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THE FEEDER ROAD SYSTEM OF MALAWI
A STUDY OF PRESENT AND FUTURE NEEDS

by

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PREFACE

Each year the Overseas Development Administration (ODA) commissions a number of ex-post evaluation studies with two aims in mind; firstly, to assess the effectiveness of its aid activities and secondly, to learn lessons for improving the effectiveness of future aid activities.

This evaluation is one such study.

Evaluation studies are undertaken by individuals or by teams especially recruited for their particular knowledge with regard to the subject under study. Sometimes these teams will include personnel from ODA (increasingly teams are a mix of ODA and external personnel).

In all cases the reports and conclusions are attributable to the authors, who are finally responsible for their contents, and not to ODA.

Evaluation Unit
Manpower and Evaluation Department

FOREWORD

Acknowledgements

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Note

Whilst the three members of the Feeder Roads Survey Mission operated as a team, the production of this report rested with:-

Part 1	Introduction	J. S. Tanner
2	Agriculture	M. R. Haswell
3	Economics	A. Smith
4	Engineering	J. S. Tanner
5	Conclusions and Recommendations	J. S. Tanner M. R. Haswell A. Smith
General editing		J. S. Tanner
Photographs		J. S. Tanner

INTRODUCTION

PART I

1.1 Following a request from the Malawi Government, the Ministry of Overseas Development, London, arranged originally for a team of specialist advisers to visit Malawi for a period of up to 3 months to assess the present situation and to make recommendations for the future development of a feeder road network.

The team comprised a Civil Engineer/Photogrammetrist (Team Leader) an Economic Adviser (Agriculture) and an Economic Adviser (Transport). The Agricultural Economic Adviser stayed in Malawi for 5 weeks whilst the two remaining members of the team were there for approximately 4½ months. During these periods visits were made to many areas and there was extensive travel over roads ranging from full width bituminous surfaced trunk roads to low standard earth roads used solely for crop extraction. Visits were also made to Zambia and Mozambique (Portugal) by road. In obtaining essential information the cooperation was sought and received from many Malawian Government departments and commercial organisstions and the British High Commission.

Terms of Reference.

The terms of reference for the Survey Mission were as follows:-

(a) To analyse the existing and planned feeder road network throughout Malawi to determine the extent to which it is adequate for the requirements of present and future agricultural production, population density and growth, and future patterns of economic and social development. This analysis should include the areas now the subject of detailed investigations by the American Feeder Road Team, using the results of the A.I.D. Team's research where appropriate.

(b) To define areas in which road development, both upgrading and new construction, should take place between 1968 and 1974.

(c) To submit to the Government of Malawi the outline of a National Feeder Road Programme, including recommendations on appropriate standards and methods of construction.

1.2 Although the Terms of Reference specify only Feeder Roads as the subject of investigation such a project as this could not be undertaken satisfactorily without, firstly, consideration of the overall economic situation and, in particular, the agriculture sector, secondly, consideration of the national transportation position and thirdly, consideration of the existing road network of Malawi.

Malawi has four principal transport systems:-

(a) Internal/External road transport

(b) Internal/External rail service

(c) Internal/External air service

(d) Lake transport

During the past decade various specialist advisory missions have produced recommendations regarding the future development of Malawi's transport systems. Decisions at high level remain to be taken on some of the recommended projects. The latter include the future of the railway from Balaka to Salima, the possible development of Liwonde as a river port and the extended use of Lake Malawi as a primary transport route. The development of lake and rail transport will undoubtedly affect the need for primary and secondary roads which must in turn result in an altered disposition of the feeder roads.

It must be emphasized that until such major decisions are taken it would not be possible for any possible future detailed feeder roads survey to be undertaken with confidence.

Following the directives of the Terms of Reference the Team operated in three overlapping fields, namely agricultural economics, transport economics (with special reference to road transport), and road design and construction. Existing data within the Malawi Government's departments were examined and the information obtained therefrom supplemented by information obtained by numerous visits to sites in the field and established agricultural producers and transport organisations.

With the agricultural data estimates have been made of possible future crop production and indications are given of the areas where development would be concomitant with a programme of feeder road construction. From these data estimates have been made of future transport demand and the economic benefits which may ensue if feeder roads are constructed in the areas of greatest agricultural potential. Road design standards have been suggested for feeder roads primarily on the basis of the highest economic rate of return consistent with overall economic objectives.

1.3 Authorities differ in the definition of a feeder road. In this survey a feeder road is defined as a road whose principal function is to facilitate the despatch of agricultural produce from the farm or estate to the village market or local buying centre or from the lesser markets and buying centres to major markets of Farmers' Marketing Board (F.M.B.) depots. Such a road could well be an existing Branch, Estate or Unclassified road or even a Secondary road.

AGRICULTURE

PART 2

2.1 There is ample evidence from many sources that the African has a shrewd idea of the methods of cultivation which yield the best return to labour, and he prefers methods of high productivity per unit of labour to those of low productivity. Costs of labour and returns to labour are more important than yields per unit of area under the prevailing conditions of relative abundance of land and the continued practice of long-term fallowing.

That much of Malawi is no exception to this general rule is evidenced by the high land/man ratios in several districts in which the working population is engaged in agriculture. Even more important perhaps is that farmers are probably well aware of the opportunity costs of their own and their families' labour when taking up temporary employment outside Malawi.

Since the development potential of agriculture in Malawi is dependent on the investment decisions of farmers and their response to economic incentives, it is imperative that data is collected on the amount of labour (their main input) which farmers currently apply to maximise returns. Indeed, the evidence of rice producing regions in other parts of the world suggests that, given the present state of technology and factors of production at the disposal of the farmer in Malawi, it is not possible for him greatly to expand production in rice growing districts without considerable increase in population densities. Yet certain other non-rice growing districts will become food deficit areas within the next twenty years, necessitating greater food production and substantial development of transportation facilities to ensure efficient distribution and marketing.

For the purpose of this study, which first seeks to answer the general question of how much land the agricultural population of Malawi need with their given techniques of production, the area of cultivable land available to each district in 1966 according to the estimate contained in Malawi Crop Potentials 1965–1985 [1] has been taken as the basis of calculation.

2.2 A convenient unit of measurement for determining at what level of population density it can be said that land is over-populated in an agricultural sense is the number of hectares of cultivated land per adult male engaged in agriculture. For most low-income economies with their higher proportion of children in the population, the number of males engaged in agricultural work may be taken as one quarter of the whole – after making allowance for village craftsmen and traders. The population statistics used in calculating land/man ratios (hectares per adult male) were obtained from the Malawi Population Census 1966 [2].

The low land/man ratios for the Cholo and Chiradzulu districts shown in Table 1 are an indication of dense population, with total clear field area corresponding closely to total cultivable area. These two districts are deficit areas in the forecast of export crop traffic given in Appendix 1. We found several farmers in Kasupe district, where land is not limited, who had migrated from Cholo district because land had become scarce.

TABLE I

Land/man ratios in districts of Malawi
(One quarter of the total population is assumed to be engaged in agriculture)

Region/District	Land/man ratio, total area basis, hectares per man	Land/man ratio, total cultivable area basis, hectares per man	Ratio of cultivable area to total area percent	Land/man ratio, total clear field area basis[a] hectares per man
NORTHERN				
Chitipa, Karonga	23.58	8.04	34.1	1.52
Nkhata Bay	21.15	5.73	27.1	0.41
Rumpi	43.74	12.56	28.7	1.35
Mzimba	19.01	13.58	71.4	2.95
CENTRAL				
Ncheu	8.35	4.71	56.4	1.96
Dedza	6.47	4.11	63.5	1.65
Lilongwe	5.56	3.72	67.0	2.04
Salima, Dowa	8.27	6.11	73.9	2.14
Ntchisi, Nkotakota	20.84	11.79	56.6	1.89
Mchinji	11.16	9.06	81.2	3.86
Kasungu	35.84	19.93	55.6	2.62
SOUTHERN				
Chiradzulu	2.22	0.90	40.5	0.82
Nsanje	9.18	4.47	48.7	1.67
Chikwawa	11.87	6.15	51.8	2.67
Cholo	3.31	0.89	26.9	0.82
Mlanje	3.60	2.16	60.0	1.42
Blantyre	9.90	4.08	41.2	2.30
Zomba	3.86	2.18	56.5	1.42
Kasupe	10.93	8.84	80.9	2.20
Ft. Johnston	10.99	7.12	64.8	1.78

[a]Clear field area includes grazing and fallow

2.7% pop
1.0% crop yield per acre

Next densely populated is Mlanje district, and to a lesser extent Zomba district; these districts become deficit areas in 1980 and 1985 respectively – or thereabouts. By contrast, total area per man engaged in agriculture in the North is a clear indication of the relative isolation of this thinly-peopled Region. Past experience in Africa has been that under these circumstances farmers tend to practice extensive rather than intensive cultivation, with little or no increase in yield per unit of area.

The forecast of export crop traffic given in Appendix 1, which is based on a population growth rate of 2.7 per cent per annum and an overall increase in crop yields per unit of area of 1 per cent per annum, indicates the long-term potential of the Northern Region. Although in the short-run development will tend to be slow in the North since the main expansion arises from continuation of existing practices of extensive agriculture by encroachment upon cultivable lands at present surplus to the requirements of the population. Meanwhile, this relatively land abundant sector does not contribute significantly to urgently needed exports. The forecast of population by District and Region is given in Appendix 2.

Strictly speaking however, the assumption that a quarter of the total population is engaged in agriculture does not hold for Malawi, because about one-sixth of the labour force is always working outside Malawi [3]. In adopting a mean of 52 per cent of the population working in agriculture, the forecast takes account of the fact that the labour force is heavily weighted with women, older men, and children, and that of those able-bodied men who are in the village many are only part-time farmers.

With the present techniques of production and structure of the labour force, Malawi may in fact decrease the number of agricultural workers (men, women and children) to 48–47 per cent of the population, but beyond this point all the export would disappear statistically speaking. Unless there is a fundamental change in cultural practices, the labour force can never sink below 42 per cent of the population without food import. This implies that there should be a transfer of labour out of subsistence production, and that hired labour must be applied to cash crops; it must also be profitable to use that labour even on food crops.

The opportunity cost of off-season labour is low. Platt [4] found this to be 0.35 kg. maize equivalent per man hour for cotton as long ago as 1939, and our findings confirm this figure for subsistence production.

The low population density in several districts allow a few years grace still, but Malawi must plan for an agriculture that does not have labour peaks. Larger farmers in Chikwawa district were found to be applying hired labour on a regular basis at a wage of 2.15 kg. maize equivalent per man hour, because 'cotton pays and it is better to stay here than go to Rhodesia'. This is consistent with the long-run opportunity costs quoted by other workers for East Africa, which range between 2.00 and 2.7 kg. maize equivalent per man hour.

In other words, 2.15 kg. maize equivalent per man hour is the most favourable price that Malawian labour is able to command when working for local farmers, which therefore tends to be

the minimum cost at which this factor of production can be obtained by cotton producers. If the farmer cannot pay that wage in the long-run, he will not get labour. The forecast of export crop traffic for the evaluation period 1970–1990 in Chikwawa assumes that hired labour will be applied to the cotton crop.

2.3 Malawi is a land-locked country comprising about 119,100 sq. km. with one-fifth covered by lakes, and three-quarters of the land area composed of plateaux; the plateaux are at 760–1370 meters elevation although altitudes vary between 60 and 3050 meters. The distribution and total precipitation of rainfall consequently varies quite widely between regions and districts within regions.

Chikwawa, for example in the Lower Shire Valley has a mean annual rainfall of about 76.2 cm. almost all of which falls during a short wet season between November and April. In the extreme north, rainfall may be as high as 230 cm. to 305 cm., even in the Northern Region, however, much of the area – notably in Mzimba and Rumpi districts – receives an annual rainfall similar to that experienced by Chikwawa in the Southern Region. On the other hand, rice – the principal export crop grown in Karonga district – requires considerably more water than other crops; for rainfed paddy this may be estimated at a minimum of about 153 cm. – an annual precipitation which does not appear to be always reached in much of Karonga district, and which may well be deficient at crucial points in the growing season even if total rainfall is adequate.

$r = f(\Delta_{ag})$ & $\Delta_{ag} = f(r)$

A forecast of export crop traffic (defined as inter-district traffic) is necessary in planning for feeder road networks – without which it will not be possible greatly to improve the agricultural production of this largely subsistence economy. The methods of transport available to the Malawian farmer were found to be so costly that produce has only to be carried a relatively short distance before much of its value from the point of view of net returns from the sale has disappeared.

In preparing the forecast of export crop traffic, reference was made to estimates in Malawi Crop Potentials 1965–85,[1] the Report on a Socio-Economic Survey conduced in Selected Areas of the 'Lilongwe Plateau'[5], the concurrent study of home economics aspects[6], the Study of Progressive Farmers in Malawi 1962–64[7], the reports of the FAO on the Lower Shire Valley Project and the Land Development Project in the Lilongwe Region, and the World Bank's review of the agriculture in the Northern Region. In addition, reference was made to an earlier work[4] of a nutrition survey in a hill, foothill and lakeshore village in 1938–9, and to various studies made by one of the Team over many years of the economics of agricultural development in low-income regions of Africa and Asia in so far as they are applicable to the present investigation. To this body of information was added the notes which were collected by the Team in Malawi.

The aim of the forecast is to establish the probable outflow of agricultural produce over the next twenty years or so, concomitant with an adequate feeder road-network. For this purpose, the cultivable area available in each district according to local sources[1] was taken as the basis of the calculations.

TABLE 2

Estimate of produce purchased from the 1966–7 crop
(by District)

(Based on sales through the Farmers' Marketing Board)

Region/District	Export crop extraction traffic[a] metric tons	Principal export crops
NORTHERN		
Chitipa	254	Coffee
Karonga	2,229	Paddy, seed cotton
Nkhata Bay	565	Paddy
Rumpi	2,073	Seed cotton, groundnuts
Mzimba	3,810	Groundnuts
	TOTAL 8,931	
CENTRAL		
Ncheu	5,424	Groundnuts, seed cotton
Dedza	4,714	Groundnuts, seed cotton
Lilongwe	42,446	Groundnuts, tobacco
Salima	2,383	Seed cotton, groundnuts
Dowa	11,791	Tobacco, groundnuts
Ntchisi	2,889	Tobacco, groundnuts
Mchinji	5,301	Groundnuts, tobacco
Kasungu	5,761	Groundnuts, tobacco
Nkotakota	1,463	Paddy, groundnuts, seed cotton
	TOTAL 82,172	
SOUTHERN		
Chiradzulu	4,583	Marketable surplus of food crops
Nsanje	6,183	Seed cotton, groundnuts, paddy
Chikwawa	21,968	Seed cotton
Cholo	17,436	Marketable surplus of food crops
Mlanje	10,772	Groundnuts, tobacco, seed cotton paddy
Blantyre	8,233	Groundnuts, seed cotton
Zomba	8,365	Groundnuts, tobacco, seed cotton
Kasupe	8,484	Groundnuts, seed cotton, paddy
Ft. Johnston	4,643	Groundnuts, seed cotton
	TOTAL 90,667	
Grand Total, All Districts	181,770	

(a) In certain districts, notably in some areas of the Lilongwe Plateau and Southern Region, maize and to a lesser extent pulses – the staple food crops – are deliberately produced for the market, indicating that peasant producers are not indifferent to the exchange economy. In other districts, because of the favourable climatic conditions in the 1966–67 crop year, foodstuffs which have come into the market have been to a large extent the surpluses of local subsistence farmers.

It seemed appropriate that the forecast of the probable outflow of the agricultural product should be taken in two steps, firstly by estimating the area which could be utilized for the production of an export surplus, and secondly the yield which will be forthcoming from this area.

Turning to the first step, the existing cultivable area, less the area required to feed the present population and that utilized for cash crops, formed the basis of the forecast. Included in the forecast, however, is an estimated increase in yield of the present National agricultural product at the rate of 1 per cent per annum (excluding estates production). Past experience in Africa has been that farmers tend to practise extensive rather than intensive cultivation with little or no increase in yield per unit of area. In fact the evidence is that yields may even fall and that where they do rise, 2 per cent per annum is about the maximum.

The area coming into cultivation due to the increase in population was then calculated on the assumption that 52 per cent of the population is actively engaged on the land and that, with given techniques of production and present practices of extensive agriculture, one worker can cultivate 0.75 hectares of food and cash crops (weeding being the limiting factor). Land required to feed the increased population, assuming a rate of population growth of 2.7 per cent per annum, was determined by multiplying population by 0.3035 hectares as indicated by Hoffman[5] that at least this area per person should be set aside for home consumption unless yields of more than 1350 kg./ha. can be expected continuously. Hoffman's estimate[5] is net availability for consumption after allowing 25 per cent for on-farm storage losses of maize (which was found to be of this order of magnitude where rat and pest infestation had damaged crop in stores inspected during the visit), and for seed requirements.

The second step estimates the yield which may be expected on surplus cultivable area newly opened up for export production with increased population. Here it was assumed that the most suitable crop for expansion of export production would be cotton, and that it would be sprayed to give a minimum yield of 785 kilograms per hectare (1700 lb per acre). It is known that in the Lower Shire River yields averaging 675 kilograms per hectare (602 lb per acre) have been obtained even without spraying, in a year of most favourable weather conditions and this is therefore considered to be a conservative estimate of potential export production from the cotton crop providing farmers adopt spraying as a matter of routine.

In a year of most favourable climatic conditions, 1956–7, such yields were gained by the Cotton Research Corporation from experiments on unsprayed cotton on African gardens; in 1965–6 yields from sprayed cotton ranged from 675 kilograms per hectare (602 lbs per acre) to over 1125 kilograms per hectare (1004 lbs per acre).

Wherever the altitude is greater than 1220 metres (4000 feet) however, this has an adverse effect on yields, and the higher the altitude the lower will be yields and the slower will be growth; but throughout the 560 metres (1837 feet) lakeshore area, and the Lower Shire River in the Southern Region and the Palombe plain, potential is very high. In the Salima district, where pests are much more serious, spraying is essential; in any one year without spraying Salima will probably secure yields of less than 180 kilograms per hectare (161 lbs per acre). There is already extensive

i.e on the one hand yields of subsist maize are independent of pop

and yields of rice are directly dep'd by pop pressure

spraying of areas newly opened up on the Shire highlands, notably on the Blantyre plateau; these areas, which were impossible for cotton production because of pests before the introduction of spraying, now have a high percentage of sprayed cotton. Areas where there is the greatest potential for increased cotton production are given in Appendix 3.

Those districts of the Central Region, notably on the Lilongwe Plateau, which are not suitable for cotton production can be expected to obtain yields reaching 785 kilograms per hectare from groundnut production particularly if this crop is adopted by men employing improved cultural practices; at present groundnuts is considered to be mainly a woman's crop. Similar yields of marketable surpluses from maize may also be expected, if not exceeded, to meet the increasing needs of food deficit areas, and to feed a growing urban population.

A minimum of 785 kilograms per hectare is certainly low for paddy production and is consistent with present yields. Yields of this labour intensive crop are not, however, likely to be greatly improved over the short run because population is too low. If the main potential for agricultural development lies in heavy concentration on increasing the area under cotton in the next two decades, in the long run with increasing pressure of population, the large-scale production of rice in those areas which are suitable for its cultivation will be essential. It is therefore important that pilot experiments of irrigated paddy production should be undertaken in the very immediate future.

As soon as population reaches the point where all the cultivable area has been taken up in any one district, that district cannot further extend its area under crop, and consequently the increase in agricultural product will be restricted to that resulting from improved techniques of production. If population increase accelerates faster than agricultural productivity, the surplus of cultivable area will decline until sooner or later it will become zero and the district will become a net importer.

2.4 The economic importance of high value export crops is clear from Appendices 4 and 5. Maize equivalents represent the amount of maize that could be purchased with the aggregate value of all crops (at 1967 prices). Low values shown in Appendix 5 represent those areas in which there is a preponderance of maize in the export crop traffic. A factor of great importance, however, is the grading result of the high value tobacco crop, and of cotton, since the percentage of low grades in the 1967 crop adversely affects the weighting system, indicating that future prospects for agricultural development will depend to some extent on quality improvement through more efficient handling and grading of high value crops.

The first priority for the expansion of export production however must be the provision of an adequate feeder-road and improved road network, and an efficient transport system. Appendix 16 indicates that traffic density is at present extremely low, and this is not unrelated to the fact that the proportion of product entering the market decreases sharply as buying points are sited farther and farther away from the main roads. This is because, with the costly methods of transport available to the farmer. Farmers have only to carry produce over a short distance before most of its value, from the point of view of net returns from the sale, has gone.

TABLE 3

The cost of different methods of transport from farm to buying point in Malawi[g]

Method and type of country	Product	Length of journey kilometres	Transport cost (original measure)	Transport cost expressed as kilograms maize equivalent per ton kilometre
PORTERAGE				
Undulating	Tobacco: fire cured	8	2/6d per 32 kg[a]	37.2
Flat	Tobacco: fire cured	21	3/–d per 13.6 kg	45.5
Undulating	Seed cotton	8	2/6d per 27 kg [b]	49.6
Steep escarpments	Maize	5–6	2/6d per 30 kg	64.9
Precipitous: headloading only means of transport	Coffee	6.4[c]	3/6d per 13.6 kg	173.6
OX CART				
Flat[d]	Groundnuts (shelled)	8	10/–d per 798 kg[e]	6.8
Flat	Tobacco: fire cured	21	22/6d per 408 kg	11.3
Rugged	Tobacco: fire cured	21	70/–d per 476 kg	30.2
BICYCLE				
Flat, undulating in parts	Maize	16	3/–d per 68 kg	11.9
In same area where no motor vehicles competing	Maize	16	5/–d per 68 kg	19.9
MOTOR VEHICLES (5 ton trucks)				
Undulating	Maize	96	2/6d per 90 kg	1.3
Flat	Maize	14	2/–d per 90 kg	6.8
Rugged[f]	Tobacco: fire cured	40	10/–d per 113 kg	9.6
Same area	Seed cotton	14	1/6d per 36 kg[b]	12.6

[a]Heavier load is carried over shorter distances
[b]Bulky
[c]Producers refuse to headload further distances
[d]Motor vehicle transport scarce in this area
[e]Distance relatively short so producers tend to overload
[f]Narrow valleys, but main road (gravel standard) passes through district
[g]The Farmers' Marketing Board have some three hundred buying points throughout Malawi

TABLE 4

Farmers' Marketing Board rates for[a] motor vehicles conveying agricultural freight from 300 buying points to their storage depots

Crop	Pence per ton kilometre	Kilograms maize equivalent per ton kilometre
Maize	4.80	1.73
Pulses	4.96	1.78
Paddy	5.14	1.85
Groundnuts	5.99	2.15
Seed cotton	6.17	2.22
Tobacco	6.17	2.22
Fertilisers[b]	5.14	1.85

[a]Rates are uniform throughout the country; main storage depots are at Mzuzu and Nkhata Bay (Northern Region), Lilongwe and Salima (Central Region, Balaka, Limbe and Luchenza (Southern Region).

[b]Inward traffic; sold to growers through Farmers' Marketing Board.

TABLE 5

Charges against Farmers' Marketing Board for hire of tugs and barges transporting paddy for milling from Kapora (extreme north) to Nkhota Kota (Central Region)

Lake Distance	Pence per ton kilometre	Kilograms maize equivalent per ton kilometre
483 km	6.28	2.26

The fixed rates paid by the Farmers' Marketing Board for motor vehicles conveying agricultural product to their depots result in crops being produced under conditions which are totally uneconomic and wasteful of resources. (See Part 3). Coffee for example, already over-produced on the world market, offers an extreme case where 226 metric tons were produced in far north Misuku in 1966–7. Owing to the difficulty of reaching the area with motor transport, this crop had still not been moved out of the area by April, 1968; it is said that the cost of moving it will be high since it takes 'a six-mile-per-gallon four-wheel-drive lorry to get it out of the Misuku'. Added to this, the cost of head porterage from farm to buying point is so great that the entire value of the crop has gone after a distance of only 6 km. If a man is to carry coffee up and down precipitous slopes, he must be well fed, which alone creates a fairly high minimum cost – and porters expect to be paid considerably more than the mere grain ration for a hard day's work.

The construction of feeder roads in areas, particularly those which have a high potential for cotton production, will not however lead to early expansion of agricultural output unless provision is also made for the availability of attractive consumer goods at village level. Apart from acting as incentives to increase cash crop production, they also add importantly to the development potential of an improved transport facility.

ECONOMICS

PART 3

3.1 Feeder roads have been defined earlier in the report. In this section their economic environment is discussed. The existing policy and situation is reviewed along with previous relevant reports and techniques of appraisal are outlined with the economic assumptions taken. A comprehensive review of the agricultural and transport economic environment will serve to indicate lines for future development and recommendations will be made accordingly.

3.2 The present distribution of roads by administrative class and surface type is given later in Appendix 22. Expenditure levels, that is, financial costs, on construction and maintenance of all roads which are the responsibility of the Ministry of Works and Supplies in the past four years are given in Table 6.

TABLE 6

Expenditure on road construction and maintenance by the Ministry of Works and Supplies

Year	CONSTRUCTION				MAINTENANCE			
	Bitumen £000s	Gravel £000s	Earth £000s	Total £000s	Bitumen £000s	Gravel £000s	Earth £000s	Total £000s
1964	0	90	80	170	42½	117	33	192½
1965	107	638	45	790	46	125	36	207
1966	154	780	34	968	40½	138	39	217½
1967	132	361	76	570	40	156½	40½	237

Note These are Departmental Costs and do not include 'overheads' which range up to 100 per cent of these figures.

The total mileage of new feeder roads constructed over the past six years has been on average, 97 miles per year. In the 1969/1971 Development Programme £240,000 (£80,000 per year) has been allocated for expenditure on feeder roads; no further breakdown is available. It is one of the purposes of this Report to advise as to the economic returns from such investments and to recommend distribution by area and the relevant methods and standards of construction.

3.3 The opportunity was taken of reviewing other relevant evidence namely, reports of other official missions to Malawi as detailed in Appendix 34, particularly the Hill Report[8], the World Bank Mission Report[9] and the further I.B.R.D. Reports. It will be recalled that the Hill Mission was of the opinion in 1965 (para 33) that a disproportionate investment on trunk roads existed as compared with the feeder road system. It continued (para 36) that there was a most urgent country-wide need for the early construction of a network of crop extraction roads. The basis for such

views was that, in the opinion of the Report, Malawi cannot afford to wait for years until a 'proper' return is realised on road development expenditure and that further regard should be paid to the relationships of costs to benefits. Although it is the intention of this report to indicate how a full analysis of costs and benefits can be effected through a deeper probing of the wider macro-economic benefits, it is not possible at this stage to endorse the view of the Hill Report[8] that Malawi cannot afford to wait until a 'proper' return is realised. It would be highly desirable to quantify this return and thus indicate the relevant rate of return for Malawi at its present stage of development. The relevant section of the World Bank Report is devoted mainly to reviewing the major road projects; however it does state (para 51) that greater consideration and financial provision is now being given to the improvement and extension of feeder roads, no recommendations were made.

Following the visit of I.B.R.D. representatives in April 1967 their confidential report stated that the inadequacy and poor condition of the road system had hampered economic progress and that lower class roads of minimum standards were required throughout the established agricultural areas. It should be noted that this comment was limited to the then established agricultural areas.

The opportunity was taken by the team to review the feeder road situation in the nearby countries of Kenya, and Tanzania and also Nigeria to ascertain their relevance to Malawi. The Kenyan Feeder Road Programme 1969/72 as presented to the I.B.R.D.[10] and other Kenyan studies were inspected and certain information derived from them. The Tanzanian Feeder Roads Programme now in the process of being drawn up, is based on specific areas selected by the I.B.R.D. and no results are yet available. The Road Development Studies for the then Regional Governments of Western, Eastern and Northern Nigeria by the Economist Intelligence Unit were discussed with the E.I.U. representatives in Nairobi; the former has been described in detail elsewhere[11]. These studies were concerned with all types of roads but it was possible to deduce that, in general, benefits through induced production were of significantly less importance than those arising through transport costs. However, it should be noted that in all cases these studies differed from this Report in that in all cases the other Reports were of a more detailed nature and that considerably more resources, including computers and time were devoted to their production. Whilst it is well beyond the Terms of Reference and resources available to this team to produce a similar comprehensive study here, it is possible to indicate the techniques recommended should a more detailed study in certain areas be thought desirable.

3.4 It is essential to include a forecast of the national economy in this study. The Ministry of Finance have forecast a 7 per cent annual growth in the short term in the momentary sector of the Gross Domestic Product (GDP). The achievement of this rate of economic growth can be regarded as a principal objective of Malawi's economic policy, although such growth is constrained by the external debt servicing ratio and foreign exchange shortages. This is, of course, a variation on a very familiar theme. It has been used in interpreting the Terms of Reference for this report. There are however certain inherent limitations which need to be taken into account: firstly alternative objectives may have to be foregone, such as maximisation of social welfare or a strong currency, secondly, the above constraints are commo. for developing countries and in the context of Malawi, it would therefore appear that this constraint implicitly gives a priority to export crops and in particular the high value export crops. These points have been discussed with the Ministries of Finance

and Economic Affairs.

As compared with other developing countries in Africa, Malawi is relatively underdeveloped. The national income per head is about $45; excluding expatriates it is estimated to be about $25 and is one of the lowest in the world. Malawi is therefore at the stage in its economic development whereby investment needs to be concentrated in the basic economic infra-structure. Other relevant transport economic statistics are shown in Appendix 14.

Building or improving a road produces numerous economic, social, cultural, political and other effects. The different economic and non-economic aspects of development are intimately interwoven and mutually dependent, they are not mutually exclusive. Whilst it is of course extremely difficult to quantify to a very high degree of accuracy all these effects, quantification is required in the application of economic criteria in order to obtain optimal allocation of the available scarce resources which is recognised as the major means of obtaining economic growth.

This study can be regarded as a typical example of the pre-investment studies which are carried out in developing countries seeking funds for the financing of capital projects. As such it will differ from the normal private industry project appraisal since it needs to be on a wider and deeper basis and include social (that is, non-user) costs and benefits which are clearly defined in the Road Track Costs Report[12], at table 2.1.

