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A SOCIAL COST APPROACH TO CHOICE OF TECHNOLOGY IN BUILDING CONSTRUCTION

A Study of Some Alternative Technologies in Kerala

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I

This paper is an attempt to apply the technique of social cost-benefit analysis to the problem of choice of technology in building construction in Kerala. In the present section a general outline of the social cost-benefit analysis is given and an approach by engineers at the decision-making level to its application to the problem of choice of technology in building construction is suggested. The approach is sufficiently straightforward that it may be made use of as part of the normal process of selecting the technology most suitable to use for a new building project. In the second section two elements of a building system have been selected and the social cost approach applied for selecting an appropriate technology from a set of alternatives. The third section puts forth certain conclusions of the authors based on the analysis carried out in Section II.

1.1 Why and What of Social Cost-Benefit Analysis

The technique of social cost-benefit analysis or what is known as project evaluation is being increasingly applied in the selection of public projects in developing countries. Their application ranges from industrial and agricultural projects producing tangible outputs to infrastructural projects (like irrigation and transport) and social amenities projects (like housing and health). The justification for social cost-benefit analysis of public projects (or for that matter the insistence on social cost-benefit analysis of projects by the aid-giving agencies) rests mainly on the following two grounds:

(a) The market prices of goods and services in the developing countries do not reflect their real social costs for various reasons. It may be due to the existence of monopoly on certain goods which makes it possible for the monopolist to charge a higher price than is warranted by demand and supply or it may be due to governmental controls like rationing or fixing of prices on certain policy grounds. For whatever reasons, if the market for a commodity is distorted, then ther exists a divergence between its market price and its social value.

(b) The second important factor is the existence of indirect effects. This refers to the costs or benefits to the society shooting off from a project and which either cannot be quantified, or, if quantifiable, cannot be properly priced. Therefore project selection on the basis of direct effects may be misleading in the presence of significant indirect effects. For instance, an industrial project may create pollution and an airport may create noise, the real social costs of which would be difficult to measure. Again, it is impossible to measure adequately the benefits to health, capacity for work and enjoyment of life which derive from improved housing conditions.

If the above reasoning is accepted, then the next question is how do we go about doing a social cost-benefit analysis? A simplified and general method may be suggested. For any given project, the first step is the enumeration of all costs and benefits - both direct and indirect. Once all costs and benefits are known then they are quantified in physical units. As a first approximation, these costs and benefits are valued at their market prices and shown in the form of a flow chart according to the time pattern of these costs and benefits. In this flow chart costs will be shown on a resource-wise basis and not on a functional basis. All transfer flows like taxes and interest payments will be excluded as they represent only a transfer of income from one party to another. In the second approximation, the market values of inputs and outputs (i.e. costs and benefits) will be replaced by social values by using a set of shadow prices. These shadow prices reflect the relative scarcity or abundance of the resources used up and produced by the project. The derivation of these shadow prices will be dealt with later in our discussion on the choice of technology. Once the net social value (the sum of benefits minus the sum of costs) for each year of the project is derived, all these year by year values may be combined into a single value, called the Present Value of the project. (There are other decision criteria used in project evaluation, which need not be gone into here).[1]

A decision criterion may then be applied to test the economic worthiness of a project. At its simplest, the criterion may be that if the Present Value of the project is positive (total benefits greater than total costs), it will be selected, whereas if the Present Value is negative, the project will be rejected. Often, however, it will be possible to select from among a number of alternative projects. In this case the project with the highest Present Value will be selected. This results in the choice of a project giving the maximum social benefits. Wherever the indirect effects of any project are very important or significant, but not measurable they have to be mentioned explicitly so as to make the decision makers aware of their consequences taking into account their relative importance to the economy.

The Problem of Choice of Technology

The method of social cost-benefit analysis outlined above is essentially a general one where one is able to present all the important costs and benefits of a project in some numerical magnitude. This is the case with most of the industrial projects and certain agricultural projects like land development. But there are public projects or programmes where it is not possible to present the benefits in any tangible way, let alone in numerical magnitudes. In such activities where the contribution to social welfare cannot be quantified, the objective is not that of increasing productivity but social consumption. Social service projects like housing is a case in point. The objectives may be specific like provision of residential buildings, educational institutions, hospitals etc. Given the objectives and a certain amount of funds, the problem facing the decision makers is how to achieve best results within the financial allocation of the project? The problem may be presented in two ways: (i) Given the target, what is the least-cost method of achieving it? or (ii) Given the objectives (say, provision of residential building to low income groups) and a certain amount of funds, what is the method of achieving maximum results? In whatever way the problem is posed, the problem is one of "cost minimisation" or "cost effectiveness".

Let us take the example of housing. For a given programme of building construction, first it is necessary to lay down the minimum technical standards to take into account various aspects like climatic conditions, strength, durability, etc. Once the norms are fixed, a good number of alternatives will get automatically eliminated and there will remain a set of technically feasible alternatives, all of them conforming to the minimum standards laid down.

The criterion of technical efficiency therefore helps in eliminating a number of alternatives but it does not help very much for choosing a technology from the remaining ones. This is because all of them are capable of achieving the desired results. There will be a technology in the set of technically feasible alternatives which may said to be the optimal technology. The notion of "optimum" in economics refers to the "best" among feasible alternatives. Ordinarily this selection of the optimal technology is done with the help of a financial analysis. The financial analysis will indicate the least cost technology as the optimal one. An implicit value judgement is contained in such a financial analysis in that financial costs of using up the resources are assumed to be the "real" or "social" costs. We have already mentioned the reasons why such an assumption may not be correct. In fact, most of the developing countries do experience a divergence in "financial" costs and "economic" or social costs resulting in the misallocation of resources. Social cost-benefit analysis can be a useful method of correcting this divergence between "financial" and "economic" costs.

