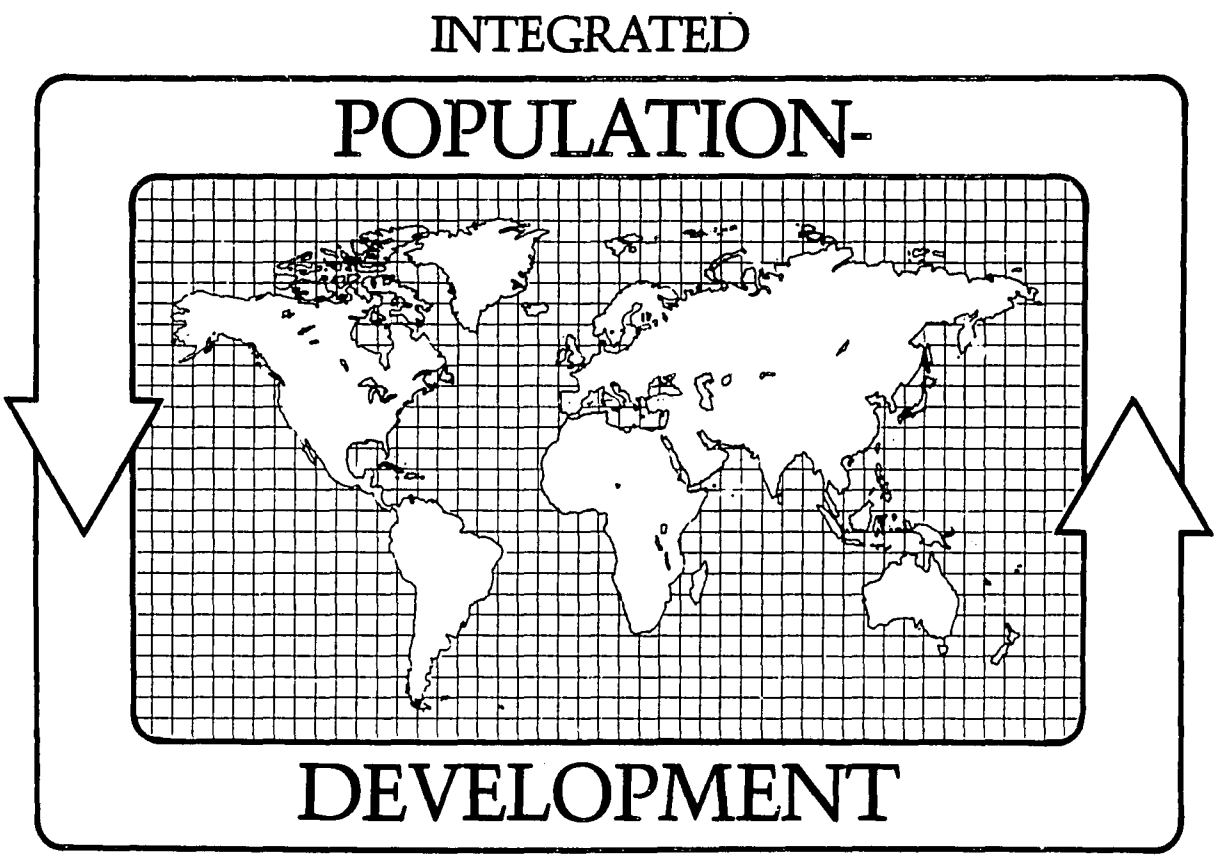
Regional Planning Model for Arusha, Tanzania



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PD-AAP-054
ISN-34401

932 0055/62

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A REGIONAL PLANNING MODEL FOR ARUSHA, TANZANIA
Version 1

September 1982

by

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Research Triangle Institute

INTEGRATED POPULATION-DEVELOPMENT PLANNING
Project Number AID/DSPE-C-0062

Under Contract to

Policy Development Division
Office of Population
Bureau for Technology and Science
Jnited States Agency for International Development
Department of State
Washington, DC 20523

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REGIONAL PLANNING MODEL FOR ARUSHA, TANZANIA

Abstract

The Regional Planning Model for Arusha (RPMA) is a microcomputer-based tool which can aid regional planners in the areas of population, education, health services, water, food and livestock. It was developed by the Integrated Population-Development Planning Project of the Research Triangle Institute, Research Triangle Park, North Carolina, under a USAID contract. The model can be used to keep track of relevant information for the seven districts of Arusha and, in combination with prespecified planning goals, calculate target levels for various outputs and resource requirements. It contains a demographic projections methodology for projecting population in the seven districts of Arusha Region which influences the calculations.

The model uses the Apple II+ computer and requires no special knowledge of computers to use. By simply responding to questions asked by the computer, the user can change assumptions, run the model for different districts, and view or print out the values of calculated variables for any sector of interest.

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REGIONAL PLANNING MODEL FOR ARUSHA, TANZANIA

Model Description

REGIONAL PLANNING MODEL FOR ARUSHA, TANZANIA

Model Description

1. Introduction

This report describes the first version of a district level planning model (RPMA) for the Arusha region of Tanzania developed by RTI/IPDP.[1] It is intended that further work will be done by RTI/IPDP in collaboration with Tanzanian counterparts in order to make the model more suitable to the specific needs and situation of Arusha as the need arises.

Effective development planning requires a clear understanding of the interactions and linkages between economic, social, and demographic factors in the development process. In particular, human resources planning must be preceded by a delineation of how the form and pace of development will alter and be altered by changes in the demograpic factors: fertility, mortality, and migration. The demographic composition and changes taking place in a society profoundly affect levels of consumption and production, labor force participation, demands for health, education, and other social services. The specification of a model allows planners to comprehend the complex network of direct and indirect relationships between the variables relevant to the alternative development policies. While a formal, empirical model is not a substitute for human judgment, a properly validated model can serve a critical complementary role by demonstrating multi-faceted interactions and exposing underlying assumptions to criticism and revision.

There are two potential uses to which computer simulation models of population and development can be put: planning and policy analysis. Planning, briefly, consists of specifying a consistent set of targets for a

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[1]Research Triangle Institute, Integrated Population-Development Planning Program. Work on part of this model was performed under subcontract with RTI by the Future's Group, Glastonbury, Connecticut and I would like to thank Ed Abel and John Stover for their valuable assistance. Karen Allen, formerly of RTI/IPDP originally conceived the model and helped with the demographic subsector. A. Mkini and A. Mtui of the government of Tanzania provided valuable support for the education sector as did Fran Heidlage of Duke University who helped with the programming for that sector.

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specified list of variables so as to achieve some pre-specified goals. Since computer models are particularly well suited to keeping track of a large number of variables and since a large proportion of these models is accounting relationships, they are potentially valuable for planning. For example, an anticipated drop in the birth rate which is not coordinated with a program to increase the number of teachers in proportion to an expected increase in school enrollment rates may result in a surplus of teachers. A model can serve to alert planners to the size of this potential problem.

Policy analysis, by contrast, involves determining the impact of changes in one variable upon another. Policy analysis, in fact, often preceeds planning. It involves analyzing not only direct effects but also indirect effects and feedbacks. Here again, computer simulation models are of potential value since variables are linked together not only directly through behavioral equations but also indirectly through the above-mentioned accounting relationships. The endogenizing of many variables (for example, fertility) which in earlier approaches were left exogenous, allows planners and policy-makers alike to recognize that programs designed explicity to have an impact in one area may have an effect in another.

The ideal model would be well suited for both policy analysis and planning. However, the structure and parameters of actual models determine that they are often more appropriate for one use than another. A policy analysis model may include a myriad of linkages, feedbacks and endogenous variables. The accuracy of the time paths of the model's variables is not as important as the qualitative information gained by manipulating policy variables in the model. For example, a policy model might answer the question: Will the introduction of a new water system in a rural area affect the growth rate of the population? Because of this emphasis on <u>qualitative</u> information, the parameter values are not as important as in planning models, which, are more concerned with quantitative information. A typical question addressed by a planning model, might be: What will be the number of primary school students in 1995?

The present model is seen as a planning model. In its present version, there are no "behavioral equations" as originally envisioned. This was

done in an effort to make the structure and parameters of the model conform as closely as possible to the situation in Tanzania as it is today. As a result, there are more fixed coefficients in the model than originally planned. It is always possible to change these coefficients as new information comes to light, or if the planner wants to experiment with his own estimates; this is one of the advantages of computer simulation models. We have allowed the coefficients to be changed easily by the user of the model and it is certainly possible to include coefficients which change over time.

It is to be emphasized that this is a first version of the model. It is hoped that in its present form, this model will provide a basis for further and continual updating and refinement. A model such as RPMA can be dynamic not only in the sense that it projects variables over time, but also in the sense that its structure and underlying assumptions can be changed as new information comes to light.

The RPMA model consists of several submodels all of which are interlinked with the first submodel via population:

1. The Demographic Submodel tracks the population by age and sex for each district. It also gives information on demographic vital rates.

   Population is projected in one year age groups using a cohort projection methodology. Survivor rates are taken from O.E.C.D model life tables in conjunction with assumed levels of life expectancy. Age specific fertility is calculated on the basis of U.N. model fertility tables. Net migration rates are used to account for population flows.

2. The Education Submodel gives the number of enrolled students in each class or standard in primary school. In addition, the required number of teachers and classrooms is also calculated.

   Student numbers are projected on the basis of assumed enrollment, dropout and repeater rates using a modified demographic cohort projection methodology. Required teachers and classrooms are calculated on the basis of ratios of students to teachers or classrooms.

3. The Health Services Submodel* projects requirements or goals for levels of health services personnel and infrastructure.

*Developed by The Future's Group for RTI.

Requirements are calculated by applying per-capita requirements coefficients to projected population totals.

4. The Water Submodel* calculates requirements for various water sources based on target levels of service and population estimates.

   Requirements are calculated by applying per-capita requirements coefficients to projected population totals.

5. The Food Production Submodel calculates agricultural output of various food, subsistence and cash crops.

   Production is calculated by applying yield coefficients to land areas under cultivation for specific crop types. Yields and land areas can change. Destinations of crops are determined as the basis of parameters.

6. The Food Requirements Submodel gives the caloric and food requirements by type of food according to WHO/FAO standards.

   Caloric requirements which are affected by the size and age structure of the population are translated into food stuff requirements by assuming an average diet, defined in terms of the proportion of calories derived from each food stuff, and the caloric content of these food stuffs.

7. The Livestock Submodel* projects the livestock population, meat production and milk production.

   Livestock numbers are calculated by using either a demographic or simple growth rate methodology. Meat and other by-products are then calculated on the basis of off-take and yield figures. Land requirements for grazing are also calculated.