The method of appraisal used is that which has come to be known as 'Cost Benefit Analysis', and the opportunity is taken for the benefit of Malawi Government staff of describing the procedures in detail. In such analyses social costs, or user and non-user costs (public and community) are quantified and compared with total social benefits which accrue to the nation if the project being considered were to be implemented. Comparison is made on a 'with and without' basis and the final result can take the form of one of the various measures of economic return – Internal Rate of Return (I.R.R.), Net Present Value (N.P.V.), First Year Rate of Return (F.Y.R.R.) or Cost/Benefit Ratios (C.B.R.). As this study intends to set out some order of priorities, the measures which enable this to be more clearly demonstrated are the Net Present Value and Internal Rate of Return. (There is no need to enter into the realm of economic theory as to why this is, but details are available if requested).

Once varying net present values and internal rates of return are established for different projects or road schemes it is then possible to list these in order of magnitude. It is possible at a later stage to compare investment within transport, and later on still, with other social investments, housing and education for example.

It is of course necessary to establish what a reasonable rate of return is for Malawi. Expert opinion has been counselled on this point (see also)[12,13] which in theoretical language is the determination of the Social Time Preference (S.T.P.) Rate, this is the rate at which the community is prepared to forego current for future consumption (that is, jam today versus jam tomorrow). It is considered that the test rate should be 12 per cent – this compares with for example 8 per cent for Great Britain, about 11 per cent for France (under VI Plan 1971/75) and 12 per cent for Thailand.

8 12% discount
1.5 multiplier ≃ 8% discount. implies $\frac{(x)1.5}{0.08} \simeq \frac{x}{0.12}$

The present World Bank test rate is 8 per cent but this excludes secondary effects included in this report via the multiplier (q.v.); where the multiplier for Malawi is included the World Bank discount rate is 12 per cent also. There are some complications if budgetary constraints are quantified to the extent of their effect on the rate of return but this is felt to be too complex for a developing economy such as Malawi's.

It is also necessary to establish the probable lives of the assets being considered for investment and to compare them with the appraisal period. Although this study covers the period 1968/74 and all values are quoted in constant prices discounted as at 1st January 1968, the period of evaluationis assumed to be twenty years. This is ten less than the standard appraisal period in Western Europe. Normally it is also necessary to introduce the residual value of an asset at the end of the evaluation period and to include such a value as a credit. But with a discount rate of 12 per cent, an evaluation period of 20 years and the problem of uncertainty, it is not thought politic to do so in this instance. Therefore for the purpose of this study the lives of the assets are assumed to be twenty years with no residual values.

Normally, implementation of the project or scheme will cause some increase in net national income, either through an increase in benefits or a decrease in costs. This increase represents a rise in income for each recipient who in turn re-spends part of this income, leading to another round of spending and so forth. Therefore the increase in net national income is in excess of the original savings and such a relationship is known as the 'multiplier', thus secondary effects are included. The multiplier is determined by (the reciprocal of) the marginal propensity to save, tax and imports, Reference to the Tan-Zam study[14] shows a multiplier of 1.2 to 1.3 for neighbouring countries but it is our opinion and that of the Malawi Ministry of Finance, following discussions with representatives of the World Bank (I.B.R.D.), that a multiplier of 1.5 is relevant for Malawi due to the higher propensity to consume in poorer countries. This figure has been used to estimate the true impact on the economy of the above additions to net national income.

In this appraisal it is of course necessary to consider taxation (see Appendix 13). Taxation is usually regarded as a transfer payment from one section of society to another and as such is excluded from economic appraisals dealing with optimal resource allocation as no resources are consumed by tax payments or credits. It is therefore necessary to exclude taxation, in general, in socio-economic appraisal exercises (q.v.). However it is necessary to include taxation when considering private decisions, such as when the individual makes a choice based on gross (including tax) costs and selects a route (that is, traffic assignment) but the economic appraisal still, of course, excludes taxation. There is however, one small exception developed later in para 3.10.

3.5 As indicated in para 3.4 the recommended method of project or scheme appraisal is by Cost Benefit Analysis. In this section it is proposed to restrict the analysis to those costs and benefits immediately associated with the project, in this case traffic on a micro-economic view; the wider macro-economic view will be discussed later. The procedure used in developed countries has been adjusted accordingly to suit local circumstances so as to be applicable in developing countries such as Malawi.

It is thus necessary to list the factors composing the benefits and costs and then to show how these factors can be measured for inclusion in the analysis. Benefits and costs of upgrading existing feeder roads and the construction of new feeder roads take the form:-

Benefits

(a) vehicle operating cost changes
(b) time savings
(c) accidents savings
(d) reduction in driver strain

Cost

(e) construction
(f) maintenance cost changes
(g) administration of highway e.g. cleansing, lighting, policing
(h) land

These items are now discussed in a local context.

(a) Vehicle operating costs – these include
  i fuel consumption
  ii engine oil consumption
  iii tyre wear
  iv depreciation
  v maintenance – labour and parts

International and local studies[12, 15,–21] were analysed to determine relevant economic and financial costs; discussions also took place locally on the relevant costs. Following observa-on the types of vehicles operating on the existing feeder roads and discussions with M.A.R.T.A. (the leading feeder roads transport operator), it was decided that instead of using a series of costs for various truck capacities, a 'typical' truck should be assumed for this appraisal. The 'typical' truck has been taken as one of 5 long tons tare weight with 5 long tons capacity operating at a 50 per cent load factor which takes into account dead mileage and overweight running. If the 7 ton tare weight lorry becomes more popular in due course, as it may do due to the upgrading of roads, no significant change would occur in the marginal cost changes. It is therefore satisfactory to use the above typical truck.

Detailed costings are shown in Appendix 8; the vital figure being the economic cost for earth road operations (excluding overheads and tax) of 5.3 pence per metric ton kilometre (8.5 pence per long ton mile). The exclusion of overheads is normal in a marginal analysis such as this (if included the figure would rise by about one third).

(b) Time savings – this is the summated value of the time saving of drivers, passengers and goods. There has been much discussion on the value of time elsewhere and this has already been

summarized[12]. In the Malawinn context it is thought that only savings in truck crews' time would be relevant in n feeder roads survey and that savings in private car and bus passengers' time can be safely ignored. Savings in truck crews' time are included in the values shown in vehicle operating costs in (a) above (see also 3.6).

(c) Accident savings – in a developed society savings accruing from accident savings can form up to 25 per cent of the total benefits. A report relating to Kenya[22] shows that the total cost of accidents there was equivalent to 1 per cent of the gross national product. Similar calculations, but on a more restricted basis (Appendix 9) show that the position in Malawi is relatively worse than in Kenya and now amounts to a loss of about £¾ million per year. Analysis of accident statistics show that a higher proportion of the fatal and serious accidents occur on gravel and earth roads despite their having significantly less traffic flows than on bitumen (Appendices 9 and 10). It is therefore essential to include in the appraisal of a feeder roads scheme benefits accruing from reduction in accidents. It is suggested that the following approximate costs be used[12,22].

TABLE 7

Cost per average injury/accident

TYPE OF ACCIDENT	COST
Fatality	£300
Serious injury	£100
Slight injury	£ 10
Administrative and damage costs of injury accident	£100
Administrative and damage costs of non-injury accident	£ 40

(d) Driver strain – a benefit for the reduction of drivers strain when driving on improved roads (usually motorway type) is used by the French[20]. It is known as a 'bonus' and is valued at Fr. 0.03 per kilometre (2d per mile). It is not thought to be relevant to feeder roads and is therefore excluded, but should be borne in mind for major road operations.

(e) Construction costs – a review has been made of the inputs required for construction of new and upgraded roads – labour, local and imported materials, plant and equipment etc. These have been costed on financial and economic bases. The latter involved the elimination of taxation (see 3.4). Overhead expenditure as at present regarded in Malawi needed to be re-allocated so as to reflect individual project expenditure. An approximation based on international comparisons is 15 per cent of local or direct works costs. Similarly tender costs need a 15 per cent addition for Ministerial overheads to arrive at financial costs. The following economic construction costs

per kilometre (mile) of road by surface were calculated from Ministry of Works and Supplies sources.

TABLE 8

Economic construction costs for new and the upgrading of, feeder roads

New earth road		Upgrading from earth to gravel	
£ per km	£ per mile	£ per km	£ per mile
500	800	2650	4300

(f) Maintenance costs – a review has been made on the same basis as for construction costs. Maintenance costs are a function of original construction and upgrading cost and average daily traffic flow (A.D.T.). It is reckoned that the feeder roads under consideration here will all be of the earth or gravel type. Tax in all forms needs to be excluded from the costs. Economic maintenance costs have been calculated, again with a re-allocation of overheads, from Ministry of Works and Supplies sources.

TABLE 9

Economic maintenance costs for new feeder roads and change in economic maintenance costs upon upgrading existing feeder roads

New feeder road (earth)				Addition for upgraded road (earth to gravel)			
Present value year 1		Present value for 20 yr appraisal period		Present value year 1		Present value for 20 yr appraisal period	
£ per km	£ per mile	£ per km	£ per mile	£ per km	£ per mile	£ per km	£ per mile
30	50	230	370	+ 25 (ii)	+ 40 (ii)	+ 500 (i)	+ 800 (i)

(i) maintenance of an upgraded road includes regravelling every 6th year; the cost of such has been discounted so as to be included on a present value basis.

(ii) excludes regravelling in (i)

(g) Highway administration – this includes such factors as policing, cleansing and street lighting. It is not thought in this instance to be of significant value with regard to feeder roads and has therefore been exluded; should the costs increase significantly then inclusion is recommended.

(h) Land – it is often necessary for land to be acquired in order that a road can be built, widened or re-aligned. This results in land being transferred from one use to another (in this case

probably agriculture to transport). In Malawi almost all the land is already Government owned but the loss of resources to the nation in such a transfer is the value of the crops that would otherwise have been produced on the acquired land. It is this value which needs to be included as an economic cost. Where the land is privately owned it is assumed that the financial costs are equal to any compensatory payment. The Ministry of Works and Supplies has detailed lists by crops of compensation payable where land is acquired for roads (Appendix 18). Economic costs need to be included even if no compensation is actually paid, which has occurred in the past following appeals for development and self-help from the Malawi Congress Party Leaders. These lists were inspected and thought to be realistic and were the basis for the following estimates.

TABLE 10

Economic cost (estimated) of land acquired for feeder roads

NEW FEEDER ROADS		UPGRADED ROAD	
£ per km	£ per mile	£ per km	£ per mile
15	25	NIL	NIL

A summary of economic costs is shown at Appendix 19.

3.6 In order to attempt to quantify the impact of transport upon economic development it is necessary to review the present transport charging situation. Rates paid by the Farmers' Marketing Board (F.M.B.) for motor vehicles conveying agricultural freight from buying point to F.M.B. storage depots are uniform throughout the country. These are given in Table 11.

TABLE 11

F.M.B. transport rates

Crop	F.M.B. quotation		kilograms maize equivalent per metric ton kilometre
	pence per short ton mile	pence per metric ton kilometre	
Groundnuts	8.75	5.99	2.15
Maize (export)	7.00	4.80	1.73
Cotton	9.00	6.17	2.22
Tobacco	9.00	6.17	2.22
Paddy (rice)	7.50	5.14	1.85
Fertilisers	7.50	5.14	1.85
Pulses	7.25	4.96	1.78

Note: For journeys between a market and an F.M.B. depot of less than 15 miles payment is made on a fixed distance of 12 miles.

It is understood that it is the intention of the F.M.B's policy to quote differential transport rates according to crop value, that is, higher valued crops are charged at a higher rate. The effects of this policy are shown in the final column of Table 11 where the transport charge is shown in kilograms maize equivalent per ton kilometre. Such a policy penalises the higher value crops on which Malawi should concentrate (see Part 2) and in our opinion there is no justification for such a policy. In addition to the rates being uniform throughout the country, the rates are applicable over all road surfaces and as shown in para 3.5 and Appendix 8, operating costs vary significantly by surface. In order to appraise this aspect of the justifiability of the F.M.B. rates it is therefore necessary to estimate vehicle mileage by surface. An approximate estimate of this has been made from the current traffic census (Appendix 6) but it is stressed that more information is required (techniques as to how this is to be obtained are outlined in Part 3) before it is possible to be categorical. From this and the traffic census it has been possible to estimate that approximately one third of the F.M.B. traffic is on earth roads and two thirds on gravel or bitumen roads. This would result in the following costs.

Economic Cost	3.9 pence per metric ton kilometre
Financial Cost	4.1 " " " " "
Financial Cost + Overheads (+ 1/3)	5.5 " " " " "

It will be seen that the financial cost plus overheads of 5.5 pence per metric ton kilometre is located near the centre of the above range (4.80 – 6.17 pence per metric ton kilometre). One large operator indicated that his total costs were about 4.5 pence per metric ton kilometre which indicates a high profit margin. From this it could appear initially that the F.M.B. rates are not unjustifiable, but such a conclusion would be premature as it is applicable only if one third of the traffic is on earth roads and two thirds on gravel or bitumen. The system of paying a fixed 12 miles charge for all journeys between markets and depots of 15 miles or less is detrimental on two counts. Firstly, observations suggest that the average trip length, within the relevant range of 0 to 15 miles, is considerably less than 12 miles and therefore the charge is too high. Secondly, such a charging system, although it may encourage distant development in certain cases, operates against overall development as it leads to a non-optimal allocation of resources. If however, an interventionalist policy is required, it should be quantified beforehand, so as the true economic costs are ascertained.

It is our advice that the F.M.B. charging system operates against Malawi's economic development. The differential rates by crop value act in a harmful manner as they discriminate against high value crops in which development should be concentrated. It is highly desirable, in the interests of overall economic development, that transport charges should reflect the cost incurred. That is, the charges should be differentiated according to distance and road surface condition. It is our conclusion that the F.M.B. rates need to be based on distance and surface condition rather than on a crop value basis.

3.7 The next stage, in order to appraise the current situation is to compare benefits with and without the proposed project or scheme relating to existing feeder roads; a proposed data and appraisal form is shown in Appendix 11(b). The comparison of benefits can be carried out by reference to the existing traffic patterns. It has been assumed that the only traffic of economic

value on feeder roads is crop extraction traffic; leisure and other traffic have been ignored. Observations showed the latter to be minute. Some aspects of the existing traffic pattern for Malawi feeder roads can be derived from the current Ministry of Works and Supplies traffic censuses. In certain instances these were confirmed and augmented by observations and counts by the team on location. Further details as to the traffic engineering methods recommended to improve this information appear in Part 4.

If an existing feeder road is improved in standard in most if not all cases, from earth to gravel surface, there should be a reduction in transport costs. For the 'typical' truck, the economic cost would change from 5.3d per metric ton kilometre (8.5d per long ton mile) on earth roads to 3.2d per metric ton kilometre (5.1d per long ton mile) on improved gravel roads. The summation of this difference for each ton kilometre of operation amounts to the savings in vehicle operating cost and time (see 3.5 (a) and (b)). It is not thought relevant in a study relating to feeder roads to include operating cost changes from earth or gravel to bitumen, but these are shown in detail in Appendix 8. It should be noted that where agricultural produce is transported over bitumen roads rather than gravel, due to road improvements, though outside the scope of this report, the relevant cost changes will need to be included in such a further study. The consideration of new generated traffic is deferred until para 3.9.

It is necessary to analyse the costs and benefits to existing traffic ensuing from a road improvement in order to determine whether such a scheme could be economically justified. This exercise is restricted in this report, to the most probable and relevant improvement in the case of existing feeder roads – an upgrading in surface from unimproved earth to improved gravel. Existing traffic has been appraised in detail, (Appendix 12), changes in discounted benefits arrived at by consideration of present export crop traffic, vehicle operating cost changes and distance of feeder road hauls in each District. As no accident data are yet available on a District road breakdown, it has not been possible to include accident savings. Costs are shown at para 3.4. It has not been possible at this stage to differentiate costs by District and constant costs have therefore been used. All costs are expressed in Present Value form, changes in future maintenance costs being discounted from the year incurred and included in Benefits as shown in Appendix 11(a). The results of this analysis are best shown as Net Present Values (NPVs) by District (that is, the net values – benefits less costs – for the next 20 years discounted to present day values), these are shown on a District basis (Appendix 15). Of these the order of priority is given in Table 12.

As can be seen only one N.P.V. is positive – Lilongwe (it is not necessary to quote Internal Rates of Return at this stage as the majority would be very low). There is therefore no economic justification, based on existing traffic, excepting the case of Lilongwe, for any general upgrading from earth to gravel standard on a District basis. In Lilongwe District it is possible to justify now upgrading of feeder roads. However this does not imply that any one particular improvement within a District is without economic justification; such a case is possible but individual project studies are outside the scope of this report.

TABLE 12

Benefits to existing traffic following feeder roads upgrading from earth to gravel standard

District	Net Present Value -£
Lilongwe	+ 1390
Chikwawa	- 571
Cholo	- 1005
Dowa	- 1546
Mlanje	- 1643

It needs to be stressed that whilst the above table indicates areas of priority, except for Lilongwe no economic case based on present traffic currently exists for an upgrading of feeder roads; the priorities which are listed are in fact of low priority.

3.8 The future development programme of the Roads Department of the Ministry of Works and Supplies, shows that for the period 1969/71 an annual average of £80,000 is allocated to feeder road improvement and construction. This amount is not derived from any economic return as none is known. It is desirable to ascertain whether in general there is justification for this and additional expenditure for the construction of new feeder roads as compared with upgrading of existing feeder roads, based on present agricultural production and traffic. Current crop production patterns and levels have been analysed and compared with the current road network (Appendix 16). These results, expressed in metric ton kilometres per kilometre, show that only in the following Districts given in Table 13 could a new feeder road construction programme now be qualitatively justified.

TABLE 13

Current annual export freight hauled

District	Export Froight Metric Ton Kilometres Per Kilometre
Cholo	869
Chikwawa	704
Lilongwe	691

For full details see Appendix 16

This is a qualitative judgement as it has not proved possible to quantify what rates of return would be earnt and it is therefore only possible to say that there is some, possible inconclusive, evidence in these areas. Beneath these Districts there is a significant gap - the next District is Chiradzulu (474 metric ton kilometres per kilometre). Only in the above cases is it possible to advise, that on current production patterns and levels there is, possibly inconclusive, evidence that it is justifiable to endorse a general district feeder road construction programme. There is no definite 'break even' point but as the gap between Lilongwe (691) and Chiradzulu (474) is so significant, it is possible to state that in all Districts except the above three, the present production is far too low to justify, in general, expenditure on new feeder roads. The same proviso as expressed earlier also applies here, in that the above advice does not rule out individual projects which have sound justification in any one of the other Districts. It is not possible in this report to identify such schemes. Similar analyses relating to the estimated future crop production level and pattern are shown in para. 3.10.

3.9 It is now relevant to introduce future traffic levels which will be associated with the future agricultural distribution, production and consumption levels. The wider effects of investment in transport or the macro-economic elements also need to be considered. As pointed out earlier, Malawi is still at the stage where its economic development is concentrated in the basic economic infra-structure which includes the agricultural, health, housing, education and labour sectors. Transport is not in fact, a separate sector but a link between sectors and as such returns can be extremely difficult to quantify. It has been stated by the Brookings Institute [23] that transport does not by itself open up areas but acts as a catalyst. Other external sources [11] [24] suggest that evidence on transport leading to development is conflicting. This is to be expected as each individual country examined is at a different stage in its development. No evidence is available however relating to Malawi and an attempt needs to be made to determine the affect of road investment in Malawi. At this stage therefore it is relevant to consider the correlation between agricultural production and other factors individually and multilaterally, i.e. simple and multiple regression.

The current situation is shown on Figures 1 to 6, where the value and volume of crop exports are related to the existing and potential road networks. Linear and multiple regression analyses are given in Appendix 7. The equation based on crop values (Y1) are clearly valueless; the crop volume (Y2) equations are more significant (at 10 per cent level) but not at the level of 5 per cent which is normally considered acceptable for practical application. This and the factors discussed in para 3.8 indicate that in Malawi's economic development to date, there is no conclusive quantitative evidence, on a District basis, that increases in road mileage have led to increases in export crop production on a value or volume basis.

However, if the analysis is concentrated on the highest significant correlations, there is evidence (Appendix 7, 7th equation) to indicate that there is a fair positive correlation between the volume of crop exports per hectare cropped (Y2) and the population per cultivable area (X2). This suggests that in the past in Malawi it has been population rather than roads which has led to economic development, or that people rather than roads have opened up the country.

The foregoing would seem to indicate that at the current stage of economic development in Malawi there is no evidence at present locally which would enable one to attribute any economic returns from any increased agricultural production to feeder road investment, that is to increase the Net Present Value (N.P.V.) or Internal Rate of Return (I.R.R.) accordingly, except where there is conclusive proof that an investment in a particular feeder road would be quantitatively conducive to a raised level of agricultural production. It should be noted that some Districts (e.g. Cholo) are by 1970 showing a negative export crop traffic forecast, that is, importing rather than exporting crops. This means that the trucks will be carrying produce inwards rather than outward and the load factor would therefore remain unaltered. Evaluation has been carried out accordingly.

After considerable thought and research(23) it has been decided to assume that one quarter of the growth in agricultural production would occur without infra-structural investment and this assumption has been used in assessing the forecasts in Part 2.

The above evidence would seem to indicate that it is necessary to prohe wider in the case of Malawi in order to quantify what economic returns from induced agricultural production can be attributed in future to roads. It is in fact the problem of allocation of returns, as dealt with elsewhere[12] induced by more than one investment project or input. In this case the other investment would be in housing (for population movement), health, education and possibly irrigation, in addition to roads. The simplest answer to such problems is to regard all the investment as one large infra-structural investment and calculate an overall return. But this does not assist with regard to priorities between sectors or in a limited field, such as feeder roads, where other investment projects are outside the terms of reference. In the circumstances it is probably best to assume that returns are proportionate to costs, that is, rates of return to each sector are equal. Whilst this assumption has inherent deficiencies it does assist considerably towards making a necessary assessment. However, other investment costs are not known for this study and it is necessary to review other infrastructural studies so as to determine the proportion of total economic returns attributable to roads [11, 14, 18, 23, 25 – 33]. From these it would appear that it is both justifiable and reasonable that approximately one quarter of the returns to a joint project should be attributed to the relevant roads. This means that one quarter of the net value of the induced agricultural production, should be added in a Net Present Value (NPV) form to the N.P.V. derived from the traffic and maintenance sectors, on the assumption that the concomitant infrastructural investment also occurs.

The net value of induced agricultural production is the producers price less the value of the inputs, other than roads, which are directly conducive to such an increase in production. These other inputs would include labour, seeds, fertiliser, etc., and are estimated, over the period of this study, to total 10 per cent of the producers price. The main input element is labour which is thought to have an economic (opportunity) cost in the short run of about 0.33 kilograms of maize equivalent per man hour and in the long term of about 2.15 kilograms of maize equivalent per man hour. These are broadly in alignment with experience elsewhere[34] and the effect of the labour supply constraint covered earlier. When the other elements - seeds, etc are added, a deduction factor of 10 per cent is not thought unreasonable, however it should be pointed out that more empirical research is probably needed on this aspect.

In "Deficit Areas" (where crops need to be imported rather than exported) it is of course, fallacious to take into account any joint benefits, as crop production will already have reached its maximum.

3.10 With these factors in mind, it is therefore necessary to determine from the estimated future agricultural production level and pattern (See Part 2), the economic returns in N.P.V. form that would accrue, concomitant with an upgrading of existing feeder roads and/or the construction of new roads. To do this it has been necessary to carry out detailed agricultural and traffic evaluations (Appendix 17) and an analysis of the road network. A similar but limited exercise has been performed on the existing crop position in paras 3.7 and 3.8. However, prior to comments on the results of such an analysis, it is necessary to add a preface.

In paras 3.7 and 3.8 the economic appraisal of existing traffic flows was covered. It is now opportune to consider the appraisal of new and generated traffic on both new and upgraded roads. This type of traffic needs to be appraised on one of three different bases, depending on its causality. Initially it is necessary to distinguish between new and generated traffic. The former can be defined as normal traffic growth which would occur if the road network remained the same. Generated traffic can be defined as that occurring as a function of an additional factor input, that is, a new or upgraded feeder road or any infrastructural investment.

Firstly, considering new traffic only, which includes that traffic associated with the agricultural investment, this is to be evaluated at the same rate as existing traffic (that is, at 2.1 pence per metric ton kilometre - q.v.).

Secondly, for that proportion of generated traffic which is not regarded as an inventory cost or input, namely, that proportion of total returns not allocable to feeder roads, (that is, for 75 per cent of the generated traffic), this should be appraised on the basis that the net benefit to each unit of traffic should be valued at half the change in net benefits to each unit of existing traffic on a similar journey, when existing traffic operating costs include total tax. (See Appendix 8 and 13) and in addition the value of the total tax paid by traffic on generated journeys must be added to obtain the national net benefit from generated journeys. This type of approach has recently been developed in more detail, so as to differentiate between types of taxation, by the U.K. Ministry of Transport [12] and the French Ministère de l'Equipement (See Appendix 13) and it is recommended here. On the basis of the evaluation techniques outlined in para 3.9, the foregoing method will apply to 75 per cent of the generated traffic. The remaining 25 per cent is classified as an input factor on the assumption, expressed earlier, of the equating of proportional economic returns to proportional project costs, (See below).

Thirdly, for that proportion of project costs (25 per cent) where a road scheme is assumed to be quantitatively conducive to increased agricultural production, this proportion (25 per cent) of generated traffic should be regarded as an inventory cost in the same category as seeds, fertilisers, storage facilities and other inputs. In this case generated traffic costs should be assessed exclusive of tax as indicated in para 3.4 as evaluated in Appendices 17 and 20. In these circumstances it would be double counting to include such operating costs again even as a negative factor and should

therefore not be included further.

The quantification of the accruing benefits for generated traffic, in the second case, that is provided these are not to be regarded as an inventory cost or input, is drawn from the estimated future patterns and levels of agricultural production (see Appendices 17 and 20). It will be noted that the benefits have been calculated for a surface change of earth to gravel on a basis of 1.3 pence per metric ton kilometre as compared with 2.1 pence per metric ton kilometre for existing traffic. This is in line with earlier recommendations. This figure has been derived as shown in Table 14.

TABLE 14

Derivation of Change in Benefits for Generated Traffic

Half change in user costs (i.e. including tax) see Appendix 8	$= \frac{(5.6-3.4)}{2} =$	1.1 pence per metric ton kilometre
Value of total tax paid by traffic on generated journeys	= 3.4-3.2 =	0.2 " "
	Total =	1.3 " "

For the appraisal of newly constructed feeder roads, traffic can be classified as either diverted or generated. It has not been possible to make overall District traffic assignments. All traffic has been assumed to be in the generated category and therefore evaluated on the above basis with the assumption that the demand function is linear. It is appreciated that the surface of operation would be earth but on the foregoing assumptions net benefits would be unlikely to be significantly different.

3.11 It may be useful at this stage to summarize the techniques used, the valuation of factors and the logic of the analysis. The reader will then be in a position to follow the various stages in detail by reference to the Appendices (referred to by Appendix and column numbers in brackets).

The forecast of total export/import crop traffic (Appendix 17 Col. 5) is derived from the agriculture forecast and can be divided into existing traffic (17/6) and new and generated traffic (17/7). It should be noted that a negative sign (-) indicates a reversal of traffic flow - an import, rather than a negative quantity. Existing traffic is evaluated at 2.1 pence per metric ton kilometre (17/11). New and generated traffic is required to be divided between that which would occur without any infrastructural investment including feeder roads and that which is a function of infrastructural investment, including feeder roads. It has been estimated that one quarter of the agricultural production increase and therefore traffic growth would occur with no infrastructural investment and this is to be treated in the same manner as existing traffic and evaluated at 2.1 pence per metric ton kilometre, (17/11). That element of new and generated traffic which is a function of infrastructural investment (75 per cent of total) needs to be considered in two different ways. It has been derived that one quarter of this traffic (18.75 per cent of the total) is in fact an input when evaluating the roads proportion of the net value of induced agricultural production. To count it again, would be

?

if the input is cheaper why isn't there a and new's benefit?

double counting, so it can safely be ignored. The remaining three quarters (56.25 per cent of the total) is that caused by the new feeder roads and is to be evaluated at 1.3 pence per metric ton kilometre (17/12) so one reaches the total traffic benefits (17/13).

The roads proportion of the net value of induced crop production can be ascertained from the export crop values in maize equivalents (17/3) and is converted to present value financial values (17/4). On the basis of allocation of joint benefits to joint costs discussed earlier, one quarter of the net value has been allocated to roads (17/6). To reach total benefits (17/18) it is necessary to add the change in maintenance costs (17/15).

In order to ascertain the exact construction and upgrading programme that is economically justifiable it is necessary to compare traffic and induced crop production benefits against costs per kilometre (construction and maintennnce) (Appendix 21). This results in a non-exclusive amount, in kilometres, which can be converted to a financial level of expenditure for the evaluation and plan periods (Appendix 21).

3.12 The final results of this quantitative analysis (Appendix 21) show the distances of feeder road construction and upgrading that would be concomitant with and conducive to the levels of future agricultural production included in this Report (Appendix 1) over the evaluation period 1970-1990.

The Districts, in order of priority where the future feeder road programme should be concentrated are:-

1. Chikwawa
2. Nsanje
3. Lilongwe
4. Mzimba
5. Mchinji
6. Dedza
7. Kasungu
8. Blantyre

Of these, emphasis should be concentrated on the first three, in the short term, in order to obtain maximum returns.

It has been stressed earlier that feeder road investment is to be regarded as an important part of overall infrastructural investment - its importance is heightened because of its catalytic qualities. It should not be undertaken in isolation because a significant part of the benefits would be lost. Over the evaluation period an expenditure of nearly £7,000,000 in current prices is justified on feeder roads and we are of the opinion that in the programme period (1969-74) an

expenditure level of £1,500,000 or about £250,000 per year in current prices is justified. This figure is of course subject to considerations regarding the method of finance and the position of the debt-servicing ratio, which are outside our terms of reference of this report. We could not support the expenditure of the above figure if it were not an integral part of overall infrastructural investment. Without such infrastructural investments it is only possible to recommend expenditure at one quarter of the above levels, that is, about £60,000 per year.

It addition to such overall expenditure on feeder roads, it is equally necessary that detailed analysis and evaluation occur in the Districts of high priority in order to determine the actual locations of the relevant roads. We have very serious doubts as to the capability of existing staff in Malawi to carry out such planning and analysis. It is our opinion that an overseas technical aid survey team may be required in order to effect the necessary detailed survey making use of the basic data incorporated in this Report.

