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LESOTHO AGRICULTURAL SECTOR ANALYSIS PROJECT

Ministry of Agriculture
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Department of Economics
Colorado State University

MANPOWER *vs* MACHINERY:
A Case Study of Conservation Works in Lesotho

Research Report No. 6
Lesotho Agricultural Sector Analysis Project

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EXECUTIVE SUMMARY

MANPOWER *vs* MACHINERY: A Case Study of Conservation Works in Lesotho

by

Ron Wykstra and Jerry Eckert

This paper is a condensation of the analysis developed in an evaluation of capital *vs* labor intensive conservation efforts done by Dr. Wykstra under contract to USAID. The present version takes into account new data on labor productivites as well as new fuel prices that have been instituted since 1979. The revised analysis is being reissued with the expressed concurrence of USAID and is done to obtain wider circulation of the conclusions as well as to contribute to LASA's objectives.

The first section of the report sets, in very abbreviated form, the context which makes rural employment generation in Lesotho so vitally important (pp. 1-2). A more detailed quantitative elaboration is presented in LASA Discussion Paper No. 7, "Lesotho's Employment Challenge: Alternative Scenarios, 1980-2000", also by the authors.

Section II summarizes costs reflecting labor intensive conservation works. These data are revisions of earlier figures and reflect one full year's experience by the Labour Construction Unit, Ministry of Works. During 1979 the LCU had an active program in the Thaba Bosiu project area during which the organization and management of work crews was tested, refined and productivities measured. Productivity figures used (Appendix Tables 1-5) represent sustained levels achieved in practice in Lesotho (pp 2-4). Table 3 (p. 4) summarizes the total costs for 1000 hectares of treated area assuming a package of conservation works delivered in densities prevailing in the efforts of the Thaba Bosiu project.

Section III develops similar figures for the capital intensive approach based on data from the actual experience of the Conservation Division, Ministry of Agriculture and from the Thaba Bosiu project (pp. 5-8). Table 6 (p. 8) summarizes these results.

Section IV presents comparisons between the two technologies. The first level of analysis used is a financial return. Since labor intensive costs are only 81 percent of those for the capital intensive methodology, the internal rates of return are 18.8 and 15.3 percent respectively (pp. 8-12).

Second, an economic evaluation is offered which includes primary and induced employment in the benefits stream. The difference between benefit

cost ratios increases in this analysis with labor and capital intensive methods at 2.25:1 and 1.35:1 respectively (pp 11-12)

Finally, some of the major assumptions in the analysis are altered to test their effects. In none of these adjustments did the labor intensive technique fall below the returns from capital methods. Furthermore, calculations are presented to show that for a wide range of assumed benefits from completed conservation works (R11 - R40 per hectare) the labor intensive method is the only viable technology since benefits from employment in the project compensate for low benefits from the works themselves. With net annual benefits from conservation in this range, capital intensive construction methods cost more than they return (pp 12-15).

An eight page appendix giving details of all the underlying cost analyses concludes the report (pp 16-23).

Acknowledgements

Many people and organizations in Lesotho made significant contributions to the parent study from which this paper was drawn. The assistance of William Niese, Jr., Regional Engineering Advisor (REDSO/EA, USAID) in the area of equipment costing was instrumental. The Ministry of Works provided valuable assistance, as did the firm of Scott, Wilson, Kirkpatrick and Partners of the U.K. Special thanks are due to LeRoy Scherer, Mike Nyquist and P.J. Bonnema of the Conservation Division, Ministry of Agriculture as well as to the former Division Head, Mr. Harold Cooper. Their assistance and commentary on earlier drafts was vital in producing and refining the analysis. Errors that remain are the responsibility of the authors.

Most special thanks are due to Messrs. Subba-Rao and J.R. Dawson of the Labour Construction Unit, Ministry of Works. They willingly provided access to the results of their work plus considerable assistance in assembling the analysis. We trust that the Government of Lesotho will fully utilize the results of the LCU in developing their future employment programs.

MANPOWER *vs* MACHINERY: A Case Study of Conservation Works in Lesotho*

Introduction

The purpose of this report is twofold: first, presentation of comparative cost data regarding labor/capital substitution; and second, analysis and evaluation of comparative benefit:cost relationships which include the impact of employment, prevailing today for the construction of village roads, terraces, grassed waterways and diversions.[1] Initially we very briefly summarize the basic problem and analytical framework (Part I), and then proceed to estimate costs for labor intensive techniques (Part II), and capital intensive techniques (Part III), followed by a cost effectiveness evaluation of employment benefits (Part IV).

I

THE FRAMEWORK

Lesotho is presently confronted with a grave employment dilemma having four essential facets. First, the most productive portion of its labor force is exported to South Africa (commonly assumed to be at least 150,000 persons or about 40 percent of total male labor). Second, growth in labor supply will add another 400,000 or more persons by the year 2000, and this growth problem is compounded by the likely return of migrants from RSA. Third, Lesotho's rural households face a situation of significant underemployment, particularly seasonally, with consequent low incomes. Finally, the bulk of Lesotho's income is spent abroad, thereby failing to induce employment growth domestically. In light of these considerations a coherent employment strategy is vitally needed. Two components of such a strategy are crucial. First is selective import substitution in order to generate demand for locally produced items. Probably more important in the short run, however, is to choose labor intensive technologies wherever possible in government and private sector activities. This paper addresses the latter issue.

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*See R.A. Wykstra, The Use of Capital and Labor in Conservation Division Construction Work, final report, Contract No. AID/AFR-C-1499, for greater detail and presentation of t' . original basis for this report.

[1] The authors are especially indebted to J.R. Dawson of the Labor Construction Unit, Ministry of Works, Lesotho who provided detailed cost information on labor intensive operations in the construction of conservation works. The firm of Scott, Wilson, Kirkpatrick and Partners were also cooperative in providing needed cost data.

