomes respectively.

$$TPAPS_s = PAPS_s(0) \cdot (1 + PB \cdot CP_i \cdot (PCI_i(t) - PCI_i(0))) \cdot SPOP_s$$

is per capita consumption of paper by student population

where:

$s = 1, \ldots, 3$ indexes elementary, high school and college population groups.

$i = 1, \ldots, 3$ indexes low, medium and high income groups.

$PAPS_s(0)$ = per capita consumption of paper by student population group s at base time (kg./year).

PB = proportion of paper that is woodpulp.

CP_i = proportional increase in per capita consumption of paper per unit increase in per capita income for the income group i (proportion/year).

$PCI_i(t)$ = per capita income for income group i at time t (₦/year).

$PCI_i(0)$ = per capita income for income group i at base time (₦/year).

$SPOP_s$ = total student population in group s.

Total paper pulp consumption by student population is given by:

$$TPAP = \sum_{s=1}^{3} TPAPS_s \text{ (kg./year)}$$

Summary

The total amount of wood, w, used for construction purposes in the various subsectors per unit time is given by the following identity:

$$TWD_w(t) = WRES_w(t) + WNRES_w(t) + WCKT_w(t) + WTMT_w(t) + WBRG_w(t) + WFAM_w(t) \text{ in cubic meters/unit time}$$

where:

$WRES_w(t)$ = wood, w, used for residential housing construction per unit time (cubic meters/unit time).

$WNRES_w(t)$ = wood, w, used for non-residential housing construction per unit time (cubic meters/unit time).

$WCKT_2(t)$ = processed wood used for casket manufacture per unit time in cubic meters.

$WTMT_2(t)$ = processed wood used for lumber truck construction per unit time in cubic meters.

$WBRG_2(t)$ = processed wood used for bridge construction per unit time in cubic meters.

$WFAM_w(t)$ = wood, w, used for farm construction per unit time in cubic meters.

Residential and elementary school housing construction subsectors are classified into traditional, semi-traditional, and non-traditional and commercial and religious building construction and farm construction are classified into traditional and semi-traditional categories. Other construction subsectors such as hospital, high school, and college housing construction; casket manufacture, lumber truck, and bridge construction subsectors are not specific with respect to wood consumption groups and are treated as nonspecific sectors. Wood, w, used for construction purposes by the wood consumption group i is given by:

$$TWDS_{iw}(t) = PR_{iw}(t) \cdot RES_w(t) + PE_{iw}(t) \cdot ELE_i(t) + PC_{iw}(t) \cdot COM_i(t) + PL_{iw}(t) \cdot REL_i(t) + PG_{iw}(t) \cdot FAMB_i(t)$$

where:

$i = 1, \ldots, 3$ indexes traditional, semi-traditional, and non-traditional.

$PR_{iw}(t)$ = average amount of wood, w, per residential building of group i (M^3).

$RES_i(t)$ = number of new residential buildings of group i per unit time.

$PE_{iw}(t)$ = average amount of wood, w, per elementary school building of group i (M^3).

$ELE_i(t)$ = number of new elementary school buildings of group i per unit time.

$PC_{iw}(t)$ = average amount of wood, w, per commercial building of group i (M^3).

$COM_i(t)$ = number of new commercial buildings of group i per unit time.

$PL_{iw}(t)$ = average amount of wood, w, per religious building of group i (M^3).

$REL_i(t)$ = number of new religious buildings of group i per unit time.

$PG_{iw}(t)$ = average amount of wood, w, per farm building of group i (M^3).

$FAMB_i(t)$ = number of new farm buildings of group i per unit time.

Wood, w, used in wood consumption group i as a proportion of total wood, w, used by all groups is given by:

$$PTWDS_{iw}(t) = TWDS_{iw}(t)/TWD_w(t) \quad \text{(proportion per unit time)}$$

Wood, w, used for construction purposes in the nonspecific subsectors is given by the following identity:

$$TWDNS_w(t) = WHOS_w(t) + WBRG_2(t) + WTMT_2(t) + WCKT_2(t) + WADM_w(t) + WHSCH_w(t)$$

where:

$WHOS_w(t)$ = wood, w, in cubic meters used in hospital housing construction per unit time.

$WBRG_2(t)$ = processed wood in cubic meters used in bridge construction per unit time.

$WTMT_2(t)$ = processed wood in cubic meters used in lumber truck construction per unit time.

$WCKT_2(t)$ = processed wood in cubic meters used in casket construction per unit time.

$WADM_w(t)$ = wood, w, used in public administration building construction per unit time in cubic meters.

$WHSCH_w(t)$ = wood, w, used in high school and college building construction per unit time in cubic meters.

For w = 3 in all subsectors the unit of measurement is kilograms. The total amounts of fuelwood and paper consumptions by wood consumption groups are calculated in their respective submodels.

