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PN-AAM-510/62

ANALYTICAL WORKING DOCUMENT # 20

AGRICULTURE-NUTRITION MODEL: REVISIONS OF NUTRITIONAL REQUIREMENTS AND ANALYSIS OF FOOD IMPORT AND EXPORT ALTERNATIVES.

PN-21641

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April 1975

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Agriculture-Nutrition Model: Revisions of Nutritional Requirements and Analysis of Food Import and Export Alternatives

The purpose of this document is to report some revisions and new analytical results of an agriculture-nutrition model of Colombia presented in an earlier Analytical Working Document. 1/ First, the minimum nutritional requirements were changed to reflect two recent reports; the model was then solved using the revised requirements. Second, the model was modified to allow changes in exports and imports of food.

Analysis of Malnutrition Problems

Before presenting the detailed results, it may be useful to put this particular analysis in a more general context. Malnutrition is a complex phenomenon caused by many interrelated social, economic and physical factors. However, at the risk of over simplifying, our analysis focuses on the production and disposition of food in relation to predetermined nutritional needs. We divide the malnutrition problem into three parts:

1/ Suttor, Richard E., Adjustments in Agricultural Production to Attain Minimum Nutritional Requirements Consistent with Consumer Incomes, Analytical Working Document #16, February 1974.

1. The available supply of food (domestic production plus net imports) may be inadequate to meet the population's nutritional requirements;
2. Some people cannot produce or purchase enough food, although the total available supply may be adequate;
3. Individuals or families choose diets that are inadequate from a nutritional point of view, although they can produce or purchase adequate food.

If the available supply in a country or region is inadequate, it may be possible to solve this aspect of the problem by changing domestic production or net imports of food. The analysis reported in this document first asks whether, with given technology and resources, the agriculture sector can produce adequate food by changing the mix of agricultural products and/or increasing total production. The results show that this can be done with relatively minor changes in Colombia's agricultural production. We then proceed to ask whether adequate food can be obtained by altering the mix of food imports and exports. According to the model results, adequate food can be obtained while at the same time increasing net foreign exchange earnings, although a very small change in agricultural production may still be needed.

The model gives some insight into the second part of the malnutrition problem by means of constraints on food purchasing power for each of four income groups. The results indicate that all four groups in Colombia, even the lowest quartile income group, can obtain enough food to attain minimum nutritional requirements. However, this does not indicate that all consumers can obtain adequate food. In all likelihood, a large but unknown proportion of the lowest income quartile cannot obtain enough. The model can only provide conclusions about averages of groups of people, and cannot precisely estimate the number of individuals or families unable to produce or purchase adequate food.

With respect to the third part of the malnutrition problem, an earlier study of Colombian working class families [2/] shows that these families could significantly lower the costs of their nutrient intake by changing the composition of their diets. The present study, although not specifically designed to answer this question, is consistent with the Florencio and Smith findings. A shift of expenditures by the lowest income group

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2/ Florencio, Cecilia A., and Victor E. Smith, "Toward More Efficient Expenditure for Food Among Colombian Families", Nutrition Reports International, Vol. 1, No.4., p. 207-230.

away from meat and fruits and toward milk, grains and vegetables is indicated. Even though total food supply need not change very much, the mix of foods purchased by the various income groups must change to allow all four income groups to attain their respective nutritional intake requirements.

Nutritional Requirements

The earlier runs of the agriculture-nutrition model used nutritional requirements developed for a study by IIT in Colombia. [3/] Subsequently, these appeared to be at variance with current expert opinion. [4/] Therefore, a new set of requirements was developed. Table 1 compares the "IIT requirements" used in the earlier runs with the "FAO/WHO and NAS requirements" used in the analysis reported in this document.

The new food energy requirements are slightly higher. The protein and constituent amino acid requirements, however, are much lower. The individual amino acid requirements are drastically reduced because (a) total protein is reduced and (b) the required amount of the amino acid per unit of protein is also reduced. The requirement for fat is eliminated;

3/ See first footnote in Table 1.

