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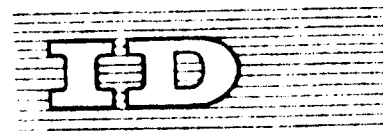
Agenda item 11/3

ESTIMATION OF FERTILIZER REQUIREMENTS IN
DEVELOPING COUNTRIES IN 1975 AND 1980 IN
RELATION TO DESIRABLE NUTRITIONAL AND
AGRICULTURAL DEVELOPMENT GOALS

by

Food and Agriculture Organization
Rome Italy

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Agenda item III

ANNEX

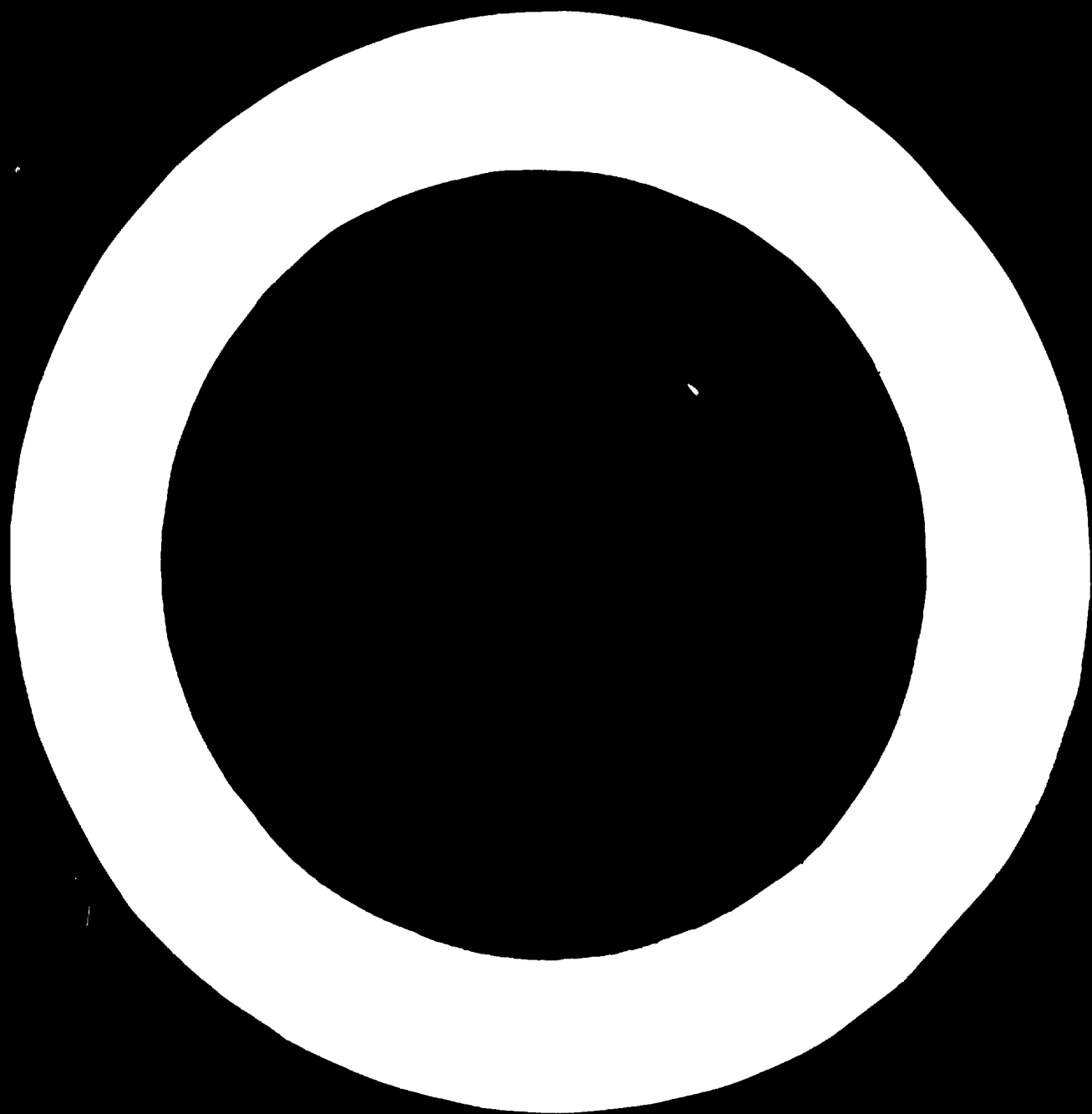
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Geneva, 1971

The growing needs for the use of modern technology in the agricultural sector of developing countries bring with it a parallel need for estimating future quantitative requirements of fertilizers. This annex helps the general planning of fertilizer production and distribution factors. The paper presents a number of alternative fertilizer use estimates, one of which is extrapolated requirements in the light of normative targets set, and compares them with objective extrapolation of trends in apparent use. The four alternatives discussed all relate to the sixty-four developing countries studied under the Indicative Five-Year Plan (IYF) of FAO. Alternative A is the IYF proposals. Alternative B takes these proposals and adjusts them upward to meet desirable nutritional demands in all of the countries studied. Alternative C is based on an adjustment of the IYF targets in the light of the higher level production targets proposed in the Second Development Decade of the UN. The last alternative is a straightforward extrapolation of the growth rates in fertilizer use experienced in the period 1962-1970.