APPENDIX B

COMPUTER MODEL OF THE WOOD CONSUMPTION COMPONENT OF NIGERIAN FORESTRY SECTOR

APPENDIX B

COMPUTER MODEL OF THE WOOD CONSUMPTION COMPONENT OF NIGERIAN FORESTRY SECTOR

```
      PROGRAM MAIN(INPUT,OUTPUT,TAPE2=OUTPUT,TAPE1=INPUT,
     +L11=65,L21=65,L31=65,L41=65,L51=65,L61=65,L71=65,L81=65,
     +L91=65,L12=65,L22=65,L32=65,L42=65,L52=65,L62=65,L72=65)
      REAL JOB
      COMMON /BLOCK/  DUR,DT,DETPRT,SELPRT,BEGPRT,PRTCHG,PRTVL1,PRTVL2
C
C         CONTINUE THE BLOCK HERE
C
      COMMON/BLOCK1/IYEAR,T,NDT,II,RES,RESH,WRES
      COMMON/BLOCK2/A3,E3,S3,T3,AGP,GDP,TVPOP,EVPOP,
     +ELPUF,AG3,P4,PCI2,PCI3,BLN,PO,POF,PSI,HB
      COMMON/BLOCK3/TPOP,THST,TCST,CST,HST,CHSTD,
     +CCST,JOB,SNI,TNI,DTHS,SMG,POP
      COMMON/BLOCK4/HSCH,HSCHW,WHSCH,ELE,ELEW,WELE
      COMMON/BLOCK5/COM,COMW,WCOM,REL,RELW,WREL,ADM,ADMW,WADM
      COMMON/BLOCK6/HOSP,BRIG,CKT,TMT,BED,PRD,RTM,WBRG,WTMT,WCKT,WHOS
      COMMON/BLOCK7/TFUEL,FUES,FUEM,FUEL,FUELS,FUELM,FAMB,ETA,FAMW,WFAM
      COMMON/BLOCK8/WPAP,PAP,TPAES,             TWOS,TWD,TWONS
      COMMON/BLOCK9/PWRES,PWELE,PWHSCH,PWADM,PWHOS,PWCOM,PWREL,PWBRG,
     +PWTMT,PWCKT,PWFAM,PWSCH,PFUES,PFUEM,PFUEL1,PFUEL2,PTWOS,PTWONS
      COMMON/BLOCK10/WSCH,PWFAD,FWRPAD(3,3),FULF
      COMMON/BLOCK11/WNRES(3),PWNR(3),PFAP(3),FTFAP     ,TWRPAD(3)
C
C         INSERT THE NUMBER OF VARIABLES IN THE BLOCK IN THE  DIMENSION
C         STATEMENT
C
      DIMENSION TPOP(3),POP(3),HST(5),CST(6)
      DIMENSION RES(3),RESW(3,3),WRES(3)
      DIMENSION HSCH(3),HSCHW(3,3),WHSCH(3),ELE(3),ELEW(3,3),WELE(3)
      DIMENSION COM(3),COMW(3,3),WCOM(3),REL(3),
     +RELW(3,3),WREL(3),ADM(3),ADMW(3,3),WADM(3)
      DIMENSION WBRG(3),WTMT(3),WCKT(3),WHOS(3)
      DIMENSION FUEL(2),FUELS(2),FUELM(2),FAMB(2),ETA(2),FAMW(3,3),
     +WFAM(3)
      DIMENSION PAP(3),TWOS(3,3),TWD(3),TWONS(3)
      DIMENSION PWRES(3),PWELE(3),PWHSCH(3),PWADM(3),PWHOS(3),
     +PWCOM(3),PWREL(3),PWBRG(3),PWTMT(3),PWCKT(3),PWFAM(3),PWSCH(3),
     +PTWOS(3,3),PTWONS(3)
      DIMENSION RWPAD(3,3),WSCH(3)
      DIMENSION NAMVAR(8)
      DATA NAMVAR/3HDUR,2HDT,6HDETPRT,6HSELPRT,6HBEGPRT,6HPRTCHG,
     +6HPRTVL1,6HPRTVL2/
C
C         CONTINUE THE DATA STATEMENT HERE
C
      DATA L11/3LL11/
      DATA L21/3LL21/
      DATA L31/3LL31/
      DATA L41/3LL41/
      DATA L51/3LL51/
      DATA L61/3LL61/
      DATA L71/3LL71/
      DATA L81/3LL81/
      DATA L91/3LL91/
      DATA L12/3LL12/
      DATA L22/3LL22/
      DATA L32/3LL32/
      DATA L42/3LL42/
      DATA L52/3LL52/
      DATA L62/3LL62/
      DATA L72/3LL72/
C
C         PLACE THE NUMBER OF VARIABLES IN THE BLOCK IN THE DATA STATEMENT
C
      DATA NVAR/8/
C
C         READ RUN PARAMETERS
C
      READ900,NRUN
C
C         BEGIN RUN LOOP
C
      DO 500 IRUN=1,NRUN
C
C         INITIAL CONDITIONS
C
C         PARAMETERS
C
```

```
C           RUN PARAMETERS
C
      DUR=29
      DT = .25
      DETPRT = 1.
      SELPRT = 0.
      BEGPRT = 1.
      PRTCHG = 100.
      PRTVL1 = 1.
      PRTVL2 = 5.
   30 CONTINUE
      WRITE(L11,111)
      WRITE(L21,211)
      WRITE(L31,311)
      WRITE(L41,411)
      WRITE(L51,511)
      WRITE(L61,611)
      WRITE(L71,711)
      WRITE(L81,811)
      WRITE(L91,911)
      WRITE(L12,121)
      WRITE(L22,221)
      WRITE(L32,321)
      WRITE(L42,421)
      WRITE(L52,521)
      WRITE(L62,621)
      WRITE(L72,721)
C     WRITE(2,901)IRUN
      IF (DETPRT .EQ. 0.) SELPRT=1.
      NITER=DUR
      T = 0.
      PRTIME = BEGPRT
      PRTVL = PRTVL1
      NOT=(1./DT)+.5
C
C           BEGIN TIME LOOP
C
      DO 500 ITER=1,NITER
      IYEAR=1962+T
      IF(IYEAR.GE.1974) GO TO 10
      READ 70 ,BLN,EB,SB,
     +AG,HB,TB,PCI2,PCI3,AGB,PDF,PD,TVPOP,ELPOP,EVPOP,GDP,AGP,P4,PSI
   10 CONTINUE
      DO 400 II=1,NOT
      T = T+DT
C
C           CALL MODEL
      IF(IYEAR.LT.1974) GO TO 11
      CALL FUN
   11 CONTINUE
      CALL POPP
      CALL RESID
      CALL NRESD
      CALL CAVIB
      CALL FAFU
      CALL PEPA
C
      IF(T.LT.PRTIME) GO TO 200
C
C           PRINT RESULTS
C
      IF(T.EQ.PRTCHG) PRTVL = PRTVL2
      PRTIME = T + PRTVL
C     PRINT920,T
C
C           PRINT STATEMENTS FOR SELECTED OUTPUT
C
C
C           SELECTED OUTPUT
C
  100 IF(DETPRT.EQ.0.) GO TO 200
C
C           DETAILED OUTPUT
C
C     IF(SELPRT.EQ.0.)GO TO 100
C     PRINT920,T
C
C           PRINT STATEMENTS FOR DETAILED OUTPUT
```

```
C
      IF(IYEAR.LE.1974) GO TO 13
      PRINT 700,IYEAR,WPAP
  700 FORMAT(*0*,20X,I4,5X,F25.0)
      WRITE(L11,112)IYEAR,AGB,EB,TB,GDP
      WRITE(L21,212)IYEAR,THST,TCST,POP
      WRITE(L31,312)IYEAR,AGP,JOB,PCI2,PCI3,RMG
      WRITE(L41,412)IYEAR,TFUEL,TWD,WPAP
      WRITE(L51,512)IYEAR,WRES(1),PWRES(1),
     +WRES(2),PWRES(2),WRES(3),PWRES(3)
      WRITE(L61,612)IYEAR,WNRES(1),PWNR(1),
     +WNRES(2),PWNR(2),WNRES(3),PWNR(3)
      WRITE(L71,712)IYEAR,WCKT(2),PWCKT(2),
     +WTMI(2),PWTMI(2),WBRG(2),PWBRG(2)
      WRITE(L81,812)IYEAR,WFAM(1),PWFAM(1),WFAM(2),PWFAM(2)
      WRITE(L91,912)IYEAR,FUEM,PFUEM,FUES,PFUES
      WRITE(L12,122)IYEAR,TWOS(1,1),PTWOS(1,1),
     +TWOS(2,1),PTWOS(2,1),TWOS(3,1),PTWOS(3,1),
     +TWONS(1),PTWONS(1)
      WRITE(L22,222)IYEAR,TWOS(1,2),PTWOS(1,2),
     +TWOS(2,2),PTWOS(2,2),TWOS(3,2),PTWOS(3,2),
     +TWONS(2),PTWONS(2)
      WRITE(L32,322)IYEAR,TWOS(1,3),PTWOS(1,3),
     +TWOS(2,3),PTWOS(2,3),TWOS(3,3),PTWOS(3,3),
     +TWONS(3),PTWONS(3)
      WRITE(L42,422)IYEAR,FUEL(1),PFUEL1  ,FUEL(2),PFUEL2
      WRITE(L52,522)IYEAR,PAP(1),PPAP(1),
     +PAP(2),PPAP(2),PAP(3),PPAP(3),TPAPS,PTPAP
      WRITE(L62,622)IYEAR,RES,ELF,HSCH(2),HSCH(3)
      WRITE(L72,722)IYEAR,COM(1),COM(2),REL(1),REL(2),
     +ADM(2),HOSP,BRIG,TMT
   13 CONTINUE
C
  200 CONTINUE
  400 CONTINUE
  500 CONTINUE
      STOP
C
C          FORMAT STATEMENTS
C
C
   70 FORMAT(2X,9E6.3/2X,5E6.3,2E7.3,F4.1,F5.2)
  111 FORMAT(*1*,59X,*APPENDIX VI-1*///
     +51X,*BASE RUN PROJECTIONS OF GDP AND*/
     +51X,*GOVERNMENT EXPENDITURES 1965-90*/
     +62X,*(N/YEAR)*//                                                   1114
     +33X,*YEAR*,9X,*AGRICULTURE*,4X,*EDUCATION*,4X,*TRANSPORT-*,
     +6X ,*GDP*,/50X,*BUDGET*,8X,*BUDGET*,6X,*ION BUDGET*)
  112 FORMAT(*0*,33X,I4,10X,F10., 4X,F11., 2X,F11., 3X,F12.)            112
  211 FORMAT(*1*,59X,*APPENDIX VI-2*///
     +43X,*BASE RUN PROJECTIONS OF SOME POPULATION ESTIMATES*//
     +29X,*HIGHSCHOOL*,9X,*COLLEGE*,12X,*TRADITIONAL*,
     +8X ,*SEMI-TRADITIONAL*,3X,*NON-TRADITIONAL*/
     +10X,*YEAR*,15X,*STUDENTS*,10X,*STUDENTS*,                          211
     +11X,*POPULATION*,9X *POPULATION*,9X,*POPULATION*/
     +29X,*(TOTAL/YEAR)*,7X,*(TOTAL/YEAR)*,
     +7X ,*(RATE/YEAR)*,8X,*(RATE/YEAR)*,8X,*RATE/YEAR)*)
  212 FORMAT(*0*,10X,I4,15X,F8.0,11X,F7.0,3(12X,F7.0))
  311 FORMAT(*1*,59X,*APPENDIX VI-3*///
     +56X,*BASE RUN PROJECTIONS*/
     +52X,*OF OTHER MODEL INPUTS 1965-90*//
     +10X,*YEAR*,15X,*AGRICULTURE*,8X,*COLLEGE LEVEL*,
     +6X, *PER CAPITA INCOME*,2X,*PER CAPITA INCOME*,2X,*RURAL-URBAN*/
     +29X,*CONTRIBUTION TO*,4X,*JOB OPENNINGS*,6X,*MEDIUM BRACKET*,
     +5X, *HIGH BRACKET*,7X,*MIGRATION*/
     +29X,*GDP (NMIL/YEAR)*,4X,*PER YEAR*,11X,*(N/YEAR)*,
     +11X,*(N/YEAR)*,11X,*(PROP/YEAR)*)
  312 FORMAT(*0*,10X,I4,14X,F11.,12X,F6.0,13X,F5.0,14X,F6.0,13X,F5.4)   312
  411 FORMAT(*1*,59X,*APPENDIX VI-4*///
     +52X,*BASE RUN PROJECTIONS OF OVERALL*/
     +51X,*ANNUAL CONSUMPTION OF WOOD 1965-90*//
     +10X,*YEAR*,15X,*FUELWOOD*,11X,*UNPROCESSED*,
     +8X ,*PROCESSED*,10X,*PULPWOOD*,11X,*PAPER PULP*/
     +29X,*(M3)*,15X,*WOOD(M3)*,11X,*WOOD(M3)*,11X,*(KG)*,15X,*(KG)*)   411
  412 FORMAT(*0*,10X,I4,15X,F9.0,10X,F8.0,11X,F8.0,11X,F7.0,12X,F11.0)
  511 FORMAT(*1*,59X,*APPENDIX VI-5*///
     +42X,*BASE RUN PROJECTIONS OF ANNUAL WOOD CONSUMPTION IN*/
     +41X,*RESIDENTIAL HOUSING CONSTRUCTION IN ABSOLUTE AMOUNTS*/
     +42X,*AND AS PROPORTIONS OF OVERALL CONSUMPTION 1965-90*//
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     +32X,*UNPROCESSED WOOD*,19X,*PROCESSED WOOD*,
     +14X,*BUILDING BOARD WOOD PULP*//                                    5116
     +11X,*YEAR*,9X,*ABSOLUTE AMOUNT*,2X,*RELATIVE PROP.*,                5117
     +3X, *ABSOLUTE AMOUNT*,2X,*RELATIVE PROP.*,
     +3X, *ABSOLUTE AMOUNT*,2X,*RELATIVE PROP.*/
     +23X,*(M3/YEAR)*,8X,*(PROP./YEAR)*,
     +5X ,*(M3/YEAR)*,8X,*(PROP./YEAR)*,
     +5X ,*(KG/YEAR)*,8X,*(PROP./YEAR)*)
 512 FORMAT(*0*,10X,I4,8X,F8.0, 9X,F5.4,2(12X,F7.0,10X,F5.4))             512
 611 FORMAT(*1*,59X,*APPENDIX VI-6*///
     +42X,*BASE RUN PROJECTIONS OF ANNUAL WOOD CONSUMPTION IN*/
     +39X,*NON-RESIDENTIAL BUILDING CONSTRUCTION IN ABSOLUTE AMOUNTS*/
     +42X,*AND AS PROPORTIONS OF OVERALL CONSUMPTION 1965-90*//
     +32X,*UNPROCESSED WOOD*,19X,*PROCESSED WOOD*,
     +14X,*BUILDING BOAD WOOD PULP*//                                     6116
     +11X,*YEAR*,9X,*ABSOLUTE AMOUNT*,2X,*RELATIVE PROP.*,
     +3X ,*ABSOLUTE AMOUNT*,2X,*RELATIVE PROP.*,
     +3X ,*ABSOLUTE AMOUNT*,2X,*RELATIVE PROP.*/
     +23X,*(M3/YEAR)*,8X,*(PROP./YEAR)*,
     +5X ,*(M3/YEAR)*,8X,*(PROP./YEAR)*,
     +5X ,*(KG/YEAR)*,8X,*(PROP./YEAR)*)
 612 FORMAT(*0*,10X,I4,6X,F8.0,11X,F5.4,2(12X,F7.0,10X,F5.4))             612
 711 FORMAT(*1*,59X,*APPENDIX V1-7*///                                    7111
     +35X,*BASE RUN PROJECTIONS OF ANNUAL CONSUMPTION OF PROCESSED WOOD
     +FOR*/35X,*CASKET MANUFACTURE AND TRUCK AND BRIDGE CONSTRUCTIONS,IN
     +*/36X,*ABSOLUTE AMOUNTS AND AS PROPORTIONS OF OVERALL CONSUMPTION
     +1965-90*//31X,*CASKET MANUFACTURE*,15X,*TRUCK CONSTRUCTION*,
     +16X,*BRIDGE CONSTRUCTION*/10X,*YEAR*,
     +9X ,*ABSOLUTE AMOUNT*,2X,*RELATIVE PROP.*,
     +3X ,*ABSOLUTE AMOUNT*,2X,*RELATIVE PROP.*,
     +3X ,*ABSOLUTE AMOUNT*,2X,*RELATIVE PROP.*/
     +23X,*(M3/YEAR)*,8X,*(PROP./YEAR)*,
     +5X ,*(M3/YEAR)*,8X,*(PROP./YEAR)*,
     +5X ,*(M3/YEAR)*,8X,*(PROP./YEAR)*)
 712 FORMAT(*0*,10X,I4,9X,F6.0,11X,F5.4,12X,F6.0,
     +11X,F5.4,12X,F5.0,12X,F5.4)
 811 FORMAT(*1*,59X,*APPENDIX V1-9*///                                    8011
     +45X,*BASE RUN PROJECTIONS OF ANNUAL CONSUMPTION OF*/                8012
     +43X,*WOOD FOR FARM CONSTRUCTIONS IN ABSOLUTE AMOUNTS AND*/          8013
     +44X,*AS PROPORTIONS OF OVERALL CONSUMPTION,1965-90*//10X,*YEAR*,    8014
     +26X,*UNPROCESSED WOOD*,37X,*PROCESSED WOOD*/                        8015
     +22X,*ABSOLUTE AMOUNT (M3/YEAR  RELATIVE PROP.(PROP./YR*             8016
     +2X ,*ABSOLUTE AMOUNT (M3/YEAR  RELATIVE PROP.(PROP./YR*)            8017
 812 FORMAT(*0*,10X,I4,8X,F10.0,19X,F5.4,20X,F6.0,21X,F5.4)
 911 FORMAT(*1*,59X,*APPENDIX V1-10*///                                   9011
     +41X,*BASE RUN PROJECTIONS OF ANNUAL CONSUMPTION OF FUELWOOD*/       9012
     +42X,*BY MARKET AND NON-MARKET SOURCES IN ABSOLUTE AMOUNTS*/         9013
     +43X,*AND AS PROPORTIONS OF OVERALL CONSUMPTION 1965-90*//           9014
     +10X,*YEAR*,20X,*FUELWOOD FROM MARKET SOURCES*,                      9015
     +22X,*FUELWOOD FROM NON-MARKET SOURCES*/                             9016
     +22X,*ABSOLUTE AMOUNT (M3/YR)*,4X,*RELATIVE PROP.(PROP./YR)*,        9017
     +1X ,*ABSOLUTE AMOUNT (M3/YR)*,3X,*RELATIVE PROP.(PROP./YR)*)        9018