4/ See second footnote in Table 1.

although two fatty acids are known to be essential, [5] the requirement for fat as such appears to be misleading. Vitamin and mineral requirements are not changed very much.

There is a great deal of uncertainty regarding nutritional needs. Food energy needs depend upon the level of physical activity, body size and other factors that we are unable to take into account in calculating aggregate requirements. Similarly, protein needs are influenced by stress factors such as infections, trauma, pain and anxiety. [6] Other nutrient requirements appear to be even more uncertain. The following quotation summarizes the current state of the art.

> Use of the term "Recommended Dietary Allowances" to describe these estimates of acceptable daily intakes has some unfortunate connotations....While a diet made up of ordinary foods meeting the RDA standard should maintain health, we are well aware that present knowledge of nutritional needs is incomplete.

5/ National Academy of Sciences, Recommended Dietary Allowances, Eight edition, Washington, D.C., 1974, p. 49.

6/ FAO/WHO Ad Hoc Expert Committee, Energy and Protein Requirements, Food and Agriculture Organization of the United Nations, Rome, 1973,

Table 1. Alternative Minimum Nutritional Requirements Per Person Per Day by Age Groups

Nutrient	Units	IIT Requirements 1/				
		Less than One Year	1 thru 4 Years	5 thru 9 Years	10 thru 14 Years	15 years and Over
Food Energy	Calories	549	1,322	1,901	2,509	2,330
Protein	Grams	27.5	35.0	39.0	68.0	72.6
Fat	Grams	25.0	38.5	54.2	71.3	66.3
Calcium	Mg.	600	700	800	800	595
Iron	Mg.	7.0	9.0	12.0	15.0	13.7
Vitamin A	I.U.	1,500	2,000	3,500	4,500	4,991
Riboflavin	Mg.	0.50	0.80	1.20	1.50	1.44
Niacin	Mg.	6.0	9.0	12.9	17.0	15.9
Vitamin C	Mg.	40.0	40.0	40.0	40.0	50.0
Isoleucine	Grams	1.81	1.86	2.07	3.61	3.34
Lysine	Grams	2.11	3.74	4.17	7.27	3.70
Methionine & Cystine	Grams	1.70	1.68	1.87	3.27	4.65
Threonine	Grams	1.21	2.14	2.38	4.14	2.25
Tryptophan	Grams	0.44	0.56	0.62	1.09	1.16
Valine	Grams	1.84	2.07	2.30	4.00	4.21

1/ Based on data in Instituto de Investigaciones Technologicos, Diseño de Dietas de Costo Minimo, Bogota, Colombia, 1972, p.23.

2/ Food energy, protein, and amino acid requirements based on data in FAO/WHO Ad Hoc Expert Committee, Energy and Protein Requirements, Food and Agriculture Organization of the United Nations, Rome, 1973 P.34, 35, 58 and 74. Vitamin and Mineral requirements are taken from National Academy of Sciences, Recommended Dietary Allowances, Washington, D.C., 1974, table following p.128.

3/ Includes allowances for pregnant and lactating women.

4/ Average of the five age groups weighted by population. See Table A1 for population data.

(CONTINUED)

Table 1. Alternative Minimum Nutritional Requirements Per Person Per Day by Age Groups

Nutrient	Units	FAO/WHO and NAS Requirements 2/					
		Less than 1 Year	1 thru 4 Years	5 thru 9 Years	10 thru 14 Years	15 Years and Over	Weighted Average 4/
Food Energy	Calories	820 3/	1,443	2,068	2,550	2,650	2,293
Protein	Grams	22.5 3/	17.0	23.0	31.3	33.5	28.9
Fat	Grams	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Calcium	Mg.	450	800	800	1,160	933	900
Iron	Mg.	12.5	13.75	10.0	17.2	14.5	14.0
Vitamin A	I.U.	1,700	2,125	2,980	4,080	4,550	3,784
Riboflavin	Mg.	0.50	0.875	1.16	1.38	1.48	1.29
Niacin	Mg.	6.5	9.75	14.4	16.9	15.8	14.5
Vitamin C	Mg.	35.0	40.0	40.0	45.0	47.8	44.5
Isoleucine	Grams	0.79	0.63	0.85	1.16	0.60	0.73
Lysine	Grams	1.17	1.28	1.73	2.35	0.74	1.20
Methionine & Cystine	Grams	0.65	0.58	0.78	1.06	0.80	0.79
Phenylalanine	Grams	0.99	0.75	1.01	1.38	0.44	0.72
Tryptophan	Grams	0.19	0.08	0.11	0.14	0.22	0.17
Valine	Grams	1.06	0.70	0.94	1.28	0.60	0.78