This Report has of course concentrated its analysis on feeder roads, but the Team also had to review the main and secondary roads. It is absolutely essential, in our opinion that construction and upgrading on these roads continue at a rate not less than that on feeder roads as part of an integral infrastructural investment. Furthermore, there are other economic recommendations to follow, the implementation of which has been assumed in arriving at the above conclusion.

3.13 Further economic recommendations are

(a) Road transport licensing. In the course of the analysis it was thought pertinent to review the transport charges for agricultural produce. These are closely associated with the road haulage licensing situation. It has been the policy to allow the two major road haulage concerns (Road Motor Services, R.M.S.; and United Transport (Malawi), U.T.M.) to have a monopoly of long distance haulage and for a loosely-knit African transport association (Malawi African Road Transport Association, MARTA) to organise and control local crop movement. We understand that it is also within the power of the Road Traffic Commissioner to control charges but at present this is not exercised(35). It is our belief that such a policy is detrimental to Malawi's economic development. Lack of competition has been partially responsible for the relatively high charges levied for road haulage and for slow growth in this sector. This has in turn caused increased operations in the private account haulage field which is not economic due to low utilisation rates.

To summarize; the present policy is in our opinion detrimental to development as it leads to high transport costs and charges. It is understood that the I.D.A. thoughts are on similar lines. Their proposals for a comprehensive enquiry in this field are fully supported.

(b) Restrictions on transport operations (I) weight limit between Ncheu and Dedza. Operations are restricted to vehicles of under 13 long tons gross during the dry season and 8 long tons gross during the wet season, with no trailers permitted over this stretch of road. Although part of this section is rather winding up an escarpment and is now under reconstruction, there does not appear to be any obvious technical reason to support such a restriction (the road between Chileka and Mpatamanga is of a far lower standard geometrically but has a weight restriction at a much

higher level of 40 tons; it carries heavy trucks with trailers and is the main route into Mozambique and S. Rhodesia). Its main purpose could be to ensure that Zambian transit traffic is diverted to rail at the Salima terminal but in doing so imposes harmful restrictions on local traffic. It is recommended that such restrictions be removed. (II) Through operations to S. Rhodesia. Operations are limited to two carriers (UTM/SWift and Clan) for the Blantyre/Tete/Salisbury route. It is appreciated firstly that cooperation is necessary between Malawian, Mozambique and S. Rhodesian authorities on this route and secondly that the Chileka-Mpatamanga-Mwanza section of this route is of a very low standard indeed for an international route (see also (b)(I) above). However it is recommended that a situation is not allowed to develop on this route which parallels the monopolistic situation within Malawi and its concomitant malfunctions. Therefore the restrictions on this route should in our opinion be reviewed.

ROAD DESIGN AND CONSTRUCTION

PART 4

4.1 In order to obtain a good general impression of the road network in Malawi extensive travelling by Landrover was necessary. The principal roads are shown in Fig. 7. It became rapidly apparent that some serious deficiencies in the primary (trunk) roads exist. Similar conditions obtain with many of the secondary roads. These defects include poor alignment, steep gradients and bad riding quality. The present low standard of some of the primary roads in however recognised in some quarters and plans are well advanced for their improvement (e.g. the M.1 road from Zomba to Lilongwe now in progress).

The present classification system for roads is a purely administrative one and gives no indication of the quality of individual roads, their structure and surfacing nor the amount of traffic they are carrying. The system is given in Table 15.

TABLE 15

Administrative road classification system

Road Type	Administrative Code Letter
Main	M followed by a road number in Arabic numerals e.g. M 1, S 69 D 271
Secondary	S
District	D
Branch	B
Estate	E
Unclassified Self help Jeep tracks	U

In general the Ministry of Works and Supplies is directly responsible, through the Director of Roads for the maintenance of all main and secondary roads. The District roads are maintained by local district councils which receive financial aid and technical advice from the Ministry. Of the Branch and Estate Roads the Ministry accepts responsibility for approximately 100 miles. The remainder, together with those of the Unclassified group are privately maintained. As will be observed, such as classification provides no indication as to the type of road surface. An agricultural classification is also in use and is as follows:

TABLE 16

Agricultural road classification system

Road type	Classification
Secondary	II
Market to Secondary or Main	III
Village to market or lightly trafficked market to Secondary	IV
Hamlet, farm or field to village	V

Again this classification gives no indication of the running surface although some idea of function is conveyed. An additional classification has been introduced within the Ministry of Works and Supplies for use principally in reporting existing road conditions. This system describes the normal state of the road as follows:

(i) All Weather : unlikely to be closed for more than 24 hours due to adverse weather
  (a) bitumen surface B
  (b) gravel surface G *
  (c) earth surface E1 *
(ii) All season : generally usable during the wet season but may be closed for periods of up to 4 weeks
  E2 * natural 'insitu' earth
(iii) Dry season
  E3 * Normally usable in the dry season only, natural 'insitu' earth

* By gravel is meant a construction prepared to specified engineering standards from imported selected material, 'imported' meaning in this instance brought from a source of supply some distance away but necessarily within Malawi. An earth road may however have short stretches of gravel imported during routine maintenance operations, often unselected and only marginally better than the existing soil.

Thus in reporting on a road the Administrative Classification would be followed by the type code letter, for example S 69 G indicates that the road is a Secondary one having a properly constructed base and running surface laid to a specified standard. The suffix describing the road base and surface is also of value to the driver as it provides some indication of the conditions he may encounter before starting his journey.

Road mileage for which the Director of Roads is the Highway Authority are given in Table 17 below. Three types of surface have been considered in obtaining the mileages by type, namely bituminous surfaced, reconstructed gravel and unimproved earth (corresponding to the classification code B; G; and E_1, E_2 and E_3).

TABLE 17

Road mileages by Class and surface type June 1968

Administrative Classification	Type of Surface						Total	
	Bitumen		Reconstructed gravel		Unimproved earth		Miles	kilometres
	miles	kilometres	miles	kilometres	miles	kilometres		
M	286	460	441	710	1094	1760	1821	2930
S	NIL	NIL	62	100	1214	1953	1276	2053
D	NIL	NIL	58	93	3021	4861	3079	4954
B	NIL	NIL	NIL	NIL	74	119	74	119
E	NIL	NIL	NIL	NIL	75	121	75	121
TOTAL	286	460	561	903	5478	8814	6325	10177

Source : The figures given in Table 17 have been taken from:

(1) The Public Road Ordinance. Declaration of Public Roads published in the Nyasaland Government Gazette Supplement 1st February, 1963; and

(2) Additional information supplied by the Ministry of Works and Supplies, Malawi.

4.2 The present road design standards in use in Malawi are briefly summarized in Appendix 22. These standards compare well with those recommended by other authorities, for example, the World Bank (International Bank for Reconstruction and Development); differing only in detail and generally demanding slightly higher standards of curvature and gradient.

From a visual examination of many miles of Malawi's roads it is obvious that these standards have yet to be met, even on some of the M classification roads. Whilst plans for considerable primary and secondary road improvements are in hand, it must be emphasized that any success of an improved feeder road system in terms of economic development will be vitiated if the Main and principal Secondary roads are inadequate for the increased traffic generated following the construction of feeder roads.

Whilst it may be desirable from the user point of view and that of nearby residents that all roads should have a bituminous surfacing, ignoring problems of revenue raising (that is, who pays?), at the present stage of Malawi's development such a standard is neither economic nor practical. Nevertheless such roads should be considered for the future. It is therefore felt advisable that wherever economically justified, feeder roads should be built to the standards consistent with the demands of present and future traffic. These standards are considered in more detail later in the report.

4.3 Traffic counts have been made regularly by the Roads Branch of the Ministry of Works and Supplies at 63 census stations comprising a total of 250 census points. The counts undertaken involve 12 hour day counts (6 a.m. – 6 p.m.) when vehicles are also classified and 12 hour night counts (6 p.m. – 6 a.m.) when vehicles are counted, but not classified, by standard roadside traffic counters. Counts are made twice a year at each station. A typical record of a traffic count is given in Appendix 23.

The traffic census figures for 1967, the latest complete set of figures, have been studied and used in obtaining approximate average flows of different vehicle types past the census points. The flows have been further broken down according to the type of road surface at each individual census point. The results obtained are given in Appendix 6. These traffic flows refer almost exclusively to Main (M) and Secondary (S) roads, only a few District (D) roads are included. To arrive at some figures of traffic flow the lesser roads some attempts were made to carry out moving vehicle counts whilst travelling in the Landrover. The object of such counts was to apply the relation

$$\text{Flow, } q = \frac{(x + y)}{ta + tw}$$ [36]

where x = number of vehicles met in the section when travelling against the stream of traffic
y = number of vehicles that overtake the observer *minus* the number that he overtakes when travelling with the stream
ta = journey time of observer when travelling against the stream

tw = journey time of observer when travelling with the stream

If the flow 'q' is obtained in vehicles per hour an approximate value for the Average Daily Traffic given by

A.D.T. = 16 q vehicles per day

Time and other factors did not allow the team to conduct these moving vehicle traffic counts in the strictly correct manner of travelling several times in each direction to obtain reliable mean values. Generally it was not possible to make more than a single journey in one direction. Some results obtained are given in Appendix 24. Although the figures given in Appendix 24 are quite inadequate for preparing any reliable estimates of Average Daily Traffic they at least indicate that traffic flows are very small and that a high proportion of the traffic comprises vehicles of less than 30 cwt unladen weight (namely, cars, pick-ups, and most Landrovers).

In the absence of more reliable data and bearing in mind the flows past the Traffic Census points, it would appear reasonable to state that most Secondary and District roads probably carry less than 40 commercial vehicles per day and many probably less than 20 (except possibly on periodic market and produce days and collection days.

The figures of traffic flow quoted in Appendix 6 have been used in conjunction with numbers of licensed vehicles in Malawi (as at December 31 st 1967) to obtain values of vehicle miles (vehicle kilometres) for the different types of road surface and different vehicle types. In the absence of other data this has been the only available approach and the figures quoted must be viewed and used with caution. The results obtained are given below in Table 18. The manner in which they were obtained is shown in Appendix 25.

TABLE 18

Traffic flow in terms of vehicle kilometres (vehicle miles) travelled per year

Road Surface	Vehicle type			
	Vehicle Kilometres (vehicle miles) per year x 1000			
	Passenger Car	Light lorry (<3 ton load)	Heavy lorry (>3 ton load)	Total
Bitumen	116,249.4 (72,249.0)	63,405.0 (39,406.4)	115,510.5 (71,790.2)	295,164.9 (183,446.2)
Gravel	6,181.2 (3,841.6)	7,492.5 (4,656.7)	21,230.0 (13,194.5)	34,903.7 (21,692.8)
Earth	4,069.8 (2,529.3)	4,995.0 (3,104 4)	11,483.5 (7,173.1)	20,548.3 (12,770.9)
Totals	126,500.4 (78,620.5)	75,892.5 (47,167.5)	148,224.0 (92,121.8)	350,616.9 (217,909.9)

Total vehicle kilometres = 350.6×10^6 on all roads by all vehicles

Total vehicle miles = 217.9×10^6 on all roads by all vehicles

level of accuracy is function of length of count. Also lower the traffic flow the higher the daily variability of flow

4.4 The design of any road demands the knowledge of present and future traffic flows. On existing roads present traffic can be estimated accurately by counting vehicles. Such counts are valuable when considering improvements to existing roads and in detecting trends over a period of years. When planning a new major road there is a need to know what traffic is likely to use the road immediately after construction and over the assumed life, that is, 20 years. In such instances a full economic appraisal would be advisable and would need to include an Origin and Destination Survey and forecasts of future numbers of vehicles. Methods of carrying out these surveys are outlined in Appendices 26 and 27. Further detailed information may be obtained in 'Research on Road Traffic' [36] and other publications. Such sophisticated methods of investigation have been developed in highly industrialised countries and may not be strictly applicable to developing countries whose production activities are primarily agricultural. Forecasts of traffic flows are more difficult to achieve but a recent publication applicable to developing countries may be of value [37]. Furthermore, except for the less important Secondary (S) roads, which fall into the category of feeder roads, their application to the improvement planning of existing minor feeder roads would have little value since origins and destinations are largely fixed, namely farms and buying points already linked by the shortest routes. Forecasts of traffic on feeder roads would be more satisfactorily made from projections of agricultural production in the individual districts concerned.

4.5 Roads are normally designed for a useful life of 20 years, which is the estimated life used in Part 3, after which major reconstruction may be necessary owing to increased traffic, greater vehicle speeds, high maintenance costs and general structural deterioration. For such design to be possible forecasts of traffic on all individual feeder roads, existing and planned would be necessary. To obtain such traffic data in Malawi would be an impossible task. However, existing figures of traffic flows show that traffic on Secondary roads is quite small (see Appendix 6) and is certainly even less on District, Branch and Estate roads. Few Secondary roads carry more than 50 commercial vehicles per day and many less than 25. (Commercial vehicles are defined here as all traffic excluding cars, motor cycles, bicycles and ox-carts; but including vehicles such as Landrovers).

The selection of existing feeder roads for improvement and of an area for the construction of new roads unfortunately is not solely a question of knowing present and future traffic flows. Road improvements and new construction must he considered on the basis of the highest economic return. The latter depends on the impact of a road on agricultural production, the transported crop volume and the distance travelled.

At this stage it is not possible to indicate precisely to what standard individual feeder roads should be constructed or upgraded. Whilst it would be valuable to the engineer to be able to formulate a guide to the required standard in terms of traffic flow, such a detailed appreciation could be achieved only by economic appraisals of individual localities. Consideration might however be given to the standards outlined in Table 19 and which might lend themselves to a simple form of stage construction.

TABLE 19

Possible feeder road types

Type of feeder road	Remarks
Low standard	Stage (b) Development Road[a], earth surface, very little traffic, mainly 4–wheel drive
Intermediate standard	Stage (a) Development Road[a], earth surface, little traffic, but occasional 5–ton trucks
High standard	Similar to Class IV road[a] but with earth surface, heavier traffic with 5 and 7–ton trucks
Class IV[a] gravel	Gravel running surface, heaviest feeder road traffic P.S.V's and high proportion of heavy trucks

Note (a) For further details see Appendix 22

Whilst the earth feeder roads are somewhat rudimentary in character, they should nevertheless, be constructed to recognised geometrical standards. Suggestions for the latter are given in Table 20.

TABLE 20

Suggested geometrical standards for feeder roads

Type of feeder road	Terrain	Design speed minimum m.p.h.	Gradient maximum per cent	Curvature minimum feet	Running surface, minimum feet
Low standard	Flat and Rolling	20	9–10	150	12
	Hilly	15	12	100	12
Intermediate standard	Flat and Rolling	25	9	200	12
	Hilly	20	11	150	12
High Standard [a]	Flat and Rolling	30	8–9	250	12
	Hilly	25	10	200	12

Note (a) The 'high standard' feeder road approximates to the Ministry of Works and Supplies Class IV standard without a gravel running surface. No hard and fast rule can be given for deciding on the type of road. The suggested standards should be regarded as flexible and must be considered in relation to other economic and social needs and to the terrain over which the road is to run.

4.6 Since an economic appraisal of each feeder road would be in itself a costly exercise and beyond the scope of the Ministry of Works and Supplies staff, it is necessary to consider the economic position of areas, such as the administrative districts. From the Cost Benefit Analysis in Part 3 it is possible to indicate which Districts have the highest priorities on the basis of existing and future agricultural production and traffic levels. This aspect is dealt with in para 3.7 in the preceding Part.

The responsible authority would then be in a position to allocate funds more rationally to obtain the highest economic return on the investment. In the absence of more detailed data in each district, the funds could reasonably be re-allocated to specific roads within a District on the basis of local knowledge of crop types and values, traffic and social needs.

4.7 It is highly unlikely that conditions demanding a bituminous surface for feeder roads will occur for many years in Malawi. Consequently it is not proposed to comment on types and methods of laying bituminous surfacings nor on the qualities of road bases needed in such roads. The construction operations for feeder roads will thus be mainly those of earthmoving, spreading of gravel, shaping and compaction. The problem thus arises as to whether capital (that is, plant) or labour intensive methods should be used in the road construction. In many cases the problem is temporarily solved by the lack of suitable machinery. Where the choice is available it should be made after a study of the economic costs of both methods. How this can be done is outlined in Appendix 28.

4.8 Bridges and culverts are expensive items in road construction; a single width concrete bridge spanning 20 feet could add £2000 to the cost of a road and light culverting in concrete (say 10 per mile) an additional £1000 per mile. Such costs would be a high proportion of the total cost of a low standard earth road. It is thus essential that every possible advantage of local topography be taken in locating feeder roads to reduce the need for these relatively costly structures.

Most bridges on the Secondary and District roads have permanent stone or concrete abutments with timber beams and decks. There is no doubt that, structurally, such bridges are adequate for present traffic when properly maintained, although the present condition of many leaves much to be desired. It would appear that financial allocations for bridge maintenance are either inadequate or are not being efficiently used. From observations and enquiries made it is evident that the vehicle most commonly used for crop transporting on feeder roads is the 5–ton capacity lorry, although some 7–tons capacity lorries are also used. It is recommended that bridges and culverts on new feeder roads be designed to take the heavier vehicle where there is evidence of the significant use of the latter.

4.9 The problem of road maintenance in Malawi is a serious one and deserving greater attention. The general impression gained is one of inadequate funds being allocated for road repairs and inadequate sub-professional supervision. On roads travelled, other than urban and main (M) roads the only maintenance observed was being done by hand and made little contribution to improving and preserving the roads.

Some maintenance on gravel and earth main roads with motor graders was seen to be detrimental rather than beneficial. Mitre drains were completely blocked by residual windrows of loose gravel and earth left by the grader. It is evident that some study is needed of the road maintenance situation especially in regard to the training of plant operators and supervisory staff. (The recently introduced system of allocating available funds to the roads most in need of attention may lead to considerable improvement in the present situation provided adequate funds are made available).

More detailed information on earth and gravel road maintenance may be found in various publications, for example Road Research Laboratory Overseas Bulletins Nos. 6[38] and 14[39]. Expenditure on road maintenance in 1967 has been studied from figures supplied by the Ministry of Works

and Supplies of departmental costs and Ministry overheads. Annual maintenance expenditure per mile of road according to road classification and type of running surface is given in a table in Appendix 29. This table quotes the direct works costs and the economic costs in Present Value form. The method by which they were obtained is indicated in Appendix 30.

Using the figures quoted in para 3.2 for road maintenance expenditure and the vehicle miles applicable to each road surface type given in Table 18 the following approximate costs have been derived – Table 21.

TABLE 21

Maintenance expenditure in 1967 including basic maintenance and some resealing

Road surface	Expenditure per kilometre £	Expenditure per mile £	Expenditure per 1000 vehicle kilometres pence	Expenditure per 1000 vehicle miles pence
Bitumen	145	234	65	104
Gravel	68	110	215	346
Earth	16	26	952	1532

The more meaningful figures of expenditure per 1000 vehicle miles (or vehicle kilometres) are revealing and indicate, even though they are only approximate, a lack of supervision and technical expertise in the maintenance of the earth roads in particular. They also suggest that maintenance by hand methods again mainly on the earth roads is a particularly expensive way of doing the job.

It is interesting to note the maintenance costs for bituminous roads in Great Britain [12] as given in Table 22.

TABLE 22

Maintenance costs on British roads

Road class	Cost per mile of road per year £	Cost per 1000 vehicle miles pence
Trunk	1047	60
Class I	883	100
Class II	670	117
Class III	394	316

Although the costs per mile of say Class I and II roads in Britain are far greater than in Malawi, the costs per 1000 vehicle miles are similar.

It would be expected that in the United Kingdom, where traffic flows are so very much greater, the cost per vehicle mile would also be greater since the wear and tear of the roads is greater. That this is not so suggests some deficiencies in maintenance of bituminous roads in Malawi. It should be borne in mind that the maintenance costs in Britain include expenditure on items not incurred in Malawi, for example salt spreading and snow clearance. In road maintenance operations there is

always a conflict between budgetary constraints (that is, what funds are allocated and spent) and what expenditure is justified on the basis of its economic return. Field research has shown that on earth and gravel roads the cost of maintaining a reasonable standard is related to the traffic flow. The formula £(50+2Q) per mile per year[40] has been suggested as a guide to maintenance costs on improved gravel roads in open savannah country (Q = average daily traffic flow). It must be emphasized that this relationship was derived from observations in areas of relatively low rainfall and terrain which provided no serious engineering problems which would affect maintenance. Under these conditions the formula has been found quite reliable. The formula should not be used in assessing the maintenance costs of bituminous surfaced roads. It refers to the maintenance of full-width improved gravel road and is based on prices of £30 for grading 30 miles per day, grading being done after the passage of 1200 vehicles and £600 per mile for 4 inches of gravel every 4 years. Prices in Malawi differ considerably and the following are suggested as being more appropriate to the conditions which obtain in the country. Hire rates for motor graders range, according to type, from £24 – £28 per day including operator, fuel and oil. On a full width (20–24 feet) gravel road an operator can grade 6 – 7 miles of road, giving 3 passes of the grader across the width of the road. One instance is known in Malawi of three graders in echelon grading 30 miles of road which is equivalent to one grader treating 10 miles of road with 3 passes. Thus for an 8 hour day using an average figure of £26 per day for the cost of the grading operation and say 8 miles of road per day, the cost of grading would be approximately £3 per mile. Experience suggests grading may be necessary after the passage of about 1200 vehicles. Then for a traffic flow of 100 vehicles per day the number of gradings needed per year would be $\frac{365 \times 100}{1200} = 30$ say. The cost per mile per year would then amount to £90. Assuming a loss of gravel of 1 in per year per 100 vehicles per day the cost of regravelling every six years would be, at current Malawi costs, £1800 per mile, that is £300 per mile per year. The annual cost of maintenance then totals Basic maintenance + £390 per mile. The basic maintenance cost which is virtually independent of traffic flow amounts to approximately £160 per year on Main and Secondary gravel roads. Thus maintenance costs may be represented by £160 + $\frac{£390\ Q}{100}$ per mile – say £(160 + 4Q) per mile per year for full width gravel roads. Figures of costs derived from this modified formula, when compared with those quoted by the Roads Department, for main gravel roads suggest that maintenance expenditure is a little lower than it ought to be. However, the formula £(50 + 2Q) has been found reasonably reliable in various other countries and the modified relationship is probably excessively high. It is unlikely that the cost of maintaining a gravel road in Malawi is more than double that in other developing African countries. For less important gravel roads where lower standards are acceptable and a narrower running surface exists the formula would probably need further modification.

It must be concluded that road maintenance in Malawi may not be being carried out in the most efficient manner. The recommendation is made that the whole problem of road maintenance be thoroughly investigated with particular reference to the more accurate costing of the operations involved.

In referring to these cost figures it must be emphasized that these are direct works costs and have not been expressed in present value form and as such are not comparable with other figures used elsewhere in this report.

4.10 From figures provided by the Roads Department estimates have been made of the costs of

construction of new roads to various standards. The results obtained are given in Appendix 31. These costs have been based largely on recent contract prices and on departmental costs for 1967. As with the analysis of road maintenance expenditure various assumptions have had to be made as accurate information was not available. Contractors profit has been assumed to be 15 per cent; The relationships between Contract Price, Direct Works Costs and Departmental Cost have been taken as follows:

(a) Contract price = Total Direct Works Cost + 15 per cent (of the total direct works cost)

(b) Total Direct Works Cost = Departmental Cost + 100 per cent overheads = 2 x Departmental Cost.

(Ministry of Works and Supplies costing procedure does not allocate all costs)

(c) Normal overheads = 14.5 per cent of direct works cost

and (d) Direct Works Marginal Economical Cost = Total Direct Works cost, less 14.5 per cent.

No accurate figures of money paid out in compensation for loss of crops and buildings due to the new road construction were available and approximate amounts have been assumed. Rates of compensation are given in Appendix 18.

Estimates of construction costs of Crop Extraction and District earth roads have also been made. There appears to be little difference in construction costs between the two standards of road (i.e. Stage (a) and Stage (b)) Appendix 32.

A further analysis has been attempted of the cost involved in upgrading an earth road to Class IV gravel standard (12 ft running surface) Appendix 33.

It must be emphasized that the cost figures obtained cannot be regarded as completely accurate. This is due largely to the current method of voting money for road maintenance and construction where, for example, the plant and vehicle maintenance vote for the whole Ministry, is grouped under one sub-head, and not allocated by project. Considerable variations in cost will naturally occur due solely to the type of terrain through which the road passes.

These costs are summarised in Table 23.

4.11 The agricultural and transport economics studies have shown that a strong case exists for the upgrading of existing roads or the construction of new ones. An engineering programme to implement the recommendations on the feeder road network would be a task of considerable magnitude requiring large quantities of road building materials. For the regravelling of the 2913 kilometres of earth road as indicated in Appendix 21 more than 3,000,000 tons of gravel would be necessary. This quantity takes no account of the normal losses which occur throughout the life of gravel roads. Over a period of 20 years the total amount of gravel required could easily exceed twice this figure.

It is thus important that should such a project of upgrading be undertaken, the location of suitable roadmaking gravels be planned and carried out in the near future. Such a task, usually the responsibility of the Materials Laboratory, is a large one demanding considerable expertise. In this, the use of aerial photographs can be invaluable not only in locating materials but also in siting bridges, detecting areas of geological instability and in fitting the road line into the topography[41,42]. For this work an experienced Engineering Geologist would need to be employed.

Both colour and black and white aerial photographs exist for much of Malawi. These could no

TABLE 23

Road construction costs for new roads and improving an earth road to gravel standard

Item	Crop Extraction and District road		Class IV	Class III	Class II	Class I				Upgrading earth to Class IV gravel
	Stage (a) Earth	Stage (b) Earth	Gravel	Gravel	Gravel	Bitumen				See note (b)
	see note (a)					12 feet width		22 feet width		
						surface dressing				
	£	£	£	£	£	Single	Double	Single	Double	£
						£	£	£	£	
Total direct works cost (2 x departmental cost)	1000	900	5108 to 10803	5464 to 11160	7044 to 14435	10184 to 17923	10844 to 18583	13865 to 21952	15079 to 23166	5030
Contract cost (Total direct works cost + 15%)	1150	1035	5874 to 12424	6284 to 12834	8100 to 16600	11712 to 20612	12471 to 21371	15945 to 25245	17341 to 26641	5785
Economic cost (Total direct works cost – 14.5%)	855	769	4367 to 9237	4672 to 9542	6023 to 12342	8707 to 15324	9272 to 15889	11855 to 18769	12893 to 19807	4301

Notes

(a) approximate costs in easy terrain

(b) costs for easy terrain

(c) ranges of costs depend on terrain, (earth-moving needed) and number of culverts and bridges required

doubt be made available for interpretation purposes.

The location of new roads, the setting out and subsequent earthworks calculations are very time consuming and again aerial photographs have in many instances proved valuable. In the case of Malawi however the resources of the Survey department (Ministry of Economic Affairs) and the Roads Department (Ministry of Works and Supplies) are not sufficient for producing large scale road maps by photogrammetric means. This aspect of a feeder road programme would probably have to be done entirely by normal survey methods on the ground.

The location in detail of roads for upgrading and for new construction is beyond the scope of this report. It may well be beyond the capabilities of the Roads Department. It is considered that a specially constituted survey team for this work is essential. Such a team should include an Economist, an Engineering Geologist and a Civil Engineer/Surveyor, The function of such a team would be firstly to study in detail the Districts for which a high priority is given in this report and secondly, to locate on the ground, road lines which would take advantage of the existing and potential agricultural situation, the geology and topography and general engineering conditions, to provide the highest economic returns.

PART 5 CONCLUSIONS AND RECOMMENDATIONS.

5.1 Following this study the team members are fully agreed on the following conclusions and recommendations.

I There is *no* economic justification, on present traffic levels, (except in the case of Lilongwe) for upgrading any existing feeder road; limited upgrading is however justified in Lilongwe District now.

II There is *no* economic justification on present traffic levels for the construction of new feeder roads now except possibly in the Cholo, Chikwawa and Lilongwe Districts. The evidence favouring construction in these Districts is inconclusive.

III There is economic justification for up to £250,000 of expenditure per annum for the period 1969–74 on new feeder roads and upgrading existing feeder roads concentrating initially in the Chikwawa, Nsanje and Lilongwe Districts, in order to induce increased agricultural production. This expenditure, however, would be supported only if it were part of a full infra-structural investment programme and if the recommendations IV V VI and VII below are implemented. If a feeder road programme were not part of a detailed infra-structural investment programme, it is recommended that expenditure be limited to £60,000 per year provided also that the recommendations IV, V, VI and VII below are implemented.

IV There is strong evidence that the Farmers' Marketing Board transport rates need to be revised so as to be based on distance and road surface condition.

V There is strong evidence to indicate that the present licensing policy is conducive to high transport costs and charges. Consequently this policy warrants further investigation. The proposals by the I.D.A. for a comprehensive enquiry on this field are fully supported by the team.

VI There is evidence that other restrictions on transport operations, for example weight limits, are incompatible with the country's economic development and should be removed.

VII There are strong reasons why expenditure on main and secondary roads should increase at a comparable rate with feeder road expenditure.

VIII There is an urgent need to examine in detail and revise the methods by which funds are allocated to road construction and maintenance in order that accurate estimates of costs may be obtained. This is essential if thoroughly sound economic appraisals are to be achieved of feeder road networks in individual Districts.

IV There is every justification for higher standards of supervision in the construction and maintenance of roads. The costing of maintenance operations needs to be examined and the system of allocating funds to Districts for road repairs without adequate technical supervision should be further investigated.

V To implement the recommendation of £250,000 per annum expenditure on feeder roads it is strongly recommended that detailed surveys be made by a specially constituted team which includes an Economist an Engineering Geologist and Civil Engineer.