 912 FORMAT(*0*,10X,I4,8X,F9.0,18X,F5.4,20X,F9.0,17X,F5.4)
 121 FORMAT(*1*,59X,*APPENDIX V1-11*///                                   1211
     +39X,*BASE RUN PROJECTIONS OF ANNUAL CONSUMPTION OF UNPROCESSED*/    1212
     +41X,*WOOD BY WOOD CONSUMPTION GROUPS IN ABSOLUTE AMOUNTS*/          1213
     +42X,*AND AS PROPORTIONS OF OVERALL CONSUMPTION,1965-90*//           1214
     +6X,*YEAR*,14X,*TRADITIONAL*,15X,*SEMI-TRADITIONAL*,                 1215
     +12X,*NON-TRADITIONAL*,13X,*NON-SPECIFIC*/                           1216
     +16X,*ABSOLUTE*,6X,*RELATIVE*,6X,*ABSOLUTE*,6X,*RELATIVE*,           1217
     +6X ,*ABSOLUTE*,6X,*RELATIVE*,6X,*ABSOLUTE*,6X,*RELATIVE*/           1218
     +16X,*AMT(M3/YR)*,4X,*PROP./YR*,6X,*AMT(M3/YR)*,4X,*PROP./YR*,       1219
     +6X ,*AMT(M3/YR)*,4X,*PROP./YR*,6X,*AMT(M3/YR)*,4X,*PROP./YR*)       12110
 122 FORMAT(*0*,6X,I4,6X,F8.0,6X,F5.4,9X,F7.0,7X,F5.4,                    1221
     +9X,F7.0,7X,F5.4,9X,F6.0,8X,F5.4)                                    1222
 221 FORMAT(*1*,59X,*APPENDIX V1-12*///                                   2211
     +39X,*BASE RUN PROJECTIONS OF ANNUAL CONSUMPTION OF PROCESSED*/      2212
     +41X,*WOOD BY WOOD CONSUMPTION GROUPS IN ABSOLUTE AMOUNTS*/          2213
     +42X,*AND AS PROPORTIONS OF OVERALL CONSUMPTION,1965-90*//           2214
     +6X ,*YEAR*,14X,*TRADITIONAL*,15X,*SEMI-TRADITIONAL*,                2215
     +12X,*NON-TRADITIONAL*,13X,*NON-SPECIFIC*/                           2216
     +16X,*ABSOLUTE*,6X,*RELATIVE*,6X,*ABSOLUTE*,6X,*RELATIVE*,           2217
     +6X ,*ABSOLUTE*,6X,*RELATIVE*,6X,*ABSOLUTE*,6X,*RELATIVE*/           2218
     +16X,*AMT(M3/YR)*,4X,*PROP./YR*,6X,*AMT(M3/YR)*,4X,*PROP./YR*,       2219
     +6X ,*AMT(M3/YR)*,4X,*PROP./YR*,6X,*AMT(M3/YR)*,4X,*PROP./YR*)       22110
 222 FORMAT(*0*,6X,I4,6X,F7.0,7X,F5.4,9X,F7.0,7X,F5.4,                    2221
     +9X,F7.0,7X,F5.4,9X,F7.0,8X,F5.4)                                    2222
 321 FORMAT(*1*,59X,*APPENDIX V1-13*///                                   3211
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     +35X,*BASE RUN PROJECTIONS OF ANNUAL PROJECTIONS OF BUILDING BOARD
     +WOOD*/41X,*PULP BY WOOD CONSUMPTION GROUPS IN ABSOLUTE AMOUNTS*/
     +42X,*AND AS PROPORTIONS OF OVERALL CONSUMPTION,1965-90*//          321
     +6X ,*YEAR*,14X,*TRADITIONAL*,15X,*SEMI-TRADITIONAL*,
     +12X,*NON-TRADITIONAL*,13X,*NON-SPECIFIC*/
     +16X,*ABSOLUTE*,6X,*RELATIVE*,6X,*ABSOLUTE*,6X,*RELATIVE*,
     +6X ,*ABSOLUTE*,6X,*RELATIVE*,6X,*ABSOLUTE*,6X,*RELATIVE*/
     +16X,*AMT(KG/YR)*,4X,*PROP./YR*,6X,*AMT(KG/YR)*,4X,*PROP./YR*,
     +6X ,*AMT(KG/YR)*,4X,*PROP./YR*,6X,*AMT(KG/YR)*,4X,*PROP./YR*)
 322 FORMAT(*0*,6X,I4,6X,F7.0,7X,F5.4,9X,F7.0,7X,F5.4,
     +9X,F7.0,7X,F5.4,9X,F7.0,8X,F5.4)
 421 FORMAT(*1*,59X,*APPENDIX V1-14*///                                  4211
     +40X,*BASE RUN PROJECTIONS OF ANNUAL CONSUMPTION OF FUELWOOD*/      4212
     +41X,*BY WOOD CONSUMPTION GROUPS IN ABSOLUTE AMOUNTS AND*/          4213
     +43X,*AS PROPORTIONS OF OVERALL CONSUMPTION 1965-90*//              4214
     +10X,*YEAR*,23X,*FUELWOOD BY TRADITIONAL GROUP*,                    4215
     +14X,*FUELWOOD BY SEMI-TRADITIONAL GROUP*/                          4216
     +33X,*ABSOLUTE AMOUNT*,8X,*RELATIVE*,                               4217
     +15X,*ABSOLUTE AMOUNT*,8X,*RELATIVE*/                               4218
     +33X,*(AMT M3/YR)*,12X,*PROP./YR*,                                  4219
     +15X,*(AMT M3/YR)*,12X,*PROP./YR*)                                  42110
 422 FORMAT(*0*,10X,I4,13X,F9.0,14X,F5.4,18X,F9.0,14X,F5.4)
 521 FORMAT(*1*,59X,*APPENDIX V1-15*///                                  5211
     +43X,*BASE RUN PROJECTIONS OF ANNUAL CONSUMPTION OF PAPER*/         5212
     +45X,*PULP BY INCOME GROUPS IN ABSOLUTE AMOUNTS AND AS*/            5213
     +46X,*PROPORTIONS OF OVERALL CONSUMPTION 1965-90*//8X,*YEAR*,       5214
     +6X ,*LOW INCOME GROUP*,10X,*MEDIUM INCOME GROUP*,                  5215
     +10X,*HIGH INCOME GROUP*,14X,*STUDENT GROUP*/                       5216
     +15X,*ABSOLUTE*,5X,*RELATIVE*,7X,*ABSOLUTE*,6X,*RELATIVE*,          5217
     +6X ,*ABSOLUTE*,6X,*RELATIVE*,6X,*ABSOLUTE*,6X,*RELATIVE*/          5218
     +15X,*AMTS(KG/YR)*,2X,*PROP./YR*,7X,*AMTS(KG/YR)*,3X,*PROP./YR*,    5219
     +6X, *AMTS(KG/YR)*,3X,*PROP./YR*,6X,*AMTS(KG/YR)*,3X,*PROP./YR*)    52110
 522 FORMAT(*0*,8X,I4,3X,F7.0,6X,F5.4,10X,F10.0,                         5221
     +4X,F5.4,9X,F11.0,3X,F5.4,9X,F10.0,4X,F5.4)                         5222
 621 FORMAT(*1*,59X,*APPENDIX V1-16*///                                  6211
     +39X,*BASE RUN PROJECTIONS OF ANNUAL CONSTRUCTION OF RESIDENTIAL*/  6212
     +43X,*AND SCHOOL BUILDINGS BY POPULATION GROUPS,1965-90*/           6213
     +61X,*(NO BLDG/YR)*//                                               6214
     +15X,*TRADITIONAL*,3X,*SEMI-TRADI.*,3X,*NON-TRADI.*,                6215
     +4X ,*TRADI. ELE.*,2X,*SEMI-TRADI.*,3X,*NON-TRADI.*,                6216
     +4X ,*HIGHSCHOOL*,4X,*COLLEGE*/8X,*YEAR*,                           6217
     +3X ,*RESIDENTIAL*,3X,*RESIDENTIAL*,                                6218
     +3X ,*RESIDENTIAL*,3X,*SCHOOL*,8X,*ELEM.SCHL.*,4X,*ELEM.SCHL.*)     6219
 622 FORMAT(*0*,8X,I4,3X ,F7.0,7X,F7.0,7X,F6.0,8X,F5.0,                  6221
     +9X,F5.0,9X,F4.0,10X,F5.0,8X,F4.0)                                  6222
 721 FORMAT(*1*,59X,*APPENDIX V1-17*///                                  7211
     +52X,*BASE RUN PROJECTIONS OF ANNUAL*/                              7212
     +48X,*CONSTRUCTION OF OTHER BUILDINGS,1965-90*/                     7213
     +61X,*(NO BLDG/YR)*//                                               7214
     +15X,*TRADITIONAL*,3X,*NON-TRADI.*,                                 7215
     +4X ,*TRADITIONAL*,3X,*NON-TRADI.*,                                 7216
     +4X ,*PUBLIC*,8X,*HOSPITAL*,5X,*BRIDGE*,7X,*TRUCK*/8X,*YEAR*,       7217
     +3X ,*COMMERCIAL*,4X,*COMMERCIAL*,                                  7218
     +4X ,*RELIGIOUS*,5X,*RELIGIOUS*,5X,*ADMIN.*)                        7219
 722 FORMAT(*0*,8X,I4,3X,F6.0,8X,F6.0,8X,F5.0,                           7221
     +9X,F5.0,9X,F5.0,9X,F4.0,10X,F5.0,9X,F5.0)                          7222
 900 FORMAT(I2)
 901 FORMAT(37H1NON-DEFAULT PARAMETER VALUES FOR RUN,I2)
 903 FORMAT(34H3SELECTED OUTPUT VARIABLES AT TIME,F6.2)
 920 FORMAT(34H3DETAILED OUTPUT VARIABLES AT TIME,F6.2)
     END
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      SUBROUTINE FUN
      COMMON /BLOCK/  DUR,DT,DETPRT,SELPRT,BEGPRT,PRTCHG,PRTVL1,PRTVL2
      COMMON/BLOCK1/IYEAR,T,NDT,II,RES,RESW,WRES
      COMMON/BLOCK2/AB,EB,SB,TB,AGP,GDP,TVPOP,EVPOP,
     +ELPOP,AGB,P4,PCI2,PCI3,BLN,PD,POF,PSI,HB
      DIMENSION RES(3),RESW(3,3),WRES(3)
      DIMENSION HBB(5),ABB(5),EBB(5),SBB(5),TBB(5),
     +AGPP(5),GDPP(5),POPTV(5),POPEV(5),POPEL(5),P44(5),
     +PCI22(5),PCI33(5),AGBB(5),BLNN(5),PDD(5),POFF(5),PSII(5)
      DATA SMALL,DIF,K/1959.,5.,5/
      DATA ABB/.437E8,.210E9,.350E9,.455E9,.758E9/
      DATA EBB/.6E8,.3E9,.5E9,.930E9,.155E10/
      DATA HBB/.53E7,.14E8,.22E8,.286E8,.477E8/
      DATA SBB/.288E9,.113E10,.188E10,.244E10,.407E10/
      DATA TBB/.109E9,.620E9,.103E10,.134E10,.223E10/
      DATA PDD/89.0,101.0,126.0,129.,132./
      DATA P44/4.09,6.43,7.06,8.06,9.06/
      DATA AGBB/0.0716E7,.147E7,.208E7,.270E7,.450E7/
      DATA AGPP/.171E10,.181E10,.199E10,.199E10,.123E10/
      DATA GDPP/.368E10,.789E10,.139E11,.214E11,.422E11/
      DATA BLNN/.105E9,.447E9,.725E9,.939E9,.164E10/
      DATA POFF/89.,107.,110.,115.,119./
      DATA PSII/1.22,1.23,1.27,1.30,1.32/
      DATA PCI22/561.,801.,1003.,1554.,2009./
      DATA PCI33/.181E4,.475E4,.661E4,.818E4,.103E5/
      DATA POPEL/.320E7,.345E7,.370E7,.574E7,.689E7/
      DATA POPEV/.194E8,.211E8,.273E8,.281E8,.286E8/
      DATA POPTV/.170E7,.194E7,.204E7,.210E7,.213E7/
      YAER=IYEAR+DT*II
      HB    =TABEX(HBB,K,SMALL,DIF,YAER)
      AB    =TABEX(ABB,K,SMALL,DIF,YAER)
      P4    =TABEX(P44,K,SMALL,DIF,YAER)
      PD    =TABEX(PDD,K,SMALL,DIF,YAER)
      EB    =TABEX(EBB,K,SMALL,DIF,YAER)
      SB    =TABEX(SBB,K,SMALL,DIF,YAER)
      TB    =TABEX(TBB,K,SMALL,DIF,YAER)
      AGB   =TABEX(AGBB,K,SMALL,DIF,YAER)
      PSI   =TABEX(PSII,K,SMALL,DIF,YAER)
      POF   =TABEX(POFF,K,SMALL,DIF,YAER)
      BLN   =TABEX(BLNN,K,SMALL,DIF,YAER)
      GDP   =TABEX(GDPP,K,SMALL,DIF,YAER)
      AGP   =TABEX(AGPP,K,SMALL,DIF,YAER)
      PCI3  =TABEX(PCI33,K,SMALL,DIF,YAER)
      PCI2  =TABEX(PCI22,K,SMALL,DIF,YAER)
      EVPOP=TABEX(POPEV,K,SMALL,DIF,YAER)
      TVPOP=TABEX(POPTV,K,SMALL,DIF,YAER)
      ELPOP=TABEX(POPEL,K,SMALL,DIF,YAER)
      END
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```
      SUBROUTINE POPP
      REAL JOB,NETV
      COMMON /BLOCK/  DUR,DT,DETPRT,SELPRT,BEGPRT,PRTCHG,PRTVL1,PRTVL2
      COMMON/BLOCK1/IYEAR,T,NDT,II,RES,RESH,WRES
      COMMON/BLOCK2/AB,EB,SB,TB,AGP,GOP,TVPOP,EVPOP,
     +ELPOP,AGB,P4,PCI2,PCI3,BLN,PO,PCF,PSI,HB
      COMMON/BLOCK3/TPOP,THST,TCST,CST,HST,CHSTO,
     +CCST,JOB,SNI,TNI,DTHS,RMG,POP
      COMMON/BLOCK8/HPAP,PAP,TPAPS,          TWDS,TWD,TWDNS
      DIMENSION HST(5),CST(6),POP(3),TPOP(3),AR(3,2),CLEN(3,2),
     +G(6),      CSG(6),POPS(2),BTH(2),STP(2),DELP(2),DELPP(2),PLP(2),
     +B(2),      DRT(3,2),RP1(10),RP2(10),OTH(3,2),PMR(3,2),POPD(3,2),
     +POUT(2),PLR(3,2),AR(3),DRTT(3),TDTH(2),TP(2)
      DATA HST/.5E5,.4E5,.5E5,.4E5,.1E5/
      DATA CST/1000.,2000.,2000.,2000.,100.,300/
      DATA THST/272500./
      DATA TCST/13520./
      DATA FOP/.34E7,.82E6,.82E5/
      DATA PCDOUT/.2E4/
      DATA TFOP/.14E8,.44E7,.41E6/
      DATA DFLPP/6.,3./
      DATA PLR/.1,.1,.1,.1,.1,.1/
      DATA PMR/.004,.024,.014,-.1,-.12,-.014/
      DATA POPS/.14E8,.2E7/
      DATA CDR/.1/
      DATA EP/.1,.1,.1/
      DATA DTH/9900.,9000.,8100.,240.,210.,180./
      DATA BTH/.4E6,.1E6/
      DATA TBTH/.5E6/
      DATA TMF/.1/
      DATA PGPN/.1/
      DATA PGRT/.1/
      DATA AR/.33E6,.3E6,.27E6,.8E5,.7E5,.6E5/
      DATA POUT/.27E6,.6E5/
      DATA CSG/0.,0.,0.,.5E3,.13E3,33./
      DATA HSG/54200./
      DATA STP/.413E7,.78E6/
      DATA FOPD/.404E7,.368E7,.34E7,.98E6,.90E6,.82E6/
      DATA PLP/.08,-.025/
      DATA HPOP2/.15E5/
      DATA CFOP3/.41E4/
      DATA CDOUT,HDOUT/.09,.06/
      DATA DELP/6.,3./
      DATA KF/10/
      DATA CLEN/4.0,4.0,4.0,3.0,3.0,3.0/
      DATA DRTT/.02,.019,.015/
      DATA DRT/.02,.02,.02,.019,.019,.019/
      DATA NC,NRUR/3,1/
      DATA IDTU,NOBTH/1,1/
      DATA FBF/1.0/
      DATA AJ,DJ,VJ/2863.,.0000009,.000005/
      DATA AC,DC,VC/88.,.00001,.056/
      DATA AS,CS,VS/-31721.,.00003,.0002/
      DATA AM,DM/0.13419,-0.000999/
      DATA AN,DN,VN/-41775,.000002,.000002/
      DATA AT,CD,VT/324.,.00000007,.000005/
      DATA SF/.24/
      DATA CBR/.1/
      DATA CFOP2/.15E3/
      DATA RHDTH/195/
      DATA RCDTH/19/
      DATA DRTH,DRTC/.01,.01/
      DATA B/.76,.24/
      DATA G/0.,0.,0.,.70,.67,1.0/
      DO10 NF=1,10
      RP1(NR)=STP(1)/DELP(1)
   10 RP2(NR)=STP(2)/DELP(2)
      DO 11 ID=1,2
      DELPP(ID)=DELP(ID)
   11 CONTINUE
      IF(II.NE.1) GO TO 2
      HSG=HST(5)