In the present version of the model there are no interlinkages between ticular submodels other than to the demographic submodel. This lack of terlinkages is not because such linkages are not thought to exist, but her because data and time constraints did not allow their inclusion at is time in the model. For example, health services might affect mortality, ication might affect agricultural productivity, or education may affect tility. In order to allow the model to be easily modified to take ount of such feedbacks, it has been programmed in such a way as to make

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*Developed by The Future's Group for RTI.

that possible. Unlike the RAPID model, which first projects the population for an entire 15 or 20 year period, and then solves for individual sectors, RPMA solves each sector sequentially for each year. Users of the model who are proficient in Applesoft BASIC, the programming language in which the model is written, are encouraged to experiment with various interactions between sectors which may be considered important.

The model is disaggregated for each of the seven districts of the Arusha region. The structural equations for each district are identical, except that no agriculture (food production and livestock) is modelled for Arusha Town district. While the equations for each district are the same, the parameters of these equations are not so that each district is distinct. At present, the districts do not interact in any way either through migration or trade flows.

The time frame of the present model is seen as 10 to 15 years. This is relatively short for an economic-demographic model, but long for a planning model. In order for changes in demographic variables to have an appreciable impact, a period of at least 10-15 years is often necessary. However, in certain sectors, for example education, a shorter time frame is sufficient for demographic factors to be felt. In addition, in districts where in- or out-migration are important, short run effects can be felt. In any case, for most planning applications a 10-15 year horizon is probably adequate.

All parameters and initial values of variables have been calculated using Tanzanian sources which are listed in Appendix A. The RPMA model is designed not only to aid planners in projections, but also to help them maintain records of existing data. Because of this, while every effort was made to collect accurate data and to calculate reasonable parameter values, the parameters actually included in the model should be viewed as provisional. However, because of the central role played by population in the model, particular care was taken in the estimation of the demographic vital rates and the base year population (see Appendix B). Readers interested in the actual levels of initial variables or parameters will have to run the model itself.

2. Demographic Submodel

The demographic subsystem is concerned with tracking the population in each period by age and sex. The demographic subsystem is the core of the regional planning model since the outputs of virtually all the other subsystems depend in one way or another on the demographic structure. Because of this, particular care must be taken in initializing this system as noted later.

The starting point for the demographic submodel was the demographic subsystem of the BACHUE-International model developed by RTI/IPDP population economist R. Scott Moreland.* In that model, many of the key demographic variables were endogenous and linked, particularly through income, with the economic submodel. The linkage between economic and socioeconomic variables was made with regression equations estimated from international cross-section data. There is now ample reason to believe that demographic phenomena in many developing countries are affected by changes in socioeconomic phenomena, particularly in the long term. The common theory underlying the endogeneity of many demographic rates is that decisions about having children, entering the workforce or relocating are made, at least in part, on the basis of individual cost-benefit calculations reflecting constraints on the use of one's time.

While it is thus theoretically desirable to have endogenous demographic variables, in the present model all are exogenous. There are two reasons for this. Firstly, the time span of the model is 10 to 15 years. With the exception of migration rates, changes in fertility and mortality have very little effect on the age distribution of the population before 15 years so it is arguable that incorporation of equations to predict demographic variables would gain little in terms of accuracy. Secondly, there were virtually no Tanzanian data available to use with which to estimate the quantitative relationship between the various socio-economic and demographic variables. As will become clear subsequently, there is even a very real

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*"An Economic-Demographic Model for Developing Countries: BACHUE-International," ILO/WEP, working paper no. 70, 1978.

problem in knowing what the levels of many demographic variables are particularly at the district level. An alternative is to use international cross-section data but this requires the assumption that there is a common underlying structure between the variables in question for the countries in the international sample and that the Arusha region of Tanzania is a part of that structure. This is a tentative assumption which seems more appropriate in the context of a policy analysis model than in the context of a planning model.

Population Projection

Starting with an initial population by age and sex, it is relatively straightforward to project the population forward in time once fertility, mortality, and migration rates are known. This is so since the population is divided into 1 year age groups so that each year, survivors in each cohort mature to the next highest cohort.

The population at age "zero" (or the first cohort) consists of people born during the period with an appropriate sex ratio (SR) applied:

$$\text{(i) age 0} \quad : \quad P^{t}_{1,L,0} = (SR) \cdot \sum_{K=15}^{44} P^{t-1}_{1,L,K} \cdot FR_{L,K}$$

and

$$P^{t}_{2,L,0} = P^{t}_{1,L,0} \cdot (1-SR)$$

where:

$FR_{L,K}$ = the fertility rate for location (or district) L, age K

SR = the proportion of total births which are female

$P^{t}_{S,L,K}$ = the population of time t, sex S, location L, and age K (S=1: females; S=2: males).

$FR_{L,K}$ is derived from a U.N. model fertility schedule corresponding to the assumed total fertility rate for district L, $\overline{FR}_L$:

$$FR_{L,K} = f(\overline{FR}_L, \overline{UNF})$$

where UNF is the matrix of model age-specific fertility schedules.

Between birth and entry into the 65+ (open-ended) interval, people maturate from one cohort to another, subject to the survival probabilities ($S^t_{S,K}$), obtained from the O.E.C.D. tables corresponding to the given level of life expectancy (EOs). Location changes due to migration are accounted for here as well as via migration probabilities, $p_{L,K}$.

(ii) Ages 1-65:

$$p^t_{S,L,K} = S^{t-1}_{S,K-1} \; p^{t-1}_{S,L,K-1} \; (1-p_{L,K}) \qquad \begin{array}{l} S=1,2 \\ K=1,\ldots.65 \end{array}$$

where:

$S^{t-1}_{S,K-1}$ = the probability of surviving from age K-1 to K for sex S in period t-1.

$P_{L,K}$ = the net probability of migrating from region L for age K.

Note that,

$$S^t_{S,K} = f(EO^t_S, \overline{OECD})$$

where $\overline{OECD}$ is the O.E.C.D. model life table of which $S_{S,K}$ is one column corresponding to life expectancy level EO^t_S. When EO^t_S does not correspond exactly to an O.E.C.D. level, then $S_{S,K}$ is calculated by interpolating between two values. A similar procedure is used in arriving at $FR_{L,K}$. Lastly the open-ended interval is calculated with an assumption of no migration:

(iii) age 65+ (open-ended interval)

$$p^t_{S,L,65+} = (p^{t-1}_{S,L,64} + p^{t-1}_{S,L,65+}) \cdot S^{t-1}_{S,65+} \qquad \begin{array}{l} S=1,2 \\ L=1,2,3 \end{array}$$

Internal Migration

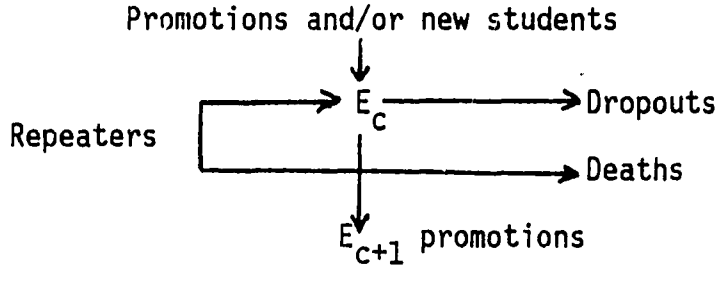
Internal migration has been an important phenomena in developing countries in general and in Tanzania in particular. In the present version of the model migration is handled by use of net migration probabilities, $p_{L,K}$, representing the probability of someone in location L, age K moving

out of L. When $p_{L,K} < 0$ then there is net migration into district L. The destination of out-migrants is not modelled, nor is the origin of in-migrants. As certain age groups are more prone to migrate than others we have assumed that the $p_{L,K}$ elements refer to the probabilities of adults ages 15-34. People younger than 15 or older than 34 have migration probabilities which are a fixed proportion of $p_{L,K}$.

At the present time the elements are constant and exogenous.* There is no inter-district migration. While this is obviously not an ideal situation, it does have the advantage that the model need only be run for a single district at a time.

3. Education Submodel

The education submodel keeps track for primary school of the current enrollment at each level, the dropouts at each level, and the graduates from standard 7. A typical cell in the model is represented schematically below:



Each cell corresponds to a class (or standard) level. Current enrollment is thus influenced by the rate of promotion from lower level classes, the number of repeaters, mortality and the dropout rate. In equation form enrollment in standards 2-7 is given by:

$$E_{c,t,K,S} = (E_{c-1,t-1,K-1,S}) \cdot (1 - r_{c-1,S} - \psi_{c-1,S}) \cdot S_{K-1,S} + (E_{c,t-1,K-1,S}) \cdot r_{c,S} \cdot S_{K,S}$$

*However, it is possible, as with other parameters of the model to specify a time pattern for the probabilities.

where,

$E_{c,t,K,S}$ = enrollment in standard c, at age K, sex S, at time t

$r_{c,S}$ = the repeat rate for standard c, sex S

$\psi_{c,S}$ = the dropout rate for standard c, sex S

$S_{K,S}$ = the survival rate for students at age K.

While in fact repetition of a standard or dropping out may not take place in the higher standards, we have built the model to take account of these possibilities. In cases where repeating or dropping out do not occur, these rates can be set to zero.

Enrollment in the first standard is slightly different, since entry takes place by people who are going to school for the first time. Because of the Tanzanian commitment to universal primary education, entry currently takes place from people of different ages. As time progresses, one would expect this to be replaced by a tendency for entry from a single age group (age 6 or 7). The equation for the number of students in standard one is:

$$E_{1,t,K,S} = \sum_{K=6}^{15} p^{t}_{S,K} \cdot ER^{t}_{S,K} + \sum_{K=7}^{14} (E_{1,t-1,K,S}) \cdot r_{c,S} \cdot S_{K,S}$$

$ER^{t}_{S,K}$ is the proportion of members of a cohort of sex S, age K in period t who enter school. The first term of the equation gives the new entrants while the second term gives the repeaters. Note that this since members of a cohort cannot enter school twice, the sum of these ER's for a given cohort must be one:

$$\sum_{K=6}^{15} ER^{K-BY}_{S,K} = 1$$

where BY = birth year

Educational Resource Needs

Educational resource needs are calculated by applying fixed coefficient to the student population at each standard. Hence, the number of required

teachers is obtained by use of a fixed student/teacher ratio and the number of classrooms by applying a fixed student/class ratio. Hence

$$PROF_1 = \sum_c E_c/\alpha_1$$

$$CLASS_1 = \sum_c E_c/\beta_1$$

where

$PROF_1$ = the required number of teachers

$CLASS_1$ = the required number of classrooms

α_1 = the teacher/student ratio

β_1 = the classroom/student ratio

E_c = the total enrollment in class c.