The tradition of adopting the most efficient (i.e., least costly) technology has strong precedents. Unfortunately, benefit/cost comparisons intended to evaluate the "best" techniques sometimes are so simplified and naive as to be misleading or of very limited value. This results from failure to perceive and measure benefits properly. In particular, the employment benefits are often misrepresented or ignored. In that event, misguided public programs may easily distort or even retard economic development. The conceptual issue is fully discussed elsewhere. In what follows, we examine this issue concerning construction activities with detailed calculations using proved field data from Lesotho.

II

LABOR INTENSIVE COSTS

Presently the Government of Lesotho is utilizing a Labor Construction Unit (LCU) for various conservation work tasks.[1] Job reports issued by the LCU indicate that worker productivity has increased since task-work systems were introduced, and that output per direct manday employed ranges from 2 to 5 cubic meters (M^3) of earth moved per man day.[2] The data in the Appendix Tables 1-5 present detailed information on direct labor and equipment costs by type of output based upon the experience of LCU activities to date. This information is summarized below in terms of direct costs.

Table 1. Labor Intensive Direct Construction Costs for Conservation Works

	Waterways	Terraces	Diversions	Village Roads
Labor Intensive Direct Costs:				
Earthwork, M^3/Km	1,200	875	3,370	948
Mandays Employed/Km	429	199	766	507
No. Ha Protected per Km Constructed	50	4	150	84
Direct Labor & Other Costs:[a]				
R per M^3 earthwork	0.858	0.80	0.80	1.13
R per Km constructed	1,030	696	2,681	1,904

[a]"Other" includes compaction costs which, while optional in certain contexts, are terraces R219 per Km, diversions R843 per Km, and roads R687 per Km.

Source: Tables 1, 2, 3 and 4 of the Appendix

[1] See various Labor Construction Unit "Job Reports," 1976-79.

[2] World Bank studies of several developing nations indicate that these productivity rates are relatively commonly achieved under task work or incentive pay systems with proper supervision. See I.K. Sud, *et al.* discussion paper in P.A. Green and P.D. Brown on Indian Roads Congress Papers of 37th Annual Session, December 1976, pp. 2-10.

As can be seen from the data presented above, substantial amounts of direct employment are created in a labor intensive operation. For example, 1,000 Ha of area protected would require over 69,000 mandays of direct employment under labor intensive methods based upon prevailing productivities shown in the tables of the Appendix. Estimated site overhead costs approximate R119,000 yearly for a 600 man labor gang working full time or 150,000 mandays annually. This represents R0.80 per manday of employment, or an average about one-third of direct wage payments. Site overhead costs for labor intensive methods are therefore approximately R200 for each man-year of employment. These costs are summarized below in Table 2 by type of output normally required in protecting 1,000 Ha of area.

Table 2. Labor Intensive Overhead Construction Costs

	Waterways	Terraces	Diversions	Village Roads
Site Overhead Costs:				
No. of Mandays/Km	429	199	766	507
Site OH Costs in R/Km	R343	R159	R613	R406
Site OH Costs in Rand per 1,000 Ha Protected	R6,900	R39,800	R4,100	R4,900

Source: Table 5 of the Appendix.

A great deal of additional cost information on labor intensive operations can be found in the World Bank's recent "Re-Employment Mission" study[1] and also in the very extensive study on "Labor Intensive Works" published by the International Labor Organization.[2] The site overhead costs noted above appear to be realistic and conform generally to similar estimates made elsewhere by agencies such as the World Bank.[3]

The true social costs of labor in a developing nation typically are lower than the prevailing wage rate, which, in Lesotho, is R2.40 per day.

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[1] International Bank for Reconstruction and Development, Lesotho, Report of the Migrant Workers Re-Employment Mission, April 1975.

[2] E. Costa, *et al.*, Guidelines for the Organisation of Special Labour Intensive Works Programs, Geneva, International Labor Organization, March 1977.

[3] IBRD, op. cit., pp. 1-4 of Annex VI. Adjusting these data for inflation from 1975 to 1979 yields a comparable total OH rate (excluding expatriate staff) of some R0.80 per manday for the 360,000 mandays in a "typical" labor intensive construction unit.

Thus, in evaluating projects from a national point of view, one might use a "shadow" wage rate to price labor.[1] If the shadow wage is approximated by the opportunity cost of unskilled labor in the private sector, labor intensive costs would be reduced to no more than 40-50 percent of the costs shown in our analysis. Comparison of project costs also may be affected by a longer time required for construction with labor intensive methods which can result in delayed benefits. A possible offset to these impacts is the longer project gestation period and equipment shipment delays often accompanying capital intensive methods in developing countries. Labor intensive methods also may be relatively more economical than shown here if local labor is used and camp costs are not needed, particularly since equipment, parts and mobilization costs tend to be significant. Finally, differing standards of durability or quality, which are sometimes assumed to characterize the two construction methods, may alter relative benefits, or increase maintenance costs. These are all important empirical considerations which should be dealt with in comparing labor and capital technologies. These are, however, beyond the scope of our considerations for the present paper.

From projects completed through 1979 by the LCU, reasonably good data are available concerning labor costs and productivity. The LCU approach cannot be termed strictly a labor intensive technology since the rate of labor to total cost is only about 66 percent. Nonetheless, as an intermediate technology, the LCU approach differs greatly in terms of employment from the very heavily capital intense methods used in Lesotho. The intermediate, labor intensive methods used by the LCU have achieved the results shown below. Total costs are R293,000 per 1,000 Ha and some 70,000 mandays of employment are provided using these construction techniques.