      DO12 J=1,4
      I=6-J
      HST(I)=HST(I-1)*(1-HDOUT-DRTH )
   12 CONTINUF
      HST(1)=AS+DS*GOP+VS*EB
      THSTL=THST
```

```
            THST=0.0
            DO13  I=1,5
         13 THST=THST+HST(I)
            CHSTD=THST-THSTL
            PHDOUT=THST*HDOUT
            CSG(6)=CST(6)*G(6)
            CST(6)=CST(5)*(1-G(5))
            CSG(5)=CST(5)*G(5)
            CST(5)=CST(4)*(1-G(4))
            CSG(4)=CST(4)*G(4)
            TCSG=CSG(6)+CSG(5)+CSG(4)
            DO14  J=1,3
            I=5-J
         14 CST(I)=CST(I-1)*(1-CDOUT-DRTH)
            CST(1)=AC+DC*EB+VC*HSG
            TCSTL=TCST
            CPOP2=TCSG-CPOP3
            TCST=0.
            HPOP2=HSG-CST(1)
            DO15  I=1,6
         15 TCST=TCST+CST(I)
            CCST=TCST-TCSTL
            RCDOUT=TCST*CDOUT
            RCDTH=TCST*DRTC
            JOB=AJ+DJ*GDP+VJ*SB
            FMG=AM+DM*FDF
            SNI=AN+DN*GDP+VN*SB
            TNI=AT+DD*AGP+VT*AB
            CPOP3=AMIN1(TCSG,JOB)
      C     NETV=NONED 12 YR OLDS
            NETV=TVPOP-HST(1)
      C     TVPOP=12 YR OLDS
          2 CONTINUE
            TBTH=B(2)*NETV
            CALL  DEMOGD(POPD(1,2),POPS(2),TP(2),SR,CLEN(1,2),AR(1,2),DRT(1,2),
           +CDR,DTH(1,2),TDTH(2),NOBTH,PBF,BR(2),CBR,BTH(2),TBTH,
           +PLR,PMR,TMR,PGRN,PGRT,NC,NRUR,DT,T,0)
            PMR(1,1)=RMG
            PMR(2,1)=RMG
            PMR(3,1)=RMG
            TBTH=B(1)*NETV
            CALL  DEMOGD(POPD(1,1),POPS(1),TP(1),SR,CLEN(1,1),AR(1,1),DRT(1,1),
           +CDR,DTH(1,1),TDTH(1),NOBTH,PBF,BR(1),CBR,BTH(1),TBTH,
           +PLR,PMF,TMR,PGRN,PGRT,NC,NRUR,DT,T,0)
            PMR(1,2)=-TMR/TP(2)
            PMR(2,2)=PMR(1,2)
            PMR(3,2)=PMR(1,2)
            CALL  DELLVF(AR(3,1),POUT(1), RP1,STP(1),
           +                PLP(   1),DELP(1),DELPP(1),
           +                DT,IDTU,KP)
            CALL  DELLVF(AR(3,2),POUT(2), RP2,STP(2),
           +                PLP(   2),DELP(2),DELPP(2),
           +                DT,IDTU,KP)
            POP(1)=POUT(1)-TNI
            POP(2)=POUT(2)+TNI+HPOP2+RCDOUT+
           +CPOP2-SNI
            POP(3)=CPOP3+SNI
            DO 101 I=1,3
            TPOP(I)=TPOP(I)+DT*(POP(I)-DRTT(I)*TPOP(I))
        101 CONTINUE
            DTHS=    (EVPOP*DRT(1,1)+RHDTH+RCDTH+TPOP(1)*DRTT(1)+
           +TPOP(2)*DRTT(2)+TPOP(3)*DRTT(3)+TDTH(1)+TDTH(2)-AR(3,1)-AR(3,2))
            END
```

```
      SUBROUTINE RESID
      REAL JOB
      COMMON /BLOCK/  DUR,DT,DETPRT,SELPRT,BEGPRT,PRTCHG,PRTVL1,PRTVL2
      COMMON/BLOCK1/IYEAR,T,NDT,II,RES,RESW,WRES
      COMMON/BLOCK2/AB,EB,S9,TB,AGF,GDP,TVPOP,EVPOP,
     +ELPOP,AGB,P4,PCI2,PCI3,BLN,PC,PDF,PSI,HB
      COMMON/BLOCK3/TPOP,THST,TCST,CST,HST,CHSTD,
     +CCST,JOB,SNI,TNI,DTHS,PMG,POP
      COMMON/BLOCK10/WSCH,PWPAD,PWRPAD(3,3),PULP
      DIMENSION TPOP(3),POP(3),HST(5),CST(6)
      DIMENSION PWPAD(3,3),WSCH(3)
      DIMENSION PR(3,3),CR(3,3),BR(3,3),P(3),
     +          RES(3),RESW(3,3),WRES(3),V(3),
     +          ROUT(3),RAC(3),RAD(3),DELR(3),
     +          DELRF(3),STR(3),PLR(3),RIN(3),
     +          RR1(10),RR2(10),RR3(10)
      DATA WRES(1),WRES(2),WRES(3)/0.0,0.0,0/
      DATA CR(1,1),BR(1,1)/1.44,0.0/
      DATA CR(1,2),BR(1,2)/1.8337,-0.9440/
      DATA CR(1,3),BR(1,3)/0.0,0.0/
      DATA CR(2,1),BR(2,1)/1.80,0.0/
      DATA CR(2,2),BR(2,2)/11.402,-7.4529/
      DATA CR(2,3),BR(2,3)/0.6,0.0/
      DATA CR(3,1),BR(3,1)/1.43,0.0/
      DATA CR(3,2),BR(3,2)/4.4812,-4.2756/
      DATA CR(3,3),BR(3,3)/3.3,0.0/
      DATA KR/10/
      DATA DELRP/15.,60.,90./
      DATA DELR/15.,60.,90./
      DATA PLR/.06,.03,.02/
      DATA RAC/.027,.006,.001/
      DATA RAD/.86,.31,.50/
      DATA STR/.205E7,.162E7,.6E4/
      DATA ROUT/.25E5,.1E4,.4E3/
      DATA IDTU/1/
      DATA P(1),P(3)/1.0,1.0/
      DATA V/1.,1.,.85/
      DO10 ID=1,3
   10 DELRP(ID)=DELR(ID)
      DO11 JR=1,10
      RR1(JR)=STR(1)/DELR(1)
      RR2(JR)=STR(2)/DELR(2)
   11 RR3(JR)=STR(3)/DELR(3)
      P(2)=PSI
      DO 12 IP=1,3
      DO 12 JP=1,3
   12 PR(IP,JP)=CR(IP,JP)+BR(IP,JP)*P(JP)   *V(JP)
      DO13 IR=1,3
   13 RIN(IR)=      RAD(IR)*POP(IR)
      CALL DELLVF(RIN(1),ROUT(1)  ,RR1,  STR(1),
     +            PLR(1),DELR(1),DELRP(1),DT,IDTU,KR)
      CALL DELLVF(RIN(2),ROUT(2)  ,RR2,  STR(2),
     +            PLR(2),DELR(2),DELRP(2),DT,IDTU,KR)
      CALL DELLVF(RIN(3),ROUT(3)  ,RR3,  STR(3),
     +            PLR(3),DELR(3),DELRP(3),DT,IDTU,KR)
      DO14 IR=1,3
      RIN(IR)=RIN(IR)+ROUT(IR)  +RAC(IR)*STR(IR)
      RES(IR)=RIN(IR)
   14 CONTINUE
      WRES(1)=WRES(2)=WRES(3)=0.
      DO15 JW=1,3
      DO15 IW=1,3
      RESW(IW,JW)=RES(IW)*PR(IW,JW)
      PWPAD(IW,JW)=RESW(IW,JW)/TPOP(IW)
   15 WRES(JW)=WRES(JW)+RESW(IW,JW)
      END
```

```
      SUBROUTINE NRESD
      REAL JOB
      COMMON /BLOCK/  DUR,DT,DETPRT,SELPRT,BEGPRT,PRTCHG,PRTVL1,PRTVL2
      COMMON/BLOCK1/IYEAR,T,NDT,II,RES,RESW,WRES
      COMMON/BLOCK2/AB,EB,S9,TB,AGP,GDP,TVPOP,EVPOP,
     +ELPOP,AGB,P4,PCI2,PCI3,BLN,PC,PDF,PSI,H9
      COMMON/BLOCK3/TPOP,THST,TCST,CST,HST,CHSTD,
     +CCST,JOB,SNI,TNI,OTHS,RMG,POP
      COMMON/BLOCK4/HSCH,HSCHW,WHSCH,ELE,ELEW,WELE
      COMMON/BLOCK5/COM,COMW,WCOM,REL,RELW,WREL,ADM,ADMW,WADM
      COMMON/BLOCK6/HOSP,BRIG,CKT,TMT,BED,FRD,RTM,WBRG,WTMT,WCKT,WHOS
      COMMON/BLOCK10/WSCH,RWPAD,PWRPAD(3,3),PULP
      DIMENSION PWPAD(3,3),WSCH(3)
      DIMENSION TPOP(3),POP(3),HST(5),CST(6)
      DIMENSION RES(3),RESW(3,3),WRES(3)
      DIMENSION CE(3,3),BE(3,3),CS(3,3),BS(3,3),PE(3,3),PS(3,3),
     +          SAD(3),SAC(3),DELS(3),DELSP(3),SOUT(3),STS(3),
     +          ELE(3),WELE(3),ELEW(3,3),WHSCH(3),HSCHW(3,3),
     +          HSCH(3),P(3),CHST(3),SIN(3),PLS(3),
     +          PS1(10),PS2(10),PS3(10),V(3) ,RE(3)
         DIMENSION CC(3,3),BC(3,3),CL(3,3),BL(3,3),CA(3,3),BA(3,3),
     +             PC(3,3),PL(3,3),PA(3,3),RC(3),RL(3),RA(3),
     +             COMW(3,3),RELW(3,3),ADMW(3,3),WCOM(3),WREL(3),
     +             WADM(3), COM(3),REL(3),ADM(3)
      DIMENSION CH(3),CB(3),CT(3),CK(3),BH(3),BB(3),BT(3),BK(3),
     +          PH(3),PB(3),PT(3),PK(3),WHOS(3),WBRG(3),WTMT(3),
     +          WCKT(3),RH(10),RB(10)
      DATA  CE(1,1),BE(1,1)/1.98,0.0/
      DATA  CE(1,2),BE(1,2)/4.78,0.0/
      DATA  CE(1,3),BE(1,3)/0.0,0.0/
      DATA  CE(2,1),BE(2,1)/0.071,0.0/
      DATA  CE(2,2),BE(2,2)/7.18,0.0/
      DATA  CE(2,3),BE(2,3)/1.375,0.0/
      DATA  CE(3,1),BE(3,1)/0.0,0.0/
      DATA  CE(3,2),BE(3,2)/4.11,0.0/
      DATA  CE(3,3),BE(3,3)/1.375,0.0/
      DATA  CS(1,1),BS(1,1)/0.0,0.0/
      DATA  CS(1,2),BS(1,2)/0.0,0.0/
      DATA  CS(1,3),BS(1,3)/0.0,0.0/
      DATA  CS(2,1),BS(2,1)/1.55,0.0/
      DATA  CS(2,2),BS(2,2)/14.47,0.0/
      DATA  CS(2,3),BS(2,3)/4.3,0./
      DATA  CS(3,1),BS(3,1)/2.47,0.0/
      DATA  CS(3,2),BS(3,2)/12.86,0.0/
      DATA  CS(3,3),BS(3,3)/5.80,0.0/
      DATA  SAD/.0,.037,.046/
      DATA  DELSP/0.,60.,90./
      DATA  STS/0.,8012.,644./
      DATA  SOUT/0.,134.,7./
      DATA  PLS/0.,.0061,.0024/
      DATA  KS,INTU/10,1/
      DATA  WELE(1),WELE(2),WELE(3)/0.0,0.0,0.0/
      DATA  WHSCH(1),WHSCH(2),WHSCH(3)/0.0,0.0,0.0/
      DATA  SAC(1),SAC(2),SAC(3)/0.0,0.0061,0.0045/
      DATA  DELS(1),DELS(2),DELS(3)/0.0,60.0,90.0/
      DATA  RE(1),RE(2),RE(3)/0.0077,0.011,0.0089/
      DATA  CC(1,1),BC(1,1)/0.22,0.0/
      DATA  CC(1,2),BC(1,2)/0.09,0.0/
      DATA  CC(1,3),BC(1,3)/0.0,0.0/
      DATA  CC(2,1),BC(2,1)/0.079,0.0/
      DATA  CC(2,2),BC(2,2)/3.49,0.0/
      DATA  CC(2,3),BC(2,3)/ 2.0,0.0/
      DATA  CC(3,1),BC(3,1)/0.0,0.0/
      DATA  CC(3,2),BC(3,2)/0.0,0.0/
      DATA  CC(3,3),BC(3,3)/0.0,0.0/
      DATA  CL(1,1),BL(1,1)/1.34,0.0/
      DATA  CL(1,2),BL(1,2)/2.20,0.0/
      DATA  CL(1,3),BL(1,3)/0.0,0.0/
      DATA  CL(2,1),BL(2,1)/1.059,0.0/
      DATA  CL(2,2),BL(2,2)/17.48,0.0/
      DATA  CL(2,3),BL(2,3)/.56,0.0/
      DATA  CL(3,1),BL(3,1)/0.0,0.0/
      DATA  CL(3,2),BL(3,2)/0.0,0.0/
      DATA  CL(3,3),BL(3,3)/0.0,0.0/
      DATA  CA(1,1),BA(1,1)/0.0,0.0/
      DATA  CA(1,2),BA(1,2)/0.0,0.0/
      DATA  CA(1,3),BA(1,3)/0.0,0.0/
      DATA  CA(2,1),BA(2,1)/1.47,0.0/
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      DATA  CA(2,2),BA(2,2)/13.75,0.0/
      DATA  CA(2,3),BA(2,3)/ 5.0,0.0/
      DATA  CA(3,1),BA(3,1)/0.0,0.0/
      DATA  CA(3,2),BA(3,2)/0.0,0.0/
      DATA  CA(3,3),BA(3,3)/0.0,0.0/
      DATA  WCOM(1),WCOM(2),WCOM(3)/0.0,0.0,0.0/
      DATA  WREL(1),WREL(2),WREL(3)/0.0,0.0,0.0/
      DATA  WADM(1),WADM(2),WADM(3)/0.0,0.0,0.0/
      DATA  FC(1),FC(2),PC(3)/0.064,0.156,0.0/
      DATA  FL(1),PL(2),PL(3)/0.012,0.012,0.0/
      DATA  FA(1),PA(2),PA(3)/0.0,0.0035,0.0/
      DATA  CH(1),BH(1)/1.47,0.0/
      DATA  CH(2),BH(2)/8.08,0.0/
      DATA  CH(3),BH(3)/ 5.0,0.0/
      DATA  WHOS/.0,.0,.0/
      DATA  HAC,BAC/.0024,.0075/
      DATA  HAD,BAD/0.025,0.15/
      DATA  DELH,DELB/90.,17./
      DATA  STH,STB/.55E5,.12E5/
      DATA  KH,KB/10,10/
      DATA  PLH,PLB/.0024,.1575/
      DATA  HOUT,BOUT/611.,714./
      DATA  AH,DH,VH/106.3,.00000004,.0002/
      DATA  V/1.,1.,.85/
      DATA  F(1),F(3)/1.0,1.0/
      F(2)=FSI
      IF(II.NE.1)GO TO 19
      RED=AH+DH*GDP+VH*HD
   19 CONTINUE
      DO 10 ID=1,3
   10 DELSF(ID)=DELS(ID)
      DELHF=DELH
      DO 11 JS=1,10
      FS1(JS)=STS(1)/DELS(1)
      FS2(JS)=STS(2)/DELS(2)
      RS3(JS)=STS(3)/DELS(3)
      FH(JS)=STH/DELH
   11 CONTINUE
      DO 12 IP=1,3
      DO 12 JP=1,3
      PE(IP,JP)=CE(IP,JP)+BE(IP,JP)*P(JP)*V(JP)
      FS(IP,JP)=CS(IP,JP)+BS(IP,JP)*P(JP)*V(JP)
      PC(IP,JP)=CC(IP,JP)+BC(IP,JP)*P(JP)*V(JP)
      FL(IP,JP)=CL(IP,JP)+BL(IP,JP)*P(JP)*V(JP)
      FA(IP,JP)=CA(IP,JP)+BA(IP,JP)*P(JP)*V(JP)
   12 CONTINUE
      DO 18 JP=1,3
      FH(JP)=CH(JP)+BH(JP)*P(JP)*V(JP)
   18 CONTINUE
      DO 16 IR=1,3
      ELE(IR)=RES(IR)*PE(IR)
      COM(IR)=RES(IR)*PC(IR)
      REL(IR)=RES(IR)*PL(IR)
      ADM(IR)=(RES(2)+RES(3))*RA(IR)
   16 CONTINUE
      CHST(1)=0. $ CHST(2)=CHSTO $ CHST(3)=CCST
      DO 13 IS=1,3
   13 SIN(IS)=      SAD(IS)*CHST(IS)
      HIN=RED*HAD
      CALL  DELLVF(SIN(2),SOUT(2),RS2   ,STS(2),
     +             PLS(2),DELS(2),DELSP(2),DT,IOTU,KS)
      CALL  DELLVF(SIN(3),SOUT(3),RS3   ,STS(3),
     +             PLS(3),DELS(3),DELSP(3),DT,IOTU,KS)
      CALL  DELLVF(HIN,HOUT,RH,STH,
     +             PLH,DELH,DELHP,DT,IOTU,KH)
      DO 14 IS=1,3
      SIN(IS)=SIN(IS)+SOUT(IS)+SAC(IS)*STS(IS)
   14 HSCH(IS)=    SIN(IS)
      HIN=HIN+HOUT+HAC*STH
      HOSP=HIN
      WELE(1)=WELE(2)=WELE(3)=0.
      WHSCH(1)=WHSCH(2)=WHSCH(3)=0.
      WCOM(1)=WCOM(2)=WCOM(3)=0.
      WREL(1)=WREL(2)=WREL(3)=0.
      WADM(1)=WADM(2)=WADM(3)=0.
      DO 15 JW=1,3
      DO 15 IW=1,3
      ELEW(IW,JW)=ELE(IW)*PE(IW,JW)
```

```
      WELE(JW)=WELE(JW)+ELEW(IW,JW)
      HSCHW(IW,JW)=HSCH(IW)*PS(IW,JW)
      WHSCH(JW)=WHSCH(JW)+HSCHW(IW,JW)
      ADMW(IW,JW)=ADM(IW)*PA(IW,JW)
      RELW(IW,JW)=REL(IW)*PL(IW,JW)
      COMW(IW,JW)=COM(IW)*PC(IW,JW)
      WREL(JW)=WREL(JW)+RELW(IW,JW)
      WCOM(JW)=WCOM(JW)+COMW(IW,JW)
      WADM(JW)=WADM(JW)+ADMW(IW,JW)
   15 CONTINUE
      DO 17 JW=1,3
      WSCH(JW)=WELE(JW)+WHSCH(JW)
      WHOS(JW)=HOSP*PH(JW)
   17 CONTINUE
      END
```