Essentially social cost analysis when applied to the problem of choice of technology seeks to find out the social value or cost of each technology. Since the problem is one of selecting a technology involving least social cost, no attempt is warranted for measuring benefits. Let us assume that a set of technically feasible alternatives for building construction is presented. The first step in an economic evaluation is to enumerate all the input items according to the amount of resources involved. Broadly speaking there are two types of resources, labour and materials. Labour may further be divided into skilled (e.g. engineering and managerial personnel), semiskilled and unskilled. Materials may be divided into domestic materials and materials involving foreign exchange. There is no strict rule for the detailed breakdown of items and it can be carried out depending on the number of categories selected in each major input.

To begin with, values of all these items are calculated according to market prices. But this only shows the financial costs or 'rupee costs' of the different inputs. In order to get the social costs, a correction has to be carried out. The principle underlying the social valuation of commodities or services is the notion of opportunity cost i.e. value in alternative use. When we take the case of skilled labour, we ask ourselves the question as to what is the opportunity cost of employing skilled labour. If there is no excess supply of skilled labour, the opportunity cost of employing skilled labour in one project is withdrawal of the required amount of skilled labour from some other activity. In this case, the market wages paid to the skilled labour will be treated as the social cost of employing skilled labour.

A different sort of situation may arise in the case of unskilled labour. If there exists a surplus of unskilled labour in an economy, say Kerala, meaning that there is wide-spread unemployment among ordinary people, the opportunity cost of employing some of them is keeping them idle, for, they have no opportunity of gainful employment. In such a situation, the market wage rate of unskilled labour does not represent its social cost. If unskilled labour can be easily drawn at site, then a shadow wage rate equal to zero representing the social cost of unskilled labour may be justifiable. If additional costs in the form of increased consumption are to be borne by the economy then the extra consumption element may be treated as the shadow wage rate. In that case, the shadow wage rate will be greater than zero but less than the market wage rate.[2]

The correction for the market prices of domestic materials may be done in the following way. If the market for a commodity is free of monopolistic practices, governmental control or rationing or such distortions, then the price prevailing in the market is deemed to be the social value of the commodity (e.g. bricks, tiles, etc.). In the case of any distortion in the market for the commodity, then the magnitude of the overestimate or underestimate of the market price from the social value has to be found out. For example let us consider the case of cement. Cement is used in most building construction activities but it is not possible to obtain as much cement as one would like to have from the market. The supply is not only regulated but its price is also controlled. The basic reason for such a situation is that the demand for

is considerably greater than the supply. Therefore government resorts to regulative measures on grounds of priority and regional distribution. The controlled price of cement is therefore not an indicator of its social cost. It is scarce and thus demands discriminate use so that it will find application only on important and essential construction activities. The shadow price or social cost of cement can be worked out by finding the extent of the underestimation of the controlled price from the social cost. This can be done by way of the price the consumers are willing to pay if there was an open market or by calculating the benefits of cement in alternative uses like, say irrigation works.

The next item is that of materials involving foreign exchange. This refers to materials which need to be imported or materials with an actual or potential export market. The official foreign exchange equivalent may not represent the opportunity cost of foreign exchange because the supply of foreign exchange is controlled by the government. Foreign exchange is one of the most scarce resources of the economy and therefore any activity which earns foreign exchange needs to be encouraged and anything which uses up foreign exchange discouraged. Steel is one of the items in building construction with an international market. By finding out the international price of steel valued at the shadow foreign exchange rate we can represent the social cost of steel. It is necessary to specify the type of steel used up in the construction work.

In actual practice the method of converting market values of commodities and services into social values is by way of deriving a set of accounting ratios for each input item. The accounting ratios represent the extent of overestimation/underestimation of the market values of inputs from the social values. By multiplying the market values with accounting ratios, the social cost of each technology can be determined. The operational part of this exercise will become clear when we deal with the shadow pricing of building materials in Section II.

Finally, the choice of technology involves the selection of that technology which involves the least social co

1.3 Sensitivity Analysis

The task of the evaluator will be easier if the accounting ratios for national parameters like labour, foreign exchange, etc. are given to him by the central planning authorities. In the absence of such a situation, the evaluator applies a set of accounting ratios which he thinks appropriate. But it may be quite possible that the decision-makers may attach a different value of certain variables. Even if there is agreement between the evaluator and decision-makers about the accounting ratios, the values of certain variables may be subject to fluctuations due to unforeseen contingencies. To take into account these factors, a sensitivity analysis may be carried out using different values of certain crucial variables. Such an analysis helps in determining whether changes in values of certain variables are crucial to the selection of a project or not.

1.4 Macro-objectives and project evaluation

In our method of evaluation suggested for the choice of technology what we really did was to take into account the major policy objectives of the government consistent with the availability of resources in the economy. When there is surplus of certain inputs like unskilled labour, the social cost of employing labour becomes less than the market wage rate which means encouragement to labour intensive technologies. This is how the policy of greater employment creation gets translated in an exercise in project evaluation. Similarly, technologies using certain locally available materials like lime, bricks, tiles, etc. will be preferred to technologies involving the use of scarce inputs like steel and cement because shadow prices of the latter are greater than their market prices. Shadow pricing of materials therefore encourages the production and consumption of locally available materials vis-a-viz scarce materials.

In effect what the technique of social cost-benef analysis tells us is that in selecting projects or technologies for implementing a project the resource constraints of the economy must be fully taken into account so that decisions taken will result in rational allocation of resources rather than further straining the economy.