4. <u>The Health Services Submodel</u>

The health services submodel is designed to project required levels of public health service personnel and infrastructure. These requirements are based on target per-capita levels of requirements which can be specified by the user. Hence, the general formula used in this sector is:

$$HH_i^t = h_i^t \sum_{S=1}^{2} \sum_{K=0}^{65+} P_{S,L,K}^t$$

where

HH_i^t is the requirement for the ith variable in year t

h_i^t is the per capita requirement for ith year t.

The variables which are kept track of in this subsector are listed below.

i	Variable
1	Medical officers
2	Assistant medical officers
3	Medical assistants
4	Rural medical assistants
5	Nurses (grade A)
6	Nurses (grade B)
7	Laboratory staff
8	MCH aides
9	Hospital beds
10	Dispensaries
11	Rural health clinics
12	MCH health clinics
13	Recurrent costs
14	Capital costs

The final two variables, recurrent and capital costs are meant to given an indication of the cost of maintaining some of the various health service levels implied by provision of variables 1-12. These last two are calculated respectively by,

$$HH_{13}^t = c_9^t \cdot HH_9^t + c_{10}^t \cdot HH_{10}^t + c_{10}^t \cdot HH_{10}^t$$

$$HH_{14}^t = (HH_9^t - HH_9^{t-1}) \cdot K_9^t + (HH_{10}^t - HH_{10}^{t-1}) \cdot K_{10}^t + (HH_{11}^t - HH_{11}^{t-1}) \cdot K_{11}^t$$

where

c_i^t is the recurrent cost in year t per unit of HH_i^t

K_i^t is the capital cost in year t per unit of investment in HH_i^t.

5. <u>The Water Submodel</u>

The water submodel is designed similarly to the health services submodel. It projects requirements for drinking water systems and the number of people served by the various types of water delivery systems. Five such systems are modeled in RPMA. These are: piped, boreholes, shallow wells, dams, and traditional sources.

Requirements for each system are calculated by:

$$WH_i^t = \left(\sum_{S=1}^{2} \sum_{K=0}^{65+} p_{S,K}^t \right) \cdot a_i^t / WP_i^t$$

where

WH_i^t is the requirement for number of systems of type i in year t

a_i^t is the proportion of the population served by system i in year t

WP_i^t is the target level of population served by system i in year t

Then the population served by various methods is given by,

$$WP_i^t = a_i^t \sum_{S=1}^{2} \sum_{K=0}^{65+} P_{S,K}^t$$

and the capital costs (WK_i^t) of the ith system in year t by,

$$WK_i^t = (WH_i^t - WH_i^{t-1}) \cdot b_i^t$$

where b_i^t is the per unit capital cost.

From these variables the number of people with "improved" systems (piped, boreholes and wells), unimproved systems (dams and traditiona) and no water as well as the cost of including additional people in the improved systems are computed.

6. Food Production Submodel

The food production submodel projects the quantity of various crops produced in each district in each year. These production figures are arrived at by applying a yield coefficient to the amount of land allocated to the crop type in question. Hence land is the only productive input in agriculture in the present version of RPMA. This is obviously not the case, and one would like to include labor and possibly capital into the formula. However, for the present version, no data were available which allowed a more sophisticated treatment of food production. The formula then for production (PF_i^t) of crop i in year t is:

$$PF_i^t = YD_i^t \cdot L_{1i}^t$$

where

YD_i^t is the yield per hectare of land of crop i in period t

L_{1i}^t is the amount of land (in hectares) planted with crop type i in period t.

In the present version, the crops produced are maize, mixed beans, seed beans, wheat, soybean, coffee, pigeon peas and millet. This covers over 90% of the agricultural production for Arusha region.

Crop production has three possible destinations: spoilage, cash and food. In order to calculate this, a use coefficient is applied to PF_i^t

$$F_{ij}^t = PF_i^t \cdot B_{ij}^t$$

where

F_{ij}^t is the amount of crop i in use j in period t

B_{ij}^t is the proportion of i used in j in period t

Here again, one can imagine that B_{ij}^t may not be fixed and may respond to socioeconomic condition or prices. While in the present version, such an interaction is not included, the user of the model is free to vary the coefficient B_{ij}^t for each or all years of a simulation. Total food available in the categories of crop production is given by the sum of locally grown food of crop type i, F_{i3}, plus purchases from outside the district, FI_i^t.

$$FD_i^t = F_{i3}^t + FI_i^t$$

where

FD_i^t is available food of type i.

Once again, while FI_i^t is exogenous, it can be specified by the user of the model to represent his or her particular assumptions.

7. Food Requirements Submodel

The food requirements subsystem of RPMA provides information on the food requirements in accord with WHO/FAO international standards. At this point, the model does not predict what actual or expected levels of nutrition and food consumption are for Arusha region. That stage in model development would require integrating the production submodel with a food consumption model. This is something which could eventually be done with enough information. Nevertheless, the nutrition submodel should provide valuable information on the food requirements of the population to the planner. In fact, according to the joint FAO/WHO committee:

"reasonably valid estimates of national energy needs can be derived since there is reason to believe that if the total supply of food is adequate and social factors are not limiting, individuals will tend to consume energy in proportion to their needs. However, caution must be expressed, since if the total food supply is even slightly low, then social and other factors may produce a very inequitable distribution within some segments of the population."*

Food requirements are calculated in two stages. Firstly, the energy (calorie) requirements of the population is calculated. Secondly, this is translated into food requirements by assuming a standard diet.

Energy needs are calculated using FAO/WHO formulae. Daily calorie requirements can be computed for a population if one knows the age distribution of the population, the average weight of the population and how active that population is. The FAO/WHO formulae are reproduced in Table I. Note that for children ages nine years and younger an absolute requirement is set. The rather high (1,090 Kcal) requirement for infants is the result of allowing for the extra requirements of pregnant and nursing women. The assumptions behind this are given in the joint FAO/WHO report.

Given the method outlined in Table I, total daily energy requirements, $RCAL_{T,L}$ can be calculated as

$$RCAL_{T,L} = \sum_{s=1}^{2} \sum_{K=1}^{65+} RCAL_{S,L,K} \cdot P_{S,L,K}$$

where $RCAL_{S,L,K}$ = the calorie requirements for sex S, age K, and per capita requirements are then,

$$RCAL_{T,L}/POP_{T,L}$$

where $POP_{T,L}$ is total population for district L.

Energy needs are translated into food needs by means of a standard diet or "rations" in combination with the energy content of food stuffs in the diet. The standard diet or ration for population group L is specified in terms of the recommended percentage of calories, $C_{i,L}$, derived from the

*WHO Technical Report Series Number 522, 1973, Report of a joint FAO/WHO committee on energy and protein requirements, page 78.

TABLE I

CALCULATION OF PER CAPUT ENERGY REQUIREMENTS*

Age group (years)	Requirements According to Weight and Age (kcal)	(MJ)	Requirements Adjusted according to activity (kcal)	(MJ)
1	1090	(4.5)	1090	(4.5)
1-3	1360	(5.7)	1360	(5.7)
4-6	1830	(7.6)	1830	(7.6)
7-9	2190	(9.2)	2190	(9.2)
Male: adolescent, adult				
10-12	2600	(10.9)	2600	(10.9)
13-15	0.97M		0.97	
16-19	1.02M		1.02	
20-39	1.00M		1.00	
40-49	0.95M		0.95	$\times \frac{M[(100-p) + pA]}{100}$
50-59	0.90M		0.90	
60-69	0.80M		0.80	
70+	0.70M		0.70	
Female: adolescent, adult				
10-12	2350	(9.8)	2350	(9.8)
13-15	1.13F		1.13	
16-19	1.05F		1.05	
20-39	1.00F		1.00	
40-49	0.95F		0.95	$\times \frac{F[(100-p)=pA]}{100}$
50-59	0.90F		0.90	
60-69	0.80F		0.80	
70+	0.70F		0.70	

M = body weight × 46 kcal (0.19MJ) = requirement of moderately active adult male at given weight.
F = body weight × 40 kcal (0.17Mj) = requirement of moderately active adult female at given weight.
A = index of adjustment for activities other than moderate: light 0.90, very active 1.17, exceptionally active 1.34.
p = percentage of population that in a given group is not moderately active.

*Source: WHO, Technical Report Series, No. 522, 1973.

ith individual foodstuff. The calorie content of the ith foodstuff, g_i, is given in terms of average calories per gram. Hence, total daily food requirements for food type i in region L ($F_{i,L}$) are calculated as:

$$F_{i,L} = \left(\sum_{s=1}^{2} \sum_{k=0}^{65+} RCAL_{S,L,K} \cdot P_{S,L,K} \right) \frac{C_{i,L}}{g_i}$$

Of interest would be a comparison of food requirements with food production and/or availability. This would require a more detailed disaggregation of agricultural production and of purchases than exists in the current model since the categories of food in the requirements submodel do not correspond on a one-to-one basis with those in the production submodel.

8. The Livestock Submodel

The livestock submodel projects the number of cattle, goats, and sheep in each year as well as the milk and meat production resulting from these animals. The model provides two alternative projection techniques for the herd size of a given animal type. In the first, herd size of animal type i in year t (LH_i^t) is seen to grow at a constant growth rate by:

$$LH_i^t = LH_i^{t-1} \cdot (1 + G_i^t)$$

where G_i^t is the growth rate for head type i in year t.

In the second method a "demographic" type projection technique is used. The number of animals in a herd in the current year is computed by adding to the previous year's herd size the births of animals and subtracting natural deaths and deaths due to slaughter. The general procedure for projection using this technique is given by,

$$LH_i^t = LH_i^{t-1} + lh_i^{t-1} - (LD_i^{t-1} + LS_i^{t-1})$$

where

lh_i^{t-1} is the births of animal type i in t-1'

LD_i^{t-1} is the natural deaths of type i in t-1

LS_i^{t-1} is the slaughter and culls of type i in t-1

and

$$lh_i^t = LH_i^t \cdot h_i \cdot l_i \cdot m_i$$

where

h_i is the proportion of LH_i which are female

l_i is the proportion of females which are fertile

m_i is the "fertility" rate of fertile females (i.e., calves per fertile period).

Also, natural deaths are computed by,

$$LD_i^t = LH^t \cdot d_i$$

where

d_i is the death rate of animal type i.

