Agrekon

VOL. 15 No. 1

JANUARY 1976

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Articles in the field of agricultural economics, suitable for publication in the journal, will be welcomed.

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The Journal is obtainable from the distributors: "AGREKON", Private Bag X144, Pretoria.

The price is 25 cents per copy or R1 per annum, post free.

The dates of publication are January, April, July and October.

"AGREKON" is also published in Afrikaans.

# Contents

# FUTURE PROBLEMS WITH NATURAL RESOURCES AND THEIR INFLUENCE ON THE GROWTH AND DEVELOPMENT OF SOUTH AFRICAN AGRICULTURE

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## INTRODUCTION

It is a very elementary, but primary proposition in economic theory that production resources are used simultaneously in order to provide output. The production function is therefore invariably of the form $y = f(x_1, x_2, \ldots x_n)$, where y is output and $x_1, x_2, \ldots x_n$ are the n inputs. The very next proposition is that the possibility of substitution amount inputs always exists. This allows for an increase in some of the inputs to be able to increase output, as opposed to the case of fixed proportions where all inputs must of necessity increase proportionally. Unfortunately, however, this also allows for a situation of concealed unemployment of some resources to develop. When one input increases, substitution takes place and output also increases. In this process other inputs may, however, recede from their previous levels of utilization. Although output will still be more than before, it will not be at its potential level.

This result of the process of substitution is possible because all resources possess at least two attributes namely a quantitative or physical characteristic and a qualitative or productive trait. Now, while the physical quality of a certain resource may remain constant, the productive performance of this resource may deteriorate as a response to an increase in another input. The production resource which probably most often causes this state of affairs, is technological progress.

Technology being defined as society's state of knowledge regarding the industrial and agricultural arts, technological progress should be able to bring about a greater output with the same inputs or the same output with less inputs. Because of the dual character of other inputs, technological progress may result in a decrease in the productive performance of labour, capital and natural resources rather than in their physical quantities. In other words, while the physical quantities of the other resources remain constant, technological progress may not affect the potential increase in output, because of a decrease in the qualitative attributes of the other inputs.

It should be clear that if this state of affairs exists, the supply of resources may increase not only in physical terms, but also in qualitative terms through a more efficient implementation of technological progress. The main theme of the present paper is that this state of affairs already exists in South Africa and that the speedy availability of and the efficient capability to implement technological progress are the two most serious bottle-necks in the basket of resources available to agriculture. With regard to future growth, these are the prime factors which may cause a deviation from the optimal growth path.

## TECHNOLOGY AND CONCEALED UNEMPLOYMENT

If, for expositionary purposes, we make the not too unrealistic assumption that the functional relationship between output and production resources in agriculture is of the Cobb-Douglas type, we encounter quite illuminating facts regarding the South African situation.

As is well-known, the simplest form of the Cobb-Douglas function has the following structure:

$$X = AL^aK^b$$

where X = output
L = labour
K = capital.

Taking the total derivative of the function, we obtain:

$$dX = a(X/L)dL + b(X/K)dK$$
$$dX/X = a(dL/L) + b(dK/K)$$

The percentage change in output is therefore equal to the percentage changes in labour and capital, multiplied by their respective exponents in the production function. In the case where $dL/L = dK/K$, one finds that $dX/X = (a+b)k$, where $k = dL/L = dK/K$. When we have constant returns to scale, $dX/X = dL/L = DK/K = k$, because $(a+b) = 1$.

When decreasing returns to scale exist, $(a+b)<1$ and consequently $dX/X < k$, while the case of increasing returns to scale yields $dX/X > k$.

We are, however, interested in the general case, when the inputs do not change proportionately. In this case it is possible to deduce certain lower limits to what may happen to output.

Let the smallest percentage increase in one of the outputs, say capital, be denoted by h, that is

$$\min (dL/L, dK/K) = dK/K = h$$

It will always be possible to express the greater of the two changes as the sum of the smaller change plus another factor, which will be a parameter, varying from case to case, but being a constant in each specific case. This means that

$$dL/L = dK/K + r$$
$$= h + r$$

We now have

$$dX/X = a(dL/L) + b(dK/K)$$
$$= a(h + r) + bh$$
$$= (a+b)\,h + ar$$

As long as $dL/L$ is greater than $dK/K$, equation (1) implies that

$$dX/X > (a+b)(\min (dL/L, dK/K))$$

From numerous empirical results[1], we have evidence that in general a ranges between 0,5 and 0,95, while b ranges between 0,1 and 0,34. In the case of a, most values are well above 0,6; while most values for b are well above 0,15. Let us, however, assume that the lower values for a and b are 0,5 and 0,1 respectively. Thus,

$$a \geqslant 0{,}5,$$
$$b \geqslant 0{,}1$$
$$\text{and } (a+b) \geqslant 0{,}6 > 0{,}5$$