The conclusions are that the four alternatives discussed in the paper for estimating future fertilizer requirements in the developing countries have yielded substantially

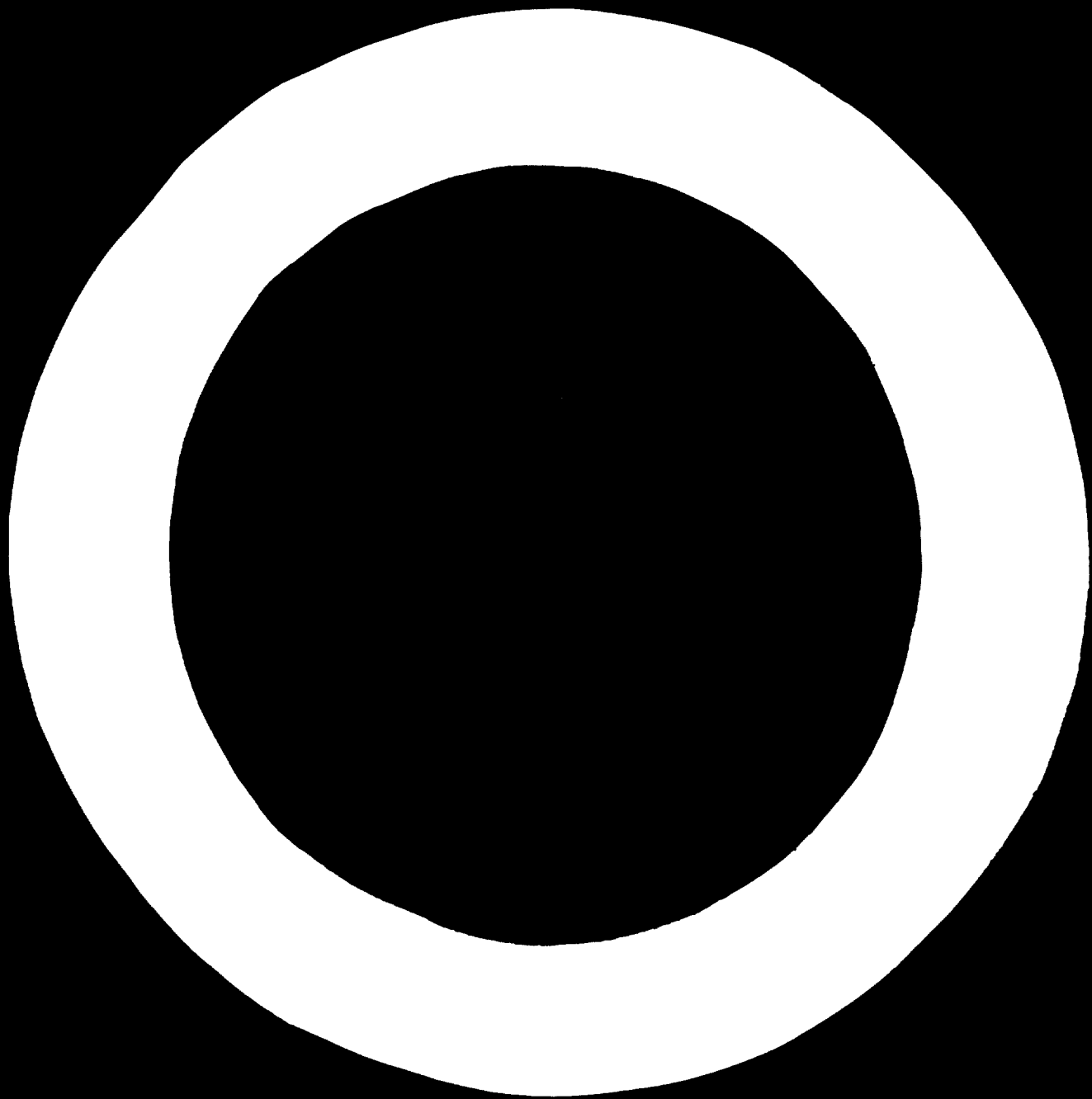


different quantities for the 1975 and 1985 planning dates. A comparison of the quantities implied is given below:

		Quantities required	
		million	tons
		<u>1975</u>	<u>1985</u>
Alternative A (IWP)	1.5	11.7	27.4
Alternative B (Nutrition)	1.0	15.0	32.0
Alternative C (DDP)	1.2	13.7	27.2
Alternative D (IWP)	6.5	13.7	18.4

The major conclusions emerging from this comparison show that the IWP approach which is normative but at the same time attempts to set targets which are well within the reach of the developing countries, has yielded fertilizer requirement estimates which are relatively close to both a modified nutritional demand based estimate of fertilizer requirements and is about 23 per cent above recent trends and their extrapolation. Substantially larger differences exist with respect to the high growth rates proposed within the DDP.

This comparison also points out how important it is to know what the goals are of, and assumptions underlying, the setting up of normative fertilizer requirements estimates before they can be used as an additional important guidepost in estimating effective future demand for fertilizers in the developing countries.