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      SUBROUTINE CAVIB
      REAL JOB
      COMMON /BLOCK/  DUR,DT,DETPRT,SELPRT,BEGPRT,PRTCHG,PRTVL1,PRTVL2
      COMMON/BLOCK1/IYEAR,T,NDT,II,RES,RESW,WRES
      COMMON/BLOCK2/AB,EB,S3,TB,AGP,GDP,TVPOP,EVPOP,
     +ELPOP,AGB,P4,PCI2,PCI3,BLN,PD,PDF,PSI,HB
      COMMON/BLOCK3/TPOP,THST,TCST,CST,HST,CHSTD,
     +CCST,JOB,SNI,TNI,DTHS,RMG,POP
      COMMON/BLOCK4/HSCH,HSCHW,WHSCH,ELE,ELEW,WELE
      COMMON/BLOCK6/HOSP,BRIG,CKT,TMT,BED,PRD,RTM,WBRG,WTMT,WCKT,WHOS
      COMMON/BLOCK5/COM,COMW,WCOM,REL,RELW,WREL,ADM,ADMW,WADM
      DIMENSION COM(3),COMW(3,3),WCOM(3),REL(3),
     +RELW(3,3),WREL(3),ADM(3),ADMW(3,3),WADM(3)
      DIMENSION HSCH(3),HSCHW(3,3),WHSCH(3),ELE(3),ELEW(3,3),WELE(3)
      DIMENSION RES(3),RESW(3,3),WRES(3)
      DIMENSION TPOP(3),POP(3),HST(5),CST(6)
      DIMENSION CH(3),CB(3),CT(3),CK(3),BH(3),BB(3),BT(3),BK(3),
     +          PH(3),PB(3),PT(3),PK(3),WHOS(3),WBRG(3),WTMT(3),
     +          WCKT(3),RH(10),RB(10),P(3),V(3)
      DATA CB(1),BB(1)/0.0,0.0/
      DATA CB(2),BB(2)/3.08,0.0/
      DATA CB(3),BB(3)/0.0,0.0/
      DATA CT(1),BT(1)/0.0,0.0/
      DATA CT(2),BT(2)/3.05,0.0/
      DATA CT(3),BT(3)/0.    ,0.0/
      DATA CK(1),BK(1)/0.0,0.0/
      DATA CK(2),BK(2)/0.058,0.0/
      DATA CK(3),BK(3)/0.0,0.0/
      DATA WBRG/.0,.0,.0/
      DATA WTMT/.0,.0,.0/
      DATA WCKT/.0,.0,.0/
      DATA HAC,BAC/.0024,.0075/
      DATA HAD,BAD/0.026,0.15/
      DATA DELH,DELB/90.,17./
      DATA STH,STB/.5555,.12E5/
      DATA KH,KB/10,10/
      DATA PLH,PLB/.0024,.1575/
      DATA HOUT,BOUT/611.,714./
      DATA IDTU/1/
      DATA P(1),P(3)/1.0,1.0/
      DATA V/1.,1.,.85/
      DATA AD,DD,VD/333.75,.00000815,.0000023/
      DATA AU,DU/37.6,.0000037/
      DATA PRC/.35/
      IF(II.NE.1) GO TO 20
      PRD=AD+DD*GDP+VD*TB
      PRD=PRC*1.31
      RTM=AU+DU*BLN
   20 CONTINUE
      DELBP=DELB
      DO 11 IR=1,10
   11 RB(IR)=STB/DELB
      P(2)=PSI
      DO 12 JP=1,3
      PB(JP)=CB(JP)+BB(JP)*P(JP)*V(JP)
      PT(JP)=CT(JP)+BT(JP)*P(JP)*V(JP)
   12 PK(JP)=CK(JP)+BK(JP)*P(JP)*V(JP)
      BIN=PRC*BAD
      CALL CELLVF(BIN,BOUT,RB,STB,
     +              PLB,DELB,DELBP,DT,IDTU,KB)
      BIN=BIN+BOUT+BAC*STB
      BRIG=BIN
      TMT=RTM
      CKT=PBC*DTHS
      DO 15 JW=1,3
      WBRG(JW)=BRIG*PB(JW)
      WTMT(JW)=TMT*PT(JW)
   15 WCKT(JW)=CKT*PK(JW)
      END
```