The next assumption we make, is that

$$dL/L > 2(dK/K)$$

because this is how the position will actually turn out once we get to our empirical analysis. Because $r = dL/L - h$,

$$r = dL/L - dK/K > 2(dK/K) - dK/K = dK/K$$

Thus $r > dK/K = h$ Substituting into (1), we find

$$dX/X = (a+b)h + ar$$
$$> (a+b)h + ah \text{ because } r > h$$
$$= 2ah + bh$$
$$\geqslant h + bh \text{ because } a \geqslant 0{,}5$$
$$= dK/K + b(dK/K)$$

Thus $dX/X > dK/K + b(dK/K)$

In reality one will always encounter some measure of technological advance. The most simple way in which we can account for this fact, is to write the production function as

$$X = AL^{a} K^{b} e^{gt}$$

where t is a measure of technological progress and g is the rate of change in output X, with respect to a change in t; $g = (dX/dt) / X$. Incorporating technological progress into our analysis, the rate of change in output can now be expressed as

$$dX/X = a(dL/L) + b(dK/K) + g(dt)$$

Making the same assumptions as before regarding the relative size of $dL/L$ and $dK/K$ and the values of a and b, we now find

$$dX/X = (a+b)\,h + ar + g(dt)$$
$$> dK/K + b(dK/K) \text{ by an even g}$$

namely $dX/X > dK/K + b(dK/K) + g(dt)$

At this stage it is worth-while to recall that minimum values for a and b are assumed. The percentage change in output would therefore probably be much bigger than $dK/K + b(dK/K) + g(dt)$. Even if we are working at the very limits where $a = 0{,}5$ and $b = 0{,}1$, it must still be true that $dX/X$ is much bigger than $dK/K + b(dK/K)$ due to the influence of $g(dt)$, our parameters representing technological progress. In fact, g may itself be quite small without endangering this position.

Summing up, we assume

$$X = AL^{a} K^{b} e^{gt}$$
$$a \geqslant 0{,}5 \text{ and } b \geqslant 0{,}1;\ g > 0 \text{ and } t > 0$$
$$\min\ dL/L, dK/K = dK/K = h$$
$$dL/L > 2(dK/K)$$

We define $r = dL/L - dK/K$ and find that $dX/X > dK/K + b(dK/K) + g(dt)$

We conclude then that, within the constraints of our assumptions, a lower boundary for the percentage change in output exists. This boundary is given by the smallest of the percentage changes in the two inputs, plus that same percentage change multiplied by the coefficient in the production function of this input, plus the influence of technological progress, plus the closing item e.

$$dX/X \geqslant dK/K + b(dK/K) + g(dt) + e$$

where $e = dL/L - 2(dK/K)$ or

$$dX/X > dK/K + b(dK/K) + g(dt)$$

This will be the case notwithstanding serious decreasing returns to scale and allowing for the minimum amount of technological progress. The greater the value of a, b and g and the faster the rate of technological progress, the greater the positive difference between the rate of change in output and that in capital, the input experiencing the smallest rate of change.

Turning now to the South African situation[2], it is well-known that local farming is relatively labour-intensive. From 1960 to 1970, the number of Black farm workers increased from 0,767 million to 1,391 million. This represents an increase of about 81 per cent over the ten-year period. The number of Blacks increased not only in absolute terms, but also in terms of their relative position to White farm workers whose number remained constant.

Extrapolation of these tendencies can readily be made, but as was stated in the introductory remarks, the productive performance of the existing number of workers is of much more importance and a matter for concern than its numerical value.

The value of capital in agriculture, expressed in constant 1970 values, increased from R1 815 million in 1960 to R2 318 million in 1970. This represents a rate of increase of about 28 per cent. The contribution of agriculture to the GNP increased from about R840 million in 1960 to R1 020 million in 1970, once again expressed in 1970 values. The volume of final output in agriculture increased therefore by about 22 per cent over the decade 1960 to 1970. Adding Whites and Blacks together, the total labour figure amounted to 0,907 million in 1960 and 1,531 million in 1970, representing an increase of 68 per cent.