Deaths due to slaughter are similarly computed by:

$$LS_i^t = LH_i^t \cdot ls_i$$

where

ls_i is the "off-take" rate of animal type i.

For the animal products derived from the herds, two types of equations are used. Annual milk production (LM), which in the model is only derived from cows, is calculated from

$$LM^t = LH_i^t \cdot h_i \cdot Z \cdot (1\text{-}cc) \cdot mp$$

where

Z is the proportion of cows which are lactating

cc is the proportion of milk consumed by calves

mp is annual milk production per cow per year.

The second animal product produced is meat. This is calculated from:

$$LF_i^t = LS_i^t \cdot w_i \cdot y_i$$

where

LF_i^t is the amount of meat of type i in year t

w_i is the average weight per animal carcass type i

y_i is the yield per carcass of type i.

In addition to these variables there are two land-related outputs in the livestock sector. These are intended to indicate the degree of pressure on grazing land. The first such variable is LL^t_1, defined as land required for animals and is meant to be an "ideal" or "target" concept. It is calculated from:

$$LL_i^t = \gamma \sum_{i=1}^{3} \alpha_i \, LH_i^t$$

where

α_i is the animal unit weight for animal type i, and

γ is the ideal or target level of land per animal unit.

The second land variable in this submodel is the projected amount of grazing land available per animal unit. Land in the RPMA model is allocated to several different uses, explained in the next section. One such use is grazing land (L_4). Hence the amount of grazing land per animal unit, $\hat{\gamma}$, is given by:

$$\hat{\gamma} = L_4 \div \sum_{i=1}^{3} \alpha_i LH_i$$

9. Land

There are four uses of land area in the RPMA model, two of which interact with subsectors of the model. These uses are cropland, abandoned land, reserved land, and grazing land. Abandoned land is land which is no longer arable or useful for agricultural purposes due to overuse. Reserved land includes parks, game reserves, and lakes. Since these four categories of land use are mutually exclusive, their sum must be equal to the total land area of a given district:

$$L_1 + L_2 + L_3 + L_4 = L_T$$

where

L_1 = Cropland

L_2 = Abandoned land

L_3 = Reserved land

L_4 = Grazing land

L_T = total land area.

Once again, these allocations are exogenous and under the control of the user. In further model development, it may be possible to take acocunt of overuse of the land for grazing or crops so that L_2 is endogenous.

REGIONAL PLANNING MODEL FOR ARUSHA, TANZANIA

User's Manual

REGIONAL PLANNING MODEL FOR ARUSHA, TANZANIA

User's Manual

I. Overview

The Regional Planning Model for Arusha Region (RPMA) is divided into three separate modules due to the memory limitations of the Apple II Plus computer. The three programs are: (1) RPMA Inputs, (2) RPMA Main, and (3) RPMA Outputs. The RPMA Inputs program permits changes to be made for the values of each variable for each sector for each district from 1978 through 1993. The RPMA Main program takes the inputs for the specified district and calculates the outputs for each variable for each district for each year from 1978 through the final year specified. The RPMA Outputs program displays (on the screen or on the printer) the calculated values for the specified variable, sector and district from 1978 through the final year specified.

At least three separate diskettes are required to run the model. The RPMA main programs diskette, always loaded in Drive 1, contains the main program files (i.e., RPMA Inputs, RPMA Main and RPMA Outputs). There are two inputs diskettes, one of which is loaded in Drive 1 when calculations are being performed and in Drive 2 when the inputs are being modified; they contain the input files for the sectors (health, water, etc.) and the districts (Arumeru, Arusha Town, etc.). The outputs diskette, always loaded in Drive 2, contains the output files (calculated values) for the sectors and districts. See Figure 1 for a summary of diskette and drive usage.

In addition to the RPMA programs there are several useful "utility" programs available on the program diskette. Program "BEERS" splits a 5 year age distribution of the population into single year age groups. "FILE CREATE" allows creation of a "text" or data file. "FILE READ/WRITE" reads and/or writes a text or data file. "FILE JOIN" joins one text file onto the end of another text file, and "FID" is the Apple II File Developer which contains several useful programs for using the Apple disk operating system. "COPYA" copies the contents of an entire disk to another disk.

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FUNCTION	DISK DRIVE CONFIGURATION	
To Change Inputs for the Variables	DRIVE I Main Programs Diskette	DRIVE II Inputs Diskette
To Perform Calculations for a District — Initially...	DRIVE I Main Programs Diskette	DRIVE II Outputs Diskette
Once Parameters Are Defined...	DRIVE I Inputs Diskette	DRIVE II Outputs Diskette
To Display Outputs for the Variables	DRIVE I Main Programs Diskette	DRIVE II Outputs Diskette

Figure 1

The RPMA programs make extensive use of the notion of a "text file." These are Apple II data files. For each district and for each sector there is a corresponding file for inputs and for outputs. For example, in Arumeru district there is a file for the demography inputs assumptions. These files are stored on the same diskette and are identified systematically. For example:

ARUMERU DEMOGRAPHY INPUTS

or NGORONGORO LIVESTOCK OUTPUTS

The space available on the diskettes does not allow all the necessary files to be kept on a single diskette. There are 56 such files for inputs alone. It is necessary then to have at least two diskettes for inputs. It is essential that all inputs files for the <u>same</u> district be kept on the <u>same</u> diskette. If the user prefers, he can keep the text (input) files for each district on a separate diskette, but this involves a lot of diskettes and is not recommended.

II. How to Run the RPMA Programs

In order to run RPMA you must have an Apple II plus computer running DOS 3.3, two disk drives and, optionally, a printer.

To run the model "boot" the program diskette (the one marked RPMA Program Disk) in Drive 1 and turn on the computer. You will be greeted with a "menu" like the following; this is referred to as the "Executive Menu". For an overview of the RPMA program structure see Figure 2.

```
* * * * * * * * * * * * * * * * * * * *
    REGIONAL PLANNING MODEL ARUSHA
* * * * * * * * * * * * * * * * * * * *

  PROGRAM DISKETTE

  WOULD YOU LIKE TO:
  1.   CHANGE THE INPUT DATA
  2.   RUN THE RPMA MODEL
  3.   LOOK AT THE RESULTS
  4.   RUN A UTILITY PROGRAM
  5.   QUIT

  ENTER 1 TO 5 TO INDICATE YOUR CHOICE:
```

In responding to this and any other menu choices with the model enter an appropriate number followed by the "return" button (hereafter, <RETURN>).

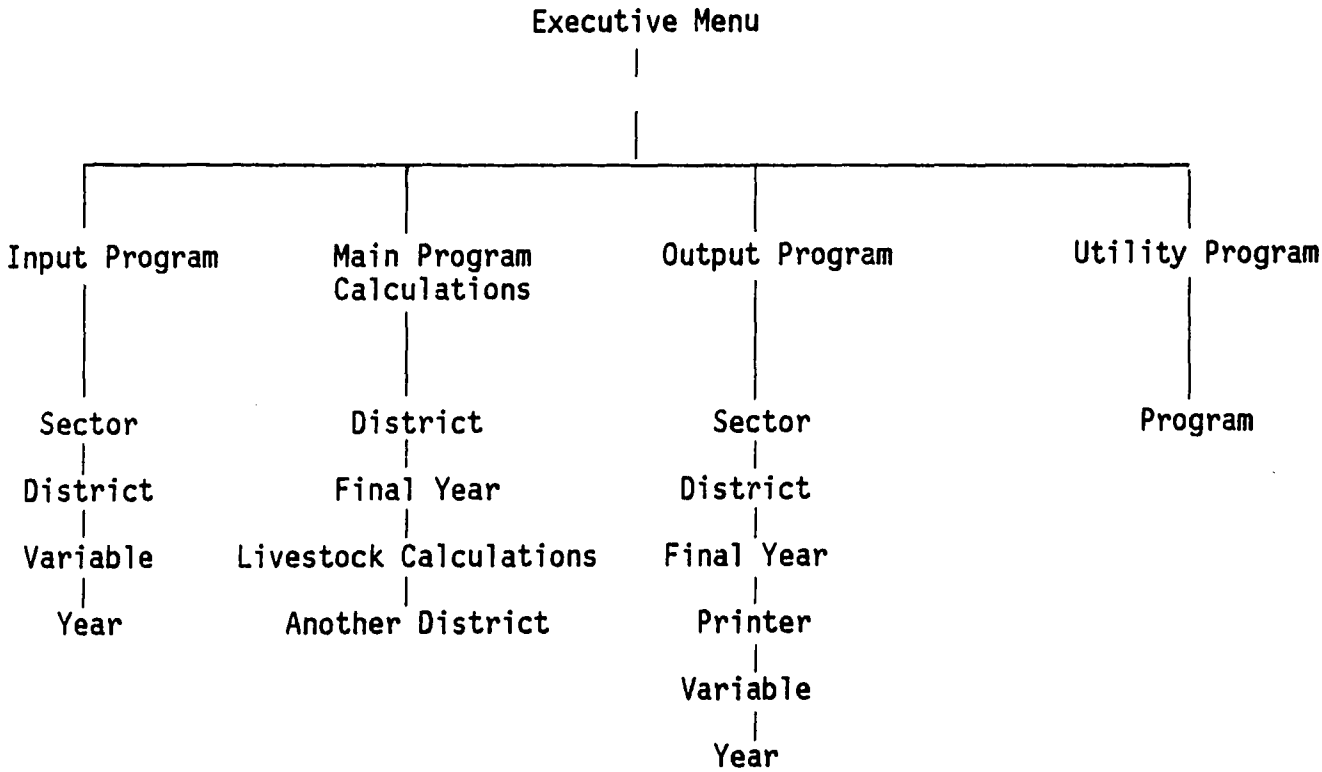

Figure 2. Program overview of RPMA program structure.

If you respond by typing 1 <RETURN>, the disk drive will spin and the inputs program will be loaded and you will be faced with a new menu.

III. Inputs Structure

The inputs program, which is designed to provide flexibility in defining variable parameters, has the same general structure for all sectors. The user should be familiar with the general structure of the RPMA model in order to understand the functions of the various parameters which can be altered in this program.

The sector for which inputs are to be changed must first be specified:

FOR WHICH SECTOR WOULD YOU LIKE TO CHANGE THE INPUTS:

1. DEMOGRAPHY
2. EDUCATION
3. HEALTH
4. WATER
5. FOOD PRODUCTION
6. FOOD REQUIREMENTS
7. LIVESTOCK
8. LAND
9. END CHANGES

ENTER 1 TO 9 TO INDICATE YOUR CHOICE

Once the sector is selected, the district whose inputs are to be changed must be then be selected.