In the following section, we attempt a social cost approach to the choice of building technology. The analysis considers the alternatives in two elements of a building system: roofing and mortars. Apart from demonstrating how the social cost approach can be applied, the exercise also throws light on the problems which have to be faced at the practical level of the choice of technology.

II

2.1 Social cost approach applied to choice of building technology

In this section a comparative study will be made of the financial and social costs of some alternative building technologies. As we are concerned only with quantifying the costs and not the benefits of the different technologies, the comparative analysis is made here only in the case of certain elements of a building for which alternative technologies of roughly comparable performance are available.

The comparisons are between three different techniques of roofing for a small residential building, and between three alternative mortars for brickwork.

Unfortunately, no two roofing systems will be of precisely the same performance, either climatically or in durability, and this is one element of a building for which non-performance factors, such as fashion, are frequently at least as important as performance in influencing the choice of technology. Nevertheless, roofing is the most costly single item in any small building,[3] and thus the item for which the choice of technology can be expected to have the greatest impact on cost. It is for this reason that roofing systems have been chosen for comparison.

Mortars, on the other hand, are a smaller item in the total building cost. Mortars and plasters together account for up to 15 per cent of typical building costs. But this is one element of a building for which a number of well-defined alternatives are available, each giving the same performance. The comparison of different mortar materials is interesting for this reason.

In any exercise in the use of social costs as a tool for decision-making it is essential that the underlying objectives of the exercise are clearly stated at the outset. In the present case there are two objectives:

1. To create, through choice of technology, the maximum amount of employment for locally available surplus labour.
2. To economise on the use of scarce resources, particularly the products of capital-intensive industries.

These objectives can be stated in quantitative terms by applying shadow prices to each of the inputs of the different technologies which are to be compared. Use of the shadow prices will lead to a social cost for the technology, which can be compared with the social cost of the alternative technologies; the technology with the lowest social cost will be that which best satisfies the stated objectives.

The primary components of cost of any completed building work are the cost of the building materials as delivered to site, and the on-site labour. The on-site cost of the building materials, however, is itself composed of numerous components, including manufacturing and transportation costs as well as labour, and each of these components must be quantified before a shadow price for the material can be determined. In this study, the following procedure will be followed. First, a detailed analysis will be made of the costs of the major building materials, in order to determine the amount of labour involved, in various categories. This analysis will then be used to determine shadow prices for these materials as delivered to site. Finally these shadow prices will be used as the basis for determining the social cost of each of the techniques to be compared.

2.2 Labour components of building materials manufacture

In general, it is possible to split the on-site cost of a building material into four components:

1. Cost of quarrying or getting raw materials and transporting to factory,
2. Cost of manufacture,
3. Cost of transporting building materials to local depot,
4. Cost of transporting building materials to site.

Each of these components of the site cost may be taken to include the profit, dealers's margin or taxes added at that stage.

In the present study, an analysis has been made of the inputs at each of these stages, and both the direct and indirect labour component determined or assessed. The indirect labour component is the labour component of the non-labour inputs (e.g. materials and services) at each stage. (For example, in the case of transport, the labour of the driver and of loading and unloading are direct labour, but the labour component of the cost of fuel and maintenance charges are indirect labour costs).

In each case the labour component in each of three categories has been assessed. The categories are:

L_1: Skilled and semi-skilled labour within Kerala,

L_2: Unskilled labour within Kerala,

L_3: Labour outside Kerala.

The purpose of this sub-division of labour will become clear when shadow prices are discussed in 2.3. The sources of information for the analysis described above are far from complete, and a number of assumptions have been made, and some provisional values assigned. The more important of these assumptions are:

1. The site is in Southern Kerala, at a distance of 10 km from the nearest rail head, building materials depot, etc. A 10 km haul is also assumed in the case of local building materials, sand, stone, lime etc.
2. The cost of materials at site is that given in the 1974 Schedule of Rates of the Public Works Department (PWD) with local transportation costs calculated as set out in the Schedule.[4]
3. Cost of transport from factory to city depot, whether by boat or truck may also be calculated according to the PWD Schedule of Rates, except in cases where a freight equalisation charge applies.
4. The remaining cost is the ex-factory value of the building materials. The proportion of this value attributable to labour and other inputs may be determined from the latest figures available for that industry in the National or State Annual Survey of Industries.[5] For some industries for which no such data exist, the information was obtained from locally conducted surveys.[6]

5. The labour component of some of the inputs to building materials manufacture or transportation on which data are not available have been provisionally assumed to be follows:

Labour component of raw materials value in cement, steel manufacture	: 40 per cent
Labour component of raw materials value in tile manufacture	: 60 per cent
Labour component of input value of all fuel (coal, oil, electricity) used in building materials manufacture and haulage	: 30 per cent
Labour component of freight equalisation charge on cement, steel	: 30 per cent

6. Where no better information is available for industries in Kerala, a division of the labour costs between skilled and unskilled categories in the ratio 1:2 has been assumed.

The analysis is thus location-specific, approximate, and provisional. As it is based on PWD rates, it is also strictly applicable only to public sector construction.[7] The full information on which it is based is set out in the Appendix.