```
      SUBROUTINE FAFU
      REAL JOB
      COMMON /BLOCK/  DUR,DT,DETPRT,SELPRT,BEGPRT,PRTCHG,PRTVL1,PRTVL2
      COMMON/BLOCK1/IYEAR,T,NDT,II,RES,RESW,WRES
      COMMON/BLOCK2/AB,EB,SB,TB,AGP,GDP,TVPOP,EVPOP,
     +ELPOP,AGB,P4,PCI2,PCI3,BLN,PD,PDF,PSI,HB
      COMMON/BLOCK3/TPOP,THST,TCST,CST,HST,CHSTD,
     +CCST,JOB,SNI,TNI,DTHS,FMG,FOP
      COMMON/BLOCK4/HSCH,HSCHW,WHSCH,ELE,ELEW,WELE
      COMMON/BLOCK5/COM,COMW,WCOM,REL,RELW,WREL,ADM,ADMW,WADM
      COMMON/BLOCK6/HOSP,BRIG,CKT,TMT,BED,PRD,RTM,WBRG,WTMT,WCKT,WHOS
      COMMON/BLOCK7/TFUEL,FUES,FUEM,FUEL,FUELS,FUELM,FAMB,ETA,FAMW,WFAM
      DIMENSION RES(3),RESW(3,3),WRES(3)
      DIMENSION TPOP(3),POP(3),HST(5),CST(6)
      DIMENSION HSCH(3),HSCHW(3,3),WHSCH(3),ELE(3),ELEW(3,3),WELE(3)
      DIMENSION COM(3),COMW(3,3),WCOM(3),REL(3),
     +RELW(3,3),WREL(3),ADM(3),ADMW(3,3),WADM(3)
      DIMENSION WBRG(3),WTMT(3),WCKT(3),WHOS(3)
      DIMENSION CG(2,3),BG(2,3),PG(2,3),CF(2),BF(2),PF(2),P(3),
     +          AG(2),DG(2),VG(2),GAC(2),GAD(2),DELG(2),DELGP(2),
     +          RG1(10),RG2(10),STG(2),PLG(2),FAM(2),FAMB(2),ETA(2),
     +          FAMW(3,3),WFAM(3),FUELM(2),TFAM(2),DRF(2),ADPG(2),
     +          FUELS(2),GOUT(2),GIN(2),FUEL(2),PFS(2),V(3)
      DIMENSION FBF(2),FSF(2)
      DATA CG(1,1),BG(1,1)/9.135,0.0/
      DATA CG(1,2),BG(1,2)/0.0,0.0/
      DATA CG(1,3),BG(1,3)/0.0,0.0/
      DATA CG(2,1),BG(2,1)/4.25,0.0/
      DATA CG(2,2),BG(2,2)/.19,0./
      DATA CG(2,3),BG(2,3)/0.0,0.0/
      DATA PDF,PSF/.1,.95,.9,.05/
      DATA PFS/2.9,2./
      DATA CF(1),BF(1)/2.9,-.18/
      DATA CF(2),BF(2)/2.1,-.12/
      DATA IDTU/1/
      DATA GAC(1),GAC(2)/0.15,0.09/
      DATA GAD(1),GAD(2)/4.70,3.89/
      DATA DELG(1),DELG(2)/3.0,7.0/
      DATA STG/.658E7,.419E6/
      DATA FAMW(3,1),FAMW(3,2),FAMW(3,3)/0.,0.,0./
      DATA ADPG/6.,4./
      DATA TFAM/.6E7,.6E4/
      DATA DRF,TFAM/.05,.15,0.,0./
      DATA GOUT/.218E7,.59E6/
      DATA PLG/.19,.17/
      DATA AG(1),DG(1),VG(1)/0.96997,-0.00000002,0.00022674/
      DATA AG(2),DG(2),VG(2)/0.02176,0.00000002,-0.000166/
      DATA KG,TFUEL/10,0./
      DATA FAM/.817E7,.523E6/
      DATA P(1),P(3)/1.0,1.0/
      DATA V/1.,1.,.85/
      P(2)=PSI
      DO 10 ID=1,2
   10 DELGP(ID)=DELG(ID)
      DO 11 JR=1,10
      RG1(JR)=STG(1)/DELG(2)
      RG2(JR)=STG(2)/DELG(2)
   11 CONTINUE
      DO 12 IP=1,2
      DO 12 JP=1,3
   12 PG(IP,JP)=CG(IP,JP)+BG(IP,JP)*P(JP)*V(JP)
      IF(II.NE.1) GO TO 20
      PF(1)=CF(1)+BF(1)*P4
      PF(2)=CF(2)+BF(2)*P4
      ETA(1)=AG(1)+DG(1)*AGB+VG(1)*PD
      ETA(2)=AG(2)+DG(2)*AGB+VG(2)*PD
   20 CONTINUE
      DO 13 IE=1,2
      FAM(IE)=ETA(IE)*POP(IE) /ADPG(IE)
      TFAM(IE)=TFAM(IE)+DT*(FAM(IE)-DRF(IE)*TFAM(IE))
      GIN(IE)=GAD(IE)*FAM(IE)
   13 CONTINUE
      CALL DELLVF(GIN(1),GOUT(1),RG1    , STG(1),
     +            PLG(1),DELG(1),DELGP(1),DT,IDTU,KG)
      CALL DELLVF(GIN(2),GOUT(2),RG2,       STG(2),
     +            PLG(2),DELG(2),DELGP(2),DT,IDTU,KG)
      DO 14 IF=1,2
      GIN(IF)=GIN(IF)+GOUT(IF)+GAC(IF)*STG(IF)
```

```
      FAMB(IF)=GIN(IF)
   14 CONTINUE
      WFAM(1)=WFAM(2)=WFAM(3)=0.
      TFUEL=FUES=FUEM=0.
      DO 15 JW=1,3
      DO 15 IW=1,2
      FAMW(IW,JW)=FAMB(IW)*PG(IW,JW)*P(JW)*V(JW)
      WFAM(JW)=WFAM(JW)+FAMW(IW,JW)
   15 CONTINUE
      DO 16 IW=1,2
      FUELM(IW)=FF(IW)*TPOP(IW)*PBF(IW)
      FUELS(IW)=FSF(IW)*PFS(IW)*TPOP(IW)
      FUEL(IW)=FUELM(IW)+FUELS(IW)
      FUES =FUES +FUELS(IW)
      FUEM =FUEM +FUELM(IW)
      TFUEL=TFUEL+FUEL(IW)
   16 CONTINUE
      END
```

```
      SURROUTINE PEPA
      REAL JOB
      COMMON /BLOCK/  DUR,DT,DETPRT,SELPRT,BEGPRT,PRTCHG,PRTVL1,PRTVL2
      COMMON/BLOCK1/IYEAR,T,NDT,II,RES,RESW,WRES
      COMMON/BLOCK2/AB,EB,SB,TB,AGP,GDP,TVPOP,EVPOP,
     +ELPOP,AGR,F4,PCI2,PCI3,BLN,PC,PDF,PSI,HB
      COMMON/BLOCK3/TPOP,THST,TCST,CST,HST,CHSTD,
     +CCST,JOB,SNI,TNI,DTHS,PMG,POP
      COMMON/BLOCK4/HSCH,HSCHW,WHSCH,ELE,ELEW,WELE
      COMMON/BLOCK5/COM,COMW,WCOM,REL,RELW,WREL,ADM,ADMW,WADM
      COMMON/BLOCK6/HOSP,BRIG,CKT,TMT,BED,PRD,PTM,WBRG,WTMT,WCKT,WHOS
      COMMON/BLOCK7/TFUEL,FUFS,FUEM,FUEL,FUELS,FUELM,FAMB,ETA,FAMW,WFAM
      COMMON/BLOCK8/WPAP,PAP,TPAPS,           TWOS,TWD,TWONS
      COMMON/BLOCK9/PWRES,PWELE,PWHSCH,PWADM,PWHOS,PWCOM,PWREL,PWBRG,
     +PWTMT,PWCKT,PWFAM,PWSCH,PFUES,PFUEM,PFUEL1,PFUEL2,PTWOS,PTWONS
      COMMON/BLOCK10/WSCH,RWPAD,PWRPAD(3,3),PULP
      COMMON/BLOCK11/WNRES(3),PWNP(3),PPAP(3),FTPAP    ,TWRPAD(3)
      DIMENSION FFS(3),RESW(3,3),WRES(3)
      DIMENSION TPOP(3),POP(3),HST(5),CST(5)
      DIMENSION HSCH(3),HSCHW(3,3),WHSCH(3),ELE(3),ELEW(3,3),WELE(3)
      DIMENSION COM(3),COMW(3,3),WCOM(3),REL(3),
     +RELW(3,3),WREL(3),ADM(3),ADMW(3,3),WADM(3)
      DIMENSION WBRG(3),WTMT(3),WCKT(3),WHOS(3)
      DIMENSION FUEL(2),FUELS(2),FUELM(2),FAMB(2),ETA(2),FAMW(3,3),
     +WFAM(3),SPOP(3)
      DIMENSION PB(3),PAPSO(3),PCI(3),PAPO(3),TWONS(3),
     +             PAP(3),PCIO(3),PAPS(3),F(3),V(3),TWOS(3,3),TWD(3)
      DIMENSION PWRES(3),PWELE(3),PWHSCH(3),PWADM(3),PWHOS(3),
     +PWCOM(3),PWREL(3),PWBRG(3),PWTMT(3),PWCKT(3),PWFAM(3),PWSCH(3),
     +PTWOS(3,3),PTWONS(3)
      DIMENSION RWPAD(3,3),WSCH(3)
      DATA PCI(1)/0./
      DATA PCIO/87.,446.,1330./
      DATA PAPSO/.23,11.52,25.92/
      DATA PAPO/.04,4.32,44.64/
      DATA PB/0.,.0019,.0033/
      DATA F(1),F(3)/1.0,1.0/
      DATA V/1.,1.,.85/
      F(2)=PSI
      PCI(2)=PCI2
      PCI(3)=PCI3
      SPOP(1)=ELPOP
      SPOP(2)=THST
      SPOP(3)=TCST
      TPAPS=0.
      WPAP=0.
      DO 10 IP=1,3
      PAPS(IP)=PAPSO(IP)*SPOP(IP)*(1+(PCI(IP)-PCIO(IP))*PB(IP))*V(3)
      PAP(IP)=PAPO(IP)*TPOP(IP)*(1+(PCI(IP)-PCIO(IP))*PB(IP))*V(3)
      TPAPS=TPAPS+PAPS(IP)
      WPAP=WPAP+PAP(IP)+PAPS(IP)
   10 CONTINUE
      DO 40 JW=1,3
      DO 40 IW=1,3
      TWOS(IW,JW)=FAMW(IW,JW)+COMW(IW,JW)
     +             +RELW(IW,JW)+ELEW(IW,JW)
     +             +RESW(IW,JW)
   40 CONTINUE
      DO 42 JW=1,3
      TWD(JW)=(WFAM(JW)+WHOS(JW)+WBRG(JW)+WHSCH(JW)
     +        +WTMT(JW)+WCKT(JW)+WCOM(JW)+WRES(JW)
     +      +WREL(JW)+WADM(JW)+WELE(JW))
      TWONS(JW)=WHOS(JW)+WBRG(JW)+WTMT(JW)
     +         +WCKT(JW)+WADM(JW)+WHSCH(JW)
      PWRES(JW)=WRES(JW)/TWD(JW)
      PWELE(JW)=WELE(JW)/TWD(JW)
      PWHSCH(JW)=WHSCH(JW)/TWD(JW)
      PWADM(JW)=WADM(JW)/TWD(JW)
      PWHOS(JW)=WHOS(JW)/TWD(JW)
      PWCOM(JW)=WCOM(JW)/TWD(JW)
      PWREL(JW)=WREL(JW)/TWD(JW)
      PWBRG(JW)=WBRG(JW)/TWD(JW)
      PWTMT(JW)=WTMT(JW)/TWD(JW)
      PWCKT(JW)=WCKT(JW)/TWD(JW)
      PWFAM(JW)=WFAM(JW)/TWD(JW)
      PWSCH(JW)=PWELE(JW)+PWHSCH(JW)
      PTWONS(JW)=TWONS(JW)/TWD(JW)
      WNRES(JW)=WCOM(JW)+WREL(JW)+WADM(JW)+WHOS(JW)+WSCH(JW)
```