Table 3. Labor Intensive Construction Cost for 1,000 Ha Area

	Waterway	Terrace	Diversion	Village Road	TOTAL
TOTAL COST (R/KM)	1,373	865	3,275	2,310	(NA)
TOTAL COST (R/1,000 HA)	27,500	213,800	22,000	27,700	291,000
Labor	20,600	174,000	17,900	22,800	235,300
Site OH & Equip[a]	6,900	39,800	4,100	4,900	55,700
EMPLOYMENT (MD/1,000 HA)[b]	8,600	49,800	5,100	6,100	69,600

[a]Site OH data re explained in detail in Appendix Table 5. Total cost would decline to some R230,000 if terrace and diversion compaction by foot proved adequate.

[b]Respectively for 1,000 Ha are 429 x 20 Km:199 x 250 Km; 766 x 6.7 Km; and 507 x 12 Km.

Source: Tables 1 and 2.

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[1] See, for example, C. Harral, *et al.*, Study of the Substitution of Labor and Equipment in Civil Construction: Phase II, Final Report, IBRD Staff Paper No. 172, January 1975.

III

COSTS OF EQUIPMENT IN CONSTRUCTION

Amounts of conservation construction works completed in Lesotho during the 1.5 years ending December 1978 are shown below.

Aggregate Outputs	18 months 7-77/12-78	6 months 7-78/12-78
Km Village Roads	40.0	7.4
Km Diversions	4.8	0.1
Km Terraces	74.8	40.8
Km Waterways	124.5	26.4

Source: Conservation Division.

These primary outputs represent Conservation Division accomplishments during a period when aggregate budget outlays approximated R1.5 million, about two-thirds of which was recurrent budget and one-third capital expenditure. Division expenditures do provide more than simply physical works since soil conservation in the broadest sense is the ultimate object of Division activities. Unfortunately data on equipment input by hours or type of output are not available. What is known is that works construction such as that detailed above relied primarily upon the use of numerous tractors with tandum scoops across several project areas during this period.

There is one very significant factor influencing a pragmatic estimate of probable equipment costs in Lesotho; namely, the actual hourly use rates of equipment on hand. This utilization rate factor dramatically affects hourly charge rates for operating time on various types of capital equipment. One might assume that when in actual operation under average conditions, technical efficiency rates on the order of 30 to 40 percent of theoretical efficiency norms are attainable in developed nation conditions as is generally alleged by engineer handbooks such as Caterpillar. Alternative efficiency levels, probably more representative of developing nations conditions, would suggest World Bank recommended rates of some 20 percent, which may be more reasonable in Lesotho's case.[1] Recognition of the historical annual operating hours attained for capital usage in conservation works in Lesotho (a rough average of some 650 hours per year) tends to confirm that the appropriate cost or hourly charge rates are the higher of those shown below.

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[1] See International Bank for Reconstruction and Development, World Bank Study of the Substitution of Labor and Equipment in Civil Construction. Technical Memorandum No. 7, May 1975, pp. 5-26; and International Bank for Reconstruction and Development, World Bank Study of the Substitution of Labor and Equipment in Civil Construction, Supplement to Technical Memorandum No. 7, August 1975, pp. 11 ff.

Table 4. Comparison of Hourly Costs for Conservation Equipment Under Alternative Annual Utilization Rates

A. Operating Life of 8 Yrs at 650 Hr/Yr	Cost of Replacement or Depreciation	+	Repairs* & Maintenance	+	POL	=	Hourly Charge Rate
Cat D-6	R 28.06		R 17.42		R 8.40		R 53.88
Scraper	25.40		15.77		8.00		49.17
Grader	22.54		14.00		7.50		44.04
Cat D-4	14.62		9.07		7.00		30.69
B. Operating Life of 8 Yrs at 1,000 Hrs/Yr							
Cat D-6	R 18.20		R 11.27		R 8.40		R 37.87
Scraper	16.50		10.20		8.00		34.70
Grader	14.65		9.05		7.50		31.20
Cat D-4	9.50		5.90		7.00		22.40

*Repairs and maintenance are estimated at 100% of price FOB Lesotho over 8 years with no cost escalation; POL denotes fuel-oil, etc. at 1980 cost levels.

Source: See Appendix to this report.

Hourly operating costs presented above are based upon both an operating time experienced (650 hour/year) and a higher target (1,000 hour/year) charge rate dependent upon full life charge-out as in the case of owner possession and utilization of capital. The latter charge rates correspond rather closely with estimated rental rates and also with present Ministry of Works plant pool charges in Lesotho. It must be recognized, however, that the lower hourly charge rates shown in "Part B" of the above data require actual operating levels of no less than 1,000 hours annually. It should be noted that these performance levels were never obtained on Thaba Bosiu construction works, even in their most productive year (1978). However, if annual rates of equipment use of 1000 hours were achieved, then costs per kilometer or per hectare would be significantly reduced. Actual hours of operation recorded in the Thaba Bosiu Project are shown in Table 5.

Comparing productivity rates in the Thaba Bosiu project for the entire period from 1973 to 1978 with the last year 1978 shows marked improvement in terraces, waterways and diversion construction. Generally speaking, in 1978 each machine hour of input produced approximately 50 percent more output. For example, during the entire five year period, an average of 27 hours of mixed scraper-grader-dozer time was used to construct one Km of terrace. In contrast, for 1978, only 17.5 aggregate machine hours were required per kilometer.

Table 5. Productivity Comparisons Between Final Year and Whole Project Averages for Thaba Bosiu Conservation Works

	Average Hours of Scraper-Grader-Dozer Required		
	(a) 1978	(b) 1973-78	(a÷b) 1978 as % of Overall Hours Req.
1 Km Village Road req:	45.3 hrs.	47.2 hrs.	96.0 %
1 Km Terrace req:	17.5 hrs.	27.0 hrs.	64.8 %
1 Km Diversion req:	44.7 hrs.	68.3 hrs.	65.4 %
1 Km Waterway req:	64.9 hrs.	108.6 hrs.	59.7 %

This improved level of productivity is largely due to the experience gained by equipment operators and project management, including lead time gained in design and planning.