1/ Based on data in Instituto de Investigaciones Technologicos, Diseño de Dietas de Costo Mínimo, Bogota, Colombia, 1972, p.23.

2/ Food energy, protein, and amino acid requirements based on data in FAO/WHO Ad Hoc Expert Committee. Energy and Protein Requirements, Food and Agriculture Organization of the United Nations, Rome, 1973 P.34, 35, 58 and 74. Vitamin and Mineral requirements are taken from National Academy of Sciences, Recommended Dietary Allowances, Washington, D.C., 1974, table following p.128.

3/ Includes allowances for pregnant and lactating women.

4/ Average of the five age groups weighted by population. See Table A1 for population data.

> Requirements of man for many nutrients have not been established. The essentiality of several nutrients has been established only within the past few years. Also, research continues to provide new information about the relationship between nutrition and resistance to infection and stress to cite just two problems under active investigation. 7/

Despite these uncertainties, the requirements used in earlier runs of the model clearly needed revision. The new requirements, although also subject to change, more accurately reflect current knowledge. Not surprisingly, the results discussed in the next section are considerably different than those reported in the earlier document on this model. 8/

7/ National Academy of Sciences, op. cit., p.2.

8/ Suttor, op. cit.

Changes in Agriculture to Meet Nutritional Requirements

As described in a previous document, [9] the linear programming model is solved to obtain the minimum change in agriculture needed to attain nutritional requirements for all four income groups. By incorporating restrictions on income, the solution is forced to be consistent with alternative income distribution patterns.

Unlike the earlier results, there is a feasible solution to the model without any income redistribution. All four income groups are able to obtain enough food to meet the new nutritional requirements without any income supplements. This finding does not rule out the possibility of a large number of individuals or families being unable to obtain adequate food. It does, however, show that the average income of the lowest income group (25.5 percent of the population) is adequate.

Table 2 summarizes the changes in agricultural production to meet nutritional requirements when food imports and exports are fixed at their 1968 levels. These results are obtained from the solution with no income redistribution; all other solutions are similar, although as more income is redistributed, the required change in agricultural production decreases slightly. Only vegetable production changes.

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[9] Ibid., P. 2-8.

Carrots, a good source of vitamin A, and cabbage increase, while tomatoes and onions decrease.

Positive shadow prices in this solution are obtained for only two nutritional restrictions--calcium and vitamin A. This is in sharp contrast to the earlier runs in which three amino acid restrictions---lysine, methionine and cystine, and tryptophan--- exhibited the highest shadow prices.[10/]

10/ Ibid., p.30.

Table 2. Changes In Agricultural Production When Imports And Exports Are Not Allowed to Change

Commodity	Valued Added		Land Area	
	1968 Actual 1/	Program Solution 2/	1968 Actual 1/	Program Solution 2/
	(Million Pesos)		(Thousand Hectares)	
Tomatoes	24.4	*	3.0	*
Onions	27.9	*	3.0	*
Carrots	5.4	22.0	3.0	12.2
Cabbage	8.0	152.8	2.0	38.1
All Others	13,092.7	13,092.7	28,094.6	28,094.6
Total	13,158.4	13,267.5	28,105.6	28,144.9

* Less than 0.05

1/ Source: Analytical Working Documents 4 and 16.

2/ Results from model solution with estimated 1968 income distribution, i.e., with no income redistribution.