FOR WHICH DISTRICT WOULD YOU LIKE TO CHANGE THE INPUTS:

1. ARUMERU
2. ARUSHA TOWN
3. HANANG
4. KITETO
5. MBULU
6. MONDULI
7. NGORONGORO
8. CONTINUE

ENTER 1 TO 8 INDICATE YOUR CHOICE

At this point you must put a diskette with the input files for the sector and district you have chosen in Drive 2 and press <RETURN>. If a file containing the inputs for the sector and district chosen is not present, the user is prompted to enter the correct diskette and the process starts

again. Drive 2 then starts to spin and input values for each variable for the sector and district chosen from 1978 through 1993 are read into the computer's memory. A list of all input variables is displayed and the variable to be changed must be specified. For example, in health the choice looks like:

```
WOULD YOU LIKE TO CHANGE THE INPUTS FOR ANY OF THE FOLLOWING
CATEGORIES:

 1.   POP. PER MEDICAL OFFICER
 2.   POP. PER ASSISTANT MED. OFFICER
 3.   POP. PER MEDICAL ASSISTANT
 4.   POP. PER RURAL MED. ASSISTANT
 5.   POP. PER NURSE (GRADE A)
 6.   POP. PER NURSE (GRADE B)
 7.   POP. PER LABORATORY STAFF
 8.   POP. PER MCH AIDE
 9.   POP. PER HOSPITAL BED
10.   POP. PER DISPENSARY
11.   POP. PER RURAL HEALTH CLINIC
12.   POP. PER MCH CLINIC
13.   RECURRENT COST/HOSPITAL BED
14.   RECURRENT COST/RHC
15.   RECURRENT COST/DISPENSARY
16.   CAPITAL COST/HOSPITAL BED
17.   CAPITAL COST/RHC
18.   CAPITAL COST/DISPENSARY
19.   CONTINUE

ENTER 1 TO 19 TO INDICATE YOUR CHOICE
```

You are next asked whether you would like to print out or edit the data:

```
WOULD YOU LIKE TO:

1.   EDIT THE INPUT DATA
2.   PRINT OUT THE INPUT DATA

ENTER 1 OR 2
```

If you want to respond with a 2, first turn on the printer and then enter a 2. After printing out the data, the menu of variables will reappear on the screen and on the printer.

If you respond with a 1, the district and the variable being changed, along with the corresponding values for each year are then displayed only on the screen.*

```
ARUMERU
FOR EACH OF THE FOLLOWING YEARS,
POP. PER MEDICAL OFFICER EQUALS:

1978      238020          1986      238020
1979      238020          1987      238020
1980      238020          1988      238020
1981      238020          1989      238020
1982      238020          1990      238020
1983      238020          1991      238020
1984      238020          1992      238020
1985      238020          1993      238020
```

The year in which the changes are to begin and the year in which the goal is to be attained are then entered.

```
ENTER YEAR TO START CHANGES
ENTER YEAR TO REACH GOAL
ENTER Ø TO END
```

The cursor is then placed at the final year and the entry for that year is made. Values for all intermediate years are calculated, using the straight line interpolation technique, based on the initial and final year values. Individual years may be changed by specifying that the initial and final years are the same. The entire period may be changed by specifying that the initial year is 1978 and the final year is 1993. Changes for the variable will continue to be accepted until a 'Ø' or <RETURN> is entered as the initial year for changes, or a 'Ø' is entered as the final year for changes.

A list of the variables contained in the sector will again be displayed and additional variables may be changed. No permanent changes will be made to the file until the option 'CONTINUE' is selected. When the "continue" option is selected, the user is asked if he would like to save the changes. If he responds by typing "Y" (Yes) then all previously stored values of the variables for the sector and district chosen will be replaced.

---

*The numbers displayed here are purely illustrative.

IT IS STRONGLY RECOMMENDED THAT A BACK-UP DISKETTE WITH ANY INPUT FILES BE KEPT. In any case, the user may wish to store new values on a different diskette in order to be able to compare the effects of different assumed values. When you have finished making changes to all the sectors and districts necessary, type "9" for "END CHANGES." You are then prompted to push <RETURN> in order to return to the "Executive Menu."

IV. Calculations Structure

To run the calculations program (i.e., the RPMA model), enter "2" to RUN THE RPMA MODEL from the Executive Menu. The diskette in Drive 1 will spin and some initial data will be loaded into memory along with the RPMA main program.

FOR WHICH DISTRICT DO YOU WANT TO SIMULATE

1. ARUMERU
2. ARUSHA TOWN
3. HANANG
4. KITETO
5. MBULU
6. MONDULI
7. NGORONGORO

ENTER 1 TO 7 TO INDICATE YOUR CHOICE

The length of the projection is then specified by entering a number between 1978 and 1993.

ENTER FINAL YEAR OF SIMULATION

Since the livestock sector permits the calculations to be performed in two distinct ways, based on an average annual growth rate or based on a livestock demographic projection, the method of calculating livestock must also be specified.

DO YOU WANT TO PROJECT LIVESTOCK USING:

1. AN AVERAGE ANNUAL RATE OF GROWTH?
2. A 'DEMOGRAPHIC' TYPE METHOD

ENTER 1 OR 2

Once these parameters are defined, the diskette containing the input files must be placed in Drive 1* (replacing the main programs diskette) and the output files' diskette must be placed in Drive 2. This second diskette can be any initialized diskette. If it contains results for the same district that have been previously calculated, they will be replaced during the current run.

Demographic calculations are then made for the specified district for the first year. All input variables for the first sector for the first year are read and stored in the computer's memory. The outputs for the sector are calculated and the results stored. Inputs, calculations and outputs are then done for the next sector. This process continues until the final sector's outputs are stored (Livestock Sector). Upon completion, the program returns to perform the demographic calculations for the next year and to calculate and store the next year's outputs for that and other sectors. Once calculations for the final year have been completed, another region's calculations may be performed.

DO YOU WANT ANOTHER DISTRICT?

If you respond by typing "Y" then the menu of districts reappears and you start over again. If you respond by typing "N" then you prompted to insert the program diskette in Drive 1 and press <RETURN>. The Executive Menu then reappears.

V. Outputs/Results

To see the results of a run which has been completed, enter 3 from the Executive Menu and press <RETURN>. The RPMA outputs program is then loaded and you are faced with a new menu.

The sector for which outputs are to be displayed is selected first.

FOR WHICH SECTOR DO YOU WANT OUTPUT:

1. DEMOGRAPHY
2. EDUCATION
3. HEALTH

---

*During initial execution of the program the presence of sector input for the district chosen is verified. If a required file is not present, the user is prompted to insert the correct diskette and the program starts over.

4. WATER
5. FOOD PRODUCTION
6. FOOD REQUIREMENTS
7. LIVESTOCK
8. END

ENTER 1 TO 8 TO INDICATE YOUR CHOICE

Once the sector is chosen, the district which is to be displayed is selected. Remember that you must have previously run the model for the district selected. If not, you will receive an error message and be prompted to start this section over.

FOR WHICH DISTRICT DO YOU WANT OUTPUT:

1. ARUMERU
2. ARUSHA TOWN
3. HANANG
4. KITETO
5. MBULU
6. MONDULI
7. NGORONGORO
8. ARUSHA REGION

ENTER 1 TO 8 TO INDICATE YOUR CHOICE

The final general parameters to be specified are the final year to be displayed. This must be a year between 1978 and 1993 and you must have previously run the model for the district chosen until at least that year.

ENTER THE FINAL YEAR TO BE DISPLAYED

You can also choose to use the printer.

DO YOU WANT TO USE THE PRINTER?

You are then prompted to put the diskette containing the relevant output file in Drive 2 and press <RETURN>. If you want to look at some results which you have just calculated, the correct diskette will already be in Drive 2.

A list of all output variables is displayed and the variable to be printed for the sector chosen is then selected. For example in health the choice is:

FOR WHICH VARIABLE DO YOU WANT OUTPUT:

1. MED OFF
2. A MED OFF
3. MED AST
4. NURSES (A)
5. NURSES (B)
6. LAB STF
7. MCH AIDES
8. HOSP BEDS
9. HOSP BEDS
10. DISPENS
11. R HLT CLN
12. MCH CLN
13. RECURRENT HEALTH COSTS
14. CAPITAL HEALTH COSTS
15. ALL THE VARIABLES

ENTER 1 TO 15 TO INDICATE YOUR CHOICE

(Option #15 above permits the printing of all variables contained in the sector).

1. Single variable displayed for an individual district. The program turns on the printer if it is to be used and each output variable contained in the file is read for each year and the selected variable is displayed on the screeen/printer. For example in livestock:

YEAR	NUMBER OF CATTLE
1978	214101
1979	218383

The printer is turned off and another variable for the same sector may be displayed.

DO YOU WANT TO PRINT ANOTHER HEALTH VARIABLE?

If another variable is to be displayed for the same sector, the program returns to a selection of the sector variables. Otherwise, the program returns to a selection of the sectors to be displayed.

If you wish to look at the results for the same district and sector, but from a different run, that is one corresponding to a different set of input values, it is necessary to return to the "outer level" of the outputs program. This can be done at this point by typing "N", selecting the same

district and sector, and changing the diskette in Drive 2 to one which contains the relevant files.

Certain of the demographic, education, food production and food requirements variables consist of columns of numbers and are therefore printed one year to a page. For example, in demography, the population by 5 year age groups and sex is a such a variable. In these cases, the user is prompted to specify the specific year requested by:

WHICH YEAR?

A year less than or equal to the one specified as the "final year" must then be entered.

2. All variables displayed for an individual district. Each variable is titled, beginning with the first variable, output variables are then read for each year and displayed. For example, in livestock

YEAR	BEEF PRODUCTION
1980	856404
1981	873532
⋮	⋮
YEAR	MILK PRODUCTION
1980	23444060
1981	23912941
⋮	⋮
YEAR	NUMBER OF GOATS
⋮	⋮
1980	214252
1981	218537
⋮	⋮
YEAR	GOAT MEAT PRODUCTION
1980	149976
1981	152976

until the final variable is displayed. The printer is turned off and another variable for the same sector may be displayed.

3. Variable(s) displayed for the entire Arusha Region. The variable to be displayed is first stored and the user is asked whether the chosen sector has had its outputs aggregated previously. If it has, then the

Arusha Region file is treated as another district file, and the results read from diskette. Otherwise, the variables for each district for each year for the sector chosen are read and the aggegated results stored in a special file entitled, for example, "Arusha Region Demography" data. Once the file has been created, the summation is not required until another sector is examined. The selected variable is then read back into memory and the program continues through the general output routine.