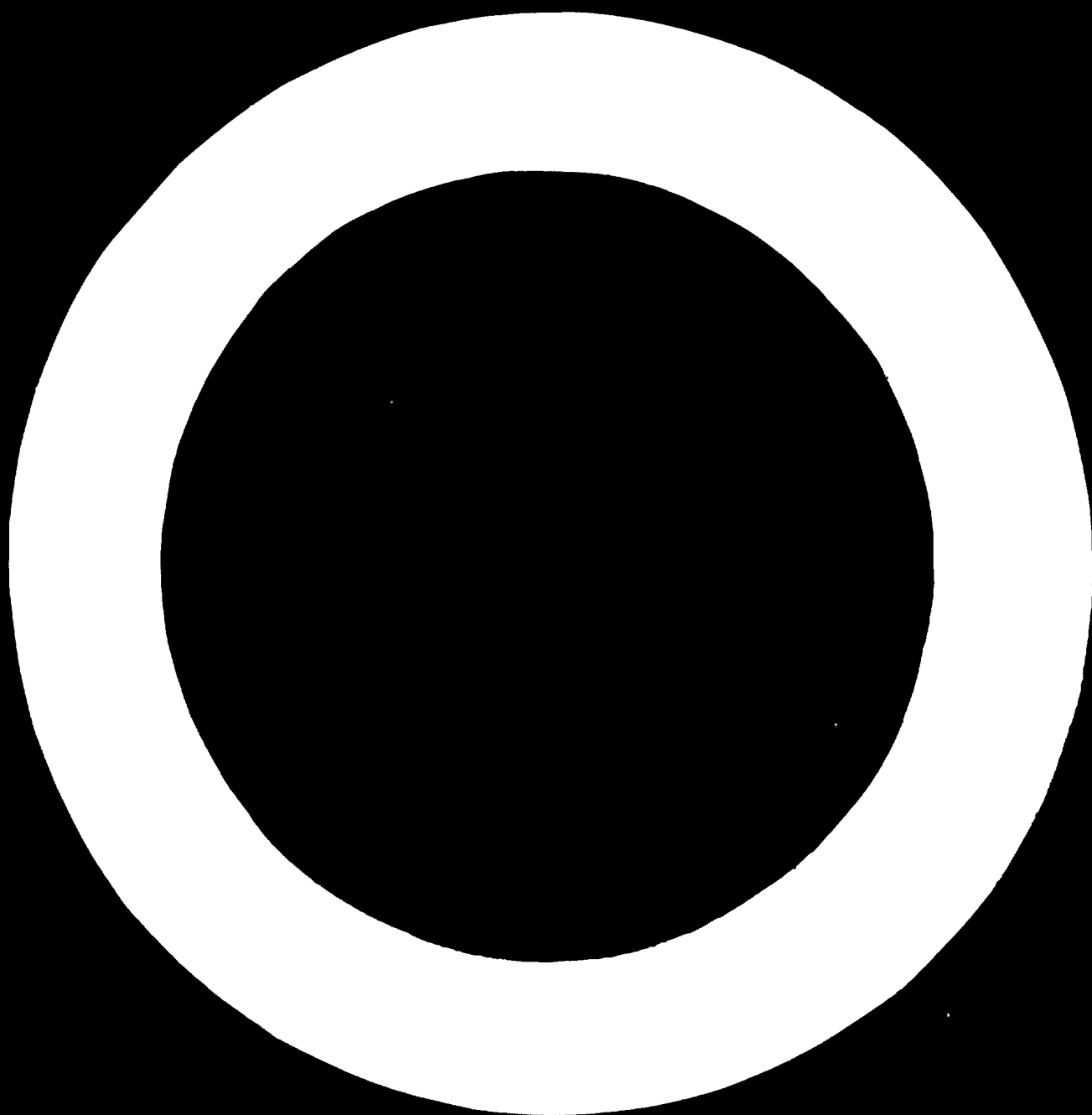
**"ESTIMATION OF FERTILIZER REQUIREMENTS IN DEVELOPING COUNTRIES
IN 1975 AND 1980 IN RELATION TO DESIRABLE NUTRITIONAL AND
AGRICULTURAL DEVELOPMENT GOALS"**

By

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In cooperation with the Nutrition Division

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1. INTRODUCTION

The growing needs for the use of modern technology in the agricultural sector of developing countries brings with it a parallel need for estimating quantitative requirements of inputs, among them fertilizers which are one of the main components of this modern technology. In turn, such forecasts of fertilizer use and requirements are useful in planning the orderly development of production and distribution facilities. At the same time, it is important to realize that the projection of expected "fertilizer use" and of "fertilizer requirements" can entail highly divergent methods and assumptions underlying the forecasts. Depending on the nature of these, the resultant estimates of quantities of fertilizers to be used or required can vary over a wide range.

It is the intention in this paper to present a number of alternative projections of fertilizer use and of fertilizer requirements. The difference between "use" and "requirements" is not only a semantic one but it has also strong conceptual reasons. In general, fertilizer use projections are "objective" in the sense that they do not include judgements on the desirability of these use levels, they simply predict what the most probable future use level will be in the light of the analysis of past trends and what is known about the future of factors influencing fertilizer use.

On the other hand, estimates of "requirements" are generally "normative" in the sense that if some kind of goal is set then, as a consequence, a given amount of fertilizer should be used to reach the goal. Such goals may be set on the basis of desirable or minimum nutritional levels, general growth of the agricultural sector, or more specific targets such as increased incomes of farmers, lowering the cost of production, or influencing the creation of employment possibilities within the economy.

The approach taken in this paper is to start off with the estimates of fertilizer requirements developed in the framework of the Indicative World Plan (IWP) of FAO. This represents fertilizer requirements in relationship to general agricultural development goals which are above the level of past performance of agriculture in the developing world. These estimates, and the underlying assumptions and methodology by which they were derived, are described in alternative A.