The Thaba Bosiu Project represents one of the more intensive and integrated conservation efforts undertaken in Lesotho. The information which follows is a compilation of available relevant data on costs and production from its inception in 1973 to 1978, the end of this project. During the period from project inception to the end of 1978, estimated conservation works completed were as follows:

Aggregate Output	Entire Period 1973-78	1 Year 1978
Km Village Roads	45.0	11.7
Km Diversions	6.0	2.6
Km Terraces	324.2	164.2
Km Waterways	46.5	10.1

Operating hours of heavy equipment used for constructing conservation works for this same time period average 650 hours of actual operation yearly.

On the basis of the equipment cost data shown earlier and the history of equipment productivity relationships over several years in Thaba Bosiu, it is possible to assess the cost of protecting a typical 1,000 Ha area. Productivity rates shown in Table 6 are based upon the same capital intensive methods as used by Thaba Bosiu, however, equipment requirements are based upon the "best" productivities experienced by Thaba Bosiu in 1978.

The total cost of protecting 1,000 hectares is estimated at approximately R360,000, about three-fourths of which represents equipment costs, the remainder being overheads and some 10,000 mandays of total employment. On the average, then, the construction of works to conserve land resources using capital intensive methods costs R360 and provides 10 mandays of employment per Ha. These costs would be reduced approximately R90 per Ha if capital equipment usage (and thus charge rates) were improved to 1,000 hours yearly per unit of equipment.

Table 6. Capital Construction Costs for 1,000 Ha Area

	Waterway	Terrace	Diversion	Village Roads	Total
TOTAL COST (R/Km)	3,675	944	2,295	2,858	(NA)
TOTAL COST (R/1,000 Ha)	73,500	235,900	15,300	34,300	359,000
Equipment Only	93,500	177,700	11,200	25,000	267,400
Site OH + Labor[a]	20,000	58,200	4,100	91,300	92,600
EMPLOYMENT (MD/1,000 Ha)	2,000	6,500	500	1,000	10,000

[a]Includes 12 drivers, 12 laborers, 5 conservation officer assistants, and 10 "other", such as engineer, 2 foremen, 2 timekeepers, 2 drivers and watchmen (R55,600 for 10,000 md) plus R37,000 materials and equipment mobilization costs.

Source: Based on Thaba Bosiu data presented in Appendix to this report.

IV

COST EFFECTIVENESS COMPARISONS

We can now summarize our cost data as shown in Table 7 below. Essentially, the labor intensive technique is seen to cost some R68,000 less and provide 60,000 additional mandays of employment per 1,000 hectares in comparison to capital intensive methods of construction.

Table 7. Comparison of Capital Intensive Versus Labor Intensive Costs in Construction for 1,000 Ha. Protected

	Capital Intensive	Labor Intensive	Difference
Cost (Rands/1,000 Ha.)	359,000	291,000	68,000
Employment (Mandays/1,000 Ha.)	10,000	69,600	60,000*

*Rounded

Source: Tables 3 and 6.

A few observations should be made on certain cost factors, however, prior to drawing comparisons.

1. The labor costs used in Tables 3 and 7 for labor intensive techniques reflect productivity levels achieved after one full year of field testing methods of organizing and managing labor workcrews.

2. Equipment cost estimates are based upon hourly charge rates that reflect the fuel price of 1980 (which is twice that of 1978). They also assume a continuation of the low annual operating rates and correspondingly higher cost estimates that are known to apply in Lesotho. If machine utilization could be based on 1,000 annual hours of realized use, overall costs for capital intensive methods would decline to some R270/Ha of area protected.

3. The productivity levels used in this comparison for capital equipment are based on the "best" year for Thaba Bosiu operations. The use of overall 1973-78 Thaba Bosiu productivities, which may best reflect what would occur for a new equipment package or a new program would raise capital intensive costs by 100-150 Rand/hectare.

4. Additionally, labor intensive operations on a broad scale may entail higher general overhead costs due to manpower recruitment and retention problems. Thus, the cost advantage shown in Table 7 might be slightly high.

5. The above cost comparisons are purely "financial." They do not reflect certain economic benefits normally associated with employment in a labor surplus economy. In looking ahead toward a growing labor surplus in Lesotho, one might, for example, quite properly use a shadow wage of R1.00/day instead of the prevailing minimum wage level of R2.40.[1] This would reduce overall costs of construction via labor intensive methods, a circumstance which would even further support more labor using methods of construction.

It is necessary to assume some value for the benefits of conservation in order to complete the analysis. Since the task of this report is to

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[1] Reflecting, let us say, the opportunity cost in the private sector, or maximum wages paid to subsistence agricultural labor.

compare capital and labor using methods, and not to determine conservation benefits,[1] we shall simply assume, to give us something to work with, that conservation benefits total R65,000 per 1,000 Ha of area protected, or R65/ha. We further assume a 12 percent discount rate into perpetuity[2] and yearly maintenance costs of R10,000 (R10/ha). Under these circumstances the discounted net present value (NPV) of construction benefits (B) is as follows (in thousand Rand):

Year	Annual Benefit Flow	Annual Maintenance Cost	NPV of Net Benefits Per Year
1	R 65	R 10	R 55 x .893 = R 49.12
2	65	10	55 x .797 = 43.84
3	65	10	55 x .712 = 39.16
4	65	10	55 x .636 = 34.98
5	65	10	55 x .567 = 31.19
6	65	10	44 x .507 27.89
.	.	.	. .
.	.	.	. .
.	.	.	. .
.	.	.	. .
Σ = N	65	10	55 x 8.333 = R458

That is, the NPV of direct financial benefits (B) is R458,000 per 1,000 Ha. This can be said to be the capitalized present value (at 12 percent), or the level of costs (C) one could incur to derive an annual net benefit stream of R55,000 yearly.[3] If costs were R458,000, the benefit/cost ratio would be:

$$\frac{B_{NPV}}{C} = \frac{458,000}{458,000} = 1.0.$$

With costs from earlier tables and presuming equal benefits to either labor or capital using methods, we show that labor using methods generate benefits of R1.56 for every R1 in costs, which clearly exceeds returns to capital intensive techniques.