Changes in Food Imports and Exports to Meet Nutritional Requirements

The model was modified to investigate the possibilities of meeting nutritional requirements by changing food imports and exports as well as domestic production. Initially, one export and one import activity for each food were added to the linear programming matrix. Since actual 1968 imports and exports are accounted for in the right hand sides, these new activities refer to additional imports and exports beyond the 1968 levels. Each activity contains two elements: (a) in the appropriate food balance equation, a negative coefficient for export activities and a positive coefficient for import activities, and (b) the foreign exchange cost or earnings per unit of the activity in a new foreign exchange row with a positive sign for exports and a negative sign for imports. For lack of better data, retail prices were used as measures of foreign exchange prices. The foreign exchange row is constrained to be greater than or equal to zero, i.e., the value of additional food exports must be greater than or equal to the value of additional food imports.

When we allow additional imports and exports of all foods, nutritional requirements can be met with no change in agricultural production or income distribution. However, this solution includes the export of some foods for which there are no traditional export markets for Colombia and the import of some foods in which international trade is very small or nonexistent.

Consequently, another run was made after deleting most international trade activities and retaining only (a) export activities for foods with net exports in 1968 and (b) import activities for foods with net imports in 1968. The results with these "traditional" import and export activities are summarized in Table 3. The only change in domestic agriculture is increased carrot production. Relatively large increases in foreign trade occur, with the value of additional imports equivalent to 27 percent of the total value of food consumption.

When no income is redistributed, total consumers' food expenditure is limited to the 1968 level. Thus, with an increase in the retail value of domestically produced food, the value of additional exports exceeds the value of additional imports. In other words, an improvement in the nutritional situation is accomplished by changing the mix of foods consumed while improving net foreign earnings.

More non-zero shadow prices for nutritional constraints appear in this solution. The lower limit on food energy is binding for one income group and the upper limits (set at 110 percent of the lower limit) are binding for other income groups. Calcium, vitamin A, vitamin [illegible] iron and niacin are also binding. All protein and amino acid restrictions are non-binding.

Table 3. Changes In Food Imports And Exports And Agricultural Production When Traditional Imports And Exports Are Allowed to Increase. 1/

Commodity	Additional Value Added In Domestic Production	Retail Value of Additional Exports	Retail Value of Additional Imports
	(Million Pesos)	(Million Pesos)	(Million Pesos)
Carrots	12.9 2/	-	-
Coffee	-	587.1	-
Sugar	-	2,751.0	-
Beef	-	5,233.9	-
Pineapple	-	53.6	-
Fish	-	1,288.4	-
Corn	-	-	1,216.2
Chicken	-	-	542.2
Milk	-	-	7,840.0
Total	12.9	9,914.0	9,598.4

1/ Results of model solution with estimated 1968 income distribution, i.e., with no income redistribution.

2/ Retail value of additional production is 91.6 million pesos. This should equal the difference between the totals for additional exports and additional imports; the inconsistency is due to some unknown numerical error in the linear programming matrix.

Consumer Expenditure Patterns

Food expenditure patterns generated by the linear programming model (Tables 4 and 5) can be compared with actual food expenditures in Cali, Colombia (Table 6). In terms of these six expenditure categories, the program solution calls for shifts in the expenditures of the two lowest income groups away from meat and fruits and into milk and eggs, grains and vegetables. According to the model, a larger share of the nation's meat supply should be consumed by the higher income groups with a sharp reduction in consumption by the lower income groups. However, lower income groups would partially compensate for this loss by consuming more of other animal products, i.e., milk and eggs.

Table 4. Food Expenditure By Consumer Group With 1968 Income Distribution And No Trade Activities

Commodity Group *	Very Low Income Group	Low Income Group	Middle Income Group	Upper Income Group
	(Million Pesos)			
Meat 1/	182.5	648.2	3,827.9	7,367.2
Milk and Eggs 2/	555.6	1,019.2	1,016.6	3,513.1
Grains 3/	1,236.4	2,621.3	-	392.7
Fruits 4/	-	243.5	2,094.9	1,465.0
Vegetables 5/	823.4	1,747.8	1,267.4	521.3
Other 6/	1,640.9	1,283.8	1,247.6	457.1
Total	4,438.9	7,563.8	9,452.8	13,716.3

1/ Poultry, Pork, beef and fish

2/ Eggs and milk

3/ Beans, corn, wheat, barley and rice

4/ Bananas, citrus fruit, plantains, pineapple and guava.