Applying the previous analysis one would expect

$$\begin{aligned} dX/X &> dK/K + b(dK/K) + g(dt) \\ &= 0{,}28 + 0{,}1(0{,}28) + g(dt) \\ &= 0{,}308 + g(dt) \end{aligned}$$

Even without taking technological progress into consideration, it is obvious that the increase in output realised was much smaller than we would have expected from a theoretical point of view. Applying the usual measure of technological progress, used in econometric analysis, namely t = 1,2,3....., one would find dt = 10 between 1960 and 1970, shifting the lower boundary for dX/X even higher.

Referring to the initial formula it is observed that

$$\begin{aligned} r &= dL/L - dK/K \\ &= 0{,}68 - 0{,}28 \\ &= 0{,}40, \end{aligned}$$

which shows that r is markedly greater than h(=dK/K). We would likewise have expected dX/X to be much greater than the 22 per cent which actually was realised. It should also be clear that the nearer the actual position is to the case of constant returns to scale, the greater will be the values of a and b and thus the higher the theoretically lower limit to a percentage increase in output. The same argument follows; the higher the rate of technological progress that is experienced.

This situation cannot be attributed to a retardation regarding technological change. It should rather be sought in the direction of a serious misuse of labour and capital. In terms of our introductory remarks, we have the situation that although the quantity of especially labour increased, the production performance per unit of this input decreased. This is nothing else but a classical case of concealed unemployment.

With respect to the availability of resources in agriculture for future growth, evidence thus exists that the supply of labour and possibly that of capital as well, may be increased significantly through a more efficient use of the existing resources.

It must be stressed that concealed unemployment may be attributed to neglect on the part of labour, but not necessarily so. It is primarily the task of the entrepreneur, in this case the farmer, to combine the different production resources efficiently in order to obtain the maximum output within the limits of the constraints set by the availability of inputs and technological know-how.

If it is asked where bottle-necks in future growth of agriculture are most likely to occur, one may safely state that it will not be in respect of labour. The relatively high natural rate of increase and the existing concealed unemployment ensures that this possibility is ruled out, if steps could be taken to prevent a continuation of the accumulation of underutilised units of labour. This takes us into the realm of technological progress and its implementation, which seems to be the real difficulty.

Technological progress does take place at quite an amazing rate. This was one of the prime reasons why the Malthusian doomsday never came upon the world. It has become customary, in fact, to refer any pessimist prophesying about the future predicaments of mankind[3] like overpopulation, food shortages and the devastating consequences of pollution, to an expected technological miracle.

Yet, in South Africa, we have reason to despair especially when we consider the growth of agriculture. It is not so much that we face a total disaster regarding the supply of resources and technology, as that we face a serious inefficient use of these resources, because of a very poor capability of optimally implementing technological progress. The agriculture sector is traditionally slow in reacting to new techniques. Locally this is even more the case. This point of view is proved dramatically by the arguments presented above.

We face the situation that South Africa is historically, except with respect to mining and possibly a few other isolated cases, not on the frontier of technological progress. Most of our technical knowledge is imported. A lag exists therefore in the first place between the birth of technological change and its local availability. More serious, however, is the fact that agriculture in South Africa in step with the rest of the country, is slow to implement technological change[4]. This may be due to the fact that the use of new technology may be regarded as being too risky an affair. Even when a minimum risk is involved, the farmer may still be slow to react because farming is to a great extent still a way of life. Other factors, such as the smallness of the market, credit problems, marketing difficulties and a lack of managerial competence aggravate the implementation problem.

In the light of the result of our production function analysis, a definite need exists for faster and more efficient implementation of technological progress in order to do justice to the availability of labour. The resource of which a scarcity exists is the profitable utilization of labour and capital. Noting the serious stumble block which technology and its implementation lay in the way of future growth through the efficient use of available resources, one should be interested in the supply of other resources.

## ENERGY

Domestic agriculture seems to be demanding an ever increasing amount of energy resources. In 1955, about one million tons of fertilizer was used. This increased to 1,8 million tons in 1967, 1,9 million tons in 1970 and 2,5 million tons in 1974. The usage of petrol amounted to 111 million litres in 1967, 126 million litres in 1970 and 159 million litres in 1974 while the amounts for disoline were 670 million, 767 million and 861 million litres.