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[1] See the recent soils conservation evaluation for more detail on conservation benefits. K.C. Nobe, *et al.*, A Reconnaissance Level Evaluation of Soil Conservation Programs and Methods in the Kingdom of Lesotho, U.S. Agency for International Development, July, 1978, Chapter IV.

[2] Land values are most commonly valued in perpetuity, thus land conservation benefits are likewise. See R.C. Suter, The Appraisal of Farm Real Estate, (Interstate Publishers, Inc.: Illinois, 1974), pp. 247 ff.

[3] The ratio $\frac{B}{i} = \frac{R55}{.12} =$ R458 capitalized value in perpetuity.

Capital Intensive	Labor Intensive
$\frac{B_{NPV}}{C} = \frac{458}{359} = 1.28$	$\frac{B_{NPV}}{C} = \frac{458}{291} = 1.57$

The analysis reveals a financial rate of return for capital-using methods of 15.3 percent while the rate of return is 18.8 percent for labor intensive methods. However, this comparison is misleading since it excludes the impact of employment effects. This is not the economic rate of return unless one makes the untenable presumption that employment is of no benefit to a developing nation which has slack labor time.

It is a fundamental economic principle that spending within an economy generates employment in proportion to the extent of labor services embodied in the final products. In this case conservation works are being purchased and the amount of employment created is strongly affected by the relative proportions of capital and labor in the technology used to produce them. It is also fundamentally understood that payments to labor constitute wages which are respent on consumption and savings which, in turn, create more demand for goods and labor. A multiplier effect can, therefore, be calculated.

Given Lesotho's unique geographic and economic situation this multiplier has significant implications on choice of technology in development programs. At the risk of some oversimplification, we assert that the suppliers of capital equipment, whether through sale or lease, are located outside of Lesotho in South Africa and other developed countries. To the extent that payments for conservation works are payments for capital equipment, these sums leave Lesotho's economy and do not generate further incomes in Lesotho. To the extent that conservation program costs are allocated to labor through wage payments they generate employment and incomes in Lesotho and although there are substantial leakages the multiplier effect is expressed more completely in Lesotho.

Very little is known about the structure of incomes or expenditures in Lesotho. The situation is certainly atypical in that an extremely high proportion of all consumption and investment items is imported. However, for simple illustrative purposes let us assume that each man year's income received generates a further demand for .2 manyears of indirect employment in Lesotho once it is respent.[1] We then calculate the benefits of conservation plus the direct employment generated plus the indirect employment generated by wages earned in the construction effort. The two technologies being discussed are compared below. Two calculations are presented. The first (Column A) places a value of R2.40 on each manday of labor regardless of skill level. The second (Column B) recognizes skill differentials and values labor equal to the total wage bill.

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[1] This could represent a situation where the import content of the consumption mix is 60 percent and the wage bill component of domestically produced consumption items is 50 percent. These guesstimates are intended to suggest levels that may well apply to the unskilled laborer in Lesotho.

Table 8. Estimation of Economic Benefit:Cost Calculations (figures per hectare)

	Capital Intensive		Labor Intensive	
	A	B	A	B
Net Present Value of Benefits Stream for Conservation Works	R458	R458	R458	R458
Value of Primary Employment	24	56	167	235
Value of Indirect Employment	5	11	33	47
Total Benefits	487	525	658	740
Total Costs	359	359	291	291
Benefit:Cost Ratio	1.36:1	1.46:1	2.26:1	2.54:1

V

SUMMARY

Calculations in Table 8 show a clear advantage for labor intensive conservation works in terms of benefit:cost comparisons. It should be noted that the existence of benefit:cost ratios above 1.0 are the result of our initial assumption of a net annual benefit of R55 per treated hectare. This assumption was not based on field data but merely taken to give us a uniform base from which to make comparisons. The benefit:cost ratio will in fact fall below 1:1 if the net annual benefit falls below R40 per hectare for capital intensive construction. For comparison, annual benefits from conservation must decline to R10.92 per hectare (R4.42/acre) before the labor intensive benefit:cost ratio drops to equality. No clear estimate of net economic benefits to conservation has yet been made for Lesotho. However, if there is any doubt as to the probable size of this figure,[1] these calculations strongly suggest that the only viable technology is the labor intensive approach where a much higher proportion of total benefits are derived from direct and indirect employment.

Several assumptions were made in the foregoing analysis. Given below are the benefit:cost ratios that would occur if these assumptions were altered. These ratios should be compared with the A columns of Table 8.

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[1] Most educated guesses put the net present value at below R40 per hectare under present cropping technology.

A. Equipment utilization was taken at 650 hours/year to reflect realistically achievable rates. If a more efficient usage rate of 1,000 hours/year could be achieved, then costs per hectare for the capital intensive method decline to R267.

CI = 1.82:1 LI = 2.27:1

Conclusion: Even with machine utilization rates that have not yet been reached in Lesotho, labor intensive techniques still have the edge.

B. We have valued labor at R2.40 per manday wherever it occurred, either as a cost or as a benefit. The point was made that a shadow wage at a much lower level might more appropriately reflect Lesotho's labor situation. To test this we assumed a shadow wage of R1.00 per manday of unskilled labor and a proportional reduction at other skill levels. The results:

	Capital Intensive	Labor Intensive
Benefits/ha	470	542
Cost/ha	327	154
B:C	1.44:1	3.52:1

Conclusion: Using a shadow wage rate for both costs and benefits increased the comparative advantage of labor intensive methods since costs were diminished more than benefits.