Alternative B presents an adjustment of these estimates with respect to nutritional targets.

The adjustment of the IWP targets in alternative C is made in the light of the increased growth targets proposed in the Second Development Decade of the United Nations (UN DD2).

In alternative D a comparison is made of the basic IWP estimates with trends between 1962^{1/} and 1970, and the growth rates are extrapolated into the future.

It is hoped that by presenting these alternatives, and the concepts, assumptions and methodologies behind them, it will help the interpretation of normative estimates and their comparison with predictions of probable use.

Alternative A:

The IWP of FAO has carried out a relatively detailed analysis of agricultural development needs, possibilities and programmes in sixty-five developing countries in four regions, including about 85 percent of the population of the developing world. The basic methodology of this study rested on demand projections for agricultural products. These were built up from a component of domestic demand and export demand. The domestic demand projections were derived from population projections, income projections and estimates of income elasticity of demand.^{2/}

Tentative preliminary export targets were used in the regional studies which were later adjusted when the results of the four regional studies were confronted with total commodity balances at the world level. In the estimation of supply targets an assessment of land and water resources and possibilities for their development were followed by inter-disciplinary team discussions on the development of production programmes and policies as related to individual crops and groups of crops. Thus, changes foreseen for the individual crops were reflected both in area and yield targets and, if the crop had heavy weight in the total of agriculture, it was further broken down into sub-sectors such as irrigated versus non-irrigated, or modern versus traditional sub-sectors.

Considerations for fertilizer use were already entering these discussions when possible yield increases were estimated. Once the yield and area targets were set, then the implications of these for fertilizer use were calculated.

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^{1/} The use of the expression 1962* denotes the 1961-63 period which was used as the base in the IWP Study.

^{2/} The detailed methodology for the demand estimates is described in FAO: Agricultural Commodities Projections for 1975 and 1985, Volumes I and II, Rome 1967.

A considerable amount of experimental work with fertilizers has been carried out in most of the countries under study. These show that although their soils vary widely in their inherent fertility, for high yields and continuous cropping on all soils nitrogen and phosphorus are required for most crops, with potassium required on a smaller number and at lower rates. In general, at the levels of use proposed for 1985 the major nutrients are required on an $N:P_2O_5:K_2O$ ratio of about 2.85:2.11:1.00. It is also apparent from experimental evidence that although the relative amounts of nitrogen, phosphorus and potassium required for a given crop vary widely between soils, the response of crops per unit of total nutrients applied was fairly uniform throughout individual regions and the response ratios based on these experimental results have therefore formed an important basis for the estimation of fertilizer requirements in the IWP.

For this purpose "base" yields had to be established for each crop. These are estimates of the yields which might be expected without the application of fertilizer, but with the introduction of other technological improvements, such as plant protection, weed control, irrigation and improved seed. These base yields vary with the native soil fertility and degree of agricultural development within countries. At the same time it must be stressed that because of the high degree of complementarity between inputs, the proposed increases in yields expected to result from the use of fertilizer would not be realized or would be only partially realized without the adoption of the whole package of inputs.

In addition to assuming similar response trends to fertilizers throughout the region, it has been assumed that, with a few exceptions, the responses to fertilizer are likely to be linear for the rates of fertilizer that are envisaged. This seems to be a reasonable assumption for the modest rates of application recommended for the first decade, and with improved practices such as selection of better varieties and better methods of cultivation, it should continue to be true for the somewhat higher rates of application proposed by 1985 ^{1/}. The total fertilizer requirement can thus be related directly to the desired increase in crop production. In fact, an increase in response of rice and wheat to fertilizer is anticipated, due to the introduction of new highly responsive varieties. Thus, for example, for India and Pakistan the response coefficient has been increased from 10 kg of rice

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1/ If, in fact, the total amounts of fertilizer available were to be spread over a greater percentage of the total area, instead of being concentrated into high potential zones as has been envisaged by the IWP, this would make the assumption of a linear response even more valid.

per kg of nutrient to 11 and 12 for 1975 and 1980 respectively, and from 8 to 9 and 10 for wheat. ^{1/}

Very fast rates of growth are proposed for fertilizer, particularly in the first period of the plan up to 1975 when an overall annual increase of 14.3 percent compound is proposed. While this might seem exceedingly optimistic it is not, in fact, much more rapid than that in the recent past (1954-1962) which averaged 10.8 percent, but which in some countries has reached 25 percent in short periods in the recent years. Total value of fertilizer applied would rise from \$ 664 million in 1962 to \$ 3 882 million in 1975 and \$ 5 970 million in 1980, representing 32 percent of the total value of all current inputs in that year. ^{2/}

In the immediate future it is expected that the strongest impetus for increased fertilizer use will come from the continued expansion of area under fertilizer responsive high yielding varieties of cereals, and of improved planting material for perennial export crops. The expansion of irrigated area, and of area under multiple cropping systems is likely to provide a basis for the longer-term growth of fertilizer consumption. Improvements in fertilizer distribution systems, subsidies, and guaranteed prices for some selected products are also expected to stimulate consumption as they have done in countries which have experienced the most rapid increase in fertilizer use since 1962.

The increases proposed by IWP would result in an average per hectare use of 40 kg by 1980, compared with only 6.7 kg/ha in 1962. Even this would be well below levels currently achieved in the more agriculturally advanced countries, and considerable scope remains both for increasing area fertilized and levels of use per hectare.