```
      PWNR(JW)=WNRES(JW)/TWD(JW)
      PPAP(JW)=PAP(JW)/WPAP
   42 CONTINUE
      DO 41 JW=1,3
      DO 41 IW=1,3
      PTWDS(IW,JW)=TWDS(IW,JW)/TWD(JW)
   41 CONTINUE
      PFUES=FUES/TFUEL
      PFUEM=FUEM/TFUEL
      PFUEL1=FUEL(1)/TFUEL
      PFUEL2=FUEL(2)/TFUEL
      PTPAP=TPAPS/WPAP
      TWRPAD(1)=TWRPAD(2)=TWRPAD(3)=0.
      DO 15 IW=1,3
      DO 15 JW=1,2
      TWRPAD(IW)=TWRPAD(IW)+RWPAD(IW,JW)
   15 CONTINUE
      DO 16 IW=1,3
      DO 16 JW=1,2
      PWRPAD(IW,JW)=RWPAD(IW,JW)/TWRPAD(IW)
   16 CONTINUE
      PULP=WPAP+TWD(3)
      RETURN
      END
```

APPENDIX C

BASE RUN PROJECTION OF INTERMEDIATE VARIABLES, 1965-1990

APPENDIX C

BASE RUN PROJECTION OF INTERMEDIATE VARIABLES, 1965-1990

Population

YEAR	HIGHSCHOOL STUDENTS (TOTAL/YEAR)	COLLEGE STUDENTS (TOTAL/YEAR)	TRADITIONAL POPULATION (RATE/YEAR)	SEMI-TRADITIONAL POPULATION (RATE/YEAR)	NON-TRADITIONAL POPULATION RATE/YEAR)
1965	251425.	7750.	355380.	181171.	7380.
1966	266960.	8979.	349276.	188432.	7227.
1967	280539.	9538.	336030.	187525.	7855.
1968	306089.	9989.	317818.	186758.	9591.
1969	328524.	10906.	297543.	182555.	9499.
1970	352059.	11501.	278920.	181912.	9909.
1971	394344.	12828.	259633.	202547.	10830.
1972	440535.	13534.	240191.	209491.	12297.
1973	583886.	15120.	232557.	214121.	20324.
1974	757235.	18446.	249773.	208412.	21103.
1975	960574.	21546.	256644.	198972.	24201.
1976	1176664.	25760.	255692.	208057.	26829.
1977	1416442.	29715.	251844.	216514.	30094.
1978	1604407.	37434.	249933.	293399.	33887.
1979	1796626.	46061.	243069.	321122.	37295.
1980	2001755.	55402.	232955.	356753.	41365.
1981	2216891.	65677.	228706.	384987.	45111.
1982	2447192.	74878.	240796.	414995.	51087.
1983	2685878.	83483.	244194.	446944.	56171.
1984	2937425.	92810.	241386.	475611.	61770.
1985	3210549.	102128.	240227.	509278.	68790.
1986	3503737.	111786.	249626.	547888.	75822.
1987	3815587.	121752.	251037.	581172.	82854.
1988	4144791.	131951.	246792.	613902.	89936.
1989	4486316.	142451.	243825.	654455.	97181.
1990	4827840.	153868.	249760.	702165.	104475.

Annual Construction of Residential and School Buildings by Population Groups
(No Bldg/Yr)

YEAR	TRADITIONAL RESIDENTIAL	SEMI-TRADI. RESIDENTIAL	NON-TRADI. RESIDENTIAL	TRADI. ELE. SCHOOL	SEMI-TRADI. ELEM.SCHL.	NON-TRADI. ELEM.SCHL.	HIGHSCHOOL	COLLEGE
1965	539844.	91724.	3924.	4157.	1009.	35.	775.	31.
1966	533373.	93645.	3883.	4107.	1030.	35.	736.	63.
1967	520082.	93051.	4236.	4005.	1024.	38.	671.	32.
1968	501495.	92517.	5151.	3862.	1018.	46.	1132.	28.
1969	479955.	90910.	5151.	3696.	1000.	46.	1031.	50.
1970	458897.	90372.	5403.	3534.	994.	48.	1087.	35.
1971	436422.	96569.	5914.	3360.	1062.	53.	1811.	70.
1972	413042.	98604.	6706.	3180.	1085.	60.	1990.	42.
1973	393381.	99979.	10823.	3075.	1100.	96.	5694.	83.
1974	408934.	98126.	11319.	3149.	1079.	101.	6942.	165.
1975	411019.	95060.	12988.	3165.	1046.	116.	8209.	157.
1976	406960.	97781.	14435.	3134.	1076.	128.	8845.	211.
1977	400502.	100361.	16216.	3084.	1104.	144.	9902.	202.
1978	395967.	124889.	18279.	3049.	1374.	163.	8119.	380.
1979	387123.	133952.	20159.	2981.	1473.	179.	8410.	428.
1980	375151.	145864.	22399.	2889.	1605.	199.	9029.	467.
1981	367899.	155653.	24489.	2833.	1712.	218.	9622.	517.
1982	375866.	166143.	27722.	2894.	1828.	247.	10190.	473.
1983	377128.	177397.	30533.	2904.	1951.	272.	10733.	470.
1984	373195.	187784.	31626.	2874.	2066.	299.	11376.	472.
1985	370543.	199876.	37462.	2853.	2199.	333.	12355.	496.
1986	377794.	213687.	41336.	2909.	2351.	368.	13291.	517.
1987	378588.	226005.	45242.	2915.	2486.	403.	14187.	538.
1988	374389.	238273.	49202.	2883.	2621.	438.	15043.	555.
1989	379940.	253158.	53274.	2856.	2785.	474.	15719.	575.
1990	375631.	270488.	57401.	2892.	2975.	511.	15934.	624.

<u>Annual Construction of Other Buildings</u>
<u>(No Bldg/Yr)</u>

YEAR	TRADITIONAL COMMERCIAL	NON-TRADI. COMMERCIAL	TRADITIONAL RELIGIOUS	NON-TRADI. RELIGIOUS	PUBLIC ADMIN.	HOSPITAL	BRIDGE	TRUCK
1965	34550.	14309.	6478.	1101.	335.	719.	516.	618.
1966	34136.	14609.	6400.	1124.	341.	711.	459.	463.
1967	33285.	14516.	6241.	1117.	341.	707.	409.	474.
1968	32096.	14433.	6018.	1110.	342.	697.	387.	448.
1969	30717.	14182.	5759.	1091.	336.	682.	358.	426.
1970	29369.	14098.	5507.	1084.	335.	672.	336.	448.
1971	27931.	15065.	5237.	1159.	359.	661.	330.	641.
1972	26435.	15382.	4957.	1183.	369.	662.	325.	1196.
1973	25560.	15597.	4793.	1200.	388.	659.	424.	1666.
1974	26172.	15308.	4907.	1178.	383.	713.	726.	1739.
1975	26305.	14829.	4932.	1141.	378.	715.	813.	1930.
1976	26045.	15254.	4884.	1173.	393.	718.	901.	2121.
1977	25632.	15656.	4806.	1204.	408.	721.	990.	2312.
1978	25342.	19483.	4752.	1499.	501.	724.	1080.	2503.
1979	24776.	20896.	4645.	1607.	539.	726.	1168.	2717.
1980	24010.	22755.	4502.	1750.	589.	725.	1247.	3002.
1981	23546.	24282.	4415.	1868.	630.	723.	1325.	3287.
1982	24055.	25918.	4510.	1994.	679.	722.	1404.	3572.
1983	24136.	27674.	4526.	2129.	728.	721.	1483.	3857.
1984	23884.	29294.	4478.	2253.	775.	724.	1583.	4182.
1985	23715.	31181.	4447.	2399.	831.	739.	1748.	4626.
1986	24179.	33335.	4534.	2564.	893.	755.	1917.	5070.
1987	24230.	35257.	4543.	2712.	949.	770.	2089.	5514.
1988	23961.	37171.	4493.	2859.	1006.	786.	2264.	5958.
1989	23740.	39493.	4451.	3038.	1073.	803.	2440.	6402.
1990	24049.	42196.	4508.	3246.	1148.	819.	2618.	6846.

Other Intermediate Variables

Year	Management Level Jobs (Openings/Year)	Deaths (Number/Year)	Rural-Urban Migration (Proportion/Year)	Hospital Beds (Number/Year)
1965	6519.	.1083	548.	1000762.
1966	5726.	.1013	599.	1000723.
1967	5639.	.1073	804.	1001112.
1968	7462.	.1173	749.	1005905.
1969	7552.	.1053	511.	1014343.
1970	7788.	.0843	454.	1027540.
1971	8461.	.0903	381.	1041933.
1972	9390.	.0853	759.	1058206.
1973	15040.	.0913	967.	1073548.
1974	16067.	.0871	3314.	1065616.
1975	17881.	.0865	3681.	1091174.
1976	19695.	.0859	4048.	1117704.
1977	21509.	.0853	4416.	1143774.
1978	23323.	.0847	4783.	1170898.
1979	25100.	.0841	5103.	1177472.
1980	26768.	.0831	5284.	1183812.
1981	28436.	.0821	5465.	1190855.
1982	30104.	.0811	5646.	1195195.
1983	31772.	.0801	5827.	1200198.
1984	33919.	.0792	6156.	1205182.
1985	37503.	.0786	6930.	1210768.
1986	41087.	.0780	7705.	1213563.
1987	44671.	.0774	8479.	1217522.
1988	48255.	.0768	9253.	1222286.
1989	51839.	.0762	10028.	1227192.
1990	55423.	.0756	10802.	1230863.

APPENDIX D

BASE RUN PROJECTIONS OF ANNUAL CONSUMPTION OF

DIFFERENT WOOD PRODUCTS IN THE AGGREGATE

AND BY USES, 1965-1990

APPENDIX D

BASE RUN PROJECTIONS OF ANNUAL CONSUMPTION OF DIFFERENT WOOD PRODUCTS IN THE AGGREGATE AND BY USES, 1965-1990

Aggregate Annual Consumption of Different Wood Products

YEAR	FUELWOOD (M3)	UNPROCESSED WOOD(M3)	PROCESSED WOOD(M3)	PULPWOOD (KG)	PAPER PULP (KG)
1965	48162946.	3738820.	652610.	107545.	50397565.
1966	48954324.	3659463.	662463.	109215.	59862935.
1967	49303408.	3521265.	638262.	109350.	42568240.
1968	49092403.	3346380.	620965.	113791.	38595867.
1969	49755737.	3148246.	600932.	111878.	59811758.
1970	49143688.	2972371.	620595.	112308.	80573689.
1971	49281395.	2821464.	668978.	123174.	108274287.
1972	48577956.	2653997.	652771.	128363.	115007249.
1973	48545117.	2583676.	704149.	159538.	153851423.
1974	48670553.	2692846.	777558.	165531.	295632495.
1975	48572173.	2743911.	785596.	173582.	334752442.
1976	48483314.	2741057.	797607.	184056.	378670239.
1977	48390004.	2713275.	813491.	196948.	426127605.
1978	48392108.	2754457.	855304.	220561.	480363967.
1979	48386540.	2720304.	878342.	236994.	541936162.
1980	48335441.	2666239.	912207.	258683.	611006677.
1981	48283176.	2653501.	941844.	277796.	687918288.
1982	48278079.	2787869.	984703.	300737.	774061751.
1983	48312137.	2852831.	1022809.	323130.	869721084.
1984	48361878.	2864496.	1060573.	346113.	985498327.
1985	48417323.	2897171.	1111565.	374828.	1115982922.
1986	48516881.	3030197.	1172358.	405113.	1262265225.
1987	48642674.	3097176.	1223853.	433895.	1425287752.
1988	48770758.	3119698.	1270875.	462635.	1605986720.
1989	48899481.	3161386.	1322003.	493472.	1805529257.
1990	49063704.	3289837.	1377558.	525014.	2025046438.

Annual Wood Consumption in Residential Housing Construction in Absolute Amounts and as Proportions of Overall Consumption

YEAR	UNPROCESSED WOOD ABSOLUTE AMOUNT (M3/YEAR)	UNPROCESSED WOOD RELATIVE PROP. (PROP./YEAR)	PROCESSED WOOD ABSOLUTE AMOUNT (M3/YEAR)	PROCESSED WOOD RELATIVE PROP. (PROP./YEAR)	BUILDING BOARD WOOD PULP ABSOLUTE AMOUNT (KG/YEAR)	BUILDING BOARD WOOD PULP RELATIVE PROP. (PROP./YEAR)
1965	948325.	.2536	483929.	.7415	67982.	.6321
1966	942404.	.2575	495276.	.7476	69001.	.6318
1967	922722.	.2620	475203.	.7445	69808.	.6384
1968	896359.	.2679	454018.	.7311	72510.	.6372
1969	862450.	.2739	438847.	.7303	71545.	.6395
1970	831530.	.2798	460239.	.7416	72053.	.6416
1971	811034.	.2875	493701.	.7380	77458.	.6289
1972	782259.	.2947	473646.	.7256	81291.	.6333
1973	771199.	.2985	468517.	.6654	95705.	.5999
1974	782355.	.2905	521490.	.6707	96227.	.5813
1975	782327.	.2851	512314.	.6521	99898.	.5755
1976	783538.	.2859	510571.	.6401	106306.	.5776
1977	781534.	.2880	507669.	.6241	113730.	.5775
1978	822227.	.2985	549026.	.6419	135254.	.6132
1979	828608.	.3046	558004.	.6353	146897.	.6198
1980	836148.	.3136	570566.	.6255	161437.	.6241
1981	846439.	.3190	580724.	.6166	174205.	.6271
1982	881609.	.3162	603902.	.6133	191169.	.6357
1983	907874.	.3182	621896.	.6080	207197.	.6412
1984	925515.	.3231	638763.	.6023	223635.	.6461
1985	949177.	.3276	660669.	.5944	243550.	.6498
1986	990252.	.3268	690539.	.5890	264622.	.6532
1987	1019386.	.3291	713287.	.5828	284900.	.6566
1988	1041332.	.3338	732313.	.5762	305334.	.6600
1989	1069216.	.3382	755255.	.5713	327699.	.6641
1990	1113314.	.3384	785760.	.5704	351716.	.6699

Annual Wood Consumption in Non-Residential Building Construction in Absolute Amounts and as Proportions of Overall Consumption

YEAR	UNPROCESSED WOOD		PROCESSED WOOD		BUILDING BOAD WOOD PULP	
	ABSOLUTE AMOUNT (M3/YEAR)	RELATIVE PROP. (PROP./YEAR)	ABSOLUTE AMOUNT (M3/YEAR)	RELATIVE PROP. (PROP./YEAR)	ABSOLUTE AMOUNT (K9/YEAR)	RELATIVE PROP. (PROP./YEAR)
1965	29707.	.0079	135828.	.2081	39563.	.3679
1966	29479.	.0081	136845.	.2066	40214.	.3682
1967	28677.	.0081	134077.	.2101	39541.	.3616
1968	28508.	.0085	138920.	.2237	41281.	.3628
1969	27356.	.0087	134720.	.2242	40333.	.3605
1970	26421.	.0089	133353.	.2149	40255.	.3584
1971	26786.	.0095	148143.	.2214	45715.	.3711
1972	26002.	.0098	150636.	.2308	47071.	.3667
1973	31286.	.0121	205367.	.2917	63834.	.4001
1974	33880.	.0126	223973.	.2880	69303.	.4187
1975	35836.	.0131	239805.	.3053	73685.	.4245
1976	36867.	.0134	251971.	.3159	77751.	.4224
1977	38282.	.0141	269149.	.3309	83218.	.4225
1978	36527.	.0133	267137.	.3123	85307.	.3868
1979	36987.	.0136	279517.	.3182	90097.	.3802
1980	37879.	.0142	298833.	.3276	97246.	.3759
1981	38903.	.0147	316344.	.3359	103591.	.3729
1982	40377.	.0145	334056.	.3392	109568.	.3643
1983	41630.	.0146	352119.	.3443	115934.	.3588
1984	42795.	.0149	370614.	.3494	122478.	.3539
1985	44667.	.0154	396009.	.3563	131279.	.3502
1986	46971.	.0155	422957.	.3608	140490.	.3468
1987	48869.	.0158	447539.	.3657	148994.	.3434
1988	50472.	.0162	471145.	.3707	157301.	.3400
1989	51918.	.0164	494537.	.3741	165773.	.3359
1990	53168.	.0162	514362.	.3734	173298.	.3301

Annual Consumption of Processed Wood for Casket Manufacture and Truck and Bridge Construction, In Absolute Amounts and as Proportions of Overall Consumption

YEAR	CASKET MANUFACTURE ABSOLUTE AMOUNT (M3/YEAR)	CASKET MANUFACTURE RELATIVE PROP. (PROP./YEAR)	TRUCK CONSTRUCTION ABSOLUTE AMOUNT (M3/YEAR)	TRUCK CONSTRUCTION RELATIVE PROP. (PROP./YEAR)	BRIDGE CONSTRUCTION ABSOLUTE AMOUNT (M3/YEAR)	BRIDGE CONSTRUCTION RELATIVE PROP. (PROP./YEAR)
1965	20315.	.0311	1886.	.0029	1589.	.0024
1966	20315.	.0307	1412.	.0021	1412.	.0021
1967	20323.	.0318	1446.	.0023	1258.	.0020
1968	20420.	.0329	1367.	.0022	1193.	.0019
1969	20591.	.0343	1300.	.0022	1104.	.0018
1970	20859.	.0336	1367.	.0022	1036.	.0017
1971	21151.	.0316	1954.	.0029	1016.	.0015
1972	21482.	.0329	3647.	.0056	1002.	.0015
1973	21793.	.0309	5080.	.0072	1305.	.0019
1974	21632.	.0278	5305.	.0068	2238.	.0029
1975	22151.	.0282	5887.	.0075	2504.	.0032
1976	22689.	.0284	6469.	.0081	2775.	.0035
1977	23219.	.0285	7052.	.0087	3049.	.0037
1978	23769.	.0278	7634.	.0089	3326.	.0039
1979	23903.	.0272	8288.	.0094	3597.	.0041
1980	24031.	.0263	9157.	.0100	3839.	.0042
1981	24174.	.0257	10026.	.0106	4082.	.0043
1982	24262.	.0246	10895.	.0111	4325.	.0044
1983	24364.	.0238	11764.	.0115	4567.	.0045
1984	24465.	.0231	12754.	.0120	4876.	.0046
1985	24579.	.0221	14108.	.0127	5385.	.0048
1986	24635.	.0210	15462.	.0132	5905.	.0050
1987	24716.	.0202	16816.	.0137	6435.	.0053
1988	24812.	.0195	18171.	.0143	6972.	.0055
1989	24912.	.0188	19525.	.0148	7515.	.0057
1990	24987.	.0181	20879.	.0152	8062.	.0059

Annual Consumption of Wood for Farm Construction
in Absolute Amounts and as Proportions
of Overall Consumption

YEAR	UNPROCESSED WOOD ABSOLUTE AMOUNT (M3/YEAR	UNPROCESSED WOOD RELATIVE PROP.(PROP./YR	PROCESSED WOOD ABSOLUTE AMOUNT (M3/YEAR	PROCESSED WOOD RELATIVE PROP.(PROP./YR
1965	2760788.	.7384	9063.	.0139
1966	2687580.	.7344	7203.	.0109
1967	2569866.	.7298	5955.	.0093
1968	2421512.	.7236	5047.	.0081
1969	2258440.	.7174	4370.	.0073
1970	2114420.	.7114	3741.	.0060
1971	1983593.	.7030	3012.	.0045
1972	1845736.	.6955	2358.	.0036
1973	1781191.	.6894	2087.	.0030
1974	1876610.	.6969	2920.	.0038
1975	1925749.	.7018	2935.	.0037
1976	1920652.	.7007	3132.	.0039
1977	1893459.	.6978	3354.	.0041
1978	1895703.	.6882	4412.	.0052
1979	1854708.	.6818	5034.	.0057
1980	1792212.	.6722	5780.	.0063
1981	1768159.	.6663	6493.	.0069
1982	1865883.	.6693	7263.	.0074
1983	1903326.	.6672	8099.	.0079
1984	1896176.	.6620	9101.	.0086
1985	1903327.	.6570	10816.	.0097
1986	1992964.	.6577	12860.	.0110
1987	2028921.	.6551	15061.	.0123
1988	2027884.	.6500	17462.	.0137
1989	2040251.	.6454	20259.	.0153
1990	2123354.	.6454	23508.	.0171

Annual Consumption of Fuelwood by Market and Non-Market Sources in Absolute Amounts and as Proportions of Overall Consumption

YEAR	FUELWOOD FROM MARKET SOURCES ABSOLUTE AMOUNT (M3/YR)	RELATIVE PROP. (PROP./YR)	FUELWOOD FROM NON-MARKET SOURCES ABSOLUTE AMOUNT (M3/YR)	RELATIVE PROP. (PROP./YR)
1965	9124551.	.1895	39038395.	.8105
1966	9759226.	.1994	39195097.	.8006
1967	9982666.	.2025	39320742.	.7975
1968	9691201.	.1974	39401203.	.8026
1969	10328138.	.2076	39427600.	.7924
1970	9739770.	.1982	39403918.	.8018
1971	9948297.	.2019	39333098.	.7981
1972	9363523.	.1928	39214334.	.8072
1973	9488705.	.1955	39056412.	.8045
1974	9735712.	.2000	38934840.	.8000
1975	9729645.	.2003	38842527.	.7997
1976	9726154.	.2006	38757160.	.7994
1977	9725854.	.2010	38664150.	.7990
1978	9815259.	.2028	38576849.	.7972
1979	9906115.	.2047	38480425.	.7953
1980	9969309.	.2063	38366132.	.7937
1981	10050610.	.2082	38232567.	.7918
1982	10148593.	.2102	38129486.	.7898
1983	10263877.	.2124	38048259.	.7876
1984	10391914.	.2149	37969964.	.7851
1985	10531800.	.2175	37885523.	.7825
1986	10689072.	.2203	37827809.	.7797
1987	10857063.	.2232	37785611.	.7768
1988	11029243.	.2261	37741514.	.7739
1989	11211386.	.2293	37688095.	.7707
1990	11410257.	.2326	37653447.	.7674

APPENDIX E

BASE RUN PROJECTIONS OF ANNUAL CONSUMPTION OF

VARIOUS WOOD PRODUCTS BY WOOD CONSUMPTION

POPULATION GROUPS, 1965-1990

APPENDIX E

BASE RUN PROJECTIONS OF ANNUAL CONSUMPTION OF VARIOUS WOOD PRODUCTS BY WOOD CONSUMPTION POPULATION GROUPS, 1965-1990

Annual Consumption of Unprocessed Wood by Wood Consumption Groups in Absolute Amounts and as Proportions of Overall Consumption

YEAR	TRADITIONAL		SEMI-TRADITIONAL		NON-TRADITIONAL		NON-SPECIFIC	
	ABSOLUTE AMT(M3/YR)	RELATIVE PROP./YR	ABSOLUTE AMT(M3/YR)	RELATIVE PROP./YR	ABSOLUTE AMT(M3/YR)	RELATIVE PROP./YR	ABSOLUTE AMT(M3/YR)	RELATIVE PROP./YR
1965	3407923.	.9115	322224.	.0862	5846.	.0016	2828.	.0008
1966	3355917.	.9171	294917.	.0806	5786.	.0016	2843.	.0008
1967	3240724.	.9203	271570.	.0771	6311.	.0018	2661.	.0008
1968	3080907.	.9207	254448.	.0760	7675.	.0023	3349.	.0010
1969	2897307.	.9203	240046.	.0762	7675.	.0024	3217.	.0010
1970	2731202.	.9189	229868.	.0773	8050.	.0027	3251.	.0011
1971	2578378.	.9138	229795.	.0814	8812.	.0031	4478.	.0016
1972	2417736.	.9110	221568.	.0835	9992.	.0038	4703.	.0018
1973	2337957.	.9049	213021.	.0848	16127.	.0062	10571.	.0041
1974	2431276.	.9029	231926.	.0861	16865.	.0063	12779.	.0047
1975	2483588.	.9051	226251.	.0825	19353.	.0071	14719.	.0054
1976	2469293.	.9009	234391.	.0855	21509.	.0078	15864.	.0058
1977	2428914.	.8952	242692.	.0894	24162.	.0089	17506.	.0065
1978	2406171.	.8736	305727.	.1110	27236.	.0099	15324.	.0056
1979	2341505.	.8608	332810.	.1223	30037.	.0110	15952.	.0059
1980	2248608.	.8434	367176.	.1377	33375.	.0125	17079.	.0064
1981	2201868.	.8298	396964.	.1496	36488.	.0138	18180.	.0069
1982	2298652.	.8245	428890.	.1538	41306.	.0148	19022.	.0068
1983	2324152.	.8147	463257.	.1624	45494.	.0159	19927.	.0070
1984	2294406.	.8010	498975.	.1742	50102.	.0175	21002.	.0073
1985	2268773.	.7831	549897.	.1898	55818.	.0193	22683.	.0078
1986	2334887.	.7705	609408.	.2011	61591.	.0203	24301.	.0080
1987	2335279.	.7540	668642.	.2159	67410.	.0218	25845.	.0083
1988	2288098.	.7334	730958.	.2343	73311.	.0235	27322.	.0088
1989	2249977.	.7114	804490.	.2545	79379.	.0251	28541.	.0090
1990	2285358.	.6947	889821.	.2705	85527.	.0260	29130.	.0089

Annual Consumption of Processed Wood by Wood Consumption Groups in Absolute Amounts and as Proportions of Overall Consumption

YEAR	TRADITIONAL ABSOLUTE AMT (M3/YR)	TRADITIONAL RELATIVE PROP./YR	SEMI-TRADITIONAL ABSOLUTE AMT (M3/YR)	SEMI-TRADITIONAL RELATIVE PROP./YR	NON-TRADITIONAL ABSOLUTE AMT (M3/YR)	NON-TRADITIONAL RELATIVE PROP./YR	NON-SPECIFIC ABSOLUTE AMT (M3/YR)	NON-SPECIFIC RELATIVE PROP./YR
1965	359550.	.5509	235795.	.3613	11444.	.0175	45821.	.0702
1966	360275.	.5438	245662.	.3708	11492.	.0173	45035.	.0680
1967	346388.	.5427	235966.	.3697	12354.	.0194	43553.	.0682
1968	329275.	.5303	226844.	.3653	14805.	.0238	50042.	.0806
1969	315132.	.5244	222315.	.3699	14805.	.0246	48681.	.0810