Finally let us very simply examine the impact of the choice between these two technologies on a possible national conservation program. Let us assume that Lesotho were to adopt the objective of completing a program of conservation protection on all land for which such protection is seriously needed. Let us assume that there are about 100,000 hectares in that condition. Let us further assume that an annual budget of R5 million could be devoted to this effort. The following comparisons result:

	Capital Intensive	Labor Intensive
Annual Budget	R5,000,000	R5,000,000
Annual Achievement (1,000's of Ha protected)	13.9	17.2
Years to Complete 100,000 ha.	7.2	5.8
Annual Employment*		
Direct (man years)	557	4,784
Indirect (man years)	111	956
Total	667	5,740

*Based on actual mandays/1,000 ha from Tables 3 and 6.

These last calculations would seem to be of great significance to Lesotho. For a given annual budget allocation, 23 percent more conservation work can be completed using LCU methods and 860 percent more jobs will result. It also would appear that completing conservation protection on Lesotho's most seriously affected areas is possible, given an adequate budget, within a reasonable time period. The choice of technology does not seriously affect the time factor. What is made quite clear by these figures, however, is that Lesotho faces the option of a conservation program meeting solely conservation objectives or one that contributes in a very substantial way to employment objectives as well.

A budget of R5 million exceeds recent allocation to the Conservation Division by a factor of 5. Similarly employment of 5000+ persons exceeds present activity levels of the LCU also by a factor of 5. Therefore, the order of magnitude of expansion suggested by the above budget is similar. It would seem feasible for either program to be expanded to this level without serious diseconomies of scale.

In summary, increasing the labor intensity of conservation works is clearly desirable in Lesotho under present circumstances. The importance of this type of change in the technology of government programs will increase markedly throughout the balance of this century as employment falls increasingly short of growth in labor supply.[1] It is well worth noting that under some circumstances (when conservation yields net annual benefits between R11.00 and R40.00 per hectare treated) labor intensive conservation works are a viable investment because of their employment benefits while capital intensive conservation works cost more than they return.

Recent evidence suggests that there has been, since 1978, a decline of 5-8000 migrants,[2] that this trend will continue in variable fashion over the next two decades,[3] and that employment is now recognized as one of Lesotho's top development priorities.[4] The LCU has developed a "Contingency Plan" of productive, labor intensive activities to be used in

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[1] For a detailed discussion and quantification of this issue, see Jerry Eckert and Ron Wykstra, "Lesotho's Employment Challenge: Alternative Scenarios 1980-2000", LASA Discussion Paper No. 7, Maseru, December 1979.

[2] Unpublished data, CPDO (from Labour Department).

[3] Eckert J. and R. Wykstra, 1979. "The Future of Basotho Migration to the Republic of South Africa", LASA Research Report No. 4, Maseru, September 1979.

[4] Statement by The Rt. Honorable, The Prime Minister, Dr. Leabua Jonathan to Parliament, 13 March 1980.

the event migration were suddengly cut off.[1] Given the present urgency for job creation it is strongly suggested that a program of labor intensive public works is needed now rather than several years from now. Reasons suggesting that the program be begun as soon as possible include:

a. The possibility that for the next 5-10 years migrants may well return in larger numbers than can be accommodated in the very small modern sector of Lesotho, regardless of how fast it can grow.

b. The probability that 8-9 years of below normal rainfall will depress agricultural productivity during the 1980s, thereby limiting employment opportunities in that sector.

Our calculations focussed exclusively on conservation works. The LCU's emergency program is devoted largely to roads. Both programs and possibly others will show the same dramatic differentials between labor and capital intensive technologies. Both conservation and roads, then, are valid strategies for further developing the infrastructure of Lesotho while simultaneously contributing in a very significant way to Lesotho's employment objectives.

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[1] Labour Construction Unit, 1979. "Report to the Coordinating Committee on 'a Contingency Plan' during a possible emergency period", Ministry of Works, Government of Lesotho.

COST APPENDIX

COST ANALYSIS OF LABOR INTENSIVE TECHNIQUES

The information which follows summarizes both direct labor costs and site overhead costs for construction of conservation works in Lesotho. It is based upon several years of operating experience of the Labour Construction Unit, Ministry of Works, specializing in labor intensive methods of building roads, terraces, diversions and ground waterways under conditions of good management and incentive pay systems.

Table A-1. Labor Intensive Labor Costs for Earthwork in Waterway Construction

SUMMARY	Earthwork Base No M^3	Mandays Employed	Cost in R Per M^3	Cost in R Per Km	Cost in R per Ha Protected
LABOR	1,200	429	R0.858	R1,029.6	R20.59

I. Productivity:

All earthworks operation = 2.8M^3 per manday

II. Each linear meter = 1.2 M^3. So 1 Km = 1,200 M^3 of earth work.

1,200 : 2.8 = 429 mandays

III. At wages of R2.40 x 429, labor costs are R1,030 per Km.

IV. An estimated 20 linear meter is needed per ha protected. The cost is then R20,600 per 1,000 ha.

Source: J.R. Dawson, Labor Construction Unit, Government of Lesotho.

Table A-2. Labor Intensive Labor Costs for Earthworks in Terrace Construction

SUMMARY	Earthwork Base No. m^3	Mandays of Employment	Cost in R per m^3	Cost in R per Km	Cost in R per Ha
LABOR	875	199	R0.55	R477	R119
COMPACTION (if required)	875	-	R0.25	R219	R 55

I. Productivity

Excavate-Spread-Shape = 4.4 m^2 per manday.

II. Each linear meter = 0.875 m^3. So 1 Km = 875 m^3.

875 ÷ 4.4 = 199 mandays

III. At wages of R2.40 per md x 199 md, labor costs are R477 per km.

IV. An estimated 250 linear meters are needed per ha protected. The cost of labor is thus R119,000 per 1,000 ha.

V. (Optional) Compaction by roller is 100 m^3 per roller at R25 daily, or R0.25 per m^3 (R0.2 per linear meter). Therefore compaction = R219 per km of terrace or R55,000 per 1,000 ha of area.