The labour components of the more important building materials, calculated as described, are shown in Table 1. It will be seen that there are two well defined groups. The first group consists of materials manufactured only outside the State, and transported long distances to site. Their method of manufacture is capital-intensive, they are subject to excise duty, and their transport costs are considerable, leading to low labour components. The bulk of this labour is employed outside the state. Cement and steel are in this category. The second group includes both the locally quarried and the locally manufactured materials (stone and sand, bricks, tiles, lime and surkhi). Both the quarrying and manufacturing of these materials is labour intensive. The cost at site, and also the labour component is very dependent on transport costs, and hence on the distance of the factory, quarry etc. from the site. With the assumptions made, the labour components vary from 45 to 70 per cent, but these percentages would be higher if haulage distances were less. The labour component of truck transportation is naturally rather low, and is largely attributable to loading and unloading.

The case of timber is unusual among the materials listed in that the raw material (forest trees) is itself in short supply, and therefore of very high value. Although the process of saw-milling (certainly in Kerala) is highly labour intensive, the value added in saw-milling is only a small proportion of the on-site cost of timber. When the labour in the forestry operations is added to that in saw-milling and transport, the total is only a little over 25 per cent of the cost at site.

Although by no means all the commonly-used building materials are listed in Table 1., those listed account for 70 to 90 per cent of the cost of materials in typical recent residential buildings in Kerala.[6] An approximate figure for the labour component of other materials could be obtained from consideration of the type of manufacture in each case.

Thus the labour component of the cost of laterite blocks could be assumed to be about the same as that for building stone, whereas electricity supply fittings, iron-mongery and paints would be in the same category as cement and steel.

2.3 Shadow prices for labour and materials

In the absence of shadow wage rates for different regions of the country determined by the central planning authorities, determination of a generally acceptable shadow price for labour is a difficult matter and is the subject of much debate among economists. In such cases, it is usual to make a number of alternative assumptions which are in line with the social objectives of the project analysis, and calculate the costs and benefits separately for each assumptions, or set of assumptions by carrying out a sensitivity analysis. A disadvantage of the sensitivity analysis is that it does not of course give any one definite value for the social cost of a project. But the procedure may be valuable for that very reason, since it leaves it to the decision-maker to make the choice on the basis of his judgement of the relative importance of the various objectives, and the accuracy of the data.

In areas such as Kerala, where unskilled labour is abundant and unemployment high, it is common to assume a shadow wage rate of zero for such labour. This gives the greatest possible weight to the objective of providing employment for those who most need it. A zero wage rate may underestimate the real social cost of employing labour, and a shadow wage rate somewhere between zero and the actual wage rate might be more appropriate. The factor by which the actual price of a commodity is multiplied to give the shadow price is called the accounting ratio. In the present study alternative accounting ratios of zero and 0.5 will be used for unskilled labour.

In Kerala, an equally important objective is the creation of employment in unskilled and semi-skilled jobs. There is a plentiful supply of unemployed at every level of education, but the supply of labour already possessing a given skill required may be less. A shadow wage rate higher than that for unskilled labour, but still a little lower than the actual wage rate may be appropriate. Alternative high and low accounting ratios of 0.5 and 1.0 will be used in the present study.

The creation of employment outside Kerala is not among the objectives of the analysis. Moreover, decisions about investment in the industries which provide these jobs is not directly affected by local decision-making. An accounting ratio of 1.0 for labour in such industries is therefore appropriate.

These alternative accounting ratios for labour are shown in Table 2.

Economy in the use of scarce resources is the second social objective of the analysis. In the case of cement and steel, the total quantity available for building is fixed by the productive capacity in the country, which can be increased only gradually.[9] Decisions to use cement and steel in one project must result in withdrawing these materials from another alternative project. In such a situation the true social cost of the use of the material may be determined by the alternative user's willingness to pay. Thus in the case of cement the social cost of using cement is better indicated by the price which a private user is prepared to pay (the open market price) than the controlled price actually paid for cement used on public projects. The two accounting ratios shown for cement in Table 2 are high and low estimates of the ratio of the present open market and controlled price of cement at site.

The case of steel is rather more complicated, since at the present time there is no scarcity of bars and rods in the domestic market, due to the low level of investment activity in the economy. There is however, a world market in steel, and any steel saved domestically could be exported. The foreign exchange so earned is of higher value to the economy than its nominal rupee equivalent, since foreign exchange for imported capital goods is at present scarce. The alternative accounting ratios given for steel in Table 2 are determined by multiplying the ratio of world market to domestic prices by alternative shadow foreign exchange ratios[10]

Accounting ratios of 1.5 and 2.0 have been applied to the nominal foreign exchange rate to obtain these shadow foreign exchange rates.

Timber is another material for which demand is at present greater than supply. It might be argued that the existing prices of timber logs already reflect this scarcity adequately. On the other hand it is clear that the scarcity of timber will increase in the future.[11] Substitution of other, at present more costly, materials for timber will increasingly be necessary. It might therefore be appropriate to use a shadow price for timber higher than its actual price to reflect the need for conservation. Alternative accounting ratios of 1.0 and 2.0 would reflect these two alternative approaches.

The remainder of the materials listed in Table 1 are considered sufficiently plentiful in supply at present, and for the froseeable future.[12]

It remains to determine how to incorporate these alternative accounting ratios into the analysis. If social valuation were to be carried out using every possible combination, a vast amount of information would be generated, and the analysis would become unintelligible. The following procedure will therefore be adopted. For a first analysis, a single set of accounting ratios will be used. These are the accounting ratios which, in the opinion of the authors most accurately reflect the objectives of the analysis. They are shown in column 2 of Table 2. In each case the lower of the two accounting ratios is preferred. The alternative technologies will first be compared on the basis of social costs determined using these accounting ratios. Subsequently, the sensitivity of the conclusions of this first analysis to changes in the assumed accounting ratios will be investigated, by independent variations of the assumed ratios. The shadow prices for the different building materials have first been determined on the basis of the accounting ratios shown in Table 2. This information is given in Table 3, which may now be used to determine the social costs of alternative building techniques.