In order to return to the Executive Menu, enter "8" when confronted with the sector menu in the outputs program. You will then be prompted to press <RETURN>; Drive 1 will spin and the Executive Menu will reappear.

VI. Utility Programs

It may occasionally be necessary to change or add to some of the RPMA data files to such an extent that the INPUTS program is inadequate. For example, if one wants to change the base year population, this cannot be done with the INPUTS program. Similarly, if one wants to add a new input variable, the text file must be initially created. Most of these tasks can be handled by using one of the six "utility" programs. We present here a brief guide to the usage of each of these.

1. BEERS

This program has been adopted from the U.S. Census Bureau's "BEERS" program by IPDP for the Apple II + computer.* It is designed to separate grouped data, into five parts. In particular, the program is designed for splitting a population in 5-year age groups into single year groups.

When the program is run from the utility programs menu, a greeting is displayed and the user is asked if the grouped data are already on disk:

THE 'BEERS' PROGRAM SPLITS
QUINQUENNIAL AGE GROUPS
INTO SINGULATE AGE GROUPS

IS DATA ALREADY ON DISK?

---

*U.S. Department of Commerce, Bureau of Census, Computer Programs for Demographic Analysis, June 1976.

If the answer is "Y" (yes), one is prompted to specify the name of the files and insert the correct disk:

GIVE THE FILE NAME FOR THE
QUINQUENNIAL DISTRIBUTION

One could respond, for example, with "ABC" if the data were in file "ABC".

INSERT THE DISK WITH THE
FILES IN DRIVE 2 AND PRESS <RETURN>

If the quinquennial distribution is <u>not</u> on disk, and one responds "N" (no), then a data entry routine is entered. A file name is first established:

WHAT DO YOU WHAT TO NAME THE QUINQUENNIAL FILE?

For example, this might be named "ABC". Then the number of 5 year age groups, <u>including</u> the open-ended interval is specified (for example 15):

GIVE NUMBER OF 5 YR AGE GROUPS (INCLUDING THE OPEN-ENDED GROUP)

After which a disk for storage must be inserted in Drive 2:

INSERT THE DISK ON WHICH YOU WANT TO STORE IN DRIVE 2
AND PRESS <RETURN>

Data entry then takes place:

```
ENTER POP. GROUPS ONE BY ONE
PRESS 'RETURN' AFTER ENTERING EACH ONE

1
?10
2
?20
3
?20
4
?20
5
?20
.
.
.
.
.
15
?7
```

After this, the program continues as in the case when the quinquennial data already existed (which is now the case). The number of 5 year groups excluding the open ended interval is then entered (for example 14).*

GIVE NUMBER OF 5 YR GROUPS
(EXCLUDING OPEN-ENDED INTERVAL)

Then the file name for the singulate age distribution file must be specified:

WHAT IS THE NAME OF THE SINGLE YEAR FILE?

For example, this might be named "DEF".

The program then performs the calculation and tells the user when it has finished and asks if another group needs to be split:

14 AGE GROUPS FROM FILE ABC WERE SPLIT
INTO 71 AGE GROUPS AND STORED ON
FILE DEF

DO YOU HAVE ANOTHER GROUP TO SPLIT?

If one responds "Y" (yes), then the program starts over, if one responds "N" (no), then one returns to the Executive Menu.

2. FID

See the Apple D.O.S. Manual, pages 184-189, for a full explanation of FID. After quitting FID, be sure the RPMA Program disk is in Drive 1 and type:

"RUN HELLO, D1"
<RETURN>

3. FILE JOIN

Occasionally it may be necessary to add one text or data file onto the end of another. For example, the RPMA MAIN Program reads the initial population singulate age distribution in such a way that it expects to find both males and females in the same file. Hence, after creating singulate age male and female files these must be "joined" into a single file.

---

*The open-ended interval cannot be split into single age groups since it contains more than 5 age groups.

After first running the program from the utility program menu, a short greeting is displayed and the user is prompted to enter the name of the first file:

-----FILE JOIN PROGRAM-----
THIS PROGRAM JOINS TWO TEXT FILES TOGETHER

GIVE NAME OF FIRST FILE

For example, one could respond "ABC" if a file ABC already existed.

You are then asked if the first element gives the length or number of elements in the file.

IS THE FIRST ELEMENT THE NUMBER OF ELEMENTS?

If the answer is N (no), then you are asked to specify the number:

GIVE NUMBER OF ELEMENTS:

The process is then repeated for the second file, and the name of the subsequent file with the two joined files must be specified:

GIVE NAME OF NEW FILE

After this is done, you are prompted to put the disk with the two files to be joined (they must both be on the <u>same</u> disk--if they are not, use "FID" or "FILE READ/WRITE" to put them on the same disk) into Drive 2.

INSERT THE DISK CONTAINING THE
FILES IN DRIVE 2 AND PRESS <RETURN>

When the joining is finished, you are asked if more joining is to take place. If the response is Y (yes) the program recycles, if it is N (no) the Executive Menu is displayed:

DO YOU WANT TO JOIN MORE FILES?

4. <u>FILE CREATE</u>

Program FILE CREATE allows the creation of a text file and is useful if one is creating a new data inputs file to be used by the RPMA MAIN and RPMA INPUTS program. When the program is run from the utility program menu, a greeting is displayed and one is prompted to supply the name of the file to be created:

THIS PROGRAM CREATES A TEXT FILE

ENTER NAME OF TEXT FILE

For example, the file might be called "ABC". Then the number of data elements in the file is requested.

NUMBER OF DATA ELEMENTS IN FILE:

For example, if one has a file for demographic inputs with four different variables (i.e., fertility, male life expectancy, female life expectancy, net migration) and one is adding a fifth variable (i.e., female labor force participation rate), then the file would contain 5 elements:

The repeat option is then specified:

TYPE 1 FOR REPEAT OPTION
TYPE 0 OTHERWISE

This is asking whether the file is to be replicated or repeated a certain number of times. For example, if the 5 elements are to be replicated 15 times (for 15 years) for use as data inputs files with RPMA, one would enter first a "1" in response to this question, followed by a "15" in response to the next question:

GIVE NUMBER OF TIMES TO REPEAT ELEMENTS

You are then prompted to insert a storage disk in Drive 2 and data entry takes place each element at a time. A typical sequence might be:

INSERT THE DISK ON WHICH YOU WISH TO WRITE IN DRIVE 2
AND PRESS <RETURN>

ENTER DATA ELEMENTS ONE BY ONE
PRESS 'RETURN' AFTER ENTERING EACH ONE

```
1
?5.3
2
?52
3
?53
4
?0.01
5
?0.56
```

After the last element (for example, the 5th) is entered, the disk in Drive 2 will start to turn and the new file will be written to disk. In the example illustrated, the first 5 elements will be 5.3, 52, 53, 0.01, 0.56; the second 5 elements will be 5.3, 52, 53, 0.01, 0.56, etc. When the process is finished, you are told so and asked if another file is to be created:

FILE ABC HAS BEEN CREATED AND WRITTEN TO DISK.

DO YOU WANT TO CREATE ANOTHER FILE?

If the answer is Y (yes), the process starts over; if it is N (no), then one is returned to the Executive Menu.

5. FILE READ/WRITE

The FILE READ/WRITE program, as its name implies, can read or write a text file. It can also be used to transfer and rename a text file from one disk to another, although one of the FID programs can also do this.

Upon running the program from the utility menu, the user is asked the name of the file to be read:

-----FILE READ/WRITE-----
THIS PROGRAM READS A DATA FILE

ENTER NAME OF DATA FILE

One is then asked if the first element is the length of the file, that is the total number of elements in the file:

IS FIRST ELEMENT OF FILE THE LENGTH?

If the answer is N (no), then the user must enter the length:

GIVE LENGTH

The correct disk must then be put into Drive 2:

INSERT THE DISK WITH THE FILE IN
DRIVE 2 AND HIT <RETURN>

You are then asked if you wish to store this file which is to be read on another disk:

DO YOU WISH TO STORE ON ANOTHER DISK?

If the answer is N (no), then you are asked if you want to use the printer:

DO YOU WANT TO USE THE PRINTER?

If Y (yes), then turn the printer on, type Y and press <RETURN>. The data will then be printed out.

If you wish to store the data which has been read on another disk, then you must first specify the name of the file under which it will be known. If it is to have the same name, then you can simply type "OLD" rather than retyping the old file name:

GIVE NEW FILE NAME OR TYPE 'OLD' FOR THE SAME NAME

You must then insert a new disk in Drive 2:

INSERT THE DISK TO WHICH YOU WANT TO WRITE
IN DRIVE 2 AND HIT <RETURN>

After the new file has been written to disk, press <RETURN> to re-enter the Executive Menu.

6. COPY A

This is the "Apple Diskette Duplication Program" and is used for copying an entire disk. See pages 38-40 of the Apple DOS Manual. After running this program the Executive Menu can be re-entered.

VII. Error Messages and Other Disasters

The RPMA set of programs have been written so that no special knowledge of computer programming is necessary in order to run them. Normally, by following the step-by-step instructions in each program and appropriately responding to prompts, you should be able to successfully run them. Nevertheless, mistakes do occur due to human error, power failure or even "bugs" in the program! In these cases, the user will want to know what to do.

The main programs (RPMA INPUTS, RPMA MAIN, and RPMA OUTPUTS) have incorporated into them "error routines" which give a message regarding an error and tell at what line number the error may have happened. In some cases, the error message is self-explanatory and by pressing the <RETURN> button one can continue. This is the case, for example, if an input file is missing while running the model or changing the data.