The IWP proposals for fertilizer requirements in terms of nutrient tons are summarized below. In the case of South America, Fertilizer requirements for increasing production from grasslands have been identified (0.9 million tons NPK by 1980) in addition to those proposed for crops.

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^{1/} These may appear to be low in the light of some of the experimental evidence which shows responses up to 18 kg for paddy and 13 kg for wheat. Relatively conservative values are used here because the widespread use of fertilizers will include some areas with poorer quality soils, less secure water supplies, inadequate availability of other inputs, and lower levels of management, thus the averages must be expected to be lower than those achieved experimentally.

^{2/} If these figures estimated for 64 countries are extrapolated to cover all developing countries (excepting Mainland China) an adjustment factor of 1.088 needs to be applied, resulting in \$ 4 224 and \$ 6 494 million respectively.

Table I. 1975 and 1980 Fertilizer Requirements for Crops (expressed in NPK) ^{1/}

	1975		Growth Rate 1962- 1975	1980		Growth Rate 1975- 1980
	Quantity '000 m ts	Index (1962*-100)		Quantity '000 m ts	Index (1975-100)	
Latin America	3 474	385	10.9	4 773	206	8.5
Africa South of the Sahara	277	531	13.7	448	239	10.1
Near East and N.W. Africa	1 387	323	9.4	1 981	186	7.4
Asia and Far East	9 819	773	17.0	15 177	218	9.1
Study Countries	14 657	569	14.3	22 379	213	8.9

The requirements considered necessary by IWP to meet the production objectives are somewhat higher than the amounts indicated by extrapolation of recent trends from countries for which there are records of past fertilizer use. In terms of growth rates, the average implied by the proposals for the period 1962-1980 would be equal to 12.7 percent per annum, while past growth for the period 1954-62 was 10.0 percent per annum. This reflects the upward changes in the growth of output proposed by IWP for most major crops as compared with past trends in yields and in production. Similarly, the proposed higher contribution of yield increases and double cropping to production compared with that from expansion of net area under cultivation calls for a more than proportionate increase in fertilizer use.

The growth rate of fertilizer use proposed for the first period up to 1975 is considerably faster than that for the period 1975-1980 (14.3 percent compared to 8.9 percent). The reasons for this are twofold:

- (1) In the first period a rapid increase of fertilizer use is proposed in conjunction with the spread of the highly fertilizer responsive cereal varieties in order to achieve the rapid growth required for cereals in the Asian Region;
- (2) The high growth rates in the first period reflect the low base of fertilizer use from which many countries started, implying a rapid increase in consumption rates to reach quantities which would make a significant impact on production.

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^{1/} These figures are adjusted values of IWP information by interpolating for 1980.

Alternative B:

As pointed out in the introduction, this alternative takes the IWP estimates and adjusts them upwards wherever necessary so as to reach desirable nutritional targets. The IWP model made use of nutritional targets in two ways; first, nutritional consistency checks were used in the estimation of income elasticity coefficients. The methodology used for demand projections resulted in a "food basket," the magnitude and composition of which is mainly dependent on the level of personal income, traditional food habits and changes in taste. Even if the estimated demand can be matched by supplies given the very low starting points for caloric intakes in some of the countries and the relatively slow growth of income foreseen, the caloric intake resulting from the increased "food basket" should rise by only 10 percent between 1962 and 1975 and 5 percent between 1975 and 1980. If this were to happen, the average caloric intake for the countries studied would exceed estimated requirements ^{1/} by 4 percent and 8 percent in 1975 and 1980 respectively.

Actually, because of supply constraints bearing mainly on meat, fish, milk products, vegetables, oils and animal fats, the level of demand, in terms of calories, will probably not be attained. Food supplies as projected will just catch requirements in 1975 and will be slightly above it by 1980.

Were this to happen, available per caput calorie supplies would be 6 percent above requirements. This margin of safety, although lower than that of the developed countries today, should allow appreciable improvement in the dietary levels of the most deprived groups provided an effort is made to reduce the inequalities of distribution within countries. Nevertheless, it is probable that the problem of undernourishment will not be entirely solved. Some 20 countries, particularly in the Andean region and the arid zones of Africa and Near East, and some in Asia will not have reached this level or will have just caught up with requirements. Local regional or seasonal deficits will very probably persist in some overpopulated parts of Asia.

Thus the indications are that relatively little adjustment is required in the production, and thus IWP fertilizer requirement targets to reach acceptable caloric intake levels which would offer also safety of diet for the lowest income group.

^{1/} For a detailed explanation of caloric requirements reference should be made to Caloric Requirements (Report of the Second Committee on Caloric Requirements: FAO Nutritional Studies No. 15, 1957). The mean annual temperature and the overall average body weights of males and females assumed for each country are the main factors defining its level.

The 20 countries ^{1/} which have been identified as being somewhat below the required calorie intakes, even if the plan's targets are fulfilled, will contain by 1980, 480 million people. For simplicity's sake it is assumed that this gap in calorie intake could be eliminated by increased wheat production; the required per caput additional intake of wheat could be assumed to equal 9.4 kg per annum ^{2/}. This is equivalent to 4.5 million tons of wheat. ^{3/} It would be useful to assume here two ways by which this additional wheat production (or wheat equivalent) could be achieved. In the first case one could postulate that 50 percent of this added production would come from the use of factors of production other than fertilizer, and in the second case the assumption would be that all of the increase would come from fertilizer use. Applying a response ratio of 1.8 for plant nutrients: wheat, the required additional fertilizer would come to 281 thousand tons, and 562 thousand tons, respectively for the two estimates as outlined above. These are indeed small adjustments representing only 1.3 percent and 2.6 percent of total fertilizer requirements proposed for 1980 by the original plan.