Signed: J. S. Tannor M. R. Haswell A. Smith

London, October 1968

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1. Relation between the value of crop exports and existing road network
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PLATES

1. Feeder road showing poor alignment and maintenance District Road
2. Feeder road – a better feeder road
3. Main road – good alignment
4. Main road – poor alignment

APPENDIX I

Crop Potentials
Forecast of export crop traffic by district
for evaluation period 1970 – 1990
(Excluding Estates' Production)

Region District	Year				
	1970	1975	1980	1985	1990
	Metric tons				
Northern					
Chitipa	1,419	2,786	4,245	5,808	7,490
Karonga	4,395	6,324	8,374	10,562	12,907
Nkhata Bay	1,508	3,414	5,448	7,630	9,979
Rumpi	2,546	3,687	4,900	6,194	7,582
Mzimba	5,679	10,976	16,625	22,677	29,189
Central					
Ncheu	6,675	10,582	14,740	19,186	23,961
Dedza	9,085	14,545	20,357	24,010	14,049
Lilongwe	48,836	62,103	66,450	49,705	29,449
Salima	6,088	8,239	10,520	12,950	15,551
Dowa	12,819	17,394	22,247	27,418	32,951
Ntchisi	4,731	6,414	8,199	10,101	12,136
Mchinji	8,833	11,275	13,859	16,605	19,535
Kasungu	9,101	11,683	14,416	17,320	20,422
Nkotakota	3,023	4,544	6,162	7,890	9,744
Southern					
Chiradzulu	–2,448	–6,116	–10,547	–15,851	–22,151
Nsanje	8,553	11,173	13,948	16,899	15,593
Chikwawa	30,951	35,887	41,065	46,520	52,291
Cholo	–4,237	–10,585	–18,253	–27,430	–38,332
Mlanje	11,285	7,740	–4,501	–19,194	–36,688
Blantyre	10,189	16,794	23,827	22,407	10,240
Zomba	9,406	16,016	10,138	–175	–12,470
Kasupe	9,973	15,378	21,129	27,275	33,872
Ft. Johnston	6,488	11,865	17,598	23,738	30,341
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The forecast is based on a population growth rate of 2.7 per cent per annum and an overall increase in crop yields per unit of area, of 1 per cent per annum.

The main expansion therefore arises from the continuation of existing practices of extensive agriculture in this relatively land abundant economy, by encroachment upon cultivable lands at present surplus to the requirements of the population.

APPENDIX 2

Forecast of population
based on the Malawi Population Census, 1966
assuming a rate of growth of 2.7 per cent per annum

Region/District	Year				
	1970	1975	1980	1985	1990
	Thousands				
Northern					
Chitipa	66.1	75.6	86.3	98.6	112.7
Karonga	87.5	99.9	114.2	130.4	149.0
Nkhata Bay	93.3	106.6	121.8	139.2	159.0
Rumpi	51.9	59.2	67.7	77.3	88.4
Mzimba	255.7	292.2	333.8	381.4	435.7
Total	554.5	633.5	723.8	826.9	944.8
Central					
Ncheu	182.6	208.5	238.3	272.2	311.0
Dedza	255.7	292.1	333.8	381.2	435.7
Lilongwe	555.9	635.1	725.6	829.0	947.2
Salima	94.6	108.1	123.5	141.1	161.2
Dowa	201.5	230.2	263.1	300.6	343.4
Ntchisi	74.1	84.7	96.7	110.5	126.2
Mchinji	102.7	117.3	134.1	153.2	175.0
Kasungu	109.2	124.7	142.5	162.8	186.0
Nkotakota	70.0	80.0	91.4	104.4	119.3
Total	1,646.3	1,880.7	2,149.0	2,455.0	2,805.0
Southern					
Chiradzulu	157.8	180.3	206.0	235.4	268.9
Nsanje	112.4	128.5	146.8	167.7	191.6
Chikwawa	175.6	200.6	229.1	261.8	299.1
Cholo	273.1	312.0	356.5	407.3	465.3
Mlanje	443.6	506.8	579.0	661.5	755.8
Blantyre	311.3	355.6	406.3	464.2	530.4
Zomba	313.5	358.2	409.2	467.5	534.1
Kasupe	250.8	286.5	327.3	374.0	427.3
Ft. Johnston	257.9	294.6	336.6	384.6	439.4
Total	2,296.0	2,623.1	2,996.8	3,424.0	3,911.9
Grand Total	4,496.8	5,137.3	5,869.6	6,705.9	7,661.7

Malawi Population Census 1966 de facto population 4,042,412; revised estimate of rate of growth in communication of Population Division of the National Statistics Office of Malawi, dated 13th December, 1966. Estimates made by OECD (1967) of population growth rates are 2.2 per cent per annum for Africa as a whole and 2.4 per cent per annum for Malawi in particular. The rate of growth used by the Population Division of the National Statistical Office of Malawi in its Provisional Report (1966) was 3.3 per cent per annum.

APPENDIX 3

Potential Areas for the expansion of cotton production

Region/District	Remarks
Northern	
Karonga	Quite a good area for cotton, a high value export crop compared with rice
Rumpi	Growth limited to warmer areas on suitable land.
Central	
Ncheu	Expansion should be encouraged all along the lakeshore
Dedza	Expansion should be encouraged all along the lakeshore
Salima	High potential for cotton production
Nkotakota	Development of present cotton growing area
Southern	
Nsanje	Scope for expansion is limited as soils become poorer
Chikwawa	Still much scope for expansion
Mlanje	Expansion should be encouraged in North Mlanje on the Palombe Plain
Blantyre	Particularly west of Lisungwe
Zomba	High potential on Palombe Plain; also in area of Chingali beyond the cement factory
Kasupe	High potential in Kasupe west all along the Shire river.
Ft. Johnston	Can greatly expand present cotton production particularly along the banks of the Shire river.

1963 FMB price
for maize £9 pt.

APPENDIX 4

Crop potentials

Forecast of export crop traffic in maize equivalents in non-discounted constant prices

Region/District	Year				
	1970	1975	1980	1985	1990
	Metric Tons				
Northern					
Chitipa	4,581	11,872	20,562	30,966	39,900
Karonga	10,629	16,861	21,534	26,950	32,900
Nkhata Bay	2,835	8,855	14,643	21,889	28,700
Rumpi	8,910	17,076	24,038	32,981	40,200
Mzimba	17,923	35,319	56,545	77,737	100,300
Central					
Ncheu	12,729	20,659	29,466	39,216	49,000
Dedza	19,874	30,989	46,085	56,770	33,500
Lilongwe	147,934	182,558	189,870	142,320	84,000
Salima	18,382	24,575	32,073	33,922	40,700
Dowa	51,234	62,371	75,834	95,690	114,800
Ntchisi	18,904	22,646	30,114	34,800	41,800
Mchinji	39,011	45,023	51,631	58,923	69,500
Kasungu	34,541	42,140	51,371	62,744	74,000
Nkotakota	6,341	9,674	13,792	18,339	22,600
Southern					
Chiradzulu	*	*	*	*	*
Nsanje	32,485	42,435	52,638	62,899	57,700
Chikwawa	115,889	135,085	154,203	173,479	194,300
Cholo	*	*	*	*	*
Mlanje	20,562	14,223	*	*	*
Blantyre	32,334	53,763	81,571	73,837	34,000
Zomba	19,025	33,315	19,749	*	*
Kasupe	13,978	22,049	30,456	39,605	49,100
Ft. Johnston	14,065	26,019	39,052	54,163	69,300
	641,000	858,000	10,354,000	11,273	11,457
	5.9%	3.8%	2.02		0.1
	3.82				

* Deficit area.

The proportion of surplus by type of crop from predictions made in Malawi Crop Potentials 1965 – 1985 [1]

See Appendix 1 for potential export crop traffic.

APPENDIX 5

Price relatives of potential export crop traffic

Region/District	Year			
	1970	1975	1980	1985
	Tons of maize equivalent per ton of traffic			
Northern				
Chitipa	3.23	4.26	4.84	5.33
Karonga	2.42	2.67	2.57	2.55
Nkhata Bay	1.88	2.59	2.69	2.87
Rumpi	3.50	4.63	4.91	5.32
Mzimba	3.16	3.22	3.40	3.43
Central				
Ncheu	1.91	1.95	2.00	2.04
Dedza	2.19	2.13	2.26	2.36
Lilongwe	3.03	2.94	2.86	2.86
Salima	3.02	2.98	3.05	2.[illegible]2
Dowa	4.00	3.59	3.41	3.49
Ntchisi	4.00	3.53	3.67	3.45
Mchinji	4.42	3.99	3.73	3.55
Kasungu	3.80	3.61	3.56	3.62
Nkotakota	2.10	2.13	2.24	2.32
Southern				
Chiradzulu	*	*	*	*
Nsanje	3.80	3.80	3.77	3.72
Chikwawa	3.74	3.76	3.76	3.73
Cholo	*	*	*	*
Mlanje	1.82	1.84	*	*
Blantyre	3.17	3.20	3.42	3.29
Zomba	2.02	2.08	1.95	*
Kasupe	1.40	1.43	1.44	1.45
Ft. Johnston	2.17	2.19	2.22	2.28

* Deficit area

The proportion of surplus by type of crop from predictions made in Malawi Crop Potentials 1965–1985.[1]

See Appendix 1 for potential export crop traffic.

APPENDIX 6

Estimated traffic flows by surface
(Average Daily Traffic (A.D.T.), 1967)

Road type	No. of Census points	Total flow past Census points	Average Daily flows by surface			
			All vehicles	Cars	Trucks less than 3 tons capacity	Trucks more than 3 tons capacity
Bitumen surface	48	56 725 Cars 31 591 <3t 14 678 >3t 10 456	1181	658 (56%)	305 (26%)	218 (18%)
Gravel surface	33	3666 Cars 1 150 <3t 1 207 >3t 1 309	111	35 (32%)	36 (32%)	40 (36%)
Earth or unimproved gravel	163	11 251 Cars 3 738 <3t 3 958 >3t 3 555	69	23 (33%)	24 (35%)	22 (32%)

Source : Ministry of Works and Supplies Traffic Census

APPENDIX 7

Regression Analysis

1. The factors considered were:

   Y1 = Export crop value, maize equivalent, metric tons/hectare cropped — value produce / area

   Y2 = Export crop volume, metric tons/hectare cropped — volume — — —

   X1 = Km of road/hectare cropped — road / area

   X2 = Population/sq. km. of cultivable land — pop / area

   X3 = Km of road/1000 hectares of cultivable land — road / potential area

2. Multiple regression analyses results:

   (i) $Y1 = 0.0648 - 0.01245\ X1 - 0.00111X2$

   Regression not significant at 10% level

   Coefficient of multiple regression (R) = 0.39

   Standard error (SE) of estimate of Y1 from regression equation = 0.264

   (ii) $Y1 = 0.5876 - 0.00012X2 - 0.0719X3$

   Regression not significant at 10% level.

   R = 0.267

   SE = 0.277

(iii) $Y1 = 0.6853 - 0.01243X1 - 0.00110X2 - 0.00061X3$

Regression not significant at 10% level

$R = 0.393$

$SE = 0.271$

(iv) $Y2 = 0.1279 - 0.0001631X1 + 0.000539X2$

Significant at 10%, but not at 5% level

$R = 0.604$

$SE = 0.077$

(v) $Y2 = 0.09210 + 0.0005572X2 + 0.006106X3$

Significant at 10%, but not at 5% level

$R = 0.59$

$SE = 0.078$

(vi) $Y2 = 0.115 - 0.002466X1 + 0.00036X2 + 0.02025X3$

Significant at 10%, but not at 5% level

$R = 0.616$

$SE = 0.079$

Eliminating individual regression coefficients which are not significant at the 5% level leaves only the following equation:

(vii) $Y2 = 0.1012 + 0.0006010X2$

Significant at 1% level

$R = 0.59$

$SE = 0.076$

3. Simple regression analysis results: (values of R ?)

Y1				
+ 0.362	Y2			
−0.207	−0.370	X1		
−0.212	+0.591	−0.432	X2	
−0.266	+0.459	+0.014	+0.729	X3

APPENDIX 8

Summary of estimates of economic (net) and user (gross) costs of the 'typical' truck by road surface

1. Economic cost	Earth		Gravel		Bitumen
pence/metric ton kilometre	5.3	(2.1)	3.2	(1.0)	2.2
pence/long ton mile	8.5	(3.4)	5.1	(1.6)	3.5
2. User cost					
pence/metric ton kilometre	5.6	(2.2)	3.4	(1.05)	2.35
pence/long ton mile	9.0	(3.5)	5.5	(1.7)	3.8

Note (a) The difference between 1 (Economic cost) and 2 (User cost) is the taxation element (see paragraph 4)

Note (b) Figures in brackets are the changes in costs due to road surface changes

Note (c) Overheads and profit are excluded

3. Basis

(a) It was felt that the most relevant original source on this aspect is the Road Research Laboratory's recent work on Central and East Africa [16]. From this the Southern Rhodesian operating costs for the 'typical' truck were used as a basis and adjusted so as to apply to local Malawi conditions. This adjustment is due to:

(i) source of S. Rhodesian figures[16] states that costs are a minimum and the requirement is to use average marginal costs.

(ii) Malawi's roads are regarded as inferior overall to S. Rhodesia's by general consensus, with consequent operating cost increases[16]. It was of course not possible to inspect any roads in S. Rhodesia.

(iii) source of costs (United Transport Ltd) is a large and efficient operator[16].

(iv) conversion to costs as at 1st January, 1968

(b) 'Typical' truck is M.A.R.T.A. (Malawi African Road Transport Association) operated, with 5 long tons tare weight, 5 long tons payload and a 50 per cent load factor and with a petrol engine.

(c) The above costs are very closely in alignment with other relevant sources.[10,12,14, 15,16,18,19,20,21] when adjusted to local conditions.

4. Malawian taxes

(a) Hydrocarbons duty:	
at 36 per cent of retail price of petrol	0.98d per vehicle mile
at 5 per cent of retail price of engine oil	0.02d .. .. ..
(b) Depreciation at 5 per cent of purchase price	0.09d .. .. ..
(c) Maintenance at 5 per cent of gross cost of materials	0.25d .. .. ..
(d) Tyres at 5 per cent of retail price	0.12d .. .. ..
Total taxation	1.46d .. .. ..

5. Surface factors

The change in operating costs due solely to surface changes

Bitumen	1.00
Bitumen to gravel	1.45
Gravel to earth	1.65
Bitumen	2.40

Sources[15,16,19]

APPENDIX 9

Accidents and Casualties - 1967

ACCIDENTS BY ROAD SURFACE																														CASUALTIES - killed and injured												
	BITUMINOUS												GRAVEL AND EARTH												TOTALS																	
MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	BIT	GRAVEL AND EARTH	ALL	PER CENT BIT	PER CENT GRAVEL & EARTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Fatal	5	4	8	5	5	4	4	6	9	4	1	7	7	4	5	7	7	4	11	3	10	7	3	7	62	75	137	45	55	13	9	14	16	12	8	15	10	20	12	5	14	148
Serious	11	10	14	16	18	9	9	11	20	9	9	11	13	9	11	10	18	14	20	18	15	10	15	17	147	170	317	46 5	53 5	36	24	34	33	50	30	32	40	51	23	31	41	425
Slight	22	28	31	39	25	40	41	34	44	24	32	31	21	18	19	21	21	30	29	46	41	25	21	13	391	305	696	55	45	73	62	71	80	73	81	97	111	139	66	167	72	1 092
Damage only	26	40	47	45	44	47	64	49	63	42	59	50	29	40	40	43	41	51	54	55	54	67	56	46	576	576	1 152	50	50	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	64	82	100	105	92	100	118	100	136	79	101	99	70	71	75	81	87	99	114	122	120	109	95	83	1 176	1 126	2 302	51	49	122	95	119	129	135	119	144	161	210	101	203	127	1 665

Fatal, Serious and Slight Accidents

Bituminous roads	600	= 52 per cent
Earth and gravel roads	550	= 48 per cent
Total	1 150	

Source

Monthly Accident returns of the Malawi Police 1967

APPENDIX 10

A comparison of accident rates between Malawi and Kenya

Country	Total No. of Vehicles (including Government vehicles)	No. of accidents			Total annual Vehicle mileage 10^6 miles	Accidents per 10^6 vehicle miles			
		Fatal	Serious	Slight		Fatal	Serious	Slight	Total
Malawi (1967)	15,000	137	317	696	218	0.6*	1.5	3.2	5.3
Kenya (1965)	95,000	429	816	1665	1140	0.4*	0.8	1.5	2.7

* Compare with U.K., 0.11 fatal accidents per 10^6 vehicle miles

Sources

Malawi: Accident Returns of the Malawi Police, Zomba
Annual Report of the Road Traffic Commissioner,[35] Blantyre

Kenya: Analysis of Road Accidents in Kenya,[22]
Ministry of Works, Nairobi

APPENDIX II(a)

The Derivation of Internal Rates of Return, Net Present Values and Cost : Benefit Ratios

1. Assumptions (a) evaluation period 20 years
   (b) residual value = zero, where applicable
   (c) discount rate = 12 per cent, where applicable

2. Benefits
   (a) change in vehicle operating costs, including time savings (V)
   (b) accidents savings (F)
   (c) change in maintenance economic costs (M)
   (d) induced agricultural production (A)
   (e) multiplier (P)

3. Costs
   (a) construction economic cost (C)
   (b) land economic cost (L)

Suffix i indicates with the proposed scheme
Suffix o indicates without the proposed scheme

4. Internal Rate of Return (IRR)

$$\text{I.R.R.} = \left\{ \frac{P(\Sigma V_i - \Sigma V_o) + (\Sigma F_i - \Sigma F_o) + \Sigma A_i - (\Sigma M_i - \Sigma M_o)}{(\Sigma C + L)} \right\} \times 100\% \quad \text{where } P = 1.5$$

If IRR is 12 per cent or greater then the scheme may be considered as economically justifiable
If IRR is under 12 per cent the scheme is economically unjustifiable
Note Values are summated *only* and *not* discounted

5. Net Present Value (NPV)

$$NPV = \sum_1^{20} d \times P \left\{ (\Sigma V_i - \Sigma V_o) + (\Sigma F_i - \Sigma F_o) + \Sigma A_i - (\Sigma M_i - \Sigma M_o) \right\} - \sum_1^{20} d \left\{ \Sigma C + L \right\}$$

where d = discount rate = 12 per cent (or for 20 years x 7.47)
P = 1.5

If N.P.V. is positive, project is economically justifiable; if N.P.V. is negative, it is not

6. Cost Benefit Ratio (C.B.R.)

$$CBR = \sum_1^{20} d \left\{ \Sigma C + L \right\} : \sum_1^{20} d\, P \left\{ \Sigma V_1 - \Sigma V_o) + (\Sigma F_i - \Sigma F_o) + \Sigma A_i + (\Sigma M_i - \Sigma M_o) \right\}$$

where P = 1.5

If C.B.R. is >1 (e.g. 1:2) project is economically justifiable, if C.B.R. is <1 it is not

APPENDIX II(b)

Recommended Project Data and Appraisal Form

1. Location
   a – road name
   b – Region and District
   c – route number
   d – map number
   e – length

The Feeder Road System of Malawi -

A Study of Present and Future Needs

ERRATA

1. Substitute the attached revised Appendix II(a) for the original which appears on page 54 of the Report.

2. Page 8, para. 4, line 4, read "700 lb per acre" instead of "1700 lb per acre".

3. Page 9, last para., line 6 for ".... transport available to the farmer. Farmers have only ...." read "transport available to the farmer, farmers have only ....".

4. Page 13, line 7 of top para., for "Malawi at its foresent stage of ..." read "Malawi at its present stage of ....".

5. Page 29, line 5 of top para., for "SWift" read "Swift".

February, 1969

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APPENDIX II(a)

The Derivation of Internal Rates of Return, Net Present Values and Cost: Benefit Ratios.

1. Assumptions (a) evaluation period = 20 years
   (b) residual value = zero, where applicable
   (c) discount rate = 12 per cent, where applicable

2. Benefits
   (a) total vehicle operating costs, including time savings (V)
   (b) total accident savings (F)
   (c) total maintenance economic costs (M)
   (d) induced agricultural production (A)
   (e) multiplier (P)

3. Costs
   (a) construction economic cost (C)
   (b) land economic cost (L)

Suffix 1 indicates with the proposed scheme
Suffix 0 indicates without the proposed scheme

4. Internal Rate of Return (IRR)

$$\text{I.R.R.} = \frac{P(\sum_i Voi - \sum_i V1i) + (\sum_i Foi - \sum_i F1i) + \sum_i Ai + (\sum_i Moi - \sum_i M1i)}{\sum_i (Ci + Li)} \times 100\%$$

where P = 1.5

If I.R.R. is 12 per cent or greater, the scheme is economically justifiable, if I.R.R. is less 12 per cent it is not.

Note Values are summated only and not discounted.

5. Net Present Value (NPV)

$$\text{N.P.V.} = \sum_{i=1}^{n} \left(\frac{1}{1+d}\right)^n \times \left[P\left\{(Voi - V1i) + (Foi - F1i) + Ai + (Moi - M1i)\right\} - (Ci + Li)\right]$$

where d = discount rate = 12 per cent
P = 1.5

If N.P.V. is positive, project is economically justifiable, if N.P.V. is negative, it is not.

6. Cost Benefit Ratio (C.B.R.)

$$\text{C.B.R.} = \sum_{i=1}^{n} \left(\frac{1}{1+d}\right)^n \left[\Sigma(Ci + Li)\right] : \sum_{i=1}^{n} \left(\frac{1}{1+d}\right)^n \left[(Voi - V1i) + (Foi - F1i) + Ai + (Moi - M1i)\right]$$

where P = 1.5

If C.B.R. is greater than 1.0, the project is economically justifiable, if C.B.R. is less than 1.0, it is not.

APPENDIX II(b)

Recommended Project Data and Appraisal Form

1. Location
   a – road name
   b – Region and District
   c – route number
   d – map number
   e – length

54b

2.	Classification	a – present status
		b – proposed status
3.	Description of work	a – features
		b – type
		c – topography
		d – geology
4.	Construction costs	a – total costs, financial and economic
		b – cost per mile/kilometre, financial and economic
		c – economic land costs
		d – basis of cost estimates
5.	Maintenance costs	a – annual maintenance costs, financial and economic
		b – change in maintenance costs, financial and economic
		c – total (discounted) costs
6.	Benefits	a – existing export crop traffic – metric tons per annum
		b – new and generated export crop traffic, with and without road investment – metric tons per annum
		c – non input export crop traffic metric tons per annum
		d – existing traffic benefits – £
		e – new traffic benefits – £
		f – generated traffic benefits – £
		g – roads proportion of joint benefits of induced net agricultural production – £
		b – total (discounted) benefits – £
7.	Economic assumptions	a – evaluation period 20 yrs.
		b – residual values 0
		c – multiplier 1·5
8.	Result	a – Internal Rate of return (IRR) per cent
		b – Net Present Value (NPV) £
		c – Cost Benefit Ratio (CBR) 1 : X
9.	Execution	a – type of contract
		b – preparation time
		c – phasing
		d – completion

7% growth of GDP
1% growth of GNP.
new route £800 p.m + £25 per land
upgrading to gravel £4,300 p.m

APPENDIX 12

Change in Benefits to Existing Traffic - Excluding Change in Maintenance Costs

Region	District	Road Mileage District Roads (Km)	Road Mileage all Roads (Km)	Crop value in maize equivalents (Metric tons)	Crop value (£)	Export crop traffic (Metric tons per year)	Change in benefits (including multiplier) for a surface change from earth to gravel (£)	Non-Discounted Change in benefits for 20 years (£)	Discounted change in benefits for 20 years at 12 per cent (£)	Discounted Change in benefits per kilometre of district road trip length (£)
Northern	Mzimba	355	1072	14,258	165,393	3,810	586	11,720	4,377	365
	Rumpi	162	437	6,162	71,470	2,073	319	6,380	2,383	199
	Nkata Bay	53	199	896	10,394	565	87	1,740	650	54
	Karonga	72	254	5,664	65,702	2,229	343	6,860	2,562	214
	Chitipa	133	294	2,087	24,209	254	39	780	291	24
	Total	775	2256	29,067	337,177	8,931	1374	27,480	10,263	856
Central	Ncheu	348	543	9,720	112,752	5,424	834	16,680	6,230	519
	Dedza	449	649	10,773	124,967	4,714	725	14,500	5,416	451
	Lilongwe	410	691	138,684	1,608,734	42,446	6530	130,600	48,779	4065
	Salima	137	258	10,773	124,503	2,383	367	7,340	2,741	228
	Dowa	282	536	55,905	648,500	11,791	1814	36,280	13,551	1129
	Ntchisi	193	288	12,499	144,988	2,889	444	8,880	3,317	276
	Mchinji	171	356	24,742	287,007	5,301	816	16,320	6,096	509
	Kasungu	421	675	23,490	272,484	5,761	886	17,720	6,618	552
	Nkotakota	153	258	3,689	42,792	1,463	225	4,500	1,681	140
	Total	2564	4252	290,235	3,366,727	82,172	12641	252,820	94,429	7868
Southern	Chiradzulu	34	116	4,583	53,086	4,583	705	14,100	5,266	439
	Nsanje	124	269	5,784	67,094	6,183	951	19,020	7,104	592
	Chikwawa	225	376	21,582	250,351	21,968	3380	67,600	25,249	2104
	Cholo	98*	241	-	-	17,436	2682	53,640	20,035	1670
	Mlanje	153	354	18,691	216,816	10,772	1657	33,140	12,378	1032
	Blantyre	293	491	32,700	379,320	8,233	1267	25,340	9,464	788
	Zomba	151	305	16,378	189,985	175	27	540	202	17
	Kasupe	154	361	33,537	389,029	8,484	1305	26,100	9,748	812
	Ft. Johnston	414	664	12,483	144,803	4,643	714	14,280	5,334	445
	Total	1646	3177	145,738	1,690,484	90,667	12688	253,760	94,780	7900

APPENDIX 13

The Treatment of Taxation in Highway Investment Assessments

Paper by the Economic Planning Directorate,
Ministry of Transport.

1. INTRODUCTION

1.1 This paper gives guidance on the treatment of road vehicle taxation and deals with hydro-carbons tax (on fuel and lubricating oil), purchase tax (on cars), licence duty, Road Goods Licence fees, and any Road Haulage Charges as originally proposed in the Transport Bill, 1968.

1.2 In determining how taxation should be treated in cost/benefit analyses of road improvement schemes, it is necessary initially to decide whether increases and decreases in revenue to the central government, which arise from road improvements, should be classed as gains and losses respectively to the nation.

2. TAXATION AND RESOURCES

2.1 Any increase in the amount of tax collected by the central government does not produce any increase in the usage of resources within the community, it only represents the transfer, from one group of individuals to another, of the power to consume the nation's resources.

2.2 Although an unplanned change in the amount of road vehicle tax collected, because of increased traffic following a road improvement, will necessarily lead to some change in the distribution of the tax burden within the community as well as a change in the total amount, the central government can readily adjust the tax structure so as to achieve the original distribution of the tax burden and the original amount of revenue.

2.3 Therefore increases or decreases in revenue because of road improvements will be regarded as 'neutral' or neutralised by complete absorbtion into fiscal policy as a whole. cannot as easily be regarded as neutral (between s and c) in a l.d.c.

3. DEFINITIONS

It is necessary to define the different kinds of costs referred to in this paper.

3.1 "User's Cost"

This is the actual total cost of a journey to the average user of a vehicle and will include all taxation costs, standing and running costs of the vehicle, and the time of the occupants. It is this level of costs which, when combined with a demand curve, gives the number of road journeys.

3.2 "User's Cost less Tax"

This refers to the total user's cost all taxes referred to in Para. 1.1.

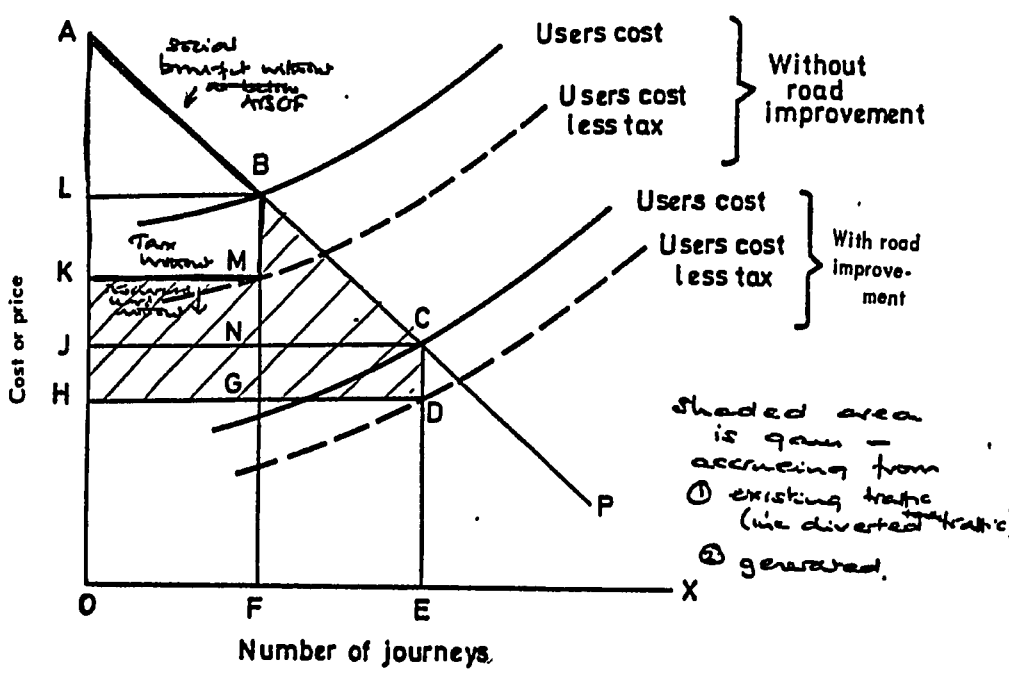
3.3 "Costs to the nation"

In Highway Investment cost/benefit analysis the net benefit we are assessing is the excess of benefit over the costs to the nation. In this paper "Costs to the nation" are the sum of user's costs, public costs and community costs as defined in Ministry of Transport Report Road Track Costs and are a measure of the resources used, bearing in mind that those factors usually classed as amenities, e.g. lack of noise, are important resources. However, because the revenue collected is not a measure of resources which have been used, tax collected must be excluded from the "costs to the nation".

3.4 The "user's cost less tax" will naturally be less than the "user's cost" depending on the relative amounts of taxation on the one hand, and public and community costs on the other.

4. DIAGRAMMATIC REPRESENTATION OF TAXATION COSTS

4.1 The relationship between operating costs, the number of journeys, tax revenue and benefit to the nation are shown diagrammatically below. Two sets of cost curves are shown (each including a "user's cost" curve and a "user's cost less tax" curve) representing costs without and with a road improvement.



58 = saving in post-tax costs in existing traffic + ½ post-tax saving in cost on generated traffic + tax on generated traffic

social benefit

4.2 It will be noticed that the diagram shows a larger tax element included in "User's Costs" without the improvement scheme than with the scheme in operation (tax BM is larger than tax NG). This is because fuel consumption per mile (and hence fuel tax per mile) will normally be less with the road improved.

4.3 The line AP is the demand curve which is a measure of the benefit from the journey to the user. The number of journeys is measured along the axis OX, so that the total area under the curve AP and to the left of the ordinate F is a measure of the total benefit from F journeys.