Source: J.R. Dawson, Labor Construction Unit, Government of Lesotho.

Table A-3. Labor Intensive Labor Costs for Earthworks in Diversion Construction

SUMMARY	Earthwork Base No. m^3	Mandays of Employment	Cost in R per m^3	Cost in R per Km	Cost in R per Ha
LABOR	3,370	766	R0.55	R1,838	R12.26
COMPACTION (if required)	3,370	-	R0.25	R 843	R 5.65

I. Productivity

Excavate-Spread-Shape = 4.4 m^3 per md.

II. Each linear meter = 3.37 m^3. So 1 km = 3,370 m^3.

3,370 ÷ 4.4 = 766 mandays

III. At wages of R2.40 per md x 766 md, labor costs are R1,838 per km.

IV. An estimated 1 km protects a 150 ha area or there are some 6.7 lm per ha of area protected at a labor cost of R12.26 per ha.

V. (Optional) Compaction by roller is 100 m^3 per roller at R25 daily, or R0.25 per m^3 (R0.84 per linear meter). Therefore compaction = R842.5 per km of div ersion, or R5,650 per 1,000 ha protected.

Source: Same as Table II.

Table A-4. Labor Intensive Labor Costs for Earthworks in Village Road Construction[1]

SUMMARY	Earthwork Base No M^3	Mandays of Employment	Costs in R per M^3	Costs in R per Km	Costs in R per Ha Protected
LABOR	948	507	R1,127	R1,217	R14.48
COMPACT * EQUIP	-	-	-	687	8.18
				R1,904	R22.66

I. Productivity:

A. Excavate-Ditch = 2 M^3 per manday.

B. Gravel load-unload = 1.5 M^3 per manday.

II. Each linear meter = .75 M^3. So 1 Km = 750 M^3 and mandays are:

A. Excavation = 750 M^3 ÷ 2 M^3 = 375 mandays.

B. Gravel (33% x 6 at 0.1 thick) = 198 M^3/Km ÷ 1.5 M^3 = 132 mandays.
507 mandays.

C. 6.7 days tipper truck (R81 day) = R535)
6.7 days compaction roller (R23 day) = R152 = R687

(Includes operator and fuel at private hire rates of R9/hr for 9 hour day, and roller cost is based on Lesotho plant pool charge rate. When hiring pedestrian operated vibrating rollers it is not necessary to pay the R2.50/hr operator chrge as one of the Labor Construction Unit's own labor oerate it at R0.35/hr.)

III. At wages = R2.40 per day x 507 m.d. = R1,217 per Km.

IV. An estimated 11.9 linear meter is needed per ha of area protected. The labor cost is thus R14.48 per ha.

V. Compaction and tipper truck required is R0.687 per linear meter or R8.18 per Ha area protected.

[1] Design layout is 6 M width at 0.5 M^3 per linear meter formation clearance with 0.25 M^3 per linear meter ditch excavation; partial gravel-compaction as noted.

Source: J.R. Dawson, Labor Construction Unit, Government of Lesotho.

Table A-5. Yearly Site Overhead Estimates for Two 300 Man Work Gangs

A. No. laborers employed: 600; 150,000 mandays; R360,000 labor bill for year.

B. Site Staff

No. Mandays	No. Persons	Work Grade	Pay Rate/Yr	Total R
500	2	PTO	R4,000	8,000
1,000	4	TO	2,140	8,560
3,000	12	TA1	1,440	17,280
6,000	24	TA2	840	20,000
1,000	4	Timekeepers	1,000	4,000
500	2	Storekeepers	1,000	2,000
1,500	6	Drivers	800	4,800
SUBTOTAL 13,500	54			64,640

C. Camp and Site Costs

48 huts (10 x 10 at R80/yr over 5 years)	= R 3,840
Set up costs huts (1,120 mandays)	= 5,376
Set up costs huts (34 tipper days)	= 5,508
Camp running costs (estimates yearly)	= 2,000
6 vehicles	= 18,000
6 Caravans (PTD & TO, R7,000 each, write off 5 years)	= 8,000
Hand tools	12,000
SUBTOTAL	R54,724

Summary of Total Costs

A. Direct Labor (150,000 mandays)	R360,000
B. Site Staff Labor Overhead (13,500 mandays)	64,640
C. Other Site Overhead (camp, equip., etc.)	54,724
SUBTOTAL	R479,364

*Site OH as % of total costs	27%
*Site OH as % of direct labor	36%
*Site OH per manday of direct labor	R0.80

Source: J.R. Dawson, Labor Construction Unit, Government of Lesotho.

Capital Equipment Cost

It is extremely difficult to determine the appropriate level of "technical efficiency" to use in a cost analysis of capital equipment since a great many factors are involved. For example, a differential haul distance of five to 50 meters alone alters Cat D-6 dozer productivities from some 1,200 M^3 to 150 M^3 per hour.[1] In addition to the above noted haul-distance, operator skill, soil conditions, work site terrain, job layout, daily versus incentive pay, national customs and traditions, quality of supervision, and climate and weather, greatly effect productivities. Also, time factors such as start up/shut down ratios, hourly rest and idling, breakdown frequency, travel time to site, maintenance needs, parts availability and repair delays determine actual hourly costs.

Detailed and well documented studies of some of these many variables recently have been exhaustively analyzed by the World Bank and others.[2] World Bank studies generally have found the percent efficiency or productivity to be somewhat lower than given in the Caterpillar Handbook. Some suggested correction factors are:[3]

average operator	.75%
soil conditions	.70
45 min. hr. work	.75
grade 10% average	.80
overall average	.32%

The general recommendations reached in these World Bank analyses are broadly based and reasonably uniform in concluding that, e.g., dozer and scraper productivity approximate "25 to 40 percent of published Caterpillar Handbook (technical efficiency) productivity at 100 percent time and operator efficiency."[4] These latter two variables typically

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[1] William Niese, Jr., P.E., Regional Engineer Advisor, REDSO/EA.