Despite recent dramatic developments regarding the importation of crude oil, there exists no imminent danger of a total collapse in the supply of oil. In fact, provision is being made for the fact that such a crisis may reoccur and that oil prices will steadily increase because the reserves of crude oil must eventually be depleted[5]. The search for oil in and around South Africa continues, now concentrated in a few selected areas. As far as industry is concerned, the domestic energy demand is satisfied from sources other than oil. Oil is almost exclusively used for transportation purposes. In this respect agriculture will therefore be much more vulnerable to future oil price increases than industry. The country is pushing ahead with its program of manufacturing oil from coal. For the time being, coal reserves seem to be sufficient to meet the increased demand. The maximum level of production of 236 million tons is expected at about the year 2020. The program for the erection of nuclear electric power stations is also gaining momentum. The contract for the first station to be erected on the Cape West Coast is due to be signed early in 1976. In its report on energy trends,[5] the Department of Planning and the Environment suggested that this program may have to be speeded up as more and more coal is used in the manufacturing of fuel for transportation purposes. In this respect the country's uranium reserves seem more than sufficient to meet the demand. In fact, the country is on the verge of becoming an exporter of enriched uranium.

One may therefore safely conclude that the supply of fuel and electricity for the country as a whole and for the agricultural sector in particular, will be sufficient to satisfy the requirements of continued growth. The one factor of direct concern may be the price of energy. In some cases, like oil, it may be because of exogenous circumstances. In general, however, once again due to the technology lag and implementation difficulties, the prices of fuel and electricity may escalate in sympathy with high processing costs.

Like the rest of the industrial production activity of any economy, the fertilizer industry locally and abroad is subjected to cyclical changes in the volume of production and in prices. Crop failures in one period are followed by increased activity in the next period, leading to an increased demand for fertilizers and sharp increases in prices. The production of fertilizers is now speeded up and as they gradually catch up with demand, the prices start to level off and eventually to decline, leading in turn to a decrease in production. According to Skeen[6] of Triomf Fertilizers, the industry experienced a slack in production during 1968 and 1969. Take-off after this period was slow, but spurted spectacularly since 1972. It is expected that the world-wide demand will increase until 1980 with a corresponding expansion in production due to escalating prices. Temporary and short-lived declines because of bottle-necks in plant construction and a shortage of skilled personnel, may of course occur from time to time. The position seems to be much the same regarding the individual items such as nitrogen, phosphorus and potassium. It is expected that the demand for, and supply of, nitrogen will be more or less in balance up to 1978, after which shortages may develop if new capacity is not provided[7]. The supply of phosphates on the world market is also increasing at present with an expected peak to be reached in 1980, whereas a surplus of potassium production is expected between now and 1980.

The supply of fertilizers thus seems to be sufficient for the next three to five years following increased prices, caused by high demand. After this period, shortages must eventually appear, but they must necessarily be wiped out again by the same price mechanism. Over the long run, when cycles average out, the fertilizer industry seems to be able to provide the necessary supply of fertilizers. The erratic and cyclical movements over the medium term, seem to be inevitable and the necessary companion of growth.

As is the case with fuel and electricity, the most urgent problem calling for attention in the quest for growth, is the rapid increase in world fertilizer prices. This occurs in sympathy with the present high rate of inflation. The price of anhydrous ammonia, for example, fluctuated between $40 and $90 in the period 1969 to 1972, after which it escalated to $450 by the end of 1974. The effects of inflation are felt in the South African fertilizer industry through higher import prices and operating costs. In the long run, however, even inflation is a temporary problem and at present there are signs that the period of unchecked price escalation is drawing to a close.

One may then expect that prices of fertilizers will continue to fluctuate, depending on the relative size of supply and demand, while a close interdependence between them will remain. Once again, however, the inefficient use of technology may put unnecessary pressure on the demand for fertilizers and thus keep the trend line in prices higher than it should actually be.

With respect to fuel and fertilizers, there seems to be scope for a more efficient use of resources. Over the period 1967 to 1974 the use of fertilizers and fuel both increased by an amount to the order of about 40 per cent[8], while the value of final output in agriculture increased by about 11 per cent. Were this increased use of energy resources labour-saving, it would have been acceptable. We saw, however, that the use of labour is increasing at an even faster rate. Once again the dual character of all resources and the difficulties associated with an inability to implement technological change effectively come to the fore.

## WATER

The uneven distribution of rainfall and prolonged droughts occurring from time to time are outstanding features on the South African scene. The average rainfall is about 450 mm per year, but only about one-quarter of the country receives more than 625 mm, while nearly 70 per cent of the country receives less than 375 mm per year. It is unlikely that this pattern will change, but something can be done to ensure that more effective preservation programs are established[9].

Unfortunately, many obstacles lie in the way of a well-planned system of water preservation projects and once again the prime culprit is the relative inability to implement technological change optimally. The position is worsened by the fact that 75 per cent of the country's rivers run through about one-third of the area of the country. The main non-agricultural demand for water originates in the metropolitan areas which are not located along the big rivers. It is estimated that the total demand for water will be about 80 million cubic metres a day by the end of the century. This exceeds the estimated maximum supply by about 7 per cent, when underground water is included in the calculations and provision has been made for an increased preservation of water.