4.4 When the number of road journeys is OF the "user's cost" is OL and tax revenue is LBMK. With the improvement, the number of journeys increases by the amount of journeys generated (FE) to E, because "user's cost" has fallen to OJ. Tax revenue is JCDH.

4.5 There is then a loss of revenue from existing traffic measured by the difference between LBMK and JNGH and a gain in revenue from generated traffic amounting to NCDG. Whether there is a net gain or loss of revenue depends on the exact costs and number of journeys.

5. MEASUREMENT OF BENEFITS

5.1 It has already been mentioned that, although we do not know the exact position of "costs to the nation" curve, it will not be below the "user cost less tax" curve. Since our knowledge is not sufficiently advanced for public and community costs to be quantified, particularly in relation to any one highway improvement, it will be assumed for the purposes of illustration that the "user's cost less tax" and "costs to the nation" curves will be the same.

5.2 Referring to the diagram –

Without the road improvement the user's and national benefit is	ABFO
(the benefit to the nation is assumed to equal the sum of user's benefits)	
Tax collected (transfer of resources from the user to the nation) is	LBMK
The "costs to the nation" (resources used) are	KMFO
The surplus to the nation (ABFO-KMFO) is	ABMK
With the improvement and extra journeys generated the position is similar -	
With the road improvement the users' and national benefit is	ACEO
Tax collected is	JCDH
The costs to the nation are	HDEO
and the surplus to the nation (ACEO-HDEO) is	ACDH

5.3 Therefore the *increase* in surplus to the nation (net benefit) is the difference between ABMK and ACDH which is KMBCDH.

This area is made of - KMGH accruing to existing traffic (including diverted traffice) and BCDG from generated journeys.

5.4 It should be noted that the former area (KMGH) can be obtained in two ways -

(1) By multiplying the difference between the two "User's cost less tax" curves by the existing number of journeys, OF. Therefore the change in benefit to existing traffic is based on "user's costs" *net* of all taxes, KH x OF

or, (2) exactly the same result can be obtained by using "User's costs" (*including* tax) with and without the road improvement, provided any reduction in tax receipts is calculated and the sum *deducted* from the change in net benefit to the nation. (KMGH = LBNJ - (LBMK - JNGH))

5.5 The latter area (BCDG) includes the area of tax, NCDG, and the approximate triangle BCN. The area of the triangle is obtained by multiplying the difference between the two "User's Cost" curves (BN) by the volume of generated traffic (NC) and, of course, dividing by 2. Therefore the net benefit derived by each unit of generated traffic can be assessed at approximately half the net benefit to each unit of existing traffic when the costs to existing traffic include tax (BN); in addition, the generated journeys give rise to a benefit equal to the value of the tax (NCDG) paid in running those journeys.

5.6 The method described above for measuring the benefit to the nation arising from generated journeys follows the second suggestion for obtaining the change in benefit on existing traffic (Para. 5.4(2)). Whichever system is adopted, it will still be necessary to calculate user's costs with and without fuel tax.

5.7 It is perhaps worth stressing that the inclusion of fuel duty paid by generated traffic in the total benefits to the nation has nothing to do with its status as a tax. The tax is included because it is merely a measure of an important part of the gross benefit of the journey to generated traffic. In the absence of the tax the net benefit to generated traffic would be BCDG but the Government imposes a tax of CDGN, transfers the power to consume a corresponding amount of resources to others and leaves a net benefit of BCN for the generated traffic. Each unit of generated traffic must receive in benefit (Marginally) more than its costs including the amount transferred to the nation in taxation.

6. CONCLUSIONS

6.1 Taxation on existing traffic

It has been argued in para. 2 that increases or decreases in the revenue collected do not increase the total benefit to the nation because the incidence of taxation does not represent the usage of real resources. There may however be a small change in national welfare because of a change in the distribution of the tax burden, but it would be extremely difficult, if not impossible, to determine the extent of any gains or losses arising from this redistribution and it is suggested that any effects from any one road improvement scheme would in fact be very small and should therefore be neglected. Therefore decreases in tax receipts from existing traffic are not losses,

and increases in tax receipts are not gains to the nation.

6.2 Taxation on generated traffic

In para. 5.3 reference is made to the need to include taxation in operating costs when assessing the net value of generated journeys. This apparently inconsistent action is necessary because of the need to value such journeys to the nation as the difference between the users' total benefit and the nation's costs, whereas for existing traffic the valuation is based on the *difference* between benefit to the nation and "costs to the nation" without and with the improvement (national benefit is assumed to equal the sum of the users' benefit).

6.3 The principles affecting the method of evaluating generated traffic are similar to those which result in taxation being included in costs when assigning traffic - it is the benefit of the journey to the user which determines whether the trip is, or is not, made.

6.4 Therefore taxation should be included in the existing traffic costs which are used in the evaluation of benefits to generated traffic. In addition, the tax paid in running generated journeys is an extra measure of the benefit derived from those journeys which is not offset by costs to the nation.

6.5 But, because it is not possible at the moment to estimate satisfactorily whether a fall in "user's costs" will result in an increase in the number of vehicles on the roads (and hence in tax receipts from licence duty and purchase tax), as well as in an increase in the mileage run, only tax on fuel should be included in the existing traffic costs and generated traffic can only be assumed to be the same, with and without the improvement, for all categories of vehicle tax except fuel tax, so all taxes other than fuel tax can be ignored in the evaluation.

7. RECOMMENDATIONS APPLICABLE TO URBAN AND INTER-URBAN HIGHWAY COST/BENEFIT ANALYSES

The procedure to be followed for the treatment of vehicle taxation is -

1. For *existing (including diverted) traffic*, when assessing the change in net benefits, two methods giving identical results are available. Either:-

   (a) operating costs should *exclude* all taxation, or

   (b) operating costs should include fuel tax only, but if total fuel tax receipts fall (as a result of a road improvement) the amount by which tax receipts have fallen should be deducted from net benefits (and any rise in tax receipts should result in a sum being added to net benefits).

2. For *generated journeys*, the net benefit to each unit of traffic should be valued at half the change in net benefits to each unit of existing traffic on a similar journey, when existing traffic operating costs *include* fuel tax but exclude all other taxes. In *addition*, the value of fuel tax paid by traffic on generated journeys must be added to obtain the national net benefit from generated journeys.

APPENDIX 14

Population and vehicle ownership in Malawi and selected African countries

Country	Population 000's			Passenger cars 000's			Commercial vehicles 000's			Population per passenger car			Population per commercial vehicle		
	1957	1960	1967	1957	1960	1965	1957	1960	1965	1957	1960	1965	1957	1960	1965
Malawi	3250	3490	3940	4.4	6.4	6.4	3.8	5.3	4.6	738.6	545.3	615.7	855.3	658.5	856.5
Kenya	7432	8115	9365	49.6	64.6	73.0	10.9	13.1	11.0	149.8	125.6	128.2	681.8	619.5	851.4
Zambia	2960	3210	3710	27.2	32.7	43.7	11.2	10.8	11.4	108.8	98.2	84.9	264.3	297.2	325.4
Ghana	6250	6777	7740	14.5	20.7	30.0	15.6	17.7	19.5	400.6	327.4	258.0	400.6	382.9	396.9
Portugal-Mozambique	6285	6537	6956	23.6	30.9	–	7.1	5.8	–	266.3	211.6	–	885.2	1127.1	–

APPENDIX 15

Net present values (N.P.V.) for feeder road upgrading existing traffic only

Region	District	Discounted changes in benefits per kilometre of average touring on district road (3a–£25) £		Discounted costs per kilometre of district road at 8% £	Net present value (Col 3b – Col 4) £
(1)	(2)	(3a)	(3b)	(4)	(5)
Northern	Mzimba	365	+ 340	2650	– 2310
	Rumpi	199	+ 174	..	– 2476
	Nkata Bay	54	+ 29	..	– 2621
	Karonga	214	+ 189	..	– 2461
	Chitipa	24	– 1	..	– 2651
Central	Ncheu	519	+ 494	2650	– 2156
	Dedza	451	+ 426	..	– 2224
	Lilongwe	4065	+ 4040	..	+ 1390
	Salima	228	+ 203	..	– 2447
	Dowa	1129	+ 1104	..	– 1546
	Ntchisi	276	+ 251	..	– 2399
	Mchinji	508	+ 483	..	– 2167
	Kasungu	552	+ 527	..	– 2123
Southern	Chiradzulu	439	+ 414	2650	– 2236
	Nsanje	592	+ 567	..	– 2083
	Chikwawa	2104	+ 2079	..	– 571
	Cholo	1670	+ 1645	..	– 1005
	Mlanje	1032	+ 1007	..	– 1643
	Blantyre	789	+ 764	..	– 1886
	Zomba	801	+ 776	..	– 1874
	Kasupe	812	+ 787	..	– 1863
	Ft. Johnston	445	+ 420	..	– 2230

Sources: Column 3 Appendix 12 and change in maintenance costs (Appendix 19 and para 2.5)
Column 3a excluding change in maintenance costs
Column 3b including change in maintenance costs
Column 4 Appendix 19

APPENDIX 16

Estimate of annual freight hauled (exportable product) from farm to buying point (a)
(based on sales of 1967–7 crop through F.M.B., Malawi)

Region/district	Annual freight hauled metric ton kilometres per kilometre of road
Northern	
Chitipa	10
Karonga (b)	105
Nkhata Bay	34
Rumpi	58
Mzimba	43
Central	
Ncheu	29
Dedza	43
Lilongwe	691
Salima	111
Dowa	263
Ntchisi	120
Mchinji	179
Kasungu	103
Nkota Kota	68
Southern	
Chiradzulu	474
Nsanje	284
Chikwawa	704
Chold	869
Mlanje	381
Blantyre	201
Zomba	330
Kasupe	281
Ft. Johnston	83

Notes: (a) Assuming a maximum journey of 24 kilometres and an average journey of 12 kilometres
(b) Of which approximately two-thirds is paddy carried in barges on Lake Malawi
(c) The basis for the above figures of metric ton kilometres per kilometre is as follows: for example, Mchinji: the present export crop extraction traffic, including surplus maize (5301 metric tons) is divided by the total area cultivated (26,282 hectares) to give the average product exported per hectare cultivated (0.2017 metric tons per hectare). This in turn is multiplied by the hectares cultivated per kilometre of road (74 hectares) to give the volume per kilometre of road (14.93 metric tons per kilometre); the latter is multiplied by the average distance hauled (12 kilometres) to result in the above estimate (179 metric ton kilometres per kilometre of road).

APPENDIX 17(a)

Benefits accruing on a Present Value Basis (that is, as at 1st January 1968)

6 + 7 = 5 8 + 9 = 7 3.8 = 9 YEAR 1970 10 × 3/4.9 (6+8)?d 10(1.3) 11+12 14-15 14 + 15 + 16

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Region/District	Kilometres of District Roads	Crop Value in maize equivalent	Crop Value in £ discounted to Present Values	Total Export/Import Crop Traffic from App I	Existing Export Crop Traffic from Table 2	New and Generated Export/Import Crop Traffic	New and Generated Export Crop Traffic without feeder road investment	New and Generated Export Crop Traffic with feeder road investment	Non-input Export Crop Generated Traffic	Existing and New Traffic Benefits at 2.1 pence per metric ton kilometre	Generated Traffic Benefits at 1.3 pence per metric ton kilometre 75%	Total Benefits on P.V Basis	Total Benefits per km of average journey on District road on P.V. Basis	Change in Maintenance Costs per km on P.V. Basis	Roads Portion of Joint Benefits of net Value of induced agricultural production ¼ · 90? 40.9	Roads Portion of Joint Benefits per km of average journey on district road	Total Benefits per kilometre of average journey on District road on P.V. Basis (for gravel £13 more for earth)
	Km	Metric tons	£	Metric tons per annum	Metric tons per annum	Metric tons per annum	Metric tons per annum	Metric tons per annum	Metric tons per annum	£	£	£	£	£ (a) (for gravel) (b) (for earth)	£	£	£
NORTHERN																	
CHITIPA	133	4 581	37 729	1 419	254	1 165	291	874 219	655	86	64	106	9	(a) -25 (b) -12	4 622	385	
KARONGA	72	10 629	87 540	4 395	2 229	2 166	542	1 625	1 218	1 184	119	925	78	" "	9 201	767	820
NKHATA BAY	53	2 835	23 349	1 508	565	943	236	707	530	125	52	125	10	" "	3 593	299	284
RUMPI	162	8 910	73 383	2 546	2 073	473	118	355	265	345	26	263	22	" "	5 092	424	421
MZIMBA	355	17 923	147 614	5 679	3 810	1 869	467	1 402	1 051	672	103	550	46	" "	6 792	566	587
TOTAL	775	44 878	369 615	15 547	8 931	6 616	1 654	4 961	3 719	2 412	364	1 969	165				
CENTRAL																	
NCHEU	348	12 729	104 836	6 675	5 424	1 251	313	938	704	882	69	675	56	" "	5 576	465	496
DEDZA	449	19 874	163 682	9 085	4 714	4 371	1 093	3 278	2 456	892	248	810	68	" "	16 865	1 405	1 448
LILONGWE	410	147 934	1 218 384	48 836	42 446	6 390	1 598	4 793	3 594	6 776	350	5 060	422	" "	17 141	1 428	1 825
SALIMA	137	18 382	151 394	6 088	2 383	3 705	926	2 779	2 084	518	203	512	43	" "	14 174	1 181	1 199
DOWA	202	51 234	421 963	12 819	11 791	1 028	257	771	578	1 854	56	1 356	113	" "	0	0	88
NTCHISI	193	18 904	155 693	4 731	2 889	1 842	461	1 382	1 036	516	101	438	37	" "	11 869	989	1 001
MCHINSI	171	39 011	321 295	8 833	5 301	3 532	1 325	2 207	1 655	1 020	161	839	70	" "	26 442	2 204	2 249
KASUNGU	421	34 541	284 480	9 101	5 761	3 340	835	2 505	1 879	1 014	183	850	71	" "	20 479	1 707	1 753
NKOTAKOTA	153	6 341	52 224	3 023	1 463	1 560	390	1 170	878	60	86	103	9	" "	4 914	410	394
TOTAL	2 564	348 950	2 873 951	109 191	82 172	27 019	7 198	19 823	14 684	13 433	1 457	10 643	889				
SOUTHERN																	
CHIRADZULU	34	0	-0	-2 448	4 583	-2 448	562	189	1 415	791	138	660	55	" "	0	0	30
NSANJE	124	32 485	267 546	8 553	6 183	2 370	593	1 778	1 333	1 042	130	832	69	" "	49 480	4 123	4 157
CHIKWAWA	225	115 889	954 462	30 951	21 968	8 966	2 242	6 725	5 043	3 725	492	2 994	249	" "	174 760	14 563	14 787
CHOLO	98*	0	-0	-4 237	17 436	-4 237	1 059	3 178	2 383	2 909	232	2 230	186	" "	0	0	161
MLANJE	153	20 562	169 349	11 285	10 772	513	128	385	287	1 677	28	1 211	101	" "	3 467	289	365
BLANTYRE	293	32 334	266 303	10 189	8 223	1 966	492	1 475	1 106	1 343	108	1 030	86	" "	0	0	61
ZOMBA	151	19 025	156 690	9 406	8 365	1 041	260	781	586	1 328	57	983	82	" "	5 058	422	479
KASUPE	154	13 978	115 197	9 973	8 484	1 489	372	1 117	838	1 362	82	1 024	85	" "	0	0	60
FT. JOHNSTON	414	14 065	115 839	6 488	4 643	1 285	321	864	648	763	63	587	49	" "	2 932	244	268
TOTAL	1 646	248 338	2 045 386	93 530	90 657	24 315	6 029	16 492	13 639	14 940	1 330	11 551	962				

5287,000 218.2 182.6 57.9 unbiscounted 6611,000 382,600

* Private tea estates predominantly

** Negative sign indicates a reversal in direction of traffic flow

56

APPENDIX 17(b)

Benefits accruing on a present value basis (that is, as at 1st January 1968)

YEAR 1975

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		16	17	18
Region/District	Kilometres of District Roads	Crop Value in maize equivalent	Crop Value in £ discounted to Present Value	Total Export/Import Crop Traffic = 647	Existing Export Crop Traffic	New and Generated Export/Import Crop Traffic = 819	New and Generated Export Crop Traffic without feeder road investment	New and Generated Export Crop Traffic with feeder road investment = 3.87/4	Non-input Export Crop Generated Traffic	Existing and New Traffic Benefits at 2 1 pence per metric ton kilometre	Generated Traffic Benefits at 1 3 pence per metric ton kilometre	Total Benefits on P V Basis	Total Benefits per Km of average journey on District road on P V Basis	Change in Maintenance Costs per km on P V Basis		Roads Portion of Joint Benefits of net value of induced agricultural production	Roads Portion of Joint Benefits per km of average journey on district road	Total Benefits per kilometre of average journey on District road on P V Basis for gravel (£13 more for earth)
	Km	Metric tons	£	Metric tons per annum	Metric tons per annum	Metric tons per annum	Metric tons per annum	Metric tons per annum	Metric tons per annum	£	£	£	£	(a) gravel £	(b) earth £	£	£	£
NORTHERN														(a)	(b)			
CHITIPA	133	11 872	55 086	2 786	254	2 532	633	3 165	2 374	132	231	145	12	-25	-12	10 215	851	838
KARONGA	72	16 861	78 235	6 324	2 229	4 095	1 024	3 071	2 303	509	225	293	24	"	"	11 688	974	973
NKHATA BAY	53	8 855	41 087	3 414	565	2 849	712	2 137	1 603	199	156	142	11	"	"	8 311	693	679
RUMPI	162	17 076	79 233	3 687	2 073	1 614	404	1 211	908	289	89	191	16	"	"	11 394	950	941
4 MZIMBA	355	35 319	163 880	10 976	3 810	7 166	1 792	5 375	4 031	827	393	488	41	"	"	21 988	1 832	1 848
TOTAL	775	89 983	417 521	27 187	8 931	18 256	4 565	14 959	11 219	2 056	1 094	1 259	104					
CENTRAL																		
NCHEU	345	20 659	95 858	10 582	5 424	5 158	1 290	3 869	2 901	1 032	283	526	44	"	"	11 420	952	971
DEDZA	449	30 989	143 789	14 545	4 714	9 831	2 458	7 373	5 531	1 103	539	657	55	"	"	21 105	1 759	1 789
3 LILONGWE	410	192 558	847 059	62 103	42 446	19 657	4 914	14 743	11 075	7 286	1 080	3 346	279	"	"	45 804	3 817	4 071
SALIMA	137	24 575	114 028	8 239	2 383	5 856	1 646	4 210	3 158	628	308	374	31	"	"	14 676	1 223	1 229
DOWA	282	62 171	289 401	17 394	11 791	5 603	1 401	4 202	3 152	2 030	307	923	77	"	"	6 750	563	615
NTCHISI	193	22 646	105 077	6 414	2 889	3 525	881	2 644	1 983	581	193	310	26	"	"	10 368	864	865
5 MCHINSI	171	45 023	208 907	11 275	5 301	5 974	1 494	449	336	1 046	33	432	36	"	"	21 174	1 765	1 776
6 KASUNGU	421	42 149	195 530	11 693	5 761	5 922	1 481	4 442	3 331	1 114	325	576	48	"	"	19 471	1 623	1 646
M'OTAKOTA	153	9 674	44 887	4 544	1 463	3 081	770	2 311	1 733	250	169	128	11	"	"	6 248	521	[illegible]
TOTAL	2 564	440 635	2 044 546	146 777	82 172	64 607	16 335	44 243	33 200	15 070	3 237	7 272	607					
SOUTHERN																		
CHIPADZULU	34	0	0	-6 116	4 583	1 533	383	1 150	862	764	85	340	28	"	"	0	0	3
2 NSANSE	124	42 435	196 898	11 173	4 970	6 183	1 248	3 743	2 807	1 943	274	927	77	"	"	38 264	3 187	3 239
CHIKWAWA	225	135 085	626 794	35 887	21 968	13 919	3 480	10 439	7 829	3 915	763	1 871	156	"	"	118 497	9 875	10 006
CHIRADZULO	98*	0	0	-10 585	17 436	-10 585	2 646	7 937	5 954	3 153	580	1 493	124	"	"	0	0	99
MLANJE	153	14 221	65 995	7 740	10 772	7 740	1 935	5 805	4 354	1 955	425	952	79	"	"	0	0	54
7 BLANTYRE	293	53 763	249 460	16 794	8 223	8 571	2 143	6 429	4 821	1 579	470	820	68	"	"	21 940	1 833	1 876
ZOMBA	151	33 315	154 582	16 016	8 365	7 651	1 913	5 738	4 304	1 582	420	801	67	"	"	17 682	1 474	1 516
KASUPE	154	22 049	102 307	15 378	8 484	6 894	1 724	5 171	3 878	1 570	378	779	65	"	"	0	0	40
FT JOHNSTON	414	26 019	120 725	11 865	4 643	7 222	1 806	5 617	4 212	972	411	561	47	"	"	14 132	1 178	1 200
TOTAL	1 646	326 889	1 516 764	131 554	90 657	69 105	17 278	52 030	39 021	24 353	3 806	8 544	711					

4952 3979 225.6 1226 1520 8714 [illegible] 1231600

* Private tea estates predominantly

** Negative sign indicates reversal in direction of traffic flow

67

APPENDIX 17(c)

Benefits accruing on a Present Value Basis (that is, as at 1st January 1968)

YEAR 1980

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		16	17	18
Region/District	Kilometres of District Roads	Crop Value in maize equivalent	Crop Value in £ discounted to Present Values	Total Export/Import Crop Traffic	Existing Export Crop Traffic	New and Generated Export/Import Crop Traffic	New and Generated Export Crop Traffic without feeder road investment	New and Generated Export Crop Traffic with feeder road investment	Non-input Export Crop Generated Traffic	Existing and New Traffic Benefits at 2 1 pence per metric ton kilometre	Generated Traffic Benefits at 1 3 pence per metric ton kilometre	Total Benefits on P V Basis	Total Benefits per Km of average journey on District road on P V. Basis	Change in Maintenance Costs per Km on P V. Basis		Roads Portion of Joint Benefits of net value of induced agricultural production	Roads Portion of joint Benefits per km of average journey on district road	Total Benefits per kilometre of average journey on District road on P.V. Basis for gravel (£13 more for earth)
	Km	Metric tons	£	Metric tons per annum	Metric tons per annum	Metric tons per annum	Metric tons per annum	Metric tons per annum	Metric tons per annum	£	£	£	£	(a) gravel £	(b) earth	£	£	£
NORTHERN														(a)	(b)			
CHITIPA	133	20 562	54 859	4 245	254	3 991	998	2 993	2 245	653	219	201	17	-25	-12	11 090	924	916
KAROKGA	72	21 534	57 453	8 374	8 333	41	10	31	23	349	2	81	7	"	"	9 527	794	776
NKHATA BAY	53	14 643	39 068	5 448	7 065	0	0	0	0	87	0	20	2	"	"	8 252	688	665
RUMPI	162	24 038	64 133	4 900	4 121	779	195	584	438	439	43	111	9	"	"	10 731	894	878
MZIMBA	355	56 545	150 862	16 625	18 867	0	0	0	0	586	0	135	11	"	"	25 385	2 115	2 101
TOTAL	775	137 322	366 375	39 592	43 940	4 811	1 203	3 608	2 706	2 114	264	548	46					
CENTRAL																		
NCHEU	348	29 466	78 615	14 740	5 424	9 316	2 329	6 987	5 240	2 267	511	639	53	"	"	11 853	988	1 016
DEDZA	449	46 085	122 955	20 357	4 714	15 643	3 911	11 732	8 799	3 132	858	918	77	"	"	21 198	1 767	1 819
LILONGWE	410	189 870	506 573	66 450	42 446	24 004	6 001	18 003	13 502	10 223	1 316	2 654	221	"	"	30 727	1 561	1 757
SALIMA	137	32 073	85 571	10 520	2 383	8 137	2 034	6 103	4 577	1 619	446	475	40	"	"	12 810	1 068	1 083
DOWA	282	75 834	202 325	22 247	11 791	10 456	2 614	7 842	5 882	3 423	573	919	77	"	"	11 963	997	-1 049
NTCHISI	193	30 114	80 344	8 197	2 889	5 310	1 328	3 982	2 987	1 261	291	357	30	"	"	10 574	881	886
MCHINJI	171	51 631	137 752	13 859	5 301	8 558	2 140	6 418	4 814	2 133	449	598	50	"	"	16 142	1 345	1 370
KASUNGU	421	51 371	137 058	14 416	5 761	8 655	2 164	6 491	4 868	2 218	475	619	52	"	"	16 737	1 388	1 415
MKOTAKOTA	153	13 792	36 797	6 162	1 463	4 699	1 175	3 524	2 643	948	258	277	23	"	"	6 065	505	503
TOTAL	2 564	520 236	1 387 990	176 950	82 172	94 778	23 696	71 082	53 312	27 224	5 197	7 456	623					
SOUTHERN				**		**	**	**	**									
CHIRADZULU	34	0	0	-10 547	4 583	-5 964	-1 491	-4 473	-3 355	1 623	327	449	37	"	"	0	0	12
NSANJE	124	52 638	140 438	13 948	6 183	7 765	1 941	-5 824	-4 368	2 146	426	592	49	"	"	28 126	2 344	2 368
CHIKWAWA	225	154 203	411 414	41 065	21 968	19 097	4 774	14 323	10 742	6 318	1 047	1 694	1 412	"	"	79 612	6 634	8 021
CHOLO	98*	0	0	-18 253	17 436	-817	-204	-613	-460	2 808	45	656	55	"	"	0	0	30
MLANJE	153	0	0	-4 501	10 772	0	0	0	0	1 657	0	381	32	"	"	0	0	7
BLANTYRE	293	81 571	217 631	23 827	8 223	15 604	3 901	11 703	8 777	3 668	856	1 041	87	"	"	29 112	2 426	2 488
ZOMBA	151	19 749	52 690	10 138	8 365	1 773	443	1 330	998	1 560	97	381	32	"	"	2 023	169	176
KASUPE	154	30 456	81 257	21 129	8 484	12 645	3 161	9 484	7 113	3 250	694	907	76	"	"	0	0	51
FT. JOHNSTON	414	39 052	104 191	17 598	4 643	12 955	3 239	9 716	7 287	2 707	710	786	66	"	"	15 949	1 329	1 370
TOTAL	1 646	377 669	1 007 621	161 006	90 657	76 620	19 154	57 466	43 100	25 737	4 202	6 887	1 846					

* Private tea estates predominantly

** Negative sign indicates a reversal in direction of traffic flow

2 762 000 2776
undiscounted
18,744,080

176·3

357900

APPENDIX 17(d)

Benefits accruing on a Present Value Basis (that is, as at 1st January 1968)

YEAR 1985

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		16	17	18
Region/District	Kilometres of District Roads	Crop Value in maize equivalent	Crop Value in £ discounted to Present Values	Total Export/Import Crop Traffic	Existing Export Crop Traffic	New and Generated Export/Import Crop Traffic	New and Generated Export Crop Traffic without feeder road investment	New and Generated Export Crop Traffic with feeder road investment	Non-Input Export Crop Generated Traffic	Existing and New Traffic Benefits at 2.1 pence per metric ton kilometre	Generated Traffic Benefits at 1.3 pence per metric ton kilometre	Total Benefits on P.V. Basis	Total Benefits per km of average journey on District road on P.V. Basis	Change in Maintenance Costs per km on P.V. Basis		Roads Portion of Joint Benefits of net value of induced agricultural production	Roads Portion of joint Benefits per km of average journey on District road	Total Benefits per kilometre of average journey on District road on P.V. Basis for gravel (£13 more for earth)
	Km	Metric tons	£	Metric tons per annum	Metric tons per annum	Metric tons per annum	Metric tons per annum	Metric tons per annum	Metric tons per annum	£	£	£	£	(a) gravel £	(b) earth £	£	£	£
NORTHERN														(a)	(b)			
CHITIPA	133	30 966	46 697	5 808	254	5 554	1 388	4 166	3 125	893	305	153	13	-25	-12	9 799	817	805
KARONGA	72	26 950	40 641	10 562	2 229	8 333	2 083	6 250	4 687	1 625	457	270	3	"	"	6 930	578	576
NKHATA BAY	53	21 839	33 009	7 630	565	7 065	1 766	5 299	3 974	1 174	387	203	17	"	"	7 123	594	586
RUMPI	162	32 981	49 735	6 194	2 073	4 121	1 030	3 091	2 318	953	226	153	13	"	"	9 100	858	846
MZIMBA	355	77 737	117 227	22 677	3 810	18 867	4 717	14 150	10 613	3 489	1 035	588	49	"	"	21 538	1 795	1 819
TOTAL	773	190 523	287 309	52 871	8 931	43 940	10 984	32 956	24 717	8 134	2 410	1 367	115					
CENTRAL																		
NCHEU	348	39 216	59 138	19 186	5 424	13 762	3 441	10 321	7 741	2 951	755	482	40	"	"	10 008	834	849
DEDZA	449	56 770	85 609	24 010	4 714	19 296	4 824	14 472	10 854	3 694	1 058	618	52	"	"	15 607	1 301	1 328
LILONGWE	410	142 320	214 619	49 705	42 446	7 259	1 815	5 444	4 083	7 647	398	1 046	87	"	"	1 234	103	165
SALIMA	137	33 922	51 154	12 950	2 383	10 567	2 642	7 925	5 944	1 993	580	335	28	"	"	7 868	639	642
DOWA	282	95 690	144 301	27 418	11 791	15 627	3 907	11 720	8 790	4 218	857	660	55	"	"	30 571	2 548	2 578
NTCHISI	193	34 800	52 478	10 101	2 889	7 212	1 803	5 409	4 057	1 554	396	254	21	"	"	7 567	631	625
MCHINJI	171	58 923	88 856	16 605	5 301	11 304	2 826	8 478	6 359	2 555	620	413	34	"	"	11 598	967	976
KASUNGU	421	62 744	94 618	17 320	5 761	11 559	2 890	8 669	6 502	2 664	634	429	36	"	"	13 319	1 118	1 129
NKOTAKOTA	153	18 339	27 655	7 890	1 463	6 427	1 607	4 820	3 615	1 214	352	204	17	"	"	4 768	397	389
TOTAL	2 564	542 724	818 428	185 185	82 172	103 013	25 755	77 258	57 945	28 490	5 650	4 441	370					
SOUTHERN				**		**												
CHIRADZULU	34	0	0	-15 851	4 583	11 268	2 817	8 417	6 338	2 439	618	397	33	"	"	0	0	3
NSANJE	124	62 899	94 852	16 879	6 183	10 716	2 679	8 037	6 028	2 600	588	414	35	"	"	19 379	1 615	1 625
CHIKWAWA	225	173 479	261 606	46 520	21 968	24 552	6 138	18 414	13 811	7 152	1 437	1 105	92	"	"	51 539	4 295	4 362
CHOLO	98*	0	0	-27 430	17 436	-9 994	2 499	7 495	5 621	4 220	548	620	52	"	"	0	0	27
MLANJE	153	0	0	-19 194	10 772	-8 422	2 106	6 316	4 737	2 953	462	440	37	"	"	0	0	12
BLANTYRE	293	73 837	111 346	22 407	8 223	14 184	3 546	10 638	7 978	3 449	778	550	46	"	"	13 958	1 163	1 184
ZOMBA	151	0	0	- 175	8 165	0	0	0	0	27	0	4	0	"	"	0	0	-25
KASUPE	154	39 605	59 724	27 275	8 484	18 791	4 698	14 093	10 570	4 196	1 030	679	57	"	"	2 059	172	204
FT. JOHNSTON	414	54 153	81 663	23 738	4 643	19 095	4 774	14 321	10 741	3 452	1 042	610	51	"	"	14 139	1 178	1 204
TOTAL	1 646	403 973	609 191	199 489	90 657	117 022	29 257	87 765	65 824	30 688	6 413	4 819	403					