Alternative C:

This alternative relates to adjustments made in the IWP targets in the light of the higher economic growth rates proposed in the Second Development Decade of the United Nations (UN DD2). In both this and in alternative D an attempt is made to trace the relationship between macro-economic growth and fertilizer requirements. Conceptually this chain of relationships operates through a complex of many factors, but here I would like to restrict the discussion to those which we may postulate as the most important ones.

First come the influences exerted on the demand side for food and agricultural raw materials. The higher the population growth rate, and the higher the growth of income per caput, the more agricultural products will be demanded. At the same time, it needs to be recognized that the composition of this demand will change as incomes rise and the movement, in general, is from basic starchy staples such as

^{1/} Bolivia, Colombia, Ecuador, Malawi, Morocco, Tunisia, Algeria, Iran, Jordan, Saudi-Arabia, Afghanistan, Chad, Ethiopia, Niger, Upper Volta, Pakistan, Philippines, Panama, Uganda, and Democ. Rep. of Congo. /....

^{2/} At this level calorie intake in this group of countries would reach 105% of calorie requirements.

^{3/} This quantity is equal to 1.2% of the total cereal production of the studied countries (442 million tons).

cereals and tubers towards a higher value diet containing more animal products, fruits and vegetables. The growing demand can then, in turn, be interpreted into production targets and related fertilizer requirements. An important intervening variable here is the economic environment for farmers fostering or hampering the growth in fertilizer use. When interpreting production targets into fertilizer targets an important variable here will be the availability of opportunities for expanding area of the crop versus the need to raise yields.

On the supply side, the important variables will be the availability of foreign exchange for importing fertilizers or the existence of a domestic capacity together with a well functioning distribution system and related advice to farmers on fertilizer use.

In the UN DD2 the major change from the IWP targets is the higher rates of economic growth which are proposed, at 6.0 percent as compared with approximately 5.7 percent which was assumed on the average for the period of GDP in the 65 developing countries studied. The implications of such higher growth rates in the economy would be that agricultural production should grow at 4.0 percent to meet demands made on this sector as compared with 3.5 percent in the IWP. The simplest shortcut method to estimating the resulting changes in fertilizer requirements is to use the concept of elasticity of fertilizer use that relates % to production.^{1/} The value of this parameter has been estimated as 4.04 for the 1962-1975 period and 2.12 for the 1975-1980 period on the basis of the IWP supply programme proposals. Conceptually, however, it is important to adjust these elasticities upwards in the light of faster growth rates required in production and in consideration of the relative slowness of expanding the land and water base for agriculture. No exact quantitative estimate of the magnitude of such an adjustment is available, but for demonstration purposes it was arbitrarily assumed to be 10 percent, resulting in an elasticity coefficient of 3.59 for the production proposals of the UN DD2.

The total fertilizer requirements for developing countries, using the above elasticity are shown in the table below:

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^{1/} Such an elasticity shows the percentage change in fertilizer use in relation to a percent change in agricultural production.

Table II.

	<u>Fertilizer Requirements</u>		<u>Growth Rates</u>	
	<u>1975</u> (million tons NPK)	<u>1980</u>	<u>1970-1975</u>	<u>1975-1980</u>
"UN-DD2" Requirements:				
Starting from actual 1970 base	13.2	27.2	16.3	15.6

In the calculations for the above table the starting point has been the actual trend in fertilizer use which was associated with a 2.7% growth rate in the GDP from agriculture of the studied countries. Then the difference in production was calculated between the values of agricultural GDP based on continued trends and those calculated as targets for DD2. Using the above stated average elasticity coefficient, the fertilizer requirements for filling this gap were then calculated. These resulted in an increase of 28% over the trend by 1975 and an increase of 48% by 1980.

Alternative D:

The effects of the earlier outlined influencing variables show up best "in total" through an examination of recent past trends, thus it appears useful to make an adjustment in the IWP targets in the light of the performance of the developing economies in the first eight years of the period covered by the plan.

The comparison of fertilizer use rates proposed by the IWP and the actual use by 1970, and its extrapolation to 1975 and 1980 are shown in Table III:

Table III.

	<u>Quantities of NTK - million tons</u>				<u>Growth Rates 1962-70</u>
	<u>1962*</u>	<u>1970</u>	<u>1975</u>	<u>1980</u>	
A. IWP Proposals	2.6	7.5	14.7	22.4	14.3
B. Apparent Use ^{1/}	2.6	6.2	10.7	18.4	11.5
Excess of A over B	-	1.3	4.0	4.0	-
Excess as % of B	-	21	37	22	-

(* refers to 1969/70)

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^{1/} "Apparent use" is employed here because most fertilizer statistics refer actually to "fertilizer distributed."

As can be seen from Table III, there was already a short fall in apparent fertilizer use levels as compared with the IWP proposals. The main differences are in those countries where the mid and late sixties have seen a very rapid rise in fertilizer use which, in turn, has slackened by 1969/70. Thus, for example, in Pakistan actual consumption at .4 million tons has reached only less than 50 percent of the target set, and in Argentina it has reached only 80 thousand tons, instead of the 340 thousand tons proposed in the IWP.