2.4 Comparative costs of alternative roofing techniques

As this analysis will only be concerned with evaluating the costs of alternative technologies, and not with the corresponding benefits, it is important that comparisons are made only between different roofing systems of roughly comparable performance. It is obvious that reduction in both the financial and social cost of housing could be achieved by the use of climatically inferior or less durable materials, but without some way of quantifying the greater climatic strain or higher replacement cost to the occupants of such houses, the comparison with other, better, types of roofing would be meaningless.

Three alternative techniques for providing a sloping roof will be compared. All are in use in Kerala at present. The details of the construction and climatic performance of the three roofs are given in Table 4.[13] Both solid reinforced cement concrete (RCC) and tile-on-timber are in common use, the reinforced concrete tile filler-slab (tilecrete) roof is a recent innovation. Climatically it is clearly an improvement over the solid RCC slab, since the air gap between the tiles reduces thermal transmittance. By replacing concrete with cheaper, lighter reject tiles, it is also claimed to reduce costs substantially, as well as economising on cement.

The cost of construction has been calculated on the assumption that the roof is to be provided for a small residential house, with a maximum unsupported span internally of 3.0 x 4.5 m. Details of materials and labour requirements have been obtained by structural calculations or from the PWD Standard Data Book.[15] Wage rates for the different categories of labour involved are taken from the PWD schedule of Rates. On-site cost of building materials are taken from Table 3 or direct from the Schedule of Rates. Accounting ratios for each of the materials used are taken from Table 3. The accounting ratio for the timber used in the formwork for the concrete roofs is taken to be the same as that for the timber used in the tiled roof, eventhough the grade of timber used is different. The difference either in labour-intensity of manufacture or scarcity is unlikely to be [redacted] enough to warrant the calculation of a new accounting ratio. For the small category of 'other materials', and for the paint used in the timber roof, an accounting ratio of 1.0 has been used. The accounting ratios for semiskilled and unskilled labour at site are 0.5 and zero, the same as those used in the calculations of shadow prices for the building materials.

Comparative costs at PWD rates and at shadow prices (i.e. social costs) are shown in Table 5. At PWD rates, the tiled roof is seen to be some 28 per cent cheaper than the alternative solid RCC roof, while the tile-crete roof shows, disappointingly, only 8 per cent improvement. Thus, even at PWD rates, the tiled roof is to be preferred among the three alternatives. At shadow prices, the ranking is not altered, but the ratios are considerably changed. The social cost of a tiled roof is only 46 per cent of that of a solid RCC slab roof, and the rating of the tilecrete roof also improves. Its cost is now 12 per cent below that of the solid RCC slab roof. The use of the shadow-pricing technique has therefore not significantly changed the basis for decision-making, in this case. It has only brought more sharply into focus the cost differences which already were apparent even at PWD prices. However, no special scarcity premium has been added to the cost of timber in this case. The effect of such a premium will be studied later by means of a sensitivity analysis.

Another way of comparing the three roofing techniques without introducing shadow prices, is to study the breakdown of expenditure of a fixed amount of money on roofing in each case. This is set out in Table 6. The increased employment generated within Kerala, as well as the increased area of roofing, provided by using the tiled roof, is especially worth noticing. The continued use of tiles or masonry products is especially crucial for employment in Kerala, and new ways may have to be found to combine masonry products with reduced quantities of cement and steel in order to find substitutes for increasingly scarce timber. This could be a fruitful area of research.

2.5 Comparative costs of alternative mortars

The three different types of mortar compared in this study are

1. 1:6 cement:sand mortar
2. 1:2:9 cement:lime:sand mortar
3. 1:1.5 lime-pozzolana: sand mortar.

The equivalence of these three types of mortar for use in structural brickworks is shown in the National Building Code.[16] The same basic design stress is permitted in each of them, though there are some other performance differences.[17] Materials for all of them are available locally.[18]

The materials and labour requirements for the three alternative mortars have, as before, been obtained from the

PWD Standard Data Book. Comparative costs at PWD rates and shadow prices are shown in Table 7. At PWD rates, there is virtually nothing to choose between the three mortars. This is therefore a case where the comparison of social cost is repecially relevant. And it will be seen that at shadow prices the situation is very different. Not only is the ranking of the three mortars altered, but the differences between their social costs is very large. The cost of the cement:lime:sand is 78 per cent of that of the sand:cement mortar while the cost of the lime:pozzolana:sand mortar is only 45 per cent of that of the sand:cement mortar at shadow prices. The reason for this very substantial change can be clearly seen by studying the breakdown of expenditure of a fixed sum of money on mortars given in Table 8. While the volume of mortar manufactured is very little different in the three cases, the amount of local employment generated by selecting the lime:pozzolana mortar is more than double that generated by the normal sand-cement mortar, while at the same time, scarce cement is eliminated.

There are thus very strong social grounds for selecting lime and pozzolana-based mortars for all plaster and brickwork, and the continued use of normal sand-cement mortars on public projects for which alternatives are available cannot easily be justified.