In other cases, it will be necessary to consult the "Table of Error Codes and Messages" below. After taking steps to correct the problem, it is probably best to return to the "Executive Menu" of RPMA. This can be accomplished by being certain that the RPMA Programs diskette in Drive 1 and entering:

PR#6
<RETURN>

Table of Error Codes and Messages

Code	Error	Most common case
1	LANGUAGE NOT AVAILABLE	Applesoft not on diskette
2,3	RANGE ERROR	Command parameter too large
4	WRITE PROTECTED	Write-protect tab on diskette
5	END OF DATA	READing beyond end of text file
6	FILE NOT FOUND	File misspelled, or not on diskette
7	VOLUME MISMATCH	Wrong Volume parameter
8	I/O ERROR	Door open, or diskette not INITED
9	DISK FULL	Too many files on diskette
1Ø	FILE LOCKED	Attempt to over-write a LOCKed file
11	SYNTAX ERROR	Bad file name, parameter, or comma
12	NO BUFFERS AVAILABLE	Too many text files OPEN
13	FILE TYPE MISMATCH	Diskette file doesn't match command
14	PROGRAM TOO LARGE	Insufficient Apple memory available
15	NOT DIRECT COMMAND	Command must be in a program
Ø	NEXT without FOR	
16	Syntax	
22	RETURN without GOSUB	
42	Out of DATA	
53	Illegal Quantity	
69	Overflow	
77	Out of Memory	
9Ø	Undefined Statement	
1Ø7	Bad Subscript	
12Ø	Redimensioned Array	
133	Division by Zero	
163	Type Mismatch	
176	String Too Long	
191	Formula Too Complex	
224	Undefined Function	
254	Bad Response to an INPUT Statement	
255	Ctrl C Interrupt Attempted	

APPENDIX A

DATA SOURCES FOR PARAMETERS

	Source	Page	Table
Demography			
Population by Age, Sex, District	6, 12	-	various
Fertility	13	-	various
Life Expectancy	13	-	various
Migration	14	-	various
Food Production			
Crop Yields	1	17	17
Crop Spoilage (%)	1	19	19 (foot note)
Cash Crop (%)	4	-	Statistical Profile
Crop Land (%)	1	15	15
Food Purchases	-	-	Hypothetical
Land			
Land Areas by Use	1	9 - 14	9 - 14
Food Requirements			
Distribution of Calories from Different Food Stuffs	5	67	Appendix 8.mil.
Education			
School Enrollment by Age and Sex	11	-	Table 1
Enrollment Rates by Age and Sex, Standard 1	-	-	-
Drop-out Rates by Standard and Sex	-	-	-
Repeat Rates by Standard and Sex	-	-	-

Previous Page Blank

Livestock	Source	Page	Table
# of Cattle in Base Year	1	3	III
Ann. Growth Rate of Cattle Herd	1	1	Notes
% of Cattle that are Cows	2	-	3
% of Cows that are Fertile	2	-	3
Calving Rate of Fertile Cows	2	-	3
Calf Death Rate	2	-	3
Adult Cattle Death Rate	2	-	4
Cull Rate of Cattle	3	15	-
Offtake Rate of Cattle	2	-	4
Average Weight/Cattle	1	6	Notes
Average Yield/Cattle Carcass	1	6	Notes
% of Cows that are Lactating	2	-	2
Milk Prod. per Cow per Day	1	20	XX
% of Milk Consumed by Calves	1	20	XX
# of Goats in Base Year	1	3	III
Ann. Growth Rate of Goat Herd	1	1	Notes
% of Goats that are Female > 2	2	-	42
Birth Rate for Female Goats > 2	2	-	42
Death Rate for Goats	2	-	43
Offtake Rate for Goats	2	-	43
Average Weight Per Goat	1	6	Notes
Average Yield Per Goat Carcass	1	6	Notes
# of Sheep in Base Year	1	3	III
Ann. Growth Rate of Sheep Herd	1	1	Notes
% of Sheep that are Female > 2	2	-	42
Birth Rate (%) of Female Sheep > 2	2	-	42
Death Rate for Sheep	2	-	44
Offtake Rate of Sheep	2	-	44
Average Weight Per Sheep	1	6	Notes
Average Yield Per Sheep Carcass	1	6	Notes
Land Required Per Animal Unit	1	2	Notes

	Source	Page	Table
Health			
Medical Officers	7	30	-
Asst. Med. Officers	7	30	-
Medical Assistants	7	30	-
Rural Med. Asst.	7	30	-
Nurses (Grade A)	7	30	-
Nurses (Grade B)	7	30	-
Laboratory Staff	7	30	-
MCH Aides	7	30	-
Hospital Aides	7	12	-
Dispensaries	7	12	-
Rural Health Centers	7	12	-
MCH Clinics	7	12	-
Recurrent Cost/Hosp. Bed	-	-	-
Recurrent Cost/RHC	-	-	-
Recurrent Cost/Dispensary	-	-	-
Capital Cost/Hosp. Bed	-	-	-
Capital Cost/RHC	-	-	-
Capital Cost/Dispensary	-	-	-
Water			
% of Pop. Served by Piped Systems	9	-	-
% of Pop. Served by Boreholes	9	-	-
% of Pop. Served by Shallow Wells	9	-	-
% of Pop. Served by Dams	9	-	-
% of Pop. Served by Traditional Sources	9	-	-
Target Pop. Per Piped System	N/A	-	-
Target Pop. Per Borehole	N/A	-	-
Target Pop. Per Shallow Well	N/A	-	-
Target Pop. Per Dam	N/A	-	-
Target Pop. Per Traditional Source	N/A	-	-
Capital Cost Per Piped System	N/A	-	-
Capital Cost Per Borehole	N/A	-	-
Capital Cost Per Shallow Well	N/A	-	-
Capital Cost Per Dam	N/A	-	-
Capital Cost Per Traditional Source	N/A	-	-
Cost to Add a Person to a Modern System	10	33	-

LIST OF SOURCES

1. "Agricultural and Livestock Production in Arusha Region: An Agricultural Economic Perspective." Merritt Sargent, October 1980.

2. "Tanzanian Livestock Meat Subsector." Regional Survey Data, Vol. IV, October 1976.

3. The Livestock Economy of Tanzania; a Study of Beef Industry. William MacKenzie, 1977.

4. Arusha Region Today: 1981, Regional Commissioner's Office, Arusha.

5. 1969 Household Budget Survey, VI: Income and Consumption, Bureau of Statistics, Tanzania, 1972.

6. 1978 Population Census Preliminary Report.

7. Inventory of Health Facilities 1978 - Arusha Region. Ministry of Health, August 1979, p. 30.

8. Evaluation of the Health Sector, 1979. Ministry of Health, September 1980. Appendixes.

9. (Papers brought back by Karen Allen -- no sources attached).

10. "Tanzania: Population Projections and Primary Eduation, Rural Health and Water Supply Goals." James E. Kocher, December 1976.

11. Enrollment Statistics, Primary Education, 1980, Statistical Section, Ministry of Education, United Republic of Tanzania.

12. A. Johnston, Population Profile of Arusha Region, January 1980.

13. R. A. Henin, The Demography of Tanzania: An Analysis of the 1973 Demographic Survey of Tanzania.

14. W. Mlay, "Assessment of Inter- and Intra-Regional Migration in Arusha Region," October 1981.

APPENDIX B

NOTES ON THE DEMOGRAPHIC DATABASE FOR THE REGIONAL PLANNING MODEL BY ARUSHA (RPMA)

by

Karen B. Allen

1. Source of Data

While population data for Tanzania as a whole are available in reasonable quantity and quality, on the regional and district level assembling a database which both accurately describes and can be used to satisfactorily project the population is much more problematical. Seven main sources were used for the RPMA demographic database; very few of these reflect contemporary, scientifically collected data specific to Arusha Region. The three most important sources of demographic data in Tanzania are the 1967 and 1978 Censuses and the 1973 National Demographic Survey. Unfortunately, complete and detailed results for the 1978 Census have not yet been released; only the 1978 Population Census Preliminary Report had been published as of July 1982.

Specific to Arusha, the Arusha Planning and Village Development Project in the Arusha Regional Development Directorate[1] has published three demographic reports. The first of these is Alan Johnston's Population Profile of Arusha Region (January 1980).[2] Johnston used the 1967, 1973, and 1978 censuses and survey, and was able to obtain unpublished district and village level data from the 1978 Census. Johnston's work is the most complete published compilation of demographic data for the region available. However, the data has not been analyzed or adjusted for reporting errors, and the projections were done based on constant assumed rates of natural increase, without including any estimates for migration.

Two reports published in October 1981 are C. L. Kamuzora's "Monitoring Population Growth in Arusha Region: Population Data Collection Systems and Suggestions for Improvement"[3] and Wilfred Mlay's "Assessment of Inter- and Intra-Regional Migration in Arusha Region".[4] Kamuzora's report essentially summarizes current estimates of district level population growth based on both

formal sources (Censuses and 1973 Survey and a small pilot survey done by the APVDP in 1979/80), and informal sources (Kamuzora's conversations with local government and party officials). In Mlay's report, "Best Possible Estimates" of net migration rates are calculated by projecting the reported 1978 population to 1981 by multiplying by an assumed rate of natural increase. The number of in-migrants less the number of out-migrants is then divided by the estimated 1981 population, and the result, multiplied by 100, is the net migration rate for the district. Mlay's source for the number of migrants (in and out) was the APVDP survey, but he adjusted the rates based on more informal estimates.

So far, six sources have been mentioned, all of them specific to Tanzania, if not to Arusha. These six were used to derive the base year population, the fertility and migration rates, and the life expectancies at birth. However, the tables used to compute the age specific mortality rates were drawn from the OECD Model Life Tables.[5] Model life tables are commonly used where complete and reliable mortality information for a population is not available. Perhaps the most frequently employed set of tables for work in less developed countries has been Ansley Coale and Paul Demeny's Regional Model Life Tables, Princeton, 1965. Whilst the relative newness of the OECD tables (Paris 1980) means they have not been as thoroughly tested as the Coale-Demeny sets, they do take advantage of some valuable refinements in the methodology and, unlike Coale-Demeny, are based on recent mortality data from less developed countries, including Tanzania.

2. Derivation of Inputs for RPMA

A. Population by Age

Since 1978 was Tanzania's most recent Census year, this was used as the base year for most of the sectors in the RPMA, including the demographic sector. The 1978 Population Census Preliminary Report gives male and female populations for Monduli, Arumeru, Arusha, Kiteto, Hanang and Mbulu districts in Arusha Region. Subsequently to the Census, Ngorongoro District was created from Monduli District. Knowing the names of the four wards comprising Ngorongoro District, and having access to the unpublished ward level Census data, Johnston was able to give figures by sex and age group for Ngorongoro in

his 1980 report. The 1978 Census Preliminary Report gives population data by largely aggregated age groups: 0 years; 1-4 years, 5-9; 10-14; 15-24; 25-34; 35-44; 45-54; 55-64; and 65 and over. The unpublished data collected by Johnston is less aggregated; it is in regular five year groups from 0-4 years through 70-74 years, with 75+ being the open-ended group. However, Johnston's quinquennial data is for both sexes combined. Wherever possible for RPMA, the published figures were checked against the unpublished figures. Infrequently, slight discrepancies appeared that could not be explained by misprinting or arithmetical error. In these cases, the published figures were used since they are the official ones.