1970	314301.	.5065	240600.	.3877	16221.	.0261	49474.	.0797
1971	311268.	.4653	277704.	.4151	18515.	.0277	61491.	.0919
1972	290593.	.4453	275491.	.4220	20706.	.0317	65881.	.1009
1973	277309.	.3938	271578.	.3857	32957.	.0468	122304.	.1737
1974	300155.	.3860	298130.	.3834	36498.	.0469	142775.	.1836
1975	298581.	.3801	283253.	.3606	41438.	.0527	162323.	.2066
1976	292560.	.3668	285646.	.3581	45561.	.0571	173841.	.2180
1977	294592.	.3502	287338.	.3532	50626.	.0622	190635.	.2343
1978	278676.	.3258	350353.	.4096	56441.	.0660	169835.	.1986
1979	270259.	.3077	370090.	.4214	61730.	.0703	176263.	.2007
1980	259777.	.2848	396775.	.4350	68015.	.0746	187637.	.2057
1981	252671.	.2683	416772.	.4425	73731.	.0783	198670.	.2109
1982	256013.	.2600	437759.	.4446	82755.	.0840	208175.	.2114
1983	254737.	.2491	459826.	.4496	90362.	.0883	217884.	.2130
1984	250671.	.2364	481679.	.4542	98940.	.0933	229283.	.2162
1985	247491.	.2227	507864.	.4569	109587.	.0986	246623.	.2219
1986	250907.	.2140	537885.	.4588	120214.	.1025	263352.	.2246
1987	250005.	.2043	563613.	.4605	130797.	.1069	279438.	.2283
1988	245818.	.1934	588700.	.4632	141406.	.1113	294951.	.2321
1989	242153.	.1832	619620.	.4687	152198.	.1151	308032.	.2330
1990	243798.	.1770	655835.	.4761	163006.	.1183	314920.	.2286

Annual Consumption of Building Board Woodpulp by
Wood Consumption Groups in Absolute Amounts
and as Proportions of Overall Consumption

YEAR	TRADITIONAL		SEMI-TRADITIONAL		NON-TRADITIONAL		NON-SPECIFIC	
	ABSOLUTE AMT(KG/YR)	RELATIVE PROP./YR	ABSOLUTE AMT(KG/YR)	RELATIVE PROP./YR	ABSOLUTE AMT(KG/YR)	RELATIVE PROP./YR	ABSOLUTE AMT(KG/YR)	RELATIVE PROP./YR
1965	.	.0000	85766.	.7975	12996.	.1208	8783.	.0817
1966	.	.0000	87562.	.8017	12861.	.1178	8791.	.0805
1967	.	.0000	87007.	.7957	14029.	.1283	8313.	.0760
1968	.	.0000	86508.	.7602	17062.	.1499	10220.	.0898
1969	.	.0000	85005.	.7598	17062.	.1525	9811.	.0877
1970	.	.0000	84502.	.7524	17896.	.1593	9910.	.0882
1971	.	.0000	90296.	.7331	19590.	.1590	13288.	.1079
1972	.	.0000	92199.	.7183	22211.	.1730	13953.	.1087
1973	.	.0000	93485.	.5860	35850.	.2247	30204.	.1893
1974	.	.0000	91752.	.5543	37490.	.2265	36288.	.2192
1975	.	.0000	88885.	.5121	43021.	.2478	41677.	.2401
1976	.	.0000	91430.	.4967	47814.	.2598	44813.	.2435
1977	.	.0000	93842.	.4765	53711.	.2727	49395.	.2508
1978	.	.0000	116776.	.5295	60544.	.2745	43240.	.1960
1979	.	.0000	125251.	.5285	66773.	.2817	44971.	.1898
1980	.	.0000	136389.	.5272	74192.	.2868	48101.	.1859
1981	.	.0000	145543.	.5239	81112.	.2920	51140.	.1841
1982	.	.0000	155351.	.5166	91822.	.3053	53563.	.1781
1983	.	.0000	165875.	.5133	101132.	.3130	56124.	.1737
1984	.	.0000	175587.	.5073	111376.	.3218	59151.	.1709
1985	.	.0000	185893.	.4986	124083.	.3310	63853.	.1704
1986	.	.0000	199807.	.4932	136916.	.3380	68390.	.1688
1987	.	.0000	211325.	.4870	149851.	.3454	72719.	.1676
1988	.	.0000	222801.	.4816	162969.	.3523	76865.	.1661
1989	.	.0000	236714.	.4797	176457.	.3576	80302.	.1627
1990	.	.0000	252919.	.4817	190126.	.3621	81970.	.1561

Annual Consumption of Fuelwood by Wood Consumption Groups in Absolute Amounts and as Proportions of Overall Consumption

YEAR	FUELWOOD BY TRADITIONAL GROUP ABSOLUTE AMOUNT (AMT M3/YR)	RELATIVE PROP./YR	FUELWOOD BY SEMI-TRADITIONAL GROUP ABSOLUTE AMOUNT (AMT M3/YR)	RELATIVE PROP./YR
1965	41268713.	.8569	6894233.	.1431
1966	41586383.	.8495	7367941.	.1505
1967	41738076.	.8466	7565332.	.1534
1968	41680556.	.8490	7411947.	.1510
1969	41860446.	.8413	7895292.	.1587
1970	41612006.	.8467	7531682.	.1533
1971	41552753.	.8432	7728640.	.1568
1972	41201073.	.8481	7376783.	.1519
1973	41021108.	.8450	7524009.	.1550
1974	40917153.	.8407	7753400.	.1593
1975	40775508.	.8395	7796664.	.1605
1976	40641034.	.8382	7842280.	.1618
1977	40498038.	.8369	7891966.	.1631
1978	40353096.	.8339	8039012.	.1661
1979	40191543.	.8306	8194997.	.1694
1980	39993536.	.8274	8341905.	.1726
1981	39772740.	.8237	8510436.	.1763
1982	39582136.	.8199	8695943.	.1801
1983	39412211.	.8158	8899926.	.1842
1984	39243082.	.8114	9118796.	.1886
1985	39065052.	.8068	9352272.	.1932
1986	38912180.	.8020	9604701.	.1980
1987	38772992.	.7971	9869683.	.2029
1988	38629556.	.7921	10141202.	.2079
1989	38473256.	.7868	10426225.	.2132
1990	38332703.	.7813	10731001.	.2187

Annual Consumption of Paper Pulp by Income Groups
in Absolute Amounts and as Proportions
of Overall Consumption

YEAR	LOW INCOME GROUP ABSOLUTE AMTS(KG/YR)	LOW INCOME GROUP RELATIVE PROP./YR	MEDIUM INCOME GROUP ABSOLUTE AMTS(KG/YR)	MEDIUM INCOME GROUP RELATIVE PROP./YR	HIGH INCOME GROUP ABSOLUTE AMTS(KG/YR)	HIGH INCOME GROUP RELATIVE PROP./YR	STUDENT GROUP ABSOLUTE AMTS(KG/YR)	STUDENT GROUP RELATIVE PROP./YR
1965	502232.	.0100	20097302.	.3988	26138277.	.5186	3659754.	.0726
1966	504149.	.0084	21251339.	.3550	34014015.	.5682	4093431.	.0684
1967	505664.	.0119	21655079.	.5087	16367596.	.3845	4039901.	.0949
1968	506591.	.0131	21587357.	.5593	12281132.	.3182	4220787.	.1094
1969	506821.	.0085	23339163.	.3902	30958068.	.5176	5007706.	.0837
1970	506410.	.0063	24837039.	.3083	49419359.	.6133	5810881.	.0721
1971	505363.	.0047	25960830.	.2398	74808439.	.6909	6999655.	.0646
1972	503681.	.0044	26538775.	.2308	80195353.	.6973	7769440.	.0676
1973	501481.	.0033	30509094.	.1983	111530514.	.7249	11310335.	.0735
1974	499762.	.0017	36704669.	.1242	239255893.	.8093	19172172.	.0649
1975	499438.	.0015	38939027.	.1163	270419575.	.8078	24895402.	.0744
1976	497199.	.0013	41252373.	.1091	304599623.	.8057	31721044.	.0839
1977	495855.	.0012	43658307.	.1025	342513880.	.8038	39459564.	.0926
1978	494484.	.0010	46704540.	.0972	384909698.	.8013	48255245.	.1005
1979	492966.	.0009	53126676.	.0980	427870498.	.7895	60446021.	.1115
1980	491176.	.0008	60139815.	.0984	475921204.	.7789	74454483.	.1219
1981	489100.	.0007	67765616.	.0985	529173878.	.7692	90489694.	.1315
1982	487391.	.0006	76038915.	.0982	589868568.	.7620	107666877.	.1391
1983	485932.	.0006	85043973.	.0978	657777386.	.7563	126413793.	.1453
1984	484479.	.0005	93779038.	.0952	744650592.	.7556	146584219.	.1487
1985	482912.	.0004	103264606.	.0925	843122201.	.7555	169113203.	.1515
1986	481653.	.0004	113622482.	.0900	954098786.	.7559	194062305.	.1537
1987	480560.	.0003	124858568.	.0876	1078457811.	.7567	221490813.	.1554
1988	479411.	.0003	136969451.	.0853	1217116076.	.7579	251421781.	.1566
1989	478100.	.0003	150123851.	.0831	1371119255.	.7594	283808051.	.1572
1990	475981.	.0002	164511520.	.0812	1541384352.	.7612	318673585.	.1574

APPENDIX F

PROJECTIONS OF ANNUAL CONSUMPTION OF DIFFERENT WOOD PRODUCTS BY USES UNDER ALTERNATIVE ASSUMPTIONS ABOUT THE RATES OF GROWTH OF GDP, 1975-1990

APPENDIX F

PROJECTIONS OF ANNUAL CONSUMPTION OF DIFFERENT WOOD PRODUCTS BY USES UNDER ALTERNATIVE ASSUMPTIONS ABOUT THE RATES OF GROWTH OF GDP, 1975-1990

Wood for Residential Housing Construction

Year	Unprocessed Wood (M^3/year)		Processed Wood (M^3/year)		Building Board Wood Pulp (kg/year)	
	6% Alt.	15% Alt.	6% Alt.	15% Alt.	6% Alt.	15% Alt.
1975	782327.	782327.	512314.	512314.	99898.	99898.
1976	783538.	783538.	510571.	510571.	106306.	106306.
1977	781534.	781534.	507669.	507669.	113730.	113730.
1978	822227.	822227.	549026.	549026.	135254.	135254.
1979	828593.	828563.	557731.	557985.	146397.	146924.
1980	836072.	835926.	569188.	570484.	158931.	161575.
1981	846292.	846045.	578207.	580594.	159569.	174459.
1982	881382.	881051.	600213.	603741.	184577.	191544.
1983	907498.	917207.	616908.	621795.	198437.	207770.
1984	921841.	925612.	629065.	640320.	210830.	226149.
1985	933275.	952203.	637093.	667943.	221891.	252585.
1986	951886.	996273.	653219.	703567.	233947.	280297.
1987	978305.	1028460.	662357.	732084.	245073.	307276.
1988	987448.	1053586.	667972.	757030.	256099.	334666.
1989	1001628.	1091413.	676615.	791916.	268000.	366807.
1990	1029589.	1165167.	689849.	850747.	279859.	407445.

Wood for Residential Housing Construction as
Proportions of Overall Wood Requirements

Year	Unprocessed Wood (Proportion/year) 6% Alt.	Unprocessed Wood (Proportion/year) 15% Alt.	Processed Wood (Proportion/year) 6% Alt.	Processed Wood (Proportion/year) 15% Alt.	Building Board Wood Pulp (Proportion/year) 6% Alt.	Building Board Wood Pulp (Proportion/year) 15% Alt.
1975	.2851	.2851	.6521	.6521	.5755	.5755
1976	.2859	.2859	.6491	.6491	.5776	.5776
1977	.2880	.2880	.6241	.6241	.5775	.5775
1978	.2985	.2985	.6419	.6419	.6132	.6132
1979	.3046	.3046	.6381	.6347	.6220	.6192
1980	.3139	.3135	.6387	.6226	.6345	.6211
1981	.3193	.3188	.6391	.6118	.6445	.6222
1982	.3166	.3159	.6439	.6069	.6590	.6292
1983	.3187	.3177	.6456	.6003	.6694	.6336
1984	.3230	.3224	.6453	.5892	.6771	.6349
1985	.3256	.3269	.6335	.5669	.6798	.6279
1986	.3232	.3262	.6359	.5490	.6921	.6236
1987	.3244	.3285	.6312	.5335	.6946	.6210
1988	.3284	.3330	.6258	.5196	.6869	.6199
1989	.3323	.3382	.6210	.5115	.6889	.6229
1990	.3312	.3414	.6190	.5148	.6919	.6326

Wood for Farm Construction

Year	Unprocessed Wood (M^3/year)		Processed Wood (M^3/year)	
	6% Alt.	15% Alt.	6% Alt.	15% Alt.
1975	1925749.	1925749.	2935.	2935.
1976	1920652.	1920652.	3132.	3132.
1977	1893459.	1893459.	3354.	3354.
1978	1895703.	1895703.	4412.	4412.
1979	1854795.	1854534.	5040.	5058.
1980	1792683.	1791741.	5813.	5920.
1981	1769095.	1767985.	6558.	6780.
1982	1867340.	1866166.	7363.	7728.
1983	1905360.	1904745.	8239.	8779.
1984	1897375.	1899423.	9059.	10012.
1985	1897753.	1908910.	9827.	11956.
1986	1977421.	2000839.	10688.	14263.
1987	1999876.	2039696.	11504.	16741.
1988	1981587.	2042273.	12333.	19442.
1989	1974378.	2063765.	13294.	22893.
1990	2038057.	2173474.	14305.	27940.

Wood for Farm Construction as Proportions of Overall Wood Requirements

Year	Unprocessed Wood (Prop./year)		Processed Wood (Prop./year)	
	6% Alt.	15% Alt.	6% Alt.	15% Alt.
1975	.7018	.7018	.0037	.0037
1976	.7007	.7007	.0039	.0039
1977	.6978	.6978	.0041	.0041
1978	.6882	.6882	.0052	.0052
1979	.6819	.6818	.0058	.0058
1980	.6728	.6721	.0065	.0065
1981	.6674	.6662	.0072	.0071
1982	.6708	.6692	.0079	.0078
1983	.6691	.6671	.0086	.0085
1984	.6648	.6617	.0093	.0092
1985	.6621	.6554	.0099	.0101
1986	.6645	.6551	.0104	.0111
1987	.6632	.6515	.0110	.0122
1988	.6590	.6456	.0116	.0133
1989	.6550	.6395	.0122	.0148
1990	.6562	.6368	.0128	.0169

Wood for Non-Residential Building Construction

Year	Unprocessed Wood (M^3/year)		Processed Wood (M^3/year		Building Board Wood Pulp (kg/year)	
	6% Alt.	15% Alt.	6% Alt.	15% Alt.	6% Alt.	15% Alt.
1975	35836.	35836.	239405.	239405.	73685.	73685.
1976	36867.	36867.	251971.	251971.	77751.	77751.
1977	38282.	38282.	269149.	269149.	83218.	83218.
1978	36527.	36527.	267137.	267137.	85307.	85307.
1979	36560.	37087.	275646.	280397.	88949.	90366.
1980	35761.	38373.	279669.	303186.	91565.	98577.
1981	35179.	39772.	282657.	323999.	93607.	105931.
1982	35126.	41602.	286568.	344852.	95499.	112867.
1983	34930.	43190.	291519.	365895.	97989.	120142.
1984	34755.	45575.	297043.	395657.	100542.	130072.
1985	35432.	51345.	308427.	457136.	104537.	149695.
1986	36587.	57356.	321680.	518429.	109036.	169206.
1987	37378.	62783.	332837.	575736.	112901.	187524.
1988	37929.	67739.	343447.	630434.	116711.	205165.
1989	38511.	71877.	355044.	580882.	121012.	222102.
1990	39237.	74274.	364733.	718973.	124605.	236673.

Wood for Non-Residential Building Construction as Proportions of Overall Wood Requirements

Year	Unprocessed Wood (Prop./year)		Processed Wood (Prop./year)		Building Board Wood Pulp (Prop./year)	
	6% Alt.	15% Alt.	6% Alt.	15% Alt.	6% Alt.	15% Alt.
1975	.0131	.0131	.3053	.3053	.4245	.4245
1976	.0134	.0134	.3159	.3159	.4224	.4224
1977	.0141	.0141	.3309	.3309	.4225	.4225
1978	.0133	.0133	.3123	.3123	.3868	.3968
1979	.0134	.0136	.3154	.3189	.3780	.3838
1980	.0134	.0144	.3138	.3309	.3655	.3789
1981	.0133	.0150	.3124	.3414	.3555	.3778
1982	.0126	.0149	.3074	.3466	.3410	.3708
1983	.0123	.0151	.3051	.3532	.3306	.3664
1984	.0122	.0159	.3047	.3641	.3229	.3651
1985	.0124	.0176	.3096	.3874	.3202	.3721
1986	.0123	.0189	.3131	.4045	.3179	.3764
1987	.0124	.0201	.3172	.4195	.3154	.3790
1988	.0125	.0214	.3218	.4327	.3131	.3801
1989	.0128	.0223	.3259	.4398	.3111	.3771
1990	.0126	.0218	.3273	.4351	.3081	.3674

Processed Wood for Casket Manufacture, and Vehicle and Bridge Construction

Year	Processed Wood for Casket Manufacture (M^3/year)		Processed Wood for Truck Construction (M^3/year)		Processed Wood for Bridge Construction (M^3/year)	
	6% Alt.	15% Alt.	6% Alt.	15% Alt.	6% Alt.	15% Alt.
1975	22151.	22151.	5887.	5887.	2504.	2504.
1976	22683.	22689.	6469.	6469.	2775.	2775.
1977	23219.	23219.	7052.	7052.	3049.	3049.
1978	23769.	23769.	7634.	7634.	3326.	3326.
1979	23965.	23902.	8192.	8203.	3579.	3607.
1980	24045.	24028.	8680.	8731.	3751.	3892.
1981	24209.	24167.	9168.	9259.	3919.	4178.
1982	24329.	24248.	9655.	9787.	4085.	4465.
1983	24468.	24341.	10143.	10315.	4249.	4754.
1984	24615.	24428.	10666.	11107.	4424.	5150.
1985	24776.	24507.	11295.	12689.	4638.	5870.
1986	24884.	24506.	11925.	14271.	4852.	6609.
1987	25019.	24509.	12555.	15853.	5067.	7363.
1988	25170.	24509.	13184.	17435.	5283.	8130.
1989	25321.	24500.	13814.	19018.	5500.	8906.
1990	25446.	24469.	14444.	20600.	5717.	9691.

<u>Processed Wood for Casket Manufacture, and Vehicle and Bridge Construction as Proportions of Overall Requirements of Processed Wood</u>

Year	Processed Wood for Casket Manufacture (Prop./year)		Processed Wood for Truck Construction (Prop./year)		Processed Wood for Bridge Construction (Prop./year)	
	6% Alt.	15% Alt.	6% Alt.	15% Alt.	6% Alt.	15% Alt.
1975	.0282	.0282	.0075	.0075	.0032	.0032
1976	.0284	.0284	.0081	.0081	.0035	.0035
1977	.0285	.0285	.0087	.0087	.0037	.0037
1978	.0278	.0278	.0089	.0089	.0039	.0039
1979	.0273	.0272	.0094	.0093	.0041	.0041
1980	.0270	.0262	.0097	.0095	.0042	.0042
1981	.0268	.0255	.0101	.0098	.0043	.0044
1982	.0261	.0244	.0104	.0098	.0044	.0045
1983	.0256	.0235	.0106	.0100	.0044	.0046
1984	.0252	.0225	.0109	.0102	.0045	.0047
1985	.0249	.0208	.0113	.0108	.0047	.0050
1986	.0242	.0191	.0116	.0111	.0047	.0052
1987	.0238	.0179	.0120	.0116	.0048	.0054
1988	.0236	.0168	.0124	.0120	.0049	.0056
1989	.0232	.0158	.0127	.0123	.0050	.0058
1990	.0228	.0148	.0130	.0125	.0051	.0059

Annual Consumption of Fuelwood by Market and Non-Market Sources, Absolute Amounts and as Proportions of Overall Consumption

Year	FUELWOOD FROM NON-MARKET SOURCES				FUELWOOD FROM MARKET SOURCES			
	6% Alt.		15% Alt.		6% Alt.		15% Alt.	
	M^3/year	Prop./year	M^3/year	Prop./year	M^3/year	Prop./yr	M^3/year	Prop./year
1975	38842527.	.7997	38842527.	.7997	9729645.	.2003	9729645.	.2003
1976	38757160.	.7994	38757160.	.7994	9726154.	.2006	9726154.	.2006
1977	38664150.	.7990	38664150.	.7990	9725854.	.2010	9725854.	.2010
1978	38576849.	.7972	38576849.	.7972	9815259.	.2028	9815259.	.2028
1979	38480467.	.7953	38480385.	.7953	9906628.	.2047	9906014.	.2047
1980	38366382.	.7937	38365896.	.7938	9972310.	.2063	9968722.	.2062
1981	38233186.	.7917	38231984.	.7919	10057885.	.2083	10049210.	.2081
1982	38130630.	.7896	38128411.	.7898	10161751.	.2104	10146105.	.2102
1983	38050072.	.7872	38046554.	.7876	10284310.	.2128	10260113.	.2124
1984	37972217.	.7847	37967522.	.7852	10415671.	.2153	10386892.	.2148
1985	37886924.	.7823	37882287.	.7826	10540408.	.2177	10525725.	.2174
1986	37827091.	.7801	37823728.	.7798	10665591.	.2199	10682165.	.2202
1987	37781525.	.7779	37780637.	.7769	10785993.	.2221	10849573.	.2231
1988	37732827.	.7759	37735614.	.7740	10896501.	.2241	11021517.	.2260
1989	37673688.	.7740	37682327.	.7706	11003247.	.2260	11214612.	.2294
1990	37633646.	.7721	37651812.	.7666	11108305.	.2279	11466493.	.2334

Annual Consumption of Paper Woodpulp
(kg/year)

Year	6% Alternative	15% Alternative
1975	334752442.	334752442.
1976	378070239.	378070239.
1977	426127605.	426127605.
1978	480363967.	480363967.
1979	541483581.	542022199.
1980	608130513.	611551935.
1981	680375511.	689339005.
1982	759353932.	776813150.
1983	845087433.	874311739.
1984	947162435.	993999419.
1985	1059292341.	1135251032.
1986	1179021702.	1299906119.
1987	1303773445.	1489615714.
1988	1450910657.	1706052981.
1989	1602834281.	1951441675.
1990	1765942878.	2228269306.

Overall Annual Wood Requirements Under Alternative Rates of Growth of GDP, 1975-1990

Year	Unprocessed Wood (M^3/year)		Processed Wood (M^3/year)		Building Board Wood Pulp (kg/year)		Fuelwood (M^3/year)		Paper Pulp (kg/year)	
	6% Alt.	15% Alt.	6% Alt.	15% Alt.	6% Alt.	15% Alt.	6% Alt.	15% Alt.	6% Alt.	15% Alt.
1975	2743311.	2743311.	785596.	785596.	173582.	173582.	48572173.	48572173.	334752442.	334752442.
1976	2741357.	2741057.	797607.	797607.	184056.	184055.	48483314.	48483314.	378070239.	378370239.
1977	2713275.	2713275.	813491.	913491.	196349.	196948.	48392004.	48392004.	426127605.	426127605.
1978	2754457.	2754457.	855304.	955304.	220561.	220561.	48392109.	48392108.	480363967.	480363967.
1979	2719949.	2720195.	874093.	879152.	235347.	237291.	48387095.	48386399.	541493581.	542022199.
1980	2664515.	2665040.	831146.	916241.	250495.	260152.	48338693.	48334619.	608130513.	611551935.
1981	2650565.	2653993.	954718.	948977.	263276.	280396.	48291072.	48281194.	690375511.	689339005.
1982	2783949.	2788819.	972213.	994822.	280076.	304411.	48292381.	48274516.	759353932.	776913150.
1983	2847799.	2855142.	955526.	1035881.	296426.	327912.	48334381.	48306667.	845097433.	874311739.
1984	2859970.	2972609.	974971.	1086674.	311372.	356219.	48387887.	48354414.	947152435.	993999419.
1985	2866461.	2912459.	936062.	1190101.	326429.	402280.	48427332.	48409012.	1058292341.	1135251032.
1986	2975994.	3054469.	1027249.	1291645.	342983.	449494.	48492682.	48505893.	1179021702.	1299306119.
1987	3015559.	3130939.	1049338.	1372287.	357974.	494800.	48567517.	48630210.	1309773445.	1489515714.
1988	3005364.	3163538.	1067389.	1457040.	372810.	539832.	48629328.	48757130.	1450910657.	1706052981.
1989	3014518.	3227054.	1099599.	1549115.	389012.	588909.	48676934.	48896938.	1602934281.	1951441675.
1990	3105993.	3412915.	1114493.	1652420.	404464.	644118.	48741951.	49118305.	1765942878.	2228269306.

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