The case of India, the largest individual user of fertilizers among developing countries is also important here. The figures shown in Table III refer to the standard definition of use which is in reality fertilizer "distributed" and in any one year there may be a substantial difference between this and actual use. Thus the quantity used for India in this table is 1.4 million tons which is described in Indian statistics as "dispatches made by the Central Fertilizer Pool and Manufacturers to different states." At the same time the Fertilizer Statistics for India published a figure for "consumption" of fertilizers which is equal to 2.0 million tons NPK and the difference comes from stocks held previously in the distribution channels. If this higher value would be used, then the difference between IWP proposals and actual use would become only 0.7 million tons, less than 10% of the IWP target.

By extrapolating the actual growth rates for future consumption the gap between the "projected" consumption and need based "requirement" estimates are the same in 1975 and 1980, but by 1980 there is a reduction in the discrepancy in terms of percent as the growth rates for "requirements" are lower for the latter part of the decade.

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II. CONCLUSIONS

The four alternatives discussed in this paper for estimating future fertilizer requirements in the developing countries have yielded substantially different quantities for the 1975 and 1980 planning dates. A comparison of the quantities implied is given in Table IV, together with the growth rates which are associated with them:

Table IV. A comparison of alternatives

	<u>Quantities Required</u> <u>million m tons</u>			<u>Growth Rates</u> <u>percentage p.a.</u>		
	<u>1970</u>	<u>1975</u>	<u>1980</u>	<u>1962-70</u>	<u>1970-75</u>	<u>1975-80</u>
Alternative A (IWP)	7.5	14.7	22.4	_____	14.3 ^{1/} _____	16.4
Alternative B ^{2/} (Nutrition)	7.5	15.0	23.0	-	_____	11.6 _____
Alternative C (DD2)	6.2 ^{3/}	13.2	27.2	11.5	16.3	15.6
Alternative D (Trend)	6.2 ^{3/}	10.7	18.4	11.5	11.5	11.5

^{1/} 1962-1975

^{2/} Using higher figure

^{3/} Using 1.4 million tons for India

Figure 1 provides this information in graph form.

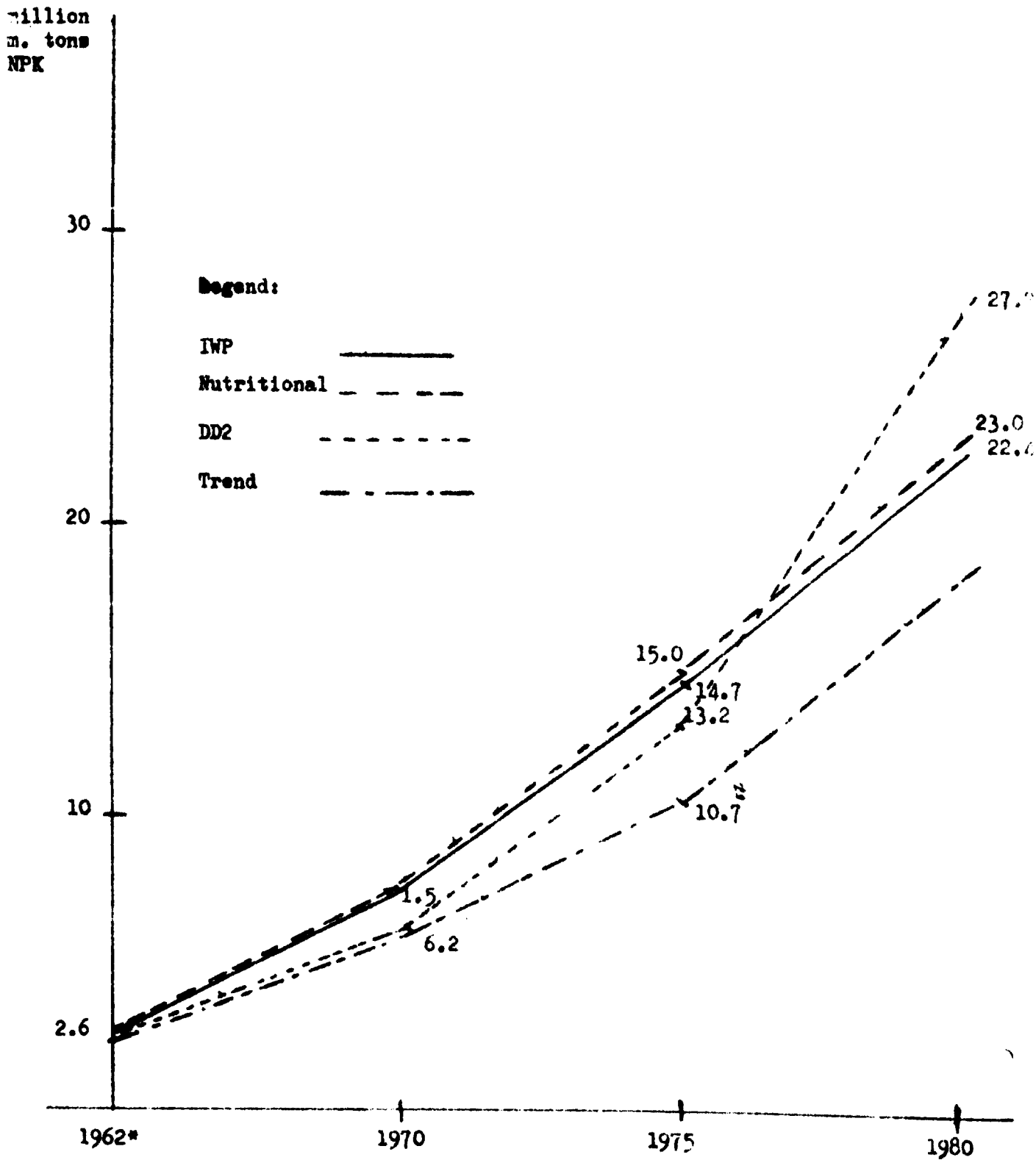
The major conclusions emerging from this comparison show that the IWP approach which is normative but, at the same time attempts to set targets which are well within the reach of the developing countries, has yielded fertilizer requirement estimates which are relatively close to both a modified nutritional demand based estimate of fertilizer requirements and is about 20% above recent trends and their extrapolation. Substantially larger differences exist with respect to the high growth rates proposed within the UN DD2.