[2] International Bank for Reconstruction and Development, World Bank Study of the Substitution of Labor and Equipment in Civil Construction, Technical Memorandum No. 7, May 1975; International Bank for Reconstruction and Development, World Bank Study of the Substitution of Labor and Equipment in Civil Construction, Supplement to Technical Memorandum No. 7, August 1975; and P.A. Green and P.D. Brown in Indian Roads Congress Papers of 37th Annual Session, December 1976, pp. 35-74.

[3] International Bank for Reconstruction and Development, World Bank Study of the Substitution of Labor and Equipment in Civil Construction, Supplement to Technical Memorandum No. 7, August 1975, p. 5; andP.A. Green and P.D. Brown in Indian Roads Congress Papers of 37th Annual Session, December 1976, pp. 46 ff.

[4] See International Bank for Reconstruction and Development, World Bank Study of the Substitution of Labor and Equipment in Civil Construction, Technical Memorandum No. 7, May 1975, p. 21.

are subject each to a 75 percent adjustment factor in developing nations, reflecting (a) a 45 minute effective work hour and (b) average operator skills. Thus the joint correction factor of .563 (derived from .75 x .75) exists. Therefore, combined technical efficiency levels appear to approximate some 20 percent of Handbook standards as they range downward from (40% x .563 =) 22.5 percent to, let us say, as low as (25% x .563 =) 14.1 percent.

Practical rates of technical operating efficiency are only one problem in determining the cost of capital intensive methods. Another and equally critical matter is establishment of an appropriate real hourly (annual) cost or charge rate, which in fact characterizes realities existing in developing nations. One primary factor which must be reflected is that of capital recovery or replacement costs. Further, operating hourly rates cannot be based upon more hours than are achievable.

The Conservation Division presently uses a 12 percent annual cost escalation factor which would appear to be a minimum charge, especially considering that it reflects insurance costs also. The impact and meaning of a 12 percent capital recovery factor over an eight year life can be illustrated by closer examination of, say, the Cat D-6 dozer at current prices of R90,600 FOB Lesotho. At these cost escalation rates, the estimated replacement price in eight years approximates R224,300, and the required annual capital recovery charge is R18,200.[1] This generates an equivalent replacement over eight years of R145,600 (R18,200 x 8). Capital recovery at this charge rate annually earning 12 percent per year for eight years will allow equipment replacement of some R224,300.[2]

A more realistic but equivalent interpretation of capital recovery charges is required under Lesotho conditions, however, since (a) equipment retains some salvage value and (b) a much lower social interest return than 12 percent (e.g., say 6%) is probable. Presuming the equipment to be in good condition (because of both the low hourly use rates prevailing in Lesotho and 100 percent maintenance) generates likely full replacement cost including salvage value as follows:

i.	R18,200 annual use charges for eight years	R145,900
ii.	Interest earnings at six percent for eight years	34,600[3]
iii.	Salvage value (approximately 45-50% cost)	43,800
	1987 REPLACEMENT COST OF CAT D-6 DOZER	R224,300

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[1] Note that it is not appropriate to develop an annual charge of R224,300 ÷ 8 = R28,000, however (see below).

[2] The capital recovery factor is equal to $i + \frac{i}{(1+i)^{N-1}}$ where i = 12 percent and N - 8 years.

[3] Based upon net capital recovery of 180,500 at i = 6 % annual interest earnings over N= eight years or the annuity factor $\frac{(1+i)^{N-1}}{i}$, plus an additional R44,700 salvage value.

The evidence available from equipment operating hours in Lesotho in both the Conservation Division and the Thaba Bosiu Project rather clearly suggests that relatively new equipment is operated 600 to 700 hours yearly. Consequently, the most likely heavy equipment eight year life operating use rate would be approximately 650 or so hours per year.[1] Lower hourly operating rates do not correspondingly lower maintenance costs or increase expected life, however. As observed elsewhere, ". . . deterioration and corrosion due to inclement weather may reduce lifetime factors more than normal wear and tear in use. . . and increase operating costs."[2] The equipment cost basis used in comparing labor intensive to capital intensive construction in this analysis is that provided below, adjusted as described above for depreciated replacement cost or capital recovery less salvage values.

Table A-6. Summary of Cost Calculations for Conservation Equipment

	Cat D-6 Dozer (W/Ripper)	Scraper Cat 613	Motorgrader Cat 120G	Cat D-4 Dozer (W/Ripper)
A. Price FOB Lesotho	R 90,600	R 82,000	R 72,800	R 47,200
B. Required Replacement Costs	224,300	203,000	180,200	116,900
less interest earn	34,600	31,300	27,800	18,100
salvage value	43,800	39,600	35,300	22,800
C. 8 YEAR RECOVERY COST				
i. Total	145,900	132,100	117,200	76,000
ii. Annual (8 yrs)	18,200	16,500	14,650	9,500
iii. Hourly (650/Yr)	28.06/Hr	25.40/Hr	22.54/Hr	14.62/Hr
iv. Hourly (1,000/Yr)	18.20/Hr	16.50/Hr	14.65/Hr	9.50/Hr

Maintenance charges based upon essentially 100 percent of initial cost. This is a rather standard costing procedure as is the treatment of petrol-oil-fuel or POL charges. As can be seen from the summary data in Table 3 of the text, operator labor rates are not included nor are overhead charges, separate tax, insurance and tire charges.[3]

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[1] Equal to 5,200 hours of actual use over an eight year life.

[2] Louis, Berger, International, Techno-Economic Feasibility Study of the Lesotho Southern Perimeter Road, Vol. III, March 1978, p. D-4, and International Labor Organization, Men or Machines, Geneva, 1978, p. 87.

[3] Essentially, the charges given represent ownership or possession expenses exclusive of overheads based upon two operating time factors.

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