A brief examination of the reported Census figures reveals no great irregularities which might be attributable to age misreporting. The quinquennial grouping tends to smooth a population distribution, and an effective analysis of error requires the examination of a singulate distribution (which the Census Bureau has not yet released). Therefore, no adjustments were made to the officially published figures except to disaggregate them into five year groups by sex and add the District of Ngorongoro. Proportions in each five year age group were calculated from Johnston's figures for males and females combined. These proportions were then applied to the published figures of ten year groups of males and of females. The implied assumption that the male and female populations have the same distributions across five year groups within each ten year group is not unrealistic, especially given the apparent regularity of the sex ratios in the ten year distribution. Obviously, it would be preferable to have the actual, reported figures, but until these are made available, the above derivation provides an acceptable database.

RPMA thus begins with a population in five year groups by sex and by district. In order to make various projections, this data must be in singulate years. Lacking the reported singulate figures, the U.S. Census Bureau's computer program 'Beers' was used to split the quinquennial groups (see User's Manual).

Having arrived at base year population figures in the form required by RPMA, the next step is to decide on fertility, mortality and migration schedules. In all three cases, it is preferable to have age and sex specific

rates. In the ideal model, these rates should also be local, i.e., one would like to have three sets of rates for each district within Arusha Region with some idea of how these rates will change over time. Since this type of detailed data is often not available on a national level, it is not surprising that it has not been collected and calculated for the seven districts of Arusha Region. After reviewing the existing demographic estimates for Arusha and Tanzania, different approaches were adopted for the fertility, mortality and migration schedules.

B. Fertility

The methodology for projecting population in RPMA requires as input a total fertility rate (per woman) for each district. These rates are then matched to a model fertility distribution schedule, with the computer program interpolating between schedules to match each rate. The schedules in RPMA are the United Nations Fertility Model for Subsaharan Africa which matches a different age specific fertility distribution to different levels of total fertility. Thus the RPMA takes into account that the shape of the fertility distribution curve may change over time in correlation with the level of fertility in a population. For instance, a country undergoing a demographic transition may gradually move from an early high or broad peak curve to a late high or broad peak curve. This has obvious implications for calculating the number of births in a year, which in RPMA depends not only upon a birth rate but also upon the number of women in a cohort experiencing different rates.

In order to arrive at the district specific rate required by the model, a number of assumptions had to be made, and some simple calculations carried out. An excellent analysis of the demography of Tanzania was done using the 1973 National Demographic Survey results.[6] From reported live births in 1972 and 1973, age specific fertility rates (per 1000 women) were derived for Tanzania as a whole, and regional estimates of total fertility rates were made. Using three different techniques, the TFR estimates for Arusha ranged between 6.3 and 6.8, among the highest in the country. (The northeastern regions of the country, including Arusha, have generally the highest fertility and the lowest mortality rates.) By converting the fertility rates schedule for Tanzania to a schedule of proportions of births by five year cohort (an age specific fertility distribution) and applying these proportions to district

specific information, district level rates can be derived. An example of this procedure, for Arusha Town District, is given in Table II. The procedure yields rates that are rather high (6.2 to 8.3), but not impossible considering recent improvements in health care, nutrition and sanitation combined with the low prevalence of modern contraceptive practice. Neighboring Kenya is experiencing similar high fertility rates.

C. Mortality

The mortality input required by RPMA is the estimate of life expectancy at birth by sex. Whilst various estimates of the crude death rate by district (Kamuzora 1981) and the regional life expectancy by sex (1973 Demographic Survey and Johnston 1980) are available, life expectancies by district have not been published. This is probably because, more than any other demographic statistic, estimates of mortality from countries with scarce and faulty data are prone to error. The 1973 NDS estimates of mortality made use of several techniques of information collection and analysis, yet there is no guarantee that the results are more reliable than the 1967 Census estimates. Kamuzora (1981) believes that the 1967 Census estimate of 12.4 is still the most accurate for the Crude Death Rate, 15 years later. In any case, the doubtful nature of mortality estimation in Arusha Region suggested that attempted manipulation of the data to elicit district level life expectancies by sex was not warranted. Given the structure and purpose of the RPMA, accurate, district level mortality estimates are less important to the population projections than are fertility estimates. Therefore, for the trial run of the model, the regional life expectancies of 53.89 for males and 57.5 for females (1973 NDS) were used in all districts. As more and better mortality information becomes available, it may well be desirable to input district specific rates.

As previously mentioned, the 1980 OECD Model Life Tables, specifically designed for use in developing countries, were selected for use in RPMA. Since life expectancy was the only available parameter for Arusha, the tables classified according to life expectancy at birth were employed. Of the four regional models, Region D seemed most appropriate to the Tanzanian mortality experience as reported from 1973 NDS. Those age specific mortality rates are characterized by a high infant mortality rate; a mortality rate for children under ten which is slightly above the average for all four OECD regions; a gradually decreasing rate through the middle age groups followed by an increas-

TABLE II

Derivation of Total Fertility Rate Estimate for Arusha Town District

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
CBR	TOT. POP.	BIRTHS	AGE GRP	WOMEN	ASFD(TAN)	BIRTHS/AGE	ASFR	TFR
40	86845	3473.8	15-19	5806	.1215617	422.281	72.732	8.293
			20-24	4828	.2511091	872.303	180.676	
			25-29	3325	.2271517	789.080	237.317	
			30-34	2833	.1730257	601.057	212.163	
			35-39	1552	.1286602	446.940	287.977	
			40-44	1163	.065661	228.093	196.125	
			45-49	805	.0328305	114.047	141.673	

Notes for Table I

(1) Column A is an estimate given in Kamuzora 1981.

(2) Column B is the 1978 Census figure.

(3) Column C is (Column B/1000) (Column A).

(4) Column D references age groups of fertile women.

(5) Column E is quinquennial groupings of women derived from the published 1978 Census results.

(6) Column F is derived from Vol. I, Table 3090B of The Demography of Tanzania (1973 National Demographic Survey).

(7) Column G is Column C times each row of Column F.

(8) Column H is, row by row, Column G/Column E × 1000.

(9) Column I is the sum of Column H × 5/1000.

ingly high rate in the older ages. While this pattern of age specific mortality rates does not correspond exactly to the OECD Region D pattern, the general pattern of the curves and the relative differences in death probabilities demonstrate an acceptable match. In fact, the model tables in Region D were derived from a file of 39 life tables, which included one from the 1967 Tanzanian Census. The tables in RPMA correspond to levels of mortality ranging between 50.27 and 72.83 for females and 50.73 and 71.38 for males. Just as with the model fertility schedules, the RPMA interpolates between the tables to match the exact age specific mortality schedule.

D. Migration Rates

The final demographic input required by RPMA is migration. The nature and quality of this input was severely constrained by the near absence of reliable data. The ideal solution would have been fairly complex, involving sets of age specific migration rates as well as matrices indicating not only interdistrict migration flows but also losses and gains from other regions in Tanzania. The long border of Arusha with Kenya might make international migration significant as well. Though this border is officially closed, a not insignificant amount of crossing by rural people does take place. None of these flows and rates have been recently and reliably estimated, although some studies of migration to Arusha Town and more recently Arumeru do exist. Several studies of inter-regional migration in Tanzania (1971 Claeson, 1973 Egero, 1979 Sabot)[7] have shown Arusha to be a region of heavy in-migration, from neighboring Kilimanjaro, Singida and Dodoma Regions in particular. The 1978 Census asked questions which should provide detailed descriptions of migration flows between 1967 and 1978. Until this is published, however, the only district level information is summarized in Mlay 1981, and this is simply a series of rough estimates of net migration rate for each district. Changes in district boundaries, underenumeration in the 1967 Census and unrealiable estimates of district level rates of natural increase are all factors complicating attempts to compare expected (through natural increase) and enumerated (reflecting net migration) populations. While awaiting the migration analysis from the 1978 Census, it seemed wise to use Mlay's estimates for the RPMA. Furthermore, it was decided not to arbitrarily impose an international model of age specific migration rates, partly because conditions in Arusha Region's

districts vary considerably. Thus the net migration rates in the preliminary version of the RPMA are simply: Arumeru - 0.5%; Arusha Town + 2.2; Hanang + 0.6%; Kiteto + 1.8%; Mbulu 0.0; Monduli + 2.0%; Ngorongoro 0.0.

3. Summary

The four basic components to the demographic database for the RPMA are the base year (1978) population by age, sex and district; a total fertility rate for each district which is related to a model age distribution of fertility; a regional life expectancy by sex (with provision made for district level rates) which is related to female and male model life tables; and, finally, a net migration rate for each district. While none of these inputs reflect ideal methodology or highly accurate estimation, they do provide a reasonable, working basis for projecting the population of Arusha Region. Full publication of the 1978 Census results should greatly enhance the amount and, it is to be hoped, quality of the demographic data available to planners. Furthermore, there has been a movement toward improving village and district level registration of demographic phenomenon. As better data becomes available to Arusha planners, the inputs to the RPMA can easily be changed, updated and improved by the computer operator.

Notes for Appendix B

1. APDP is funded by USAID and was begun in 1979. Its purpose is to "combine a regional planning process with the simultaneous development and implementation of village income generating and related development projects."

2. Johnston, Alan; Population Profile of Arusha Region; Report prepared for the Regional Development Directorate, Regional Commissioner's Office, Arusha, Tanzania; January 1980.

3. Kamuzora, Chrysanth Lwechungura; "Monitoring Population Growth in Arusha Region: Population Data Collection Systems and Suggestions for Improvement"; Report prepared for the Regional Development Directorate, Regional Commissioner's Office, Arusha, Tanzania; October 1981.

4. Mlay, Wilfred; "Assessment of Inter- and Intra-Regional Migration in Arusha Region"; Report prepared for The Regional Development Directorate, Regional Commissioner's Office, Arusha, Tanzania; October 1981.

5. Clairin, Rémy, Condé, Julien et. al; Mortality in Developing Countries, Tome III, Development Centre of the Organisation for Economic Co-operation and Development, Paris 1980.

6. Henin, Roushdi A., Editor; The Demography of Tanzania: An Analysis of the 1973 Demographic Survey of Tanzania; a multivolume joint publication of the Bureau of Statistics, Ministry of Finance and Planning and the Demographic Unit, Bureau of Resource Assessment and Land Use Planning, University of Dar es Salaam, Tanzania.

7. Claeson, Claes-Fredrik and Bertil Eger; "Inter-regional Migration in Tanzania", African Population Conference, Accra, Ghana, 9-18 December 1971, quoted in Johnston 1980, op.cit.