5/ Yuca, potatoes, tomatoes, arracacha, onions, beets, carrots, cabbage, lettuce and peas.

6/ Coffee, green coconuts, sugar cane, sesame, soybeans, African palm and cotton seeds. Edible oil is derived from sesame, soybeans, African palm and cotton seed, and is assumed to be the only product produced for human consumption from these crops.

Table 5. Percentage Distribution of Food Expenditures Over Commodity Groups With 1968 Income Distribution and No Trade Activities

Commodity Group	Very Low Income Group	Low Income Group	Middle Income Group	Upper Income Group
	(Percent)			
Meat 1/	4.0	8.6	40.5	53.7
Milk and Eggs 2/	12.5	13.5	10.8	25.6
Grains 3/	27.8	34.6	-	2.9
Fruits 4/	-	3.2	22.2	10.9
Vegetables 5/	18.5	23.1	13.4	3.9
Other 6/	37.0	17.0	13.1	3.3
* Total	100.0	100.0	100.0	100.0

* Total may not equal 100 percent due to rounding error.

1/ Poultry, pork, beef and fish.

2/ Eggs and milk.

3/ Beans, corn, wheat, barley and rice.

4/ Bananas citrus fruit, plantains, pineapple and guava.

5/ Yuca, potatoes, tomatoes, arracha, onions, beets, carrots, cabbage, lettuce and peas.

6/ Coffee, green coconuts, sugar cane, sesame, soybeans, African Palm and cotton seeds. Edible oil is derived from sesame, soybeans, African palm and cotton seed, and is assumed to be the only product produced for human consumption from these crops.

Table 6. Percentage Distribution Of Food Expenditures Over Commodity Groups In Cali, Spring 1969 *

Commodity Group	Very Low Income Group	Low Income Group	Middle Income Group	Upper Income Group
	(Percent)			
Meat	27.2	30.3	32.3	33.8
Milk and Eggs	8.2	12.9	15.7	16.5
Grains	24.8	22.1	20.4	13.7
Fruits	9.7	11.0	9.5	14.2
Vegetables	7.8	6.2	4.2	7.8
Other	22.0	17.0	16.4	14.1
Total 1/	100.0	100.0	100.0	100.0

* Commodity grouping same as in Tables 4 and 5.
Source: Based on Riley, Harold, et. al. Market Coordination in the Development of the Cauca Valley Region - Colombia, Michigan State University, East Lansing, 1970.

1/ Total may not equal 100 percent due to rounding error.

The diet of the lowest income group in the model solutions in terms of quantity of food (Table 7) consists mainly of corn, milk and panela. These are also the most important items in an earlier least cost diet study of Colombian families.[11/] Carrots are a common element of the diets. The quantity of meat is very small or zero in the diets.

11/ Florencio and Smith, op. cit.

Table 7. Comparison Of Diets Indicated By Linear Programming Models

Food	Diet of Lowest Income Group in Agriculture-Nutrition Model		Florencio & Smith Least Cost Diet Model 1/
	With Trade Activities	Without Trade Activities	
	Kg/Day/Person	Kg/Day/Person	Kg/Day/Family
Corn & Corn Flour	0.51	0.35	2.10
Milk & Cheese	0.66	0.17	1.56
Panela	0.15	0.35	0.41
Potatoes	-	0.07	-
Yuca	-	0.06	-
Arracacha & Plantains	-	-	0.39
Dry Lentils & Black Beans	-	-	0.06
Cabbage	0.02	0.11	-
Carrots	0.03	0.02	0.05
Chicken	-	*	-
Beef	-	*	-
Oranges	-	-	0.07
Vegetable Oil	0.02	-	0.01
Guava	0.01	-	-

1/ Source: Average of eight cities using "minimum standard" in Florencio, Cecilia A., and Victor E. Smith, "Toward Move Efficient Expenditure for Food Among Colombian Families", Nutrition Reports International, Vol. 1, No. 4 (April 1970), p.224.