2.6 Sensitivity Analysis of the Social Costs of Alternati Roofing Systems and Mortars

So far our comparisons of the alternative roofing systems and mortars have been based on a set of accounting ratios (given in tables 5 and 7) which the authors consider appropriate. Since shadow pricing of inputs consists of such crucial items as cement, steel and labour, it is possible that our accounting ratios may be questioned. It is also equally possible that the social value of inputs like timber may be subject to fluctuations. In order to take into account the possible objections and uncertainties pertaining to the social values of important items, we resort to a sensitivity analysis. The sensitivity analysis is carried out under three different sets of accounting ratios Under assumptions 1, the original values of the accounting ratios (shown in col 2 of table 2) for all items have been retained except for cement and steel. Under assumption 2, the original set of accounting ratios has been adopted except for unskilled and semiskilled labour. Under assumption 3 the original values of the accounting ratios have been retained except for timber (to take into account the long-term shortage of timber). The alternative accounting ratios used for the primary inputs are those shown in col 3 of Table 2. The corresponding alternative sets of accounting ratios for building materials at site are given in table 9.

The resulting accounting ratios are presented in table 10 and 11 for roofing system and mortar respectively.

An interesting result emerging from the sensitivity analysis is that the ranking of alternative technologies for both roofing and mortar does not change under any set of accounting ratios. This shows that even after allowing for variations in the values of accounting ratios, the options open to us for the choice of technology on social grounds remain the same. For the sake of convenience we have presented the ranking of technologies under alternative assumptions of shadow pricing and their percentage differences in social cost in table 12. Under assumption 1, the tile on timber roofing is found to be 65 per cent cheaper than solid RCC slab; while tilecrete slab is cheaper by 13 per cent. The least difference under assumption 3 shows that tile on timber and tilecrete are cheaper by 42 per cent and 12 per cent respectively compared to the solid RCC slab. For mortar, lime:pozzolana:sand is 65 per cent cheaper than cement:sand under assumption 1, while under assumption 3, it is cheaper by 26 per cent. On the other hand, cement:lime:sand is 25 per cent cheaper than cement:sand under assumption 1, while it is cheaper by only 3 per cent under assumption 2.

III

Conclusions

3.1 The technique of social cost analysis is a helpful tool for engineers at the decision-making level to determine the appropriate technology for building construction based on the criterion of minimum social cost. If engineers are given a set of accounting ratios for building materials and labour (such as table 3) by the state planning authorities, social cost analysis can simply be incorporated into the normal project feasibility reports. The analysis carried out in the paper shows that comparisons of alternative technologies at their financial cost can result in the misallocation of scarce resources. In situations where the evaluator is not presented with a set of accounting ratios by the planning authorities, a sensitivity analysis may be used for selection of an appropriate technology.

3.2 Both at financial costs and social costs, the tile on timber roofing is found to be the cheapest. The fact that solid RCC slab roofing which is considerably more expensive (both from the financial and social points of view) than the tile on timber roofing is commonly used even by governmental agencies implies either a complete disregard for rational allocation of resources or an overriding concern for fashion in roof design. If it is 'fashion' which influences the decision-making process, then a poor state like Kerala is bearing a very high social cost. It may not be out of place to mention here the delay in the construction of Idikki project - an important power project of the State - due to non-availability of cement while residential building construction using cement and steel gets a boom. If conservation of scarce resources and generation of employment to the unemployed is a social objective, then there is no social justification for the continued use of RCC slab roofing and cement:sand mortar in building constructions (like Government servants' quarters and private residential buildings) where it can be substituted with cheaper materials. While governmental agencies can set the pace by selecting the appropriate technology, private construction can certainly be regulated through legal instruments.

3.3 Social cost analysis carries the assumption that the project being considered is small enough not to affect the supply position of the inputs used. In the context of our analysis the supply position of bricks and tiles is very favourable. The idle capacity in the tile factories could be utilized more effectively thus creating more employment in the tile industry. But the supply position of timber could become unfavourable in the event of widespread adoption of tile on timber roofing. Apart from the need for a long term plan of reforestation, there is also a case for an urgent research programme for the development of new roofing systems which could be produced in the local tile industry. Three such systems, tilecrete, hourdis on precast beam, and shellcon roofs are advocated in the Government of Kerala Expert Committee Report on <u>Performance Approach to Cost Reduction in Building Construction</u>. All these have already been proved structurally and climatically sound but their widespread application will only follow from government initiatives favouring these roof types and growing familiarity with them by the engineers, clients and contractors.

3.4 The analysis of alternative mortars reveals that lime:pozzalana mortar is to be preferred to cement:sand mortar for brickwork and plasters. Introduction of this type of material may be resisted by engineers on two grounds: (i) that the stated quality materials are not available, and extra mixing is needed, so that quality control is much more difficult; and (ii) a spurt in demand may result in pushing the prices further up until financial costs are prohibitive. The first objection may be answered in that even if the extra social cost for quality control were added, it is extremely unlikely that its social cost would exceed that of cement: sand mortar. It would not be a difficult matter for regular quality control procedures to be established. In the case of lime and pozzolana, standard tests are available and there are a number of laboratories (e.g. engineering colleges) competent to carry out these tests. The second objection relates to the possibility of what is called a short-run inelasticity in supply, i.e. the existing productive capacity not being able to cater to the increase in demand. Actually, the shift in favour of lime:pozzolana could be a gradual switch over and the increasing trend in demand will attract entrepreneurs to set up units to produce the material. If active support for the setting up of small-scale plants for the production of lime:pozzolana mortar is given by government, then any likely increase in price in the short-run will only be temporary. It has been shown elsewhere[20] that there is considerable scope for the production of lime-pozzolana mortar through small scale plants all over the state of Kerala.