1715006

11,747,658

258200

* Private tea estates predominantly

** Negative sign indicates reversal of traffic flow

APPENDIX 17(c)

Benefits accruing on a present value basis (that is as at 1st January 1969)

YEAR 1990

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		16	17	18
Region/District	Kilometres of District Roads	Crop Value in maize equivalent	Crop Value in £ discounted to Present Values	Total Export/ Import Crop Traffic	Existing Export Crop Traffic	New and Generated Export/ Import Crop Traffic	New and Generated Export Crop Traffic without feeder road investment	New and Generated Export Crop Traffic with feeder road investment	Non-input Export Crop Generated Traffic	Existing and New Traffic Benefits at 2.1 pence per metric ton kilometre	Generated Traffic Benefits at 1.3 pence per metric ton kilometre	Total Benefits on P V Basis	Total Benefits per km of average journey on District road on P.V Basis	Change in Maintenance Costs per km on P.V Basis		Roads Portion of Joint Benefits of net value of induced agricultural production	Roads Portion of joint Benefits per km of average journey on District road	Total Benefits per kilometre of average journey on District road on P.V Basis for gravel (£13 more for earth)
	Km	Metric tons	£	Metric tons per annum	Metric tons per annum	Metric tons per annum	Metric tons per annum	Metric tons per annum	Metric tons per annum	£	£	£	£	(a) earth	(b) gravel	£	£	£
NORTHERN														(a)	(b)			
CHITIPA	133	39 900	32 399	7 490	254	7 236	1 809	5 427	4 070	317	397	50	4	-25	-12	6 908	576	555
KARONGA	72	32 900	26 715	12 907	2 229	10 678	2 670	8 008	6 006	754	586	94	8	"	"	4 976	415	398
NKHATA BAY	53	28 700	23 304	9 979	565	9 414	2 354	7 060	5 295	449	516	68	6	"	"	5 080	423	406
RUMPI	162	40 200	32 642	7 582	2 073	5 509	1 377	4 132	3 099	530	302	58	5	"	"	6 219	518	498
MZIMBA	355	100 300	81 444	29 189	3 810	25 379	6 345	19 034	14 276	1 562	1 392	207	17	"	"	15 720	1 310	1 302
TOTAL	775	242 000	196 504	67 147	8 931	58 216	14 555	43 661	32 746	3 612	3 193							
CENTRAL																		
NCHEU	348	49 000	39 783	23 961	5 424	18 537	4 634	13 903	10 427	1 547	1 017	179	15	"	"	775	600	590
DEDZA	449	33 500	27 202	14 049	4 714	9 335	2 334	7 001	5 251	1 084	512	112	9	"	"	4 152	346	330
LILONGWE	410	84 000	68 208	29 449	42 446	0	0	0	0	6 510	0	457	38	"	"	0	0	13
SALIMA	137	40 700	33 048	15 551	2 383	13 168	3 292	9 876	7 407	873	722	112	9	"	"	5 475	456	440
DOWA	282	116 800	93 218	32 951	11 791	21 160	5 290	15 870	11 903	2 628	1 161	265	22	"	"	10 535	878	875
NTCHISI	193	41 800	33 942	12 136	2 889	9 247	2 312	6 935	5 201	800	507	91	8	"	"	7 409	617	609
MCHINJI	171	69 500	56 434	19 535	5 301	14 234	3 559	10 675	8 006	1 364	781	151	13	"	"	12 245	1 020	1 008
KASUNGU	421	74 000	60 088	20 422	5 761	14 661	3 665	10 996	8 247	1 450	804	158	13	"	"	9 228	769	757
NKOTAKOTA	153	22 600	18 351	9 744	1 463	8 281	2 070	6 211	4 658	543	454	70	6	"	"	3 455	289	270
TOTAL	2 564	529 900	430 279	177 798	82 172	108 623	27 156	81 467	61 100	15 819	5 958							
SOUTHERN				**		**	**	**										
CHIRADZULU	34	0	0	-22 151	4 583	-17 568	-4 392	-13 176	9 882	1 381	963	164	14	"	"	0	0	-11
NSANJE	124	57 700	46 852	15 593	6 183	9 410	2 353	7 057	5 293	1 313	516	128	11	"	"	9 485	790	776
CHIKWAWA	225	194 300	157 772	52 291	21 968	30 323	7 581	22 742	17 057	4 546	1 663	434	36	"	"	31 556	2 629	2 640
CHOLO	98*	0	0	-38 332	17 436	-20 896	-5 224	-15 672	11 754	3 486	1 146	324	27	"	"	0	0	2
MLANJE	153	0	0	-36 688	10 772	-25 916	-6 479	-19 437	14 578	2 654	1 421	285	24	"	"	0	0	-1
BLANTYRE	293	34 000	27 608	10 240	8 223	2 017	504	1 513	1 135	1 344	111	102	8	"	"	238	20	3
ZOMBA	151	0	0	-12 470	8 365	-4 105	-1 026	-3 079	2 309	1 445	225	117	10	"	"	0	0	-15
KASUPE	154	49 100	39 870	33 872	8 484	25 388	6 347	19 041	14 281	2 281	1 392	257	21	"	"	2 844	237	233
FT. JOHNSTON	414	69 300	56 272	30 341	4 643	25 698	6 425	19 273	14 455	1 702	409	218	18	"	"	10 381	865	858
TOTAL	1 646	404 400	328 374	251 978	90 657	161 321	40 331	120 990	90 744	20 152	8 846							

* Private tea estates predominantly

** Negative sign indicates reversal of traffic flow

11460,000 4969 328 374 146700

APPENDIX 18

Compensation for loss of buildings and crops due to new road construction

Compensation is not paid if buildings are constructed or crops planted after due notice has been served of the future construction. Nevertheless an economic cost of the value of the crops lost should be included in the total economic cost in the project's appraisal since they are a loss of resources to the country.

748 - 7162

Perennial crops

Crop	Class	Compensation per plant or tree etc.	
		Country	Town
Avocado	large	£ 1 0 0	£ 2 0 0
	medium	15 0	£ 1 10 0
	small	15 0	10 0
Mango	large	10 0	£ 1 0 0
	medium	7 6	15 0
	small	5 0	5 0
Guava Paw-paw Mulberry	large	4 0	5 0
	medium	2 0	2 6
	small	1 0	1 3
Common peach	large	16 0	£ 1 10 0
	medium	11 0	£ 1 0 0
	small	5 0	5 0
Apple Plum Peach	large	£ 1 5 0	£ 1 10 0
	medium	16 0	£ 1 0 0
	small	8 0	10 0
Banana	per mature stem	1 0	1 3
Grenadilla	per mature plant	4 0	5 0
Pineapple	per mature plant	6	6
Sugar cane	per clump	1 6	2 0
Coffee	In bearing		
	good	10 0	-
	medium	7 6	-
	poor	5 0	-
	immature - good	5 0	-
	medium	2 6	-
	poor	1 3	-

Appendix 18
(continued)

Annual Crops

Crop	Class	Compensation per acre	
		Country	Town
Maize Sorghums	Good Average Poor	£ 8 0 0 £ 5 0 0 £ 3 5 0	£13 5 0 £10 0 0 £ 6 15 0
Cassava	good average poor	£12 10 0 £ 8 5 0 £ 4 5 0	£25 0 0 £16 15 0 £ 8 5 0
Pigeon pea	good average poor	£ 6 0 0 £ 3 0 0 £ 1 5 0	£ 8 0 0 £ 5 0 0 £ 2 0 0
Beans	good average poor	£ 5 0 0 £ 3 5 0 £ 1 15 0	£ 7 10 0 £ 5 0 0 £ 2 10 0
Groundnuts	good average poor	£20 0 0 £13 5 0 £ 6 15 0	£30 0 0 £20 0 0 £10 0 0
Tobacco (Western) Rates doubled for Turkish flue-cured and burley	good average poor	£30 0 0 £15 0 0 £ 5 0 0	- - -
Sweet potatoes	good average poor	£12 10 0 £ 8 5 0 £ 4 5 0	£25 0 0 £16 15 0 £ 8 5 5
Castor	mature plant	£ 0 0 8 each	£ 0 0 8 each
Chillies	mature bush	£ 0 1 0 each	£ 0 1 0 each

Buildings

	Roof	Rate Shillings/pence per sq. ft.
Wattle and Daub	Thatched	1-0
Pine	Thatched	1-3
Pine	Corrugated iron	2-6
Sunburnt brick	Thatched	1-6
Sunburnt brick	Corrugated iron	2-9
Burnt brick	Thatched	3-0
Burnt brick	Corrugated iron	5-0
Burnt brick-cement pointed	Thatched	4-0
Burnt brick-cement pointed	Corrugated iron	6-0

Source:- Ministry of Works and Supplies.

APPENDIX 19

Construction, maintenance and land economic costs

(Present value £/kilometre (£/mile))

	Upgrading existing earth road to gravel standard		new feeder earth road	
Construction	2,650	(4 300)	500	(800)
Maintenance (change)	500	(800)(a)	230	(37)
Land	0	(0)(b)	15	(25)
Administration	0	(0)	0	(0)
Total	3,150	(5,100)	745	(1,195)
Total costs for cost benefit analysis (c)	2,650	(4,300)	515	(825)

Notes

(a) Calculated so:-

	£	£
i Present Value annual basic maintenance of gravel road, per Km	420	
ii Less Present Value annual maintenance of earth road, per Km	230	190
iii Plus re-gravelling every 6th year, per annum P.V. per Km		310
Change in economic maintenance costs for upgraded road, per Km		500

(b) Road is already in existence and as no realignment or widening is considered no land is required.

(c) Maintenance costs (changes) are included as a deduction under Benefits and not under Costs.

APPENDIX 20

1968-74 Feeder road programme - annual total benefits, excluding change in maintenance costs

New feeder roads and upgrading existing roads

(£ as at 1st January 1968)

REGION	DISTRICT	1970 £	1971 £	1972 £	1973 £	1974 £	1975 £	1976 £	1977 £	1978 £	1979 £	1980 £	1981 £	1982 £	1983 £	1984 £	1985 £	1986 £	1987 £	1988 £	1989 £	1990 £	TOTAL £
NORTHERN	CHITIPA	4 728	5 800	6 900	8 000	9 100	10 360	10 500	10 700	10 900	11 100	11 291	11 000	10 700	10 400	10 200	9 952	9 400	8 800	8 200	7 600	6 958	193 089
	KARONGA	10 126	10 400	10 800	11 200	11 600	11 981	11 500	11 000	10 500	10 000	9 608	9 100	8 600	8 100	7 600	7 200	6 800	6 400	6 000	5 500	5 070	189 085
	NKHATA BAY	3 718	4 600	5 500	6 400	7 400	8 453	8 400	8 400	8 300	8 300	8 272	8 100	7 900	7 700	7 500	7 326	6 900	6 500	6 100	5 600	5 148	146 517
	RUMPI	5 355	6 600	7 800	9 000	10 200	11 585	11 500	11 400	11 300	11 200	11 142	10 600	10 400	10 000	9 600	9 253	8 600	8 000	7 400	6 800	6 277	194 012
	MZIMBA	7 342	10 300	13 300	16 300	19 400	22 476	23 000	23 600	24 200	24 800	25 520	24 800	24 200	23 600	23 000	22 126	20 800	19 600	18 400	17 200	15 927	419 891
CENTRAL	NCHEU	6 251	7 500	8 500	9 500	10 500	11 946	12 000	12 000	12 000	12 000	12 492	12 100	11 700	11 300	10 900	10 490	9 900	9 300	8 700	8 000	7 354	214 433
	DEDZA	17 675	18 000	19 000	20 000	21 000	21 762	22 000	22 000	22 000	22 000	21 116	20 100	19 100	18 100	17 100	16 225	13 800	12 400	10 000	7 600	4 264	365 242
	LILONGWE	22 201	27 600	33 000	38 400	43 800	49 150	46 000	43 000	40 000	36 000	33 381	27 000	21 000	15 000	8 000	2 080	1 700	1 400	1 100	800	457	491 069
	SALIMA	14 686	14 700	14 800	14 900	15 000	15 050	14 700	14 300	13 900	13 500	13 285	12 200	11 200	10 200	9 200	8 203	7 700	7 200	6 700	6 100	5 587	243 211
	DOWA	1 356	2 500	3 700	5 000	6 300	7 673	8 700	9 700	10 700	11 700	12 882	16 500	20 100	23 700	27 300	31 231	27 000	23 000	19 000	15 000	10 800	293 842
	NTCHISI	12 307	12 000	11 600	11 200	10 900	10 678	10 700	10 800	10 800	10 900	10 931	10 300	9 700	9 100	8 500	7 821	7 800	7 700	7 700	7 600	7 500	206 537
	MCHINJI	27 281	26 000	25 000	24 000	23 000	21 605	20 600	19 600	18 600	17 600	1 674	15 800	14 900	14 000	13 000	12 011	12 000	12 000	12 000	12 000	12 398	370 133
	KASUNGU	21 329	21 000	21 000	20 000	20 000	20 046	19 500	19 000	18 500	18 000	17 356	16 700	16 000	15 300	14 500	13 748	12 800	11 900	11 100	10 100	9 378	347 255
	NKOTAKOTA	5 017	5 300	5 600	5 900	6 100	6 376	6 300	6 300	6 300	6 300	6 342	6 100	5 800	5 500	5 200	4 972	4 600	4 300	4 000	3 700	3 525	113 532
SOUTHERN	CHIPADZULU	660	600	500	400	400	340	400	400	400	400	440	400	400	400	400	397	300	300	200	200	164	8 050
	MZANDE	50 372	48 000	45 000	44 000	42 000	39 151	37 000	35 000	33 000	30 000	28 718	26 700	25 100	23 300	21 500	19 793	18 000	16 000	14 000	12 000	9 613	613 227
	CHIWAWA	177 754	165 000	144 000	141 000	132 000	120 369	111 000	101 000	96 000	89 000	81 306	75 000	69 000	63 000	57 500	52 644	48 000	44 000	40 000	36 000	31 999	172 062
	CLCA	2 230	2 100	1 900	1 700	1 500	1 193	1 300	1 100	900	700	656	600	600	600	600	620	500	500	400	400	328	20 723
	MULANJE	4 578	3 800	3 100	2 400	1 700	752	800	700	600	500	381	400	400	400	400	440	400	400	300	300	285	23 236
	ELANTYRE	1 030	5 000	9 000	13 000	17 500	22 810	24 200	25 600	27 000	28 500	30 153	27 000	24 000	20 900	17 700	14 568	11 000	8 000	5 000	2 000	340	334 301
	ZOMBA	6 041	8 400	10 800	13 200	15 800	18 483	15 000	12 000	9 000	8 500	2 404	1 000	500	0	0	4	0	0	100	100	117	118 449
	KASUPE	1 024	1 000	900	800	800	779	800	800	900	900	907	1 000	1 300	1 700	2 200	2 738	2 800	2 800	2 900	3 000	3 101	33 149
	FT JOHNSTON	3 529	5 900	8 300	10 500	12 700	14 693	15 100	15 500	15 900	16 300	16 735	16 300	15 900	15 500	15 100	14 749	13 800	13 000	12 200	11 600	10 599	273 915
		4067																					

NOTE Figures for 1970 1975 1980 and 1990 have been obtained from Appendix 17 (col 13 + col 16)
Figures for intermediate years have been interpolated.

GRAND TOTAL £6 937 530

APPENDIX 21

Feeder Road Programme 1969 - 1990
Upgrading or Construction

1	2	3	4	5	6	7
Region	District	Total benefits 1970-1990 present value basis £	Total costs, upgrading + change in maintenance costs per kilometre present value basis) £	Kilometres of upgrading justified (earth to gravel standard) Km	Total costs of new roads + change in maintenance costs per kilometre present value basis £	Kilometres of new earth road justified. Km
Northern						
	Chitipa	193089	2381	81	469	412
	Karonga	189085	2381	79	469	403
	Nkhata Bay	146517	2381	62	469	312
	Rumpi	194012	2381	81	469	414
	Mzimba	419891	2381	176	469	895
	Total			479		2436
Central						
	Ncheu	214433	2381	90	469	457
	Dedza	365242	2381	153	469	779
	Lilongwe	491069	2381	206	469	1047
	Salima	243211	2381	102	469	519
	Dowa	293842	2381	123	469	627
	Ntchisi	206537	2381	87	469	440
	Mchinji	370133	2381	155	469	789
	Kasungu	347255	2381	146	469	740
	Nkotakota	113532	2381	48	469	242
	Total			1110		5640
Southern						
	Chiradzulu	8050	2381	3	469	17
	Nsanje	613227	2381	258	469	1308
	Chikwawa	1725062	2381	725	469	3678
	Cholo	20723	2381	9	469	44
	Mlanje	23236	2381	10	469	50
	Blantyre	334301	2381	140	469	713
	Zomba	118449	2381	50	469	253
	Kasupe	33149	2381	14	469	71
	Ft. Johnston	273915	2381	115	469	584
	Total			1324		6718
			Grand Total	2913	Grand Total	14794

Note: The above distances for upgrading and new construction are not exclusive of each other and are therefore dependent of alternatives.

Total expenditure in evaluation period (range) £6,9000,000.
(i.e. 2913 x £2381 or 14794 x £469)

APPENDIX 22

Road design standards

Authority	Class	Terrain	Design Speed m.p.h Desirable	Design Speed m.p.h Minimum	Gradients % Desirable	Gradients % Maximum	Curvature-radius feet Desirable	Curvature-radius feet Minimum	Paved Width feet	Formation Width feet	Shoulder feet
Malawi MOWES Roads Branch	I	Normal Mountainous	60 50	50 40	4 5	5 7.14	3,000 1,000	800 500	22 22	32 32	5 5
	II	Normal Mountainous	50 40	50 30	5 6.7	6.7 8.4	2,000 500	250 230	18 18	32 32	7 7
	III	Normal Mountainous	40 30	30 25	6.7 8.4	8.4 10	500 300	250 200	16 16	24 24	4 4
	IV	Normal Mountainous	40 30	30 25	6.7 8.4	8.4 10	500 300	250 200	12 12	24 24	6 6
	Crop extraction development roads	Not specified. earth surfaces: cut + fill, 24 to 26 feet cleared width, running surface 12 feet approx.									
Various Typical Values	Primary	Flat rolling Hilly Mountainous	70 50 35	50 35 25	-	4 5 to 7 7 to 9	600 to 1 200 minimum 300 to 600 minimum 150 to 300 minimum		20 to 24 20 to 24 20 to 24	32 to 42 32 to 42 26 to 32	
	Secondary	Flat rolling Hilly Mountainous	50 35 30	40 30 20	-	5 5 to 7 7 to 9	350 to 600 minimum 250 to 350 minimum 110 to 250 minimum		20 to 22 20 to 22 20 to 22	32 to 40 32 to 40 26 to 30	
	Feeder	Flat rolling Hilly Mountainous	35 30 20	30 20 15	-	7 7 to 9 9 to 12	250 to 350 minimum 110 to 250 minimum 70 to 110 minimum		18 to 20 18 to 20 18 to 20	24 to 26 24 to 26 24 to 26	
IBRD (World Bank)	Primary	Level and rolling Hilly Mountainous	63 44 34	44 34 25	- 5 7	4 7 9	990 493 328	493 328 164	21½ to 24 20½ to 24 20 to 24	27½ to 30 25½ to 30 23½ to 30½	Cut 6 fill 6 cut 5 fill 6 cut 3½ fill 6½
	Secondary	Level and rolling Hilly Mountainous	50 38 31	38 31 22	- 5 7	5 7 9	659 395 264	395 264 132	19½ to 23 19 to 23 18 to 21½	24½ to 29½ 22½ to 29½ 21½ to 28	cut 5 fill 6½ cut 3½ fill 6½ cut 3½ fill 6½
MEXICO	Type C Rural Roads	Level ground and low hills	44	31	3	5	maximum degree of curve 16° 30'		23		
		Mountainous terrain	38	25	4	6	maximum degree of curve 26°		23		
		Steep mountainous terrain	25	19	4.5	6.5	maximum degree of curve 47°		21½		
		Very steep mountainous terrain	21	16	5.0	7.0	maximum degree of curve 67°		19½		

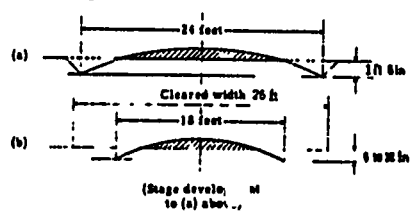
Planning and Research for Road Transport in Developing Countries by R.S.P. Bonny and R.S. Millard Conference on Civil Engineering Problems Overseas pp 191-205 June 1966.

World Highways December 1967 Vol. XVII No.12.

NOTE

1. Cut + Fill
2. Cross sections shown represent standards for gently undulating country

Development or Crop Extraction Roads, Malawi



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TRAFFIC CENSUS FORM AS USED BY M.O.W.& S.

TRAFFIC NUMERICAL CENSUS 1968

Date 8th/9th May 1967 Day Monday Season Dry Grade 1 Location 7

Local market days Daily Road conditions Dry

Local conditions Dry sunny day

Visual count station All Sykes automatic count stations All

Station

	TRUCKS				TRUCKS AND TRAILERS		
	UNDER 3T	3T ~ 5T	5T ~ 10T	OVER 10T	3T ~ 5T	5T ~ 10T	OVER 10T
1	32	4	26	=	=	=	=
2	31	8	26	2	=	=	=
3	48	9	20	=	=	=	=
4	30	5	5	=	=	=	=
5	35	7	8	=	=	=	=
6	9	3	3	=	=	=	=

	BICYCLES	MOTORCYCLES	CARS	BUSES	OFFICE USE	SYKES 6 PM	SYKES 6 AM
1	=	=	31	2		89	22
2	=	=	38	7		117	11
3	=	=	38	2		117	26
4	=	=	32	=		72	11
5	=	=	36	3		89	17
6	=	=	9	3		24	13

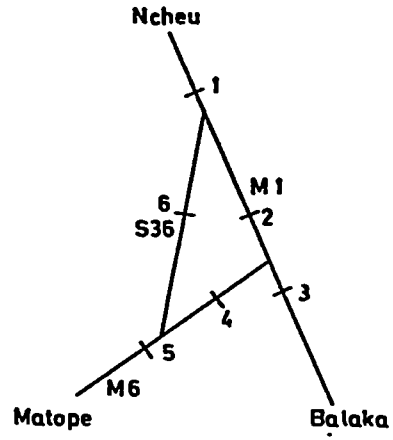
STATION	1	2	3	4	5	6
SYKES 24 HRS	111	123	143	83	106	37
STATION						
SYKES 24 HRS						

Signed

Rayen

Clerk i/c

Ref 1/7 N.W. of Balaka



When completed this form must be returned immediately to :-

C.P. E. (Roads)
Ministry of Works,
P.O. Box 45,
Zomba.

APPENDIX 24

Results of moving vehicle traffic counts

Road	Duration of count	Vehicles encountered excluding bicycles motorcycles, ox-carts	Possible A.D.T. (approximate only)
S 62 Chiradzulu	2.45 pm – 4.10 pm Single journey only	1 Landrover 1 Bus 1 Lorry. 6 Cars	108
S 41 Palombe plain	8.40 am – 11.10 am Single journey only	2 Landrovers 7 Trucks 3 Cars	77
S 69 L Chilwa	11.10 am – 1.00 pm	1 Truck 1 Bus 1 Car	26 50 say
	2.00 pm – 3.00 pm return journey	3 Trucks 1 Car	64
S 56 Liwonde Forest Reserve	1.55 pm – 3.05 pm Single journey only	2 Trucks 1 Landrover 1 Car	55
D 221 Liwonde	3.05 pm – 4.00 pm Single journey only	Nil	
D 240 Lirangwe	1.55 pm – 3.20 pm Single journey only	1 Truck 3 Cars 2 Landrovers	68
D 236 Blantyre	4.40 pm – 5.00 pm	3 Cars	
D 32 Lilongwe	8.28 am – 8.37 am	Nil	Sunday traffic
D 31 Malingunde	8.37 am – 9.20 am	2 Cars 1 Bus	Sunday traffic
D 46 Namitete	10.00 am – 11.30 am	Nil	Sunday traffic
S 70 Walkers Ferry	11.15 am – 11.45 am	1 Car	
D 147 Mlanje	3.10 pm – 4.15 pm	3 Trucks 1 Car	Public Holiday
S 43 Fort Lister	4.15 pm – 5.20 pm	Nil	Public Holiday
S 40 Palombe	5.30 pm – 6.10 pm	2 Cars	Public Holiday
D 85 Madisi	3.35 pm – 4.05 pm	Nil	

APPENDIX 24 (Continued)

Results of moving vehicle traffic counts

Road	Duration of count	Vehicles encountered excluding bicycles motorcycles, ox-carts	Possible A.D.T. (approximate only)
D 82 Mponela	4.05 pm - 4.42 pm	1 Light van 1 Truck	52
D 48 from M1 to just past the Bembeke Mission	9.47 am - 10.10 am Single journey only	1 Landrover	-
D 48 Bembeke Mission to D50 Mua Mission	10.10 am - 12.30 pm Road virtually impossible - two hours to travel six miles down escarpment	Nil	-
D 50 to Ntakataka	12.30 am to 12.40 pm and return 12.50 to 1.00 pm	1 Truck (MOW & S) 1 Truck (MOW & S)	
D 50 Mua Mission to 522 junction	1.00 pm to 1.30 pm single journey only	1 Landrover 1 Pick up	
522 to M1 Massasa	1.40 pm to 2.30 pm	Nil	

APPENDIX 25

Derivation of traffic flow in terms of vehicle-kilometres per year

Numbers of vehicles of all types were obtained from the Road Traffic Commissioner. Excluding motor cycles, road construction vehicles and government vehicles there was a total of 13,177 vehicles as at 31st December 1967.

A breakdown of types was made as follows:

Passenger cars	8268
Light lorries (<3 tons carrying capacity)	2992
Heavy lorries (>3 tons carrying capacity)	1528
Light tractors (<3 tons carrying capacity)	381
Heavy tractors (>3 tons carrying capacity)	8
	13177

A comparison was made with the classification used by de Weille [15] and the following grouping made

de Weille	Malawi	No. of vehicles	Average distance travelled per year be each vehicle kilometres (de Weille)
Passenger car	passenger car	8268	15.3 x 1000
Truck Type I	Nil	Nil	14.5 x 1000
Truck Type II	light lorries light tractors	2992 381 3373	22.5 x 1000
Truck Type III	heavy lorries heavy tractors	1528 8 1536	96.5 x 1000
Truck Type IV	Nil	Nil	112.6 x 1000

Using flow values in Appendix 8 and the ratios between vehicle types figures for flows of different vehicles on the three types of road surface were obtained: thus

Cars total 8268

No. on bitumen	8268 x 658/716	= 7598
No. on gravel	8268 x 35/716	= 404
No. on earth	8268 x 23/716	= 266

Type II vehicles total 3373

No. on bitumen	3373 x 305/365	= 2818
No. on gravel	3373 x 36/365	= 333
No. on earth	3373 x 24/365	= 222

Type III vehicles total 1536

No. on bitumen	1536 x 218 280	1197
No. on gravel	1536 x 10 280	220
No. on earth	1536 x 22 280	= 119

From these figures the vehicle-kilometres for each vehicle type according to road surface have been calculated

e.g.

Gravel	Type II	333 vehicles, 22.5 x 1000 km. per year (de Weille)
surface	hence	333 x 22.5 x 1000 = 7492.5 x 1000 veh. km. per year

The results have been tabulated and are contained in the body of the report in Table 18.

APPENDIX 26

Origin and Destination Surveys : Summary of Methods [36]

Five main methods of carrying out origin-and-destination surveys are available:

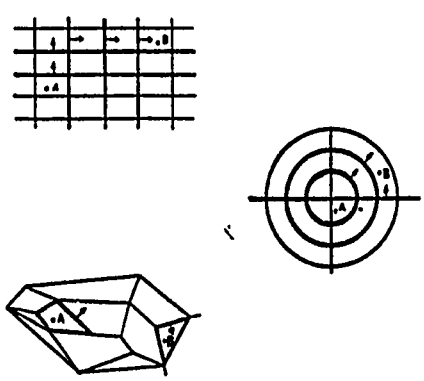
1. By roadside interview,
2. By giving postcards to drivers,
3. By noting registration numbers,
4. By placing tags on vehicles and
5. By home interview.

Roadside Interview

Vehicles are stopped at a number of points and drivers are questioned about their journeys.

The survey stations are usually situated at points where the road system intersects one or more cordons; these are chosen to intercept all important movements in the area under consideration.

Layout of cordons for roadside interview and postcard origin and destination surveys



(a) rectangular grid of cordons

(b) ring and radial cordons

(c) irregular network of cordons

One arrangement uses two sets of cordons at right angles to form a rectangular grid as in fig. (a). An alternative arrangement particularly suited to a single town has a series of cordons round the city centre combined with radial cordons, fig. (b). If the movements being studied are mainly in one direction at each point in the area one set of cordons may suffice, e.g. radial cordons may not be needed in towns. Short cordons that divide the area into irregular zones, fig. (c) can be used but it is more difficult to make efficient use of the data. Both directions of traffic at a survey station should be interviewed.