The old cliché remains, that the solution to these problems must be sought along the lines of a more efficient use of existing natural water resources, including recirculation. Desalting may also become an important additional source of water[10].

Projections regarding the demand and supply of water clearly suggest an imminent increase in the price of water. Although this may be more important to residential and industrial users, one must keep in mind that it will eventually spill over to intensive farming projects which are dependent on water from irrigation schemes. Furthermore, even though an increase in the price of water may not affect agriculture seriously in a direct way, a higher industrial cost structure must eventually end in higher prices for agricultural inputs bought from the industrial sector.

Solutions to the shortage of water will also put quite a strain on the available intellectual skill, which once again will affect the agricultural sector directly and indirectly via the industrial sector. The relative inefficiency in the implementation of new technology will not help to alleviate the difficulty.

## LAND

Superficially it may appear that South Africa possesses more than enough land for agricultural purposes. Of a total area of about 122 million hectares, approximately 106 million hectares or 88 per cent of the total area is still classified as being used for agricultural purposes[11]. However, only about 10,5 per cent of the total area of farms owned by Whites is cultivated and it is estimated that this figure may be raised to not more than 15 per cent except by switching to revolutionary new cultivation methods. In the Black homelands about 49 per cent of the area can be cultivated. Within the existing framework of labour productivity and technological know-how, the economic efficiency potential of the soil is rather low in comparison with that of the U.S.A. and Europe. For example, the yield per acre in the U.S.A. with regard to maize is of the order of 2 000 kg compared to 800 kg in South Africa[12].

The low and unevenly distributed rainfall, mentioned earlier, is of prime importance when one searches for the causes of the present position. In addition, one usually finds that areas where rainfall is high, are mountainous and not suitable for agricultural purposes. It is clear that the contribution of land towards the growth potential is somewhat on the low side. As was the case with the other resources, it will be necessary to assist the potential of this resource by implementing more sophisticated technological know-how at a faster rate.

## THE RESOURCES OF SOUTH AFRICA AND THE GROWTH POTENTIAL OF THE AGRICULTURAL SECTOR

Having glanced over the scene where the position regarding the most important inputs is displayed, we must now turn back to the introductory remarks. We started off by noting that output is produced by the simultaneous use of many inputs: $y=f(x_1,x_1,\ldots x\ )$. In the same way as we did our analysis regarding labour, we may write

$$dy=(\partial f/\partial x_1)\,dx_1+(\partial f/\partial x_2)\,dx_2+\ldots+(\partial f/\partial x_n)\,dx_n$$

The point was made that any of the $dx_i$; $i=1,2\ldots,n$ consists of two parts, the one owing its existence to an increase in the physical quantity of $x_i$ and the other to a change in the qualitative performance of the input. (We regard the marginal productivity $\partial f/\partial x_1$ as a technical parameter. While the marginal productivity of labour may remain unchanged, an increase in the number of labourers may result in the same number of work units being employed).

If the quantity of $x_i$ increases, but the performance decreases, the $dx_i$ to be used in calculating dy may be left unchanged.

As far as labour, capital, including land and water and energy resources are concerned, we found no evidence that the quantitative supply may in the next thirty to forty years become a serious bottle-neck. We obtained evidence, however, of a serious underutilization of these resources. This fact seems to be the weak link in the South African growth chain.

If $x_n$ represents technology, it appears that $dx_n$ leads to a decrease in the qualitative attribute of the other inputs. Historically, this was definitely the case with labour and energy resources and we may presume that it was the same regarding land and water. Because a certain measure of substitution among inputs is always possible, this state of affairs is to a large extent concealed. Instead of giving rise to higher output, technological progress apparently leads to an inefficient use of other resources.

Circumstances become even more ironical when we consider the fact that we are not on the frontiers of technological progress and that a considerable lag exists between the birth of new techniques abroad and their local implementation. In this respect, the growth in the agricultural sector may be seriously hampered and we may reach the situation where some resources appear to be very scarce.

On the other hand, however, a much more positive side exists as well. If the available resources are used optimally through an efficient implementation of technological know-how, the local supply of resources is more than ample to sustain accelerated growth for decades to come. This seems, in fact, to be the most appropriate conclusion to draw with regard to our productive resources.

Price changes are in the long run not really important from the point of view of real growth, because any increase in input prices is eventually passed on to output prices. What is important, however, is that the concealed inefficient use of technology must be cured. If this can be affected, we can so to speak, continue to grow for a considerable time without a significant increase in the quantity of any of the other resources.

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