* Less than 0.005.

Implications for Policies and Programs

The agriculture-nutrition model was not designed to analyze specific policies or programs, however, the results do have implications for these activities. In the following paragraphs we discuss some rather general conclusions which we believe are consistent with our analysis, but are by no means definitive. Much more work is needed to design coherent and effective policies and programs to combat malnutrition.

In the long run, both the demand and supply of food can be influenced by governmental initiatives to improve the nutritional status of the population. On the demand side, efforts should be directed toward increasing the demand for food by the poorest groups, including (a) helping the smallest farmers produce more or earn more off-farm income, (b) creating greater demand for the labor of the landless rural poor and the urban poor. Both formal and informal food and nutrition education programs to modify the composition of food demand may be effective in helping the poor to obtain greater nutritional benefit from their food expenditures.

Long run efforts to influence supply should be directed toward lowering the cost of food to the poor. It should be possible to focus on specific products on which the poor spend large proportions of their incomes and/or products for which it is desirable

to increase consumption from a nutritional point of view. Two possibilities are (a) corn and corn products, which account for a large part of the poors' food expenditure and appear to be efficient nutrient sources, and (b) milk and milk products, which are not consumed in large quantities by the poor, but are efficient nutrient sources. The retail cost of these foods can be lowered by increasing the efficiency of farm production or processing and marketing functions between the farmer and the consumer.

Increased demand for selected foods might best be met by increased domestic production rather than imports. Related to this issue, however, are possible conflicts between the objectives of lowered food costs and higher incomes for the poorest farmers and rural landless workers. Specific programs and policies need to be assessed from both points of view.

In the short run, programs to deliver food to the poor can be implemented relatively quickly. These might include free food distribution, price subsidies or food for work. Consideration should be given to purchasing food locally rather than relying on imported foods. Also, fortification of food purchased by the poor to meet specific nutritional deficits (e.g., vitamin A) may be feasible and cheap.

Our analysis suggests that it is not necessary to increase the consumption of most "high protein" foods among the poor, or the population as a whole. As pointed out in the previous

section, cheap and nutritionally adequate diets can consist mainly of corn and corn products, panela and smaller quantities of other foods with only one food usually thought of as a "high protein" food, i.e., milk.

Programs to modify the protein content of traditional foods or to promote specially formulated high protein foods do not appear to be effective. We conclude that (a) plant breeding programs should be directed toward producing more corn rather than altering the amino acid content, e.g., high lysine corn, (b) amino acid fortification will be of little or no benefit, and (c) the poor should be encouraged to purchase increased amounts of selected traditional foods rather than specially formulated high protein foods. There may well be an important role for plant breeding, fortification and specially blended foods in meeting vitamin and mineral needs, but attempts to use these instruments to provide more protein or essential amino acids would probably be a misallocation of scarce resources.

A systematic assessment of ongoing nutrition programs and policies in Colombia should be carried out. Such an assessment would identify linkages among programs and implementing agencies. The various linkages and implementing agencies could be coordinated through a central unit in such a manner that would permit complimentary action in attempting to improve national nutritional levels.

Table A1, Estimated Population by Age Group, Colombia, 1968

Age Group	Population 1/ (Thousands)
Less than one year 2/	1,115
1 thru 4 years 2/	2,601
5 thru 9 years	3,064
10 thru 14 years	2,683
15 years and over	10,819
Total:	20,282

1/ Source: Enrique Perez Sanin, "Parametros Demograficos Colombianos 1951-1964, Proyecciones de Poblacion 1965-1985", p. 269.

2/ Source shows population 0-4 years; 30 percent of this aggregate was allocated to "less than one year" category.