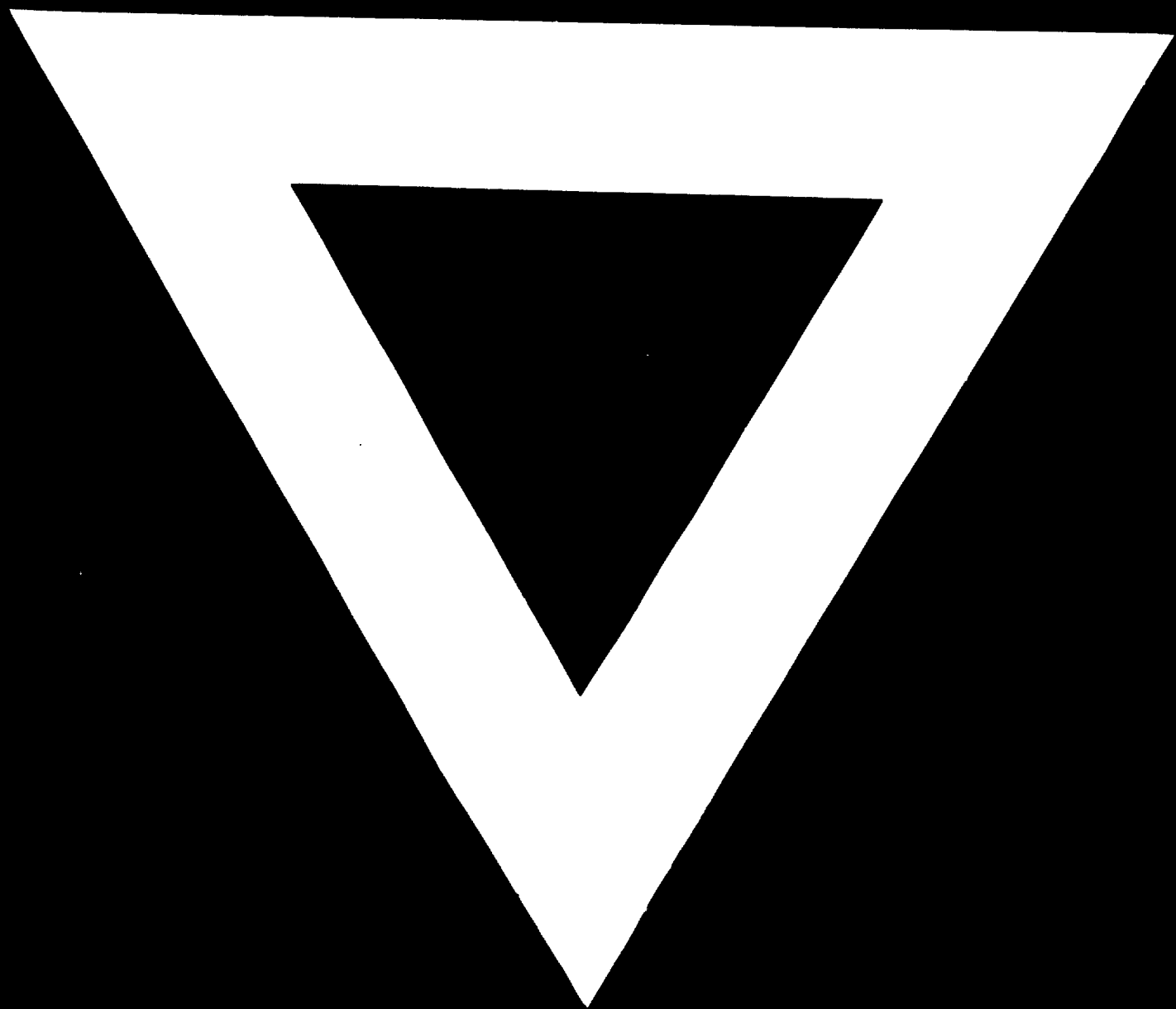
This comparison of alternative estimates also points out how important it is to know what the goals are of, and assumptions used in, the setting up of normative fertilizer requirements estimates before they can be used as an additional important guidepost in estimating effective future demand for fertilizers in the developing countries.

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Figure 1.

Comparison of alternative estimates of
fertilizer use in 64 developing countries





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