The questions asked depend on the purpose of the survey and are usually designed to determine the last point that the vehicle needed to be at and the next point to which it needs to go. This information may be obtained by direct questioning or by a series of questions:

e.g. Where did you start this journey?
Have you made any calls since you left there?
(if answer is yes) Where was the last place at which you called?

If the origin or destination of a journey is a considerable distance from the area being considered it may be decided that the point of entry to or exit from the area will be unchanged by any modification to the road layout. If so, the questions should be designed to determine the point of entry or exit. The questions put to drivers of commercial vehicles are sometimes different from those put to drivers of cars so that each is most likely to give the correct answers.

The main disadvantage of the roadside interview is that drivers are delayed while being interviewed.

Postcard Method

This method involves asking each driver to complete and return a prepaid postcard given to him as he passes one of a number of selected points. The method is basically similar to the roadside interview method. Vehicle delay is negligible and the method is simpler and cheaper than most.

Registration Numbers

Observers, stationed at points forming a cordon, record registration numbers of vehicles entering and leaving an area. The results are analysed by comparing the two lists of registration numbers one for vehicles entering the area and the other for vehicles leaving it. Each registration number that occurs in both lists corresponds to a vehicle movement between the two points where the number was observed. Registration numbers that occur in one list only are assumed to represent journeys, which originate or finish inside the area. It is usually an advantage to record times of entry and exit as this information can be used to determine journey times.

The advantages of this method are that traffic is not normally delayed and that police control is not usually necessary. The disadvantages are, a large number of observers is needed since recording must be done at all points simultaneously. Information about each journey is limited to point of entry and exit from the area being studied; neither the original nor the destination is obtained. Mistakes in recording can be a serious source of bias, e.g. a through journey which has one of its registration numbers recorded incorrectly will be recorded as two terminating journeys instead of one through journey.

Tagged vehicle method

Coded tags are placed on vehicles as they enter an area and are taken off when they leave it. Times of entering and leaving may be marked on the tags so that journey times can be determined. The method is similar to the registration number method but errors are less likely and analysis is easier. The disadvantage is that drivers may object to the tags and may remove them.

Home interview

A sample of the population is interviewed in their homes. The proportion of households that are interviewed normally lies between 1 and 10 per cent, and it is customary to obtain information on the journeys of all members of the households. The questions asked depend on the object of the study but it is usual to obtain details of journeys made by persons or vehicles on the previous day or days. The method is particularly suitable for studying traffic demands in large urban areas. Unlike other methods it enables information to be obtained on journeys, by public transport (bus, rail etc.) and on foot. This method is expensive and requires detailed planning and trained interviewers, but the possibility of bias is small and errors and omissions are unlikely as the interviews can be carried out unhurriedly.

APPENDIX 27

Forecasting of future numbers of vehicles – British Method[56]

Economic forecasting of the numbers of vehicles which will be licensed in the future is considered to be an extremely risky undertaking and lacking in a high degree, the reliability desirable. Nevertheless the value of such forecasts is such that the attempt is worth making. Trends over the next 20 years or so are obviously important in relation to proposed road improvement; while trends over 50 years or so are necessary in considering the provision of garage space in new housing areas.

In Great Britain we are concerned with numbers of vehicles per head of population and the rate of increase of this quantity. For Great Britain the number of vehicles means the number of motor vehicles licensed at any time in the three months ending September.

Four classes of vehicles are distinguished

i Cars	(classified by c.c. or by h.p.)
ii Motor cycles	(including mopeds, scooters, combinations)
iii Agricultural tractors	
iv Other vehicles	(including commercial vehicles, P.S.V's., taxis, pedestrian controlled vehicles, other tractors).

The population figures used are the mid-year estimates of the 'de facto' population made by the Registrars General for England and Wales and for Scotland and include persons of all ages including children.

The basic quantity to be studied is vehicles per head of population (that is for the four classes of vehicles). Forecasts are made (for the 50 years from 1960 say for each of these classes) by using projections of the population (made by the Government Actuary in Great Britain). For each class of vehicle therefore a curve is required stretching from say 1960 – 2010. It will be postulated

firstly that this will be a smooth curve and various assumptions have to be made, e.g. that there will be no major social or economic event which would cause sharp changes in the development of the numbers of vehicles per head: that there are no catastrophic events (such as World War III) that there will be no substantial substitution by other means of transport, such as helicopters, for which motor vehicles are at present used. It seems reasonable to suppose that as well as being smooth the growth curve should continue the curve of growth experienced in the immediate past. The algebraic form of the forecast curves is largely open to choice. It must have at least three constants that can be filled. If there were only two the whole curve would be determined by the current numbers of vehicles per head and its rate of growth. On the other hand it is improbable that the reliability of any forecasts would be such as to justify more than three constants.

A type of curve often used to represent growth in both social and biological phenomena, is the Logistic Curve. It has three constant and tends upwards towards a limit with the passage of time. The percentage rate of growth decreases steadily as the upper limit is approached. This curve is used for the forecasts of the number of vehicles *per head*. Forecasts of the number of vehicles follow a slightly less regular curve, since the predicted population growth is not quite uniform. To find the *third* constant required to determine the forecast curve it is necessary to estimate the upper limit, i.e. the maximum number of vehicles per head that will ever be demanded (Saturation Level).

The Saturation Level for cars in Great Britain has been taken as 0.40 cars per person. This is regarded as a conservative estimate. For motor cycles a Saturation Level of 0.06 has been assumed, and for agricultural tractors a value of 0.01. For 'other vehicles' a Saturation Level of 0.08 'other vehicles' per head has been assumed but is not a figure in which much confidence is placed. Adding the saturation levels for the four separate classes of vehicles gives 0.55 motor vehicles per person. This value was already exceeded in 1960 in four states in the United States.

The forecast

Basic calculations.

The three constants	i	ownership per head in base year (1960)	X
	ii	assumed rate of increase of ownership	r
	iii	saturation level	a

are required to be known.

These are substituted in the Logistic Equation.

$$x = \frac{aX}{X + (a - X)e^{-art/(a-X)}}$$

The derivation of this equation is given below.

This formula may be used to estimate for the whole range of vehicles by using it separately for the different types and summing the results.

The Logistic Curve : Derivation of logistic equation

Denote time by 't' and vehicles per head by x.

For base year (1960) t = 0 and x = X.

The most general logistic growth formula satisfies the differential equation:

$$\frac{dx}{dt} = cx\,(a-x) \qquad \ldots\ldots (1)$$

where c and a are constants. The solution to equation (1) is:

$$x = \frac{a}{1 + be^{-act}} \qquad \ldots\ldots (2)$$

This is an S–shaped curve, asymptotic to x = 0 as t approaches – infinity and to x = a as t approaches + infinity.

Equation (1) shows that the percentage rate of increase of x is 100 (a–x)c.

i.e. it is proportional to the difference between x and its asymptotic value a.

If equation (2) is to give x = X when t = 0 then:

$$X\,(1 + b) = a \qquad \ldots\ldots (3)$$

If, further the percentage rate of growth at t = 0 is known to be 100r per cent per year, then

$$c\,(a - X) = r \qquad \ldots\ldots (4)$$

Formula (2) may thus be put into the form.

$$x = \frac{aX}{X + (a - X)e^{-art/(a-X)}} \qquad \ldots\ldots (5)$$

in which the only unknown is the asymptotic level, a.

Thus a logistic curve can be found to correspond with the current actual level of vehicles per head and with the current actual percentage rate of increase of vehicles per head. The curve is uniquely determined by fixing the asymptotic level.

APPENDIX 28

A comparison of the costs of Capital (that is, Plant) and Labour Intensive methods of road construction

The following note based on information obtained outside Malawi indicates how such a comparison can be made provided certain basic data are available on costs, taxes, and plant and labour outputs.

Information is first required on depreciation and maintenance of plant, fuel and operator costs, fuel and oil taxes, plant and labour outputs for various operations and the works common to both methods of construction.

The figures quoted as an example here do not necessarily apply to Malawi but can be modified to confirm to local conditions.

The comparison is most easily made, in steps, in tabular form as follows: costs are quoted in East African shillings.

1. Hourly costs

Item of Plant	Depreciation and maintenance E.A. shillings	Fuel E.A. shillings	Operator E.A. shillings
D. 811A tractor	52.00	29.38	2.54
Dozer blade	6.00	–	–
D. 811 tractor	70.00	36.72	2.54
Scraper 80	27.00	–	–
Angle dozer blade	6.00	–	–
Ripper	8.89	–	–
19 RB face shovel	23.00	7.34	4.37
7–ton tipper truck	15.89	5.88	2.38

Depreciation and maintenance costs include an annual licence charge of 100 E.A. Shillings for construction plant and say 88 E.A. Shillings for a 7–tons tipper truck.

Using an industrial average of 200 working hours per month which allows for holidays and other non-working time: the hourly taxation deductions become

(a) Plant, $\frac{100 \text{ sh.}}{12 \times 200} = 0.04$ shillings

(b) Tippers $\frac{880 \text{ sh.}}{12 \times 200} = 0.37$ shillings

Unskilled labour is reckoned to have an economic cost to the country (Malawi) in the long term of 2.15 kilograms maize equivalent per man hour which in certain conditions can be equated to about sixpence per hour, that is, about four shillings per day. This is above the present statutory minimum wage in Malawi but due to future labour supply constraints, is considered to be a reasonable long term reflexion of the opportunity cost of labour for use in this study.

Costs for operators and drivers are the standard industrial rates, including costs of social security contributions, holiday pay etc. (See note (a) below). No profits or overhead allowances are included and the capital cost of the machines is depreciated over their expected useful lives.

Fuel cost used in the calculations is 4.08 E.A. shillings per gallon and the tax element 1.75 E.A. shillings per gallon; the tax element is thus $\frac{175}{408} \times 100 = 42.89$ per cent.

The fuel costs are thus reduced to 57.11 per cent of those shown above, since fuel tax is an internal transfer payment.

Note (a) The employer's social security contribution on behalf of the employee should be included but *not the employee's;* as indicated in the paper on the value of time [12].

2. The Economic hourly costs can now be calculated as in the following table

Economic hourly costs

Item of Plant	Depreciation and maintenance E.A. shillings	Fuel E.A. shillings	Operator E.A. shillings	Total E.A. shillings
D 814A tractor	51.96	16.75	2.54	71.25
Dozer blade	6.00	–	–	6.00
D 811 tractor	69.96	20.93	2.54	93.43
Scraper 80	26.96	–	–	26.96
Angle dozer blade	6.00	–	–	6.00
Ripper	8.89	–	–	8.89
19 RB face shovel	22.96	4.18	4.37	31.51
7–tons tipper truck	15.52	3.35	2.38	21.25

3. An estimate needs to be made of plant and labour outputs. The following might serve as examples in Malawi until possibly more accurate values can be obtained.

Operation	Plant and labour outputs
Clear light bush	D 814A tractor and dozer blade clear 0.41 acres per hour 17 men clear 1 acre per day
Remove topsoil	D 811 tractor and Scraper 80 move 120 cu.yd. per hour 21 men move 50 cu.yd. per day
Cut to crossfall or camber	D 811 tractor and Angle dozer move 150 cu.yd per hour 21 men move 50 cu.yd per day
Clear medium bush	as for light bush
Excavate gravel	D 811 tractor with dozer blade and ripper move 100 cu.yd. per hour
Load gravel and transport to site	19 RB face shovel and 3 7–ton tipper trucks load 31 cu. yd. per hour 21 men and 3 7–ton tipper trucks load 85½ cu.yd. per day

4. Works common to both methods need not be considered. These might be listed as

(a) Drainage culverts (hand)

(b) Compaction and watering of earthworks and gravel surfacing (plant)

(c) Spreading gravel and fill (plant)

(d) Final cleaning up and tidying of shoulders and verges (hand)

5. A comparison of costs can now be made as in the following table for say 1 mile of 12 feet wide gravel road.

Operation	Unit	Quantity	Labour		Plant	
			Rate	Amount	Rate	Amount
Clear light bush	Acre	5.25	17 x 4.00 = 68.00 sh.	357.00	(71.25 + 6.00) x 1 / 0.41 = 188.41 sh.	989.15 sh.
Remove topsoil	Acre					
Total				X		Y

6. The difference in costs can thus be obtained by comparing the two totals X and Y. These costs do not represent the full cost of constructing a mile of road; they include only those items which would be carried out by the two different methods.

Such a comparison as this could be done in Malawi and applied to districts where wages and plant operating costs differ in order to determine the particular method most economical for the prevailing local conditions.

APPENDIX 29

Direct Works and Economic Costs (at Present Values) of road maintenance, according to road classification

based on 1967 figures – per mile of road

Road Classification	Road Surface	Traffic	Basic Maintenance		Regravel every six years				Regravel every six years				Total Costs			
					22 feet width		12 feet width		22 feet width		12 feet width					
			Direct	Economic	Direct	Economic	Direct	Economic	Direct	Economic	Direct	Economic	Direct		Economic	
			P.V. Year 1 / P.V. 1 to 20 Years	P.V. Year 1 / P.V. 1 to 20 Years	P.V. Year 1 / P.V. 1 to 20 Years	P.V. Year 1 / P.V. 1 to 20 Years	P.V. Year 1 / P.V. 1 to 20 Years	P.V. Year 1 / P.V. 1 to 20 Years	P.V. Year 1 / P.V. 1 to 20 Years	P.V. Year 1 / P.V. 1 to 20 Years	P.V. Year 1 / P.V. 1 to 20 Years	P.V. Year 1 / P.V. 1 to 20 Years	Present Values 1 to 20 years			
		V.P.D	£	£	£	£	£	£	£	£	£	£	22 ft £	12 ft £	22 ft £	12 ft £
M	BITUMEN	120 (average)	140 / 1 050	120 / 900	430 / 2 296	368 / 1 965	300 / 1 602	257 / 1 373					3 346	2 652	2 865	2 273
		150	150 / 1 125	128 / 960	600 / 3 204	511 / 2 739							4 329		3 699	
	GRAVEL	55 (average)	160 / 1 200	137 / 1 028					150 / 801	128 / 684	110 / 587	94 / 502	2 001	1 787	1 712	1 530
		60	165 / 1 238	141 / 1 058					175 / 935	150 / 801			2 173		1 859	
		100	175 / 1 313	149 / 1 118					325 / 1 736	279 / 1 490			3 049		2 608	
	EARTH	90 (average)	80 / 600	68 / 510									600		510	
		100	300 / 2 250	257 / 1 928									2 250		1 928	
S	GRAVEL	45 (average)	110 / 825	94 / 705					150 / 801	128 / 684	110 / 587	94 / 502	1 626	1 412	1 389	1 207
		100	120 / 900	103 / 773					380 / 2 029	329 / 1 756			2 929		2 507	
	EARTH	80 (average)	70 / 525	60 / 450									525		453	
		100	300 / 2 250	257 / 1 928									2 250	Width variable 1 928		
D	EARTH	18 (average)	60 / 450	51 / 383										450		383

P.V. = Present Value.

APPENDIX 30

Note on the estimation of the economic cost of road maintenance

Within the Ministry of Works and Supplies the determination of the financial and economic costs of road maintenance is difficult. This is due to the costing system which does not provide sufficient allocation and breakdown of individual costs and to the costs of various items being contained in a number of votes. Thus the cost of a job as indicated in the estimates is not a true reflexion of the cost to the Department. The following breakdowns were obtained for 1967 maintenance costs and are used to indicate how approximate figures of Direct Works costs and Economic costs were obtained.

For 1967 maintenance 'overheads' were equal to 100 per cent of the quoted departmental costs. The breakdown of 'overheads' was as follows

1. Personal emoluments	(a) H.Q. Supervision and Planning	⅓ x 28%
	(b) Site supervision	⅔ x 28%
2. H.Q. administration, postal services, telephones etc.		17%
3. Maintenance of plant		22%
4. Replacement of plant		33%
	Total	100%

Total Direct Works Cost = Quoted departmental cost + 100%
= 2 x quoted departmental cost

To obtain the Direct Works Marginal Economic Cost items 1 (a) and 2 are subtracted from the Direct Works cost and a further deduction (qv) is made to eliminate transfer payments.

Item 3 includes an element of taxes on materials and which should be taken off as should the fuel tax. Since only limited information is available on the proportions of these quantities, 5 per cent has been deducted to account for them and also for an element of social security payments.

Item 4 includes a proportion for depreciation which should be removed as the original cost included tax. As only limited figures are available a deduction of 5 per cent of the replacement of plant cost is removed. Thus to arrive at the Economic Cost the following calculations have been made.

Departmental Cost + 'Overheads' = Total cost or Direct Works Cost
i.e. Departmental cost + 100% = Direct Works Cost for *1967* figures
Direct Works Marginal Economic Cost = Direct Works Cost – Item 1 (a) - Item 2 - 5% of Item 3
5% of Item 4

$$E = \text{Direct Works Cost} - \left[\frac{1}{3} \cdot \frac{28}{100} + \frac{17}{100} + \frac{5}{100} \cdot \frac{22}{100} + \frac{5}{100} \cdot \frac{33}{100}\right] \times \text{'Overheads'}$$

$$E = \text{Direct Works Cost} - \frac{29}{100} \text{ ['Overheads']}$$

Note The quantity $\frac{29}{100}$ ('Overheads'), is what is customary to refer to as the normal overheads. As a proportion of the Direct Works Cost they amount in this particular case to 14.5 per cent which is a reasonable figure.

APPENDIX 31

Road construction costs by type of road, per mile of road.

(New road construction)

(Contract prices as at 31st December, 1967).

Item			Class IV gravel	Class III gravel	Class II gravel	Class I bitumen 12 ft	Class I bitumen 22 ft
Formation width		ft.	24	24	32	32	32
Running surface		ft.	12	16	18	12	22
Field survey		£	275	275	275	275	275
Materials survey		£	89	89	89	89	89
Design		£	50	50	50	50	50
Aerial photography		£	80	80	80	80	80
Air photographs		£	13	13	13	13	13
Earthworks	Light	£	2 250	2 250	3 000	3 000	3 000
including	Medium	£	4 500	4 500	6 000	6 000	6 000
compaction	Heavy	£	6 750	6 750	9 000	9 000	9 000
at 6/-s per cu. yd.							
Culverts	Light	£	900	900	1 000	1 200	1 400
£ 100 each 30 ft.	Medium	£	1 800	1 800	2 000	2 400	2 800
£ 90 each 24 ft.	Heavy	£	2 700	2 700	3 000	3 600	4 200
Bridges	Single Width	£	750	750	1 500	1 500	1 500
£ 750 single light	Double Width	£	1 000	1 000	2 000	2 000	2 000
£1 000 double light							
£1 500 single heavy							
£2 000 double heavy							
Sub-base							
4 in. gravel at 21/-s per cu. yd. compacted		£				822	1 507
Base							
6 in. gravel at 21/-s per cu. yd. compacted		£	1 232	1 642	1 848	1 232	2 259
Shoulders							
(2) Total thickness feathered to nil over 2 ft. at 21/-s per cu. yd. compacted		£	205	205	205	342	342
Stabilization							
4 per cent cement at £20 per ton, over running surface plus 2 ft.		£				1 370	2 350
Stabilization							
processing and compaction at 50 per cent of cement cost		£				685	1 175
Surfacing						Single / Double	Single / Double
Single or double surface dressing							
Prime							
M.C.O., .15 gall. per sq. yd. at 3/4d. per gallon						176 / 176	323 / 323
First Seal							
80/100 pen at .22 gall. per sq. yd. at 2/11d. per gallon		£				225 / 225	415 / 415
Second Seal - as First		£				225	415
Losses - 10 per cent		£				40 / 63	74 / 116

APPENDIX 31
(continued)

Item		Class IV gravel	Class III gravel	Class II gravel	Class I bitumen 12 ft.		Class I bitumen 22 ft.	
					Single	Double	Single	Double
Chippings ½in. at 90 sq. yd. per ton at 60/-s per ton	£				235		431	
Spreading Bitumen and chippings - 50 per cent of cost of bitumen and chippings	£				338		622	
Double Surface Dressing First application ¾ in. 70 sq. yd. per ton at 60/-s. per ton	£					301		552
Second application 3/8 in. 110 sq. yd. per ton at 60/-s. per ton	£					192		353
Spraying and spreading at 50 per cent of cost bitumen and chippings	£					591		1 087
Total for surfacing	£				1 014	1 773	1 865	3 261
Total construction cost range, excluding compensation for loss of crops - range	£	5 844 to 12 394	6 254 to 12 804	8 060 to 16 560	11 672 to 20 572	12 431 to 21 331	15 905 to 25 205	17 301 to 26 601

NOTE The lower cost figure in each case refers to the condition of single width bridging, least number of culverts per mile and least amount of earthworks. The higher refers to the condition of double-width bridging, most culverts per mile and maximum earthwork. Other combinations can be obtained by summing the appropriate costs.

Compensation Average amounts paid on projects including 15 per cent H.Q. administration cost.	£	30	30	40	40	40	40	40
Total Contract Cost (including 15% profit)	£	5 874 to 12 424	6 284 to 12 834	8 100 to 16 600	11 712 to 20 612	12 471 to 21 371	15 945 to 25 245	17 341 to 26 641
Profit (15 per cent of basic contract cost)	£	766 to 1 621	820 to 1 674	1 050 to 2 165	1 528 to 2 639	1 627 to 2 788	2 080 to 3 293	2 262 to 3 475
Direct Works Cost	£	5 108 to 10 803	5 464 to 11 160	7 044 to 14 435	10 184 to 17 923	10 844 to 18 583	13 865 to 21 952	15 079 to 23 166
Marginal Economic Cost	£							
Direct Works Marginal Economic Cost [Direct Works Cost -14.5 per cent (overheads)]	£	4 367 to 9 237	4 672 to 9 542	6 023 to 12 342	8 707 to 15 324	9 272 to 15 889	11 855 to 18 769	12 893 to 19 807

APPENDIX 31
(continued)

In making these estimates of construction costs various assumptions have been necessary to allow for variations in terrain and drainage conditions.

For the purposes of calculation of the following values have been used per mile of road.

Earthworks (Volume)	Road Class IV and III	Road Class II and I
Light	7 500 cu. yd.	10 000
Medium	15 000 cu. yd.	20 000
Heavy	22 500 cu. yd.	30 000

Culverts (No. per mile)	Road Class IV and III	Road Class II	Road Class I Bitumen 12 ft.	Road Class I Bitumen 22 ft.
Light	10 at £90 each	10 at £100 each	12 at £100 each	14 at £100 each
Medium	20 at £90 each	20 at £100 each	24 at £100 each	28 at £100 each
Heavy	30 at £90 each	30 at £100 each	36 at £100 each	42 at £100 each

Bridges	Road Class IV and III	Road Class II and I
Single width	£ 750 per mile of road	£1 000 per mile of road
Double width	£1 000 per mile of road	£2 000 per mile of road

APPENDIX 32

Road construction costs for crop extraction and district roads (earth surface)

Item	Departmental cost per mile Stage (a)	Stage (b)
Planning, field survey, design	£50	£50
Earthworks, very variable	200	150
Culverts 25 /- per linear foot, say 16 ft culverts, i.e. £20 per culvert, say 5 culverts per mile	100	100
Bridges £500 – £2000 per bridge approximately £150 per mile	150	150
Total Departmental Cost	£500	£450
Add 100 per cent for Ministry and Departmental 'Overheads'	£500	£450
Total Direct Works Cost	£1000	£900
Direct Works Marginal Economic Cost = Direct Works Cost – 29 per cent of 'Overheads'	£1000– £145= £855	£900– £131= £769
Contract Cost = total direct works cost + 15 per cent profit	£1000+ £150= £1150	£900+ £135= £1035
Compensation for loss of crops and buildings	£25	£25

It must be emphasized that these figures are approximate only and refer to conditions of gently rolling ground requiring little earthmoving and a minimum of drainage works.

APPENDIX 33

Road construction costs of upgrading an earth road to Class IV Gravel standard

Item	Cost per mile
Field survey – assumed done before for Design the original road Materials survey – location of and testing gravel	nil nil £25
Earthworks – additional to those already done	£1100
Culverts – additional culverts, repairs and replacements	£350
Bridges – strengthening existing bridges replacing damaged parts	£325
Base – 6 in gravel over 12 ft width and shoulders	£715
Total Department Cost	£2515
Add 100 per cent for 'Overheads'	£2515
Total Direct Works Cost	£5030
Direct Works Marginal Economic Cost = Total Direct Works Cost – 29 per cent of overheads	£5030 – £729 = £4301
Contract Cost = Total Direct Works Cost + 15 per cent profit	£5030 + £755 = £5785

Note These figures are approximate and apply to gently undulating ground. Hilly ground would require greater earthworks. It is assumed that the pipe culverts and timber decks of bridges are not all replaced by concrete structures which would add appreciably to the cost.

APPENDIX 34

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(c) Accident Costs
(d) Valuation of the social benefits from a reduction in accidents
(e) Road journey costs

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APPENDIX 35

List of persons outside the Malawi Government contacted in Africa

His Excellency Thomas Tull, Esq., C.B.E., D.S.O.	British High Commissioner
K. J. Windsor	First Secretary British High Commission
Lt. Col. R. H. Garnett, M.B.E.,	Defence Adviser, ...
S. Othello Coleman	Executive Director I.B.R.D. (World Bank)
V. H. Gale, O.B.E.	Chairman, Malawi Development Corporation
..	Chairman, Malawi Railways
..	Acting Chairman, Farmers Marketing Board
D. G. Mann	Acting General Manager Malawi Railways
F. Lacey	Chairman, Motor Traders Association of Malawi
..	General Manager United Transport (Malawi) Ltd.,
E. A. Sanford	Manager, Shell (Malawi) Ltd.,
A. Mahommed, B. Bessani, K. Kunze	Malawi African Road Transporters Associated (MARTA)
T. Moser	U.S. AID Officer Malawi
J. Van Dijck	I.B.R.D. office, Nairobi, Kenya
R. G. Smith	Director, East Africa Transport Study for I.B.R.D. and East African Community Nairobi, Kenya
P. Arlidge	East Africa Transport Study, Nairobi, Kenya
J. D. G. F. Howe	East African Transport Planning Research Unit, Nairobi, Kenya
E. Irgens	Ministry of Works, Nairobi, Kenya

R. B. Olliver	Economist Intelligence Unit (South Africa), Johannesburg
D. R. Beatty	Ministry of Economic Affairs and Development Dar-es-Salaam, Tanzania
I. Smith	East Africa Transport Study, Nairobi, Kenya
G. Williams	Principal, The Polytechnic, Blantyre
R. M. Dean	Economic Adviser, I.B.R.D.
W. Jaycox	Economic Adviser, I.B.R.D.