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Table I

ON SITE COST AND LABOUR COMPONENTS OF BUILDING MATERIALS

Category	Unit	Cost at site (Rs)	% of cost at site: Labour in Kerala – Skilled	Labour in Kerala – Unskilled	Labour outside Kerala	Total Labour
1	2	3	4	5	6	
Cement	tonne	291	-	1	25	26
Steel	tonne	2510	-	-	30	30
Timber (irul rafters)	m^3	596	8	17	-	25
Stone (18 mm)	m^3	40.7	16	53	-	69
Sand	m^3	16.7	11	40	-	59
Tile (Mangalore pattern)	'000	430	16	32	-	48
Brick (country)	'000	96.3	12	49	-	61
Lime	m^3	90.6	3	48	-	51
Surkhi	m^3	117	15	30	-	45

Table 2

ALTERNATIVE ACCOUNTING RATIOS FOR DIFFERENT INPUT FACTORS

	Preferred accounting ratios	Alternative accounting ratios
	2	3
Cement	1.5	2.0
Steel	2.3	3.1
Timber (logs)	1.0	2.0
Labour (unskilled, in Kerala)	0.0	0.5
Labour (Semi-skilled in Kerala)	0.5	1.0
Labour (Outside Kerala)	1.0	1.0
Foreign exchange	1.5	2.0

Table 5

SHADOW PRICES AND ACCOUNTING RATIOS FOR BUILDING MATERIALS AT SITE

	Unit	Price at shadow	market prices	Accounting ratio
Cement	tonne	291.0	428.0	1.47
Steel	tonne	2510.0	5780.0	2.30
Timber (irul rafters)	m^3	996.0	912.0	0.85
Stone (10 mm)	m^3	40.7	15.9	0.39
Sand	m^3	16.7	9.0	[illegible].6[illegible]
Tile (Mangalore pattern)	'000	[illegible]	762.0	[illegible]
Lime	m^3	90.6	[illegible]	0.[illegible]
Surkhi	m^3	117.0	75.6	0.45
Brick (country burnt)	'000	96.3	[illegible]	[illegible]

A.R. for cement at site slightly less than for cement at depot on account of element of labour in transportation.

Table 6

Alternative Roofing Systems

Description	Details of construction	U-value $W/m^2\,°C$	Excess* ceiling temperature
Tile-on-timber (with ceiling)	Mangalore tiles on irul wood rafters and reepers with 12 mm timber plank ceiling, painted	2.2	12.[illegible]
Solid reinforced concrete slab (RCC)	100 mm RCC slab; 15 mm 1:4 mortar waterproofing, painted white fine sand:cement plaster to underside	4.[illegible]	[illegible].3
Reinforced concrete tile filler	[illegible] mm RCC tile filler slab; 15 mm 1:4 mortar waterproofing, painted white, fine sand: cement plaster to underside	[illegible]	7.7

* Excess ceiling temperature is the difference between ceiling temperature and air temperature, at mid-day, with air temperature 32 ° C.

Table 5

FINANCIAL AND SOCIAL COSTS OF ALTERNATIVE ROOFING TECHNIQUES (Cost in Rs/m^2 roofed area)

Material	Accounting ratio	Solid RCC slab (1)	Solid RCC slab (2)	Tile-crete slab (1)	Tile-crete slab (2)	Tile on Timber (1)	Tile on Timber (2)
Cement	1.47	11.17	16.40	7.90	11.60	-	-
Steel	2.3	7.95	18.30	7.44	17.10	-	-
Sand	0.54	1.10	0.59	0.84	0.45	-	-
Stone	0.39	3.68	1.43	2.43	0.94	-	-
Timber	0.85	3.51	2.98	3.51	2.98	9.36	7.95
Tile	0.61	-	-	2.20	1.34	9.20	5.61
Paints	1.0	-	-	-	-	3.70	3.70
Others	1.0	0.32	0.32	0.32	0.32	0.09	0.09
Site labour (semi skilled)	0.5	5.68	2.84	5.62	2.61	4.11	2.06
Site labour (unskilled)	0.0	5.25	0.0	4.86	0.0	2.54	0.0
Total cost at PWD rates		38.66		35.13		27.69	
Total cost at shadow price (=social cost)			42.66		37.44		19.41

Col. (1) for each roofing technique is cost at PWD rates

Col. (2) is shadow prices = col (1) multiplied by accounting ratio.

Table 6

EFFECT OF Rs. 1,000 EXPENDITURE ON ROOFING USING ALTERNATIVE TECHNIQUES

	Solid RCC slab	Tilecrete slab	Tile on Timber
1	2	3	4
Area of roofing constructed (m^2)	25.90	28.40	36.00
Expenditure on employment in Kerala	Rs 387	413	438
Expenditure on employment outside Kerala	Rs 135	117	-
Expenditure on cement	Rs 292	220	-
Expenditure on steel	Rs 208	207	-

Table 7

FINANCIAL AND SOCIAL COSTS OF ALTERNATIVE MORTARS

Material in $1m^3$ brick work	Accounting Ratio	Cement: sand mortor		Cement-lime: sand mortar		Lime-pozzolona: sand mortar	
	K	1	2	1	2	1	2
Cement	1.47	16.9	24.8	11.2	16.5	-	-
Sand	0.54	4.0	2.2	4.0	2.2	4.0	2.2
Lime	0.51	-	-	4.8	2.4	4.8	2.4
Surkhi	0.63	-	-	-	-	12.4	7.8
Labour on site (unskilled)	0	3.5	0	3.5	0	3.5	0
Total cost at PWD rates		24.4		23.5		24.7	
Total cost at shadow price (=social cost)			27.0		21.1		22.4

Col (1) for each mortar is cost at PWd rates

Col (2) is shadow cost = col (1) multiplied by accounting ratio.