Table A2. Calculation of National Nutritional Requirements for the Year 1968 [1]

Nutrient	Units	Less than One Year		1 thru 4 Years		5 thru 9 Years		10 thru 14 Years		15 Years and Over		Total National Requirement
		Per Capita Requirement	Total Requirement	Per Capita Requirement	Total Requirement	Per Capita Requirement	Total Requirement	Per Capita Requirement	Total Requirement	Per Capita Requirement	Total Requirement	
		(Units)	(Million Units)	(Units)	(Million Units)	(Units)	(Million Units)	(Units)	(Million Units)	(Units)	(Million Units)	(Million Units)
Food Energy	1,000 Calories	299	333	527	1,371	755	2,313	931	2,498	967	10,462	16,977
Protein	Hectogram	82.1	91.5	62.1	161.5	84.0	257.4	114.2	306.4	122.3	1,323.2	2,140.0
Calcium	Gram	164	182	292	759	292	895	423	1,135	341	3,689	6,650
Iron	Centigram	456	508	502	1,306	365	1,118	628	1,685	529	5,723	10,340
Vitamin A	1,000 I.U.	621	692	776	2,018	1,088	3,334	1,489	3,995	1,661	17,970	28,009
Riboflavin	Milligram	183	204	319	830	423	1,296	504	1,352	540	5,842	9,524
Niacin	Centigram	237	264	356	926	526	1,612	617	1,655	577	6,243	10,700
Vitamin C	Decigram	128	143	146	380	145	447	164	440	174	1,883	3,293
Isoleucine	Gram	288	321	230	598	310	950	423	1,135	219	2,369	5,373
Lysine	Gram	427	476	467	1,215	631	1,933	858	2,302	270	2,921	8,847
Methionine & Cystine	Gram	237	264	212	551	285	873	387	1.038	292	3,159	5,855
Threonine	Gram	361	403	274	713	369	1,131	504	1,352	161	1,742	5,341
Tryptophan	Gram	69.4	77.4	29.2	75.9	40.2	123.2	51.1	137.1	80.3	868.8	1,282.4
Valine	Gram	387	431	256	666	343	1,051	467	1,253	219	2,369	5,770

[1] Per capita daily requirements from Table 1 are converted to annual basis and expressed in units that are used in computer program. Total requirements are obtained by multiplying per capita requirements by population estimates from Table A1.

Table A3. Allocation of Nutrient Requirements by Income Group [1/]

Nutrient	Units	Income Groups				Total National Requirement
		Very Low	Low	Middle	High	
		(Million Units)	(Million Units)	(Million Units)	(Million Units)	(Million Units)
Food Energy	1,000 Calories	4,329.1	4,940.1	4,295.2	3,412.7	16,977
Protein	Hectogram	545.7	622.7	541.4	430.1	2,140.0
Calcium	Gram	1,698.3	1,938.1	1,685.0	1,338.6	6,660.0
Iron	Centigram	2,636.7	3,008.9	2,616.1	2,078.3	10,340.0
Vitamin A	1,000 I.U.	7,142.3	8,150.6	7,086.3	5,629.8	28,009.0
Riboflavin	Milligram	2,428.6	2,771.5	2,409.6	1,914.3	9,524.0
Niacin	Centigram	2,728.5	3,113.7	2,707.1	2,150.7	10,700.0
Vitamin C	Decigram	839.7	958.3	833.1	661.9	3,293.0
Isoleucine	Gram	1,370.1	1,563.5	1,359.4	1,080.0	[illegible]73.0
Lysine	Gram	2,256.0	2,574.5	2,238.3	1,778.3	8,847.0
Methionine & Cystine	Gram	1,500.7	1,712.5	1,488.9	1,182.9	5,885.0
Threonine	Gram	1,362.0	1,554.2	1,351.3	1,073.5	5,341.0
Tryptophan	Gram	327.0	373.2	324.4	257.8	1,282.4
Valine	Gram	1,471.4	1,679.0	1,459.8	1,159.8	5,770.0

1/ The assumption is that nutrient requirements are distributed by income groups in relation to population percentages. See Table A2 for derivation of total national requirements.