APPENDIX 36

Metric equivalents as used in the calculations in this report

1 foot	=	0.3018 metres
1 yard	=	0.9144 metres
1 mile	=	1609.35 metres
	=	1.60935 kilometres
1 lb	=	0.45359 kilograms
1 ton (long)	=	1016.05 kilograms
	=	1.01605 metric tons
1 cu.yd	=	0 836131 sq. metres
1 acre	=	0.404687 hectares
1 sq. mile	=	259.0 hectares
	=	2.59 sq. kilometres
1 metre	=	3.2808 feet
1 kilometre	=	0.62137 miles
1 kilogram	=	2.20462 lbs
1 metric ton	=	0.9842 long tons
	=	2204.62 lbs
1 hectare	=	2.47104 acres

CODE OF SYMBOLS USED IN FIGURES 1 – 6

Region	District	Symbol
Northern	Mzimba	● MA
	Rumpi	● RI
	Nkata Bay	● NY
	Karonga	● KA
	Chitipa	● CA
Central	Ncheu	Δ NU
	Dedza	Δ DZA
	Lilongwe	Δ LE
	Salima	Δ SA
	Dowa	Δ DWA
	Ntchisi	Δ NI
	Mchinji	Δ MI
	Kasungu	Δ KU
	Nkotu Kota	Δ NA
Southern	Nsanje	O NE
	Chikwawa	O CA
	Cholo	O CO
	Mlanje	O ME
	Blantyre	O BE
	Zomba	O ZA
	Kasupe	O KE
	Fort Johnston	O FN

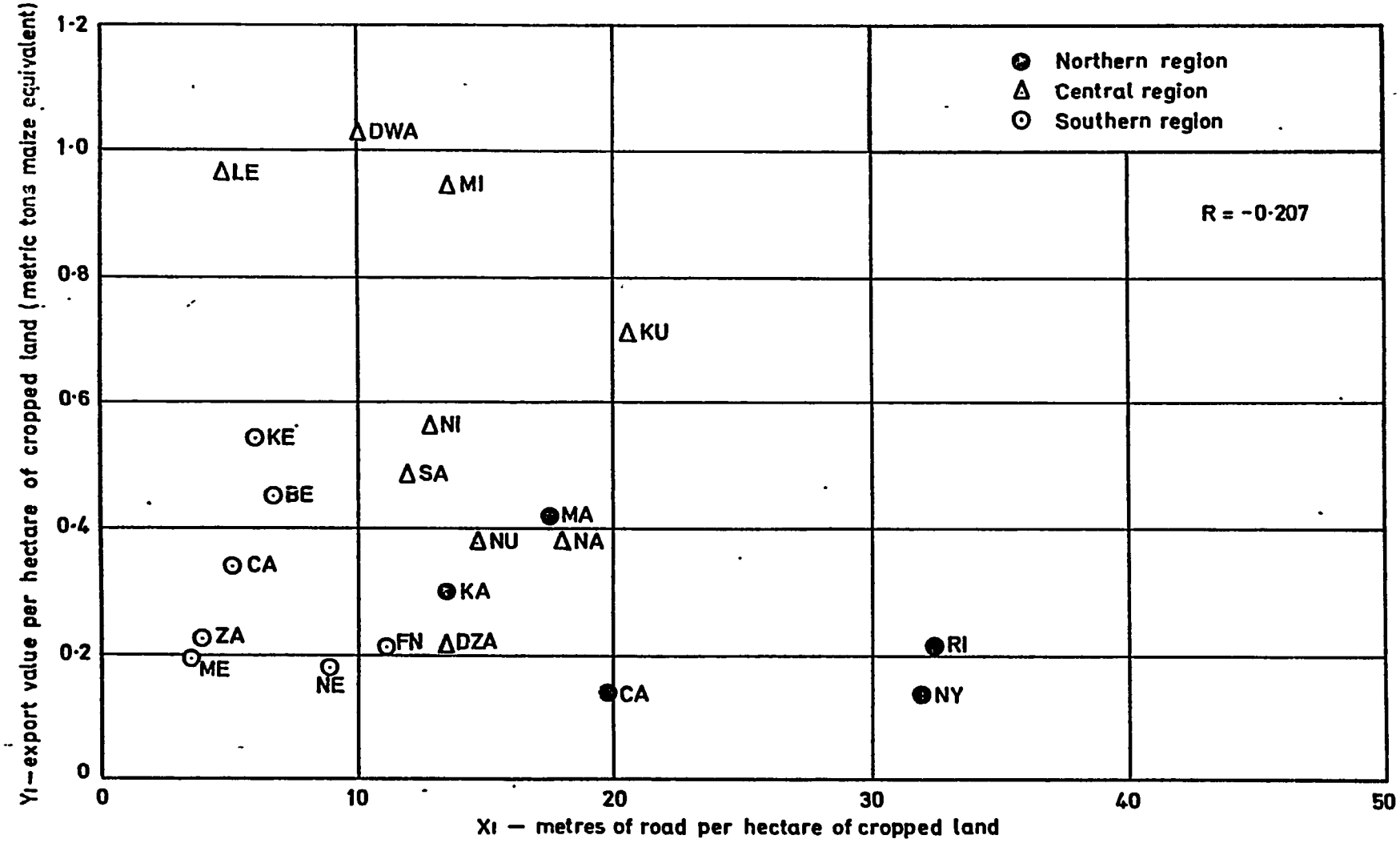


Fig.1. RELATION BETWEEN THE VALUE OF CROP EXPORTS AND EXISTING ROAD NETWORK

Road Research Laboratory M.o.T
G 1510

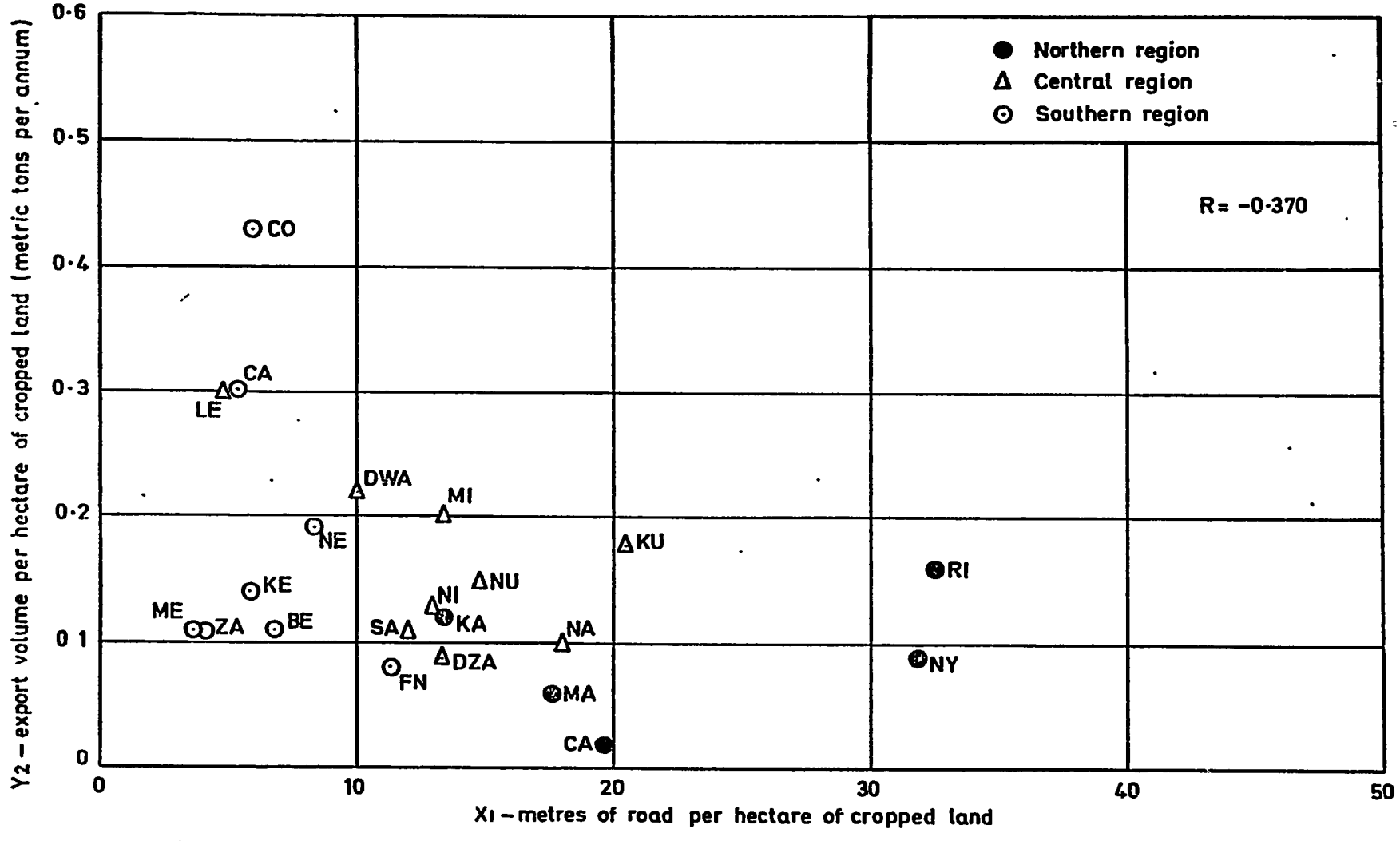


Fig 2. RELATION BETWEEN THE VOLUME OF CROP EXPORTS AND EXISTING ROAD NETWORK

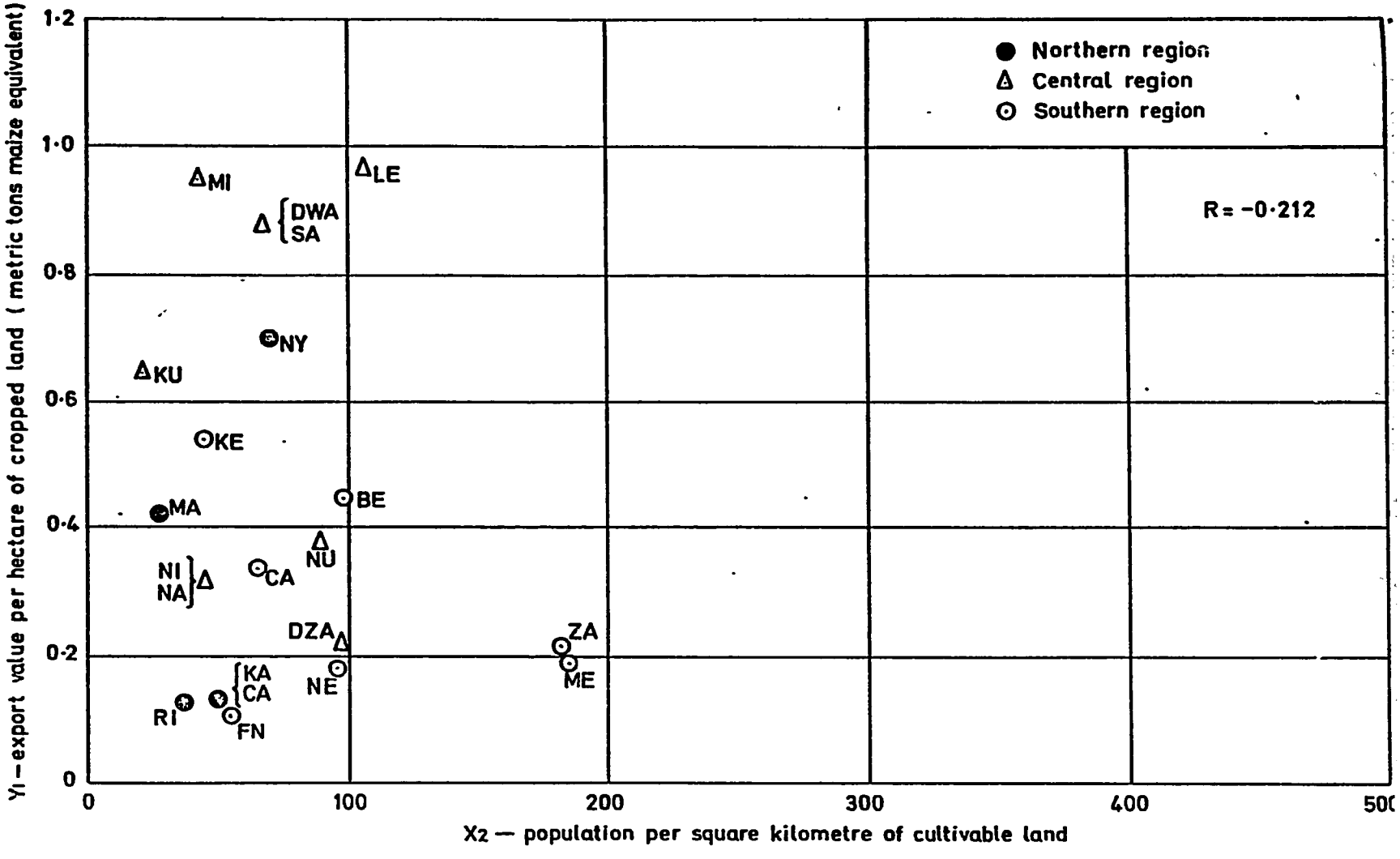


Fig.3. RELATION BETWEEN POPULATION DENSITY AND VALUE OF CROP EXPORTS

Road Research Laboratory M.o.T.
G.1512 (10)

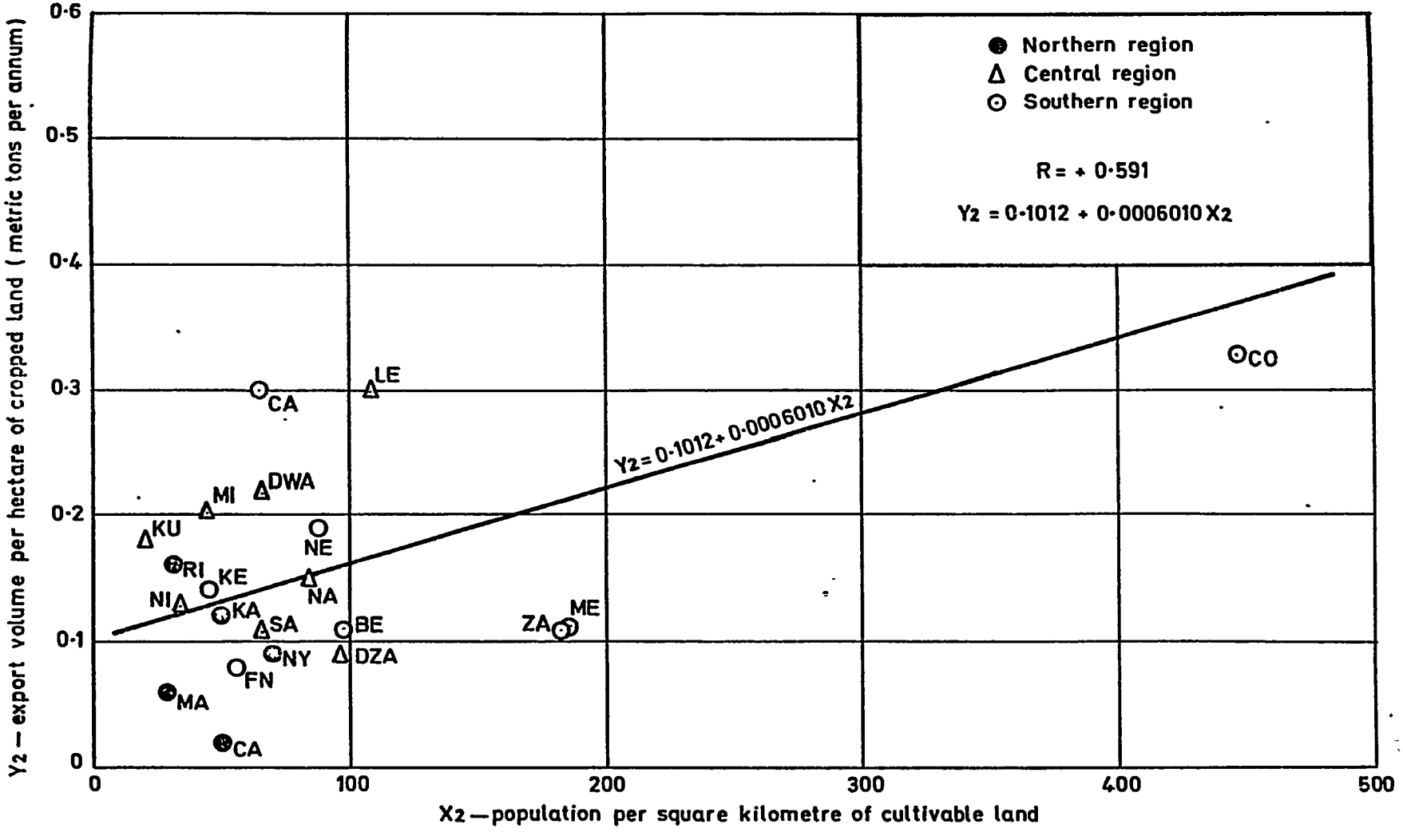


Fig. 4. RELATION BETWEEN POPULATION DENSITY AND VOLUME OF CROP EXPORTS

Road Research Laboratory M.o.T.
G.1513/102.

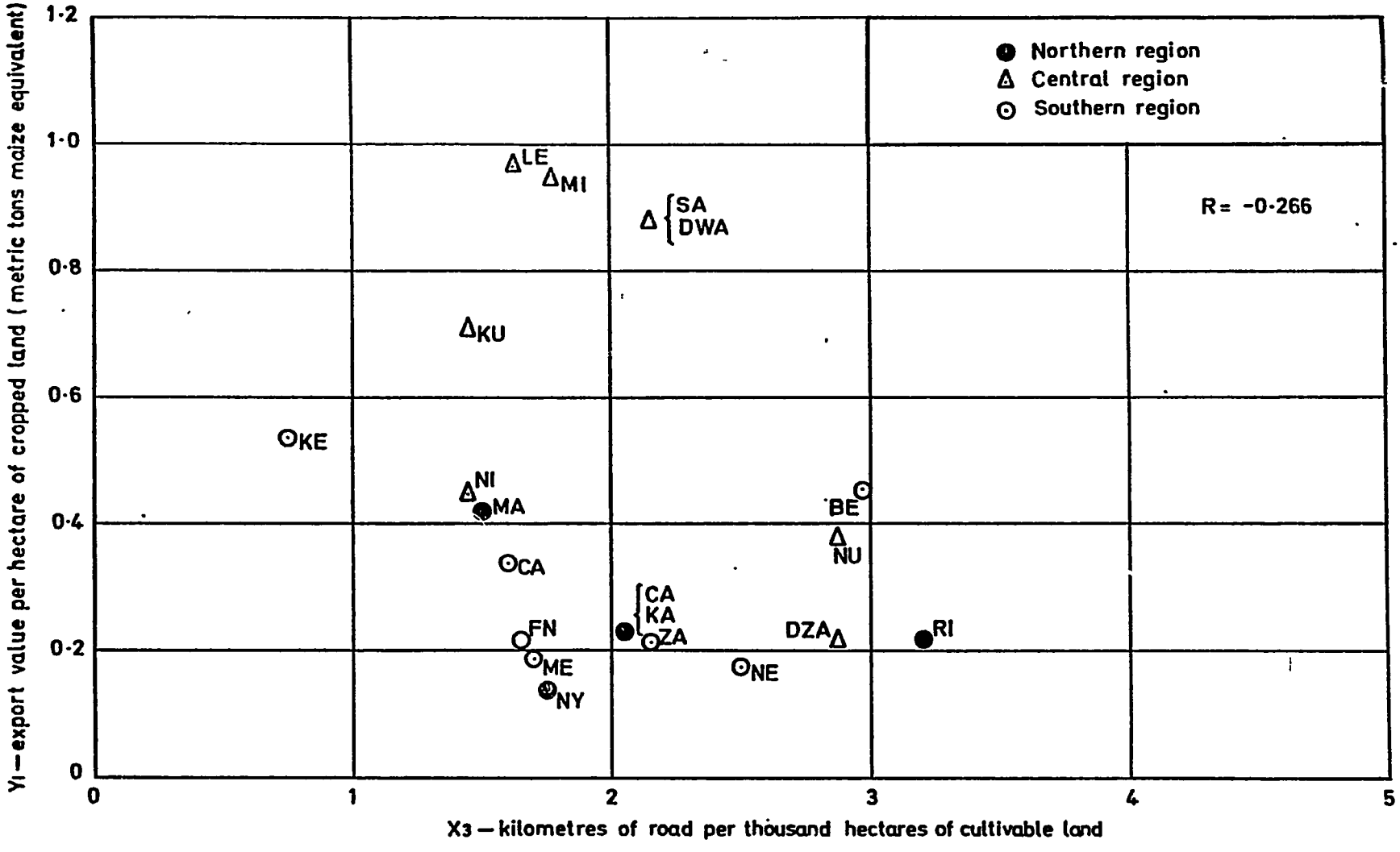


Fig 5. RELATION BETWEEN VALUE OF CROP EXPORTS AND POTENTIAL ROAD NETWORK

Road Research Laboratory M.o.T.

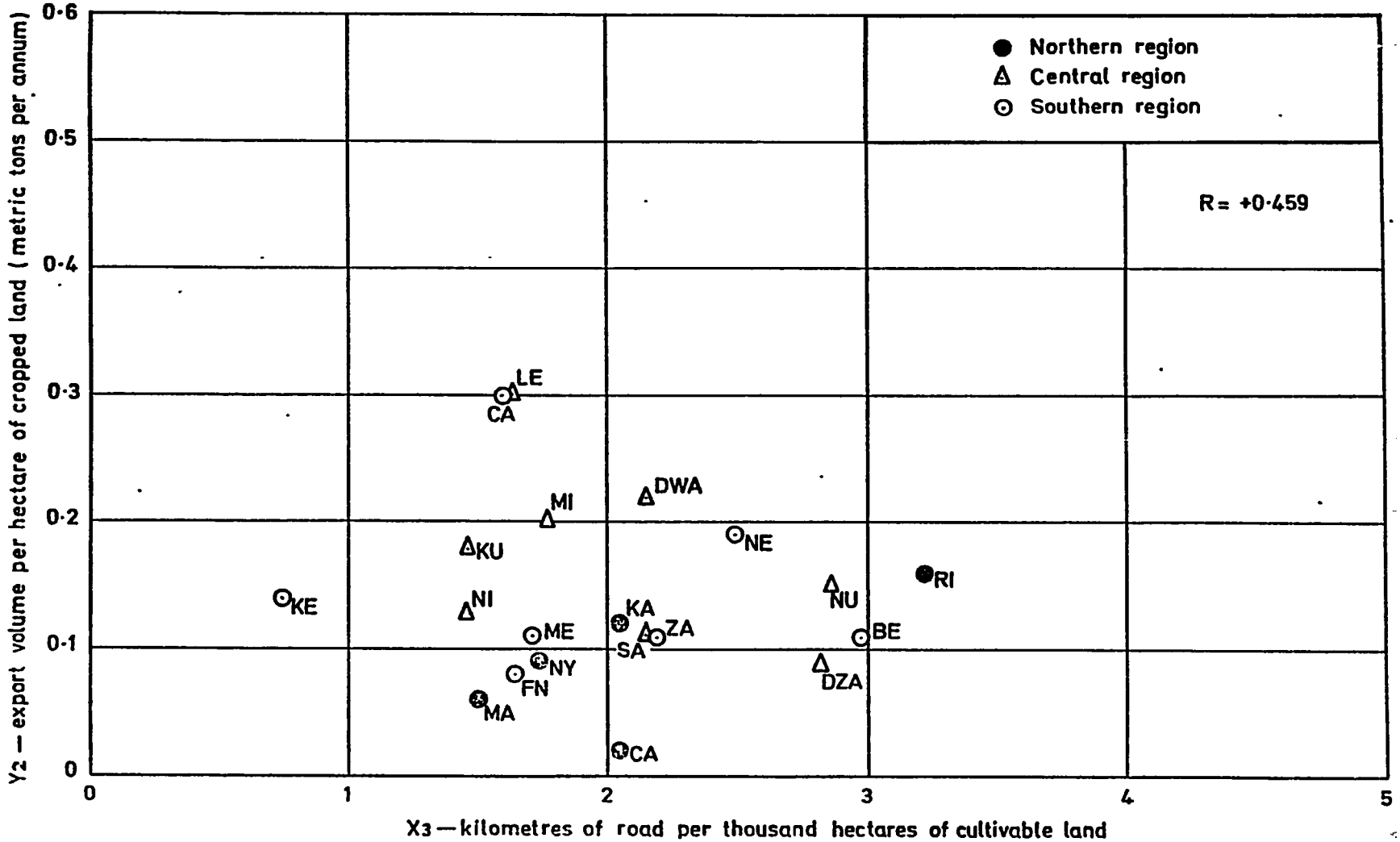


Fig 6. RELATION BETWEEN VOLUME OF CROP EXPORTS AND POTENTIAL ROAD NETWORK

Road Research Laboratory M.o.T.
G.1515

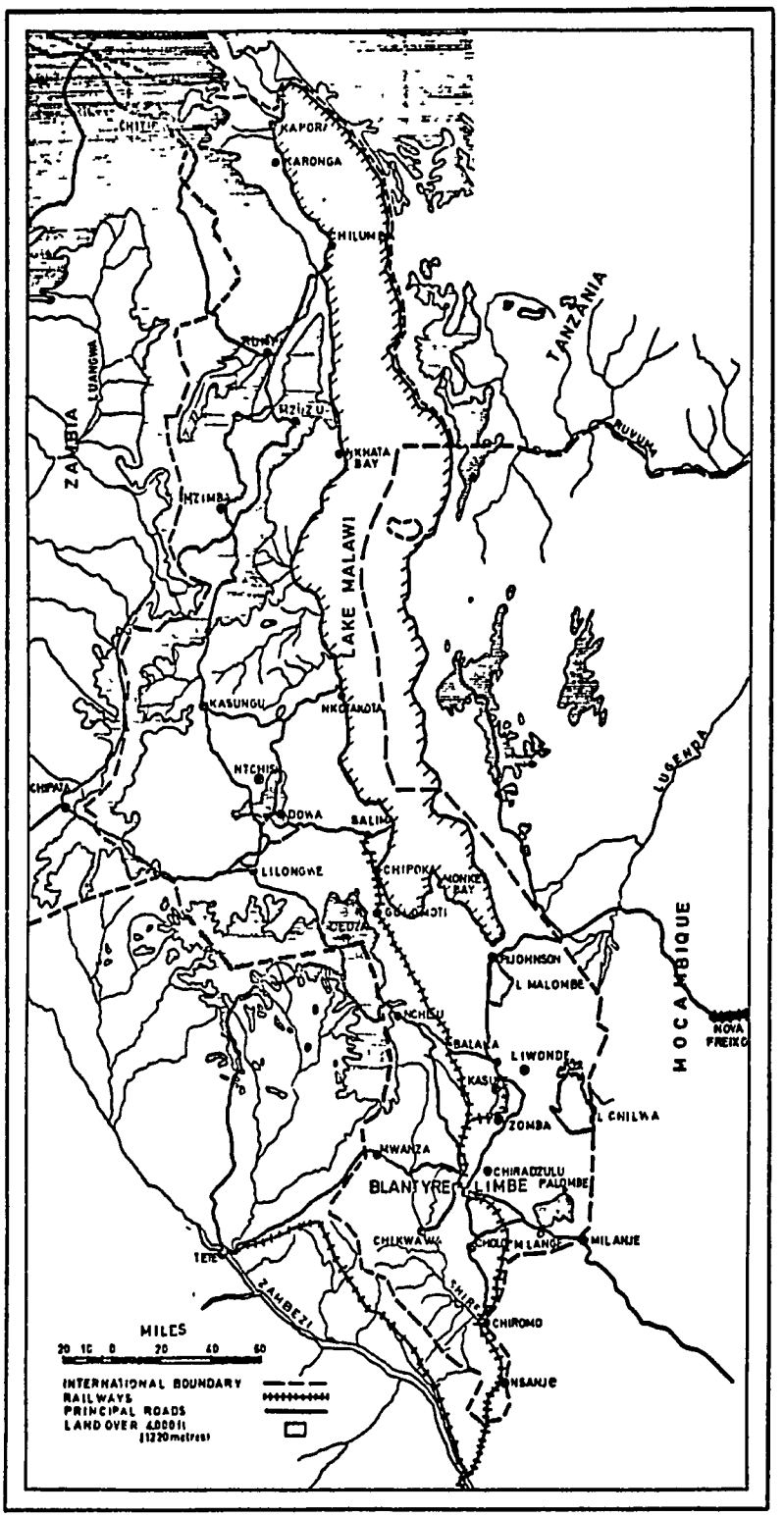
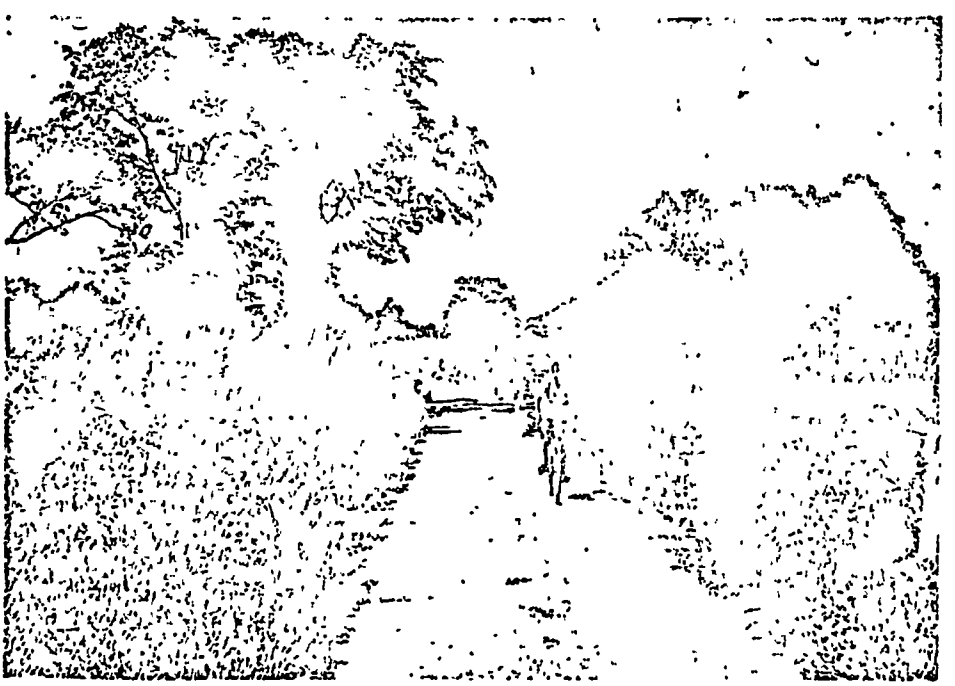
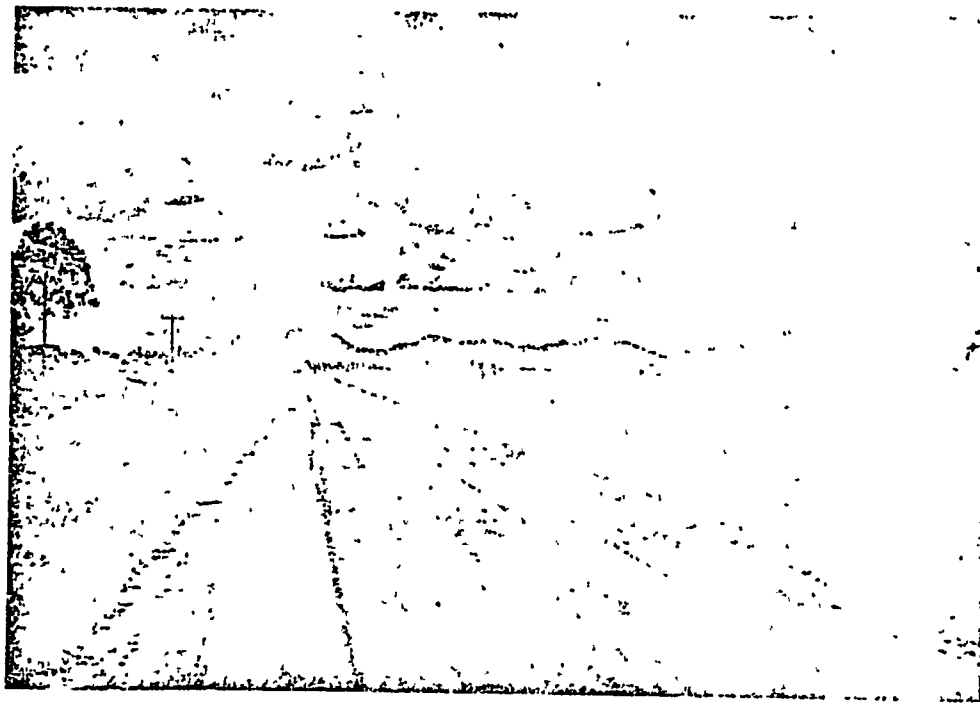

KAPORI
KARONGA
CHILUMBA
TANZANIA
RUVUMA
LUANGWA
ZAMBIA
RUMPI
MZIZU
NKHATA BAY
MZIMBA
LAKE MALAWI
KASUNGU
NKHOTAKOTA
NTCHISI
CHIPATA
DOWA
BALIMA
LILONGWE
CHIPOKA
MONKEY BAY
KEUDA
LUGENDA
JOHNSON
L MALOMBE
NCHISU
BALAKA
LIWONDE
MOCAMBIQUE
NOVA FREIXO
KASUNGU
ZOMBA
L CHILWA
MWANZA
CHIRADZULU
BLANTYRE
LIMBE
PALOMBE
CHILKAWA
MLANJE
TETE
ZAMBEZI
SHIRE
CHIROMO
NSANJE
MILES
20 10 0 20 40 60
INTERNATIONAL BOUNDARY
RAILWAYS
PRINCIPAL ROADS
LAND OVER 4,000 ft (1220 metres)

Fig 7. MALAWI

Feeder Road showing poor alignment and maintenance.



Feeder Road better alignment and profile.



Main Road with a good alignment and reasonable profile.

Main Road with poor alignment sharp bends poor profile.

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