Table 8

EFFECTS OF 1,000 EXPENDITURE ON ALTERNATIVE MORTARS

	Cement: sand mortar	Cement:lime:sand mortar	Lime-pozzolana sand mortar
1	2	3	4
Volume of mortar manufactured (m^3)	9.9	10.2	9.7
Expenditure on employment in Kerala (Rs)	227.0	339.0	548.0
Expenditure on employment outside Kerala (Rs)	172.0	119.0	-
Expenditure on cement (Rs)	690.0	476.0	-

Table 9

ALTERNATIVE SETS OF ACCOUNTING RATIOS FOR SENSITIVITY ANALYSIS

Material	A1	A2	A3	Preferred values
1	2	3	4	5
Cement	1.96	1.17	1.47	1.47
Steel	3.10	2.30	2.30	2.30
Timber	Same as Col.(5)	0.99	1.59	0.85
Stone	"	0.75	same as Col.(5)	0.39
Sand	"	0.80	"	0.54
Tile	"	0.84	"	0.61
Lime	"	0.76	"	0.51
Surkhi	"	0.85	"	0.63
Brick	"	0.76	"	0.45

Assumption (A1) : Preferred accounting ratio (col 2 of table 2) except for cement and steel (col 3 of table 2)

Assumption (A2) : Preferred accounting ratio for all items except labour (skilled and unskilled (col 3 of the Table 2)

Assumption (A3) : Preferred accounting ratio for all items except timber (col 3 of table 2)

TABLE 10

SENSITIVITY ANALYSIS OF THE SOCIAL COST OF ALTERNATIVE ROOFING SYSTEMS
(Rs. per m^2 of roofed areas)

Material	Solid RCC slab			Tile-crete slab			Tile on timber		
	Shadow prices under			Shadow prices under			Shadow prices under		
	A1	A2	A3	A1	A2	A3	A1	A2	A3
Cement	21.89	16.42	16.42	15.48	11.61	11.61	-	-	-
Steel	24.65	18.29	18.29	23.06	17.11	17.11	-	-	-
Sand	0.59	0.88	0.59	0.45	0.67	0.45	-	-	-
Stone	1.41	2.76	1.44	0.95	1.82	0.95	-	-	-
Timber	2.98	3.51	5.58	2.98	3.51	5.58	7.96	9.36	14.88
Tile	-	-	-	1.34	1.35	1.34	5.61	7.73	5.61
Paints	-	-	-	-	-	-	3.70	3.70	3.70
Others	0.32	0.32	0.32	0.32	0.32	0.32	0.09	0.09	0.09
Site Labour (semiskilled)	2.84	5.68	2.84	2.81	5.62	2.81	2.96	4.11	2.06
Site Labour (unskilled)	0.00	2.63	0.00	0.00	2.43	0.00	0.00	0.62	0.00
Total cost at shadow prices (= social cost)	54.49	50.49	45.48	47.39	44.94	40.17	19.42	25.61	26.34

TABLE 11

SENSITIVITY ANALYSIS OF THE SOCIAL COST OF ALTERNATIVE MORTARS
(Cost in Rs. for 0.24 m³ of mortar)

Material	Cement:sand Mortar shadow prices under			Cement:lime Mortar shadow prices under			Lime-pozzolana:sand mortar shadow prices under		
	A1	A2	A3	A1	A2	A3	A1	A2	A3
Cement	33.12	24.84	24.84	21.95	16.46	16.46	-	-	..
Sand	2.16	3.20	2.16	2.16	3.20	2.16	2.16	3.20	2.15
Lime	..	..	..	2.45	3.65	2.45	2.45	3.65	2.45
Surkhi	..	..	..	..	..	..	7.81	10.54	7.81
Labour (on site Unskilled)	0.00	1.75	0.00	0.00	1.75	0.00	0.00	1.75	0.00
Total cost at shadow price (= social cost)	35.20	25.79	27.00	26.56	25.06	21.07	12.42	19.14	12.42

Table 12

RANKING OF TECHNOLOGIES UNDER ALTERNATIVE ASSUMPTIONS OF SHADOW PRICING AND THEIR PERCENTAGE DIFFERENCES IN SOCIAL COST

Social Cost under / Technology (Roofing)	Tile on timber	Tile-crete slab	Solid R C C slab	Difference between 2 and 4 (as % of 4)	Difference between 3 & 4 (as % of 4)
1	2	3	4	5	6
Assumption 1	1	2	3	65	13
Assumption 2	1	2	3	49	11
Assumption 3	1	2	3	42	12

Social cost under / Technology (Mortar)	Lime-pozzolana: sand mortar	Cement: Lime: sand mortar	Cement: sand mortar	Difference between (2) & (4) (as % of 4)	Difference between (3)&(4) (as % of 4)
Assumption 1	1	2	3	65	25
Assumption 2	1	2	3	26	3
Assumption 3	1	2	3	54	22

APPENDIX

LABOUR COMPONENT OF COST OF BUILDING MATERIALS

Table 1 in the text shows the percentage of the on-site cost of building materials contributed by labour. The labour is further sub-divided into three categories. The tables in this Appendix give further breakdown of these labour costs, in order to show from what sources of information they have been obtained, and on what assumptions they are based. In many cases the assumptions are large, and the only justification for making them is that the probable errors in them do not individually contribute much in the aggregate analysis. The general bias in estimating is towards low values of labour component so that in the subsequent analysis the difference between social, and financial costs should not be exaggerated. As the procedure differs somewhat for the different materials, each of the materials contributing significantly to the cost will be considered separately.

Steel

Aggregate production cost breakdown figure for the Steel industry, including both manufacture of steel itself and rolling of heavy and light structural section, is given in the Government of India's Annual Survey of Industries. The most recent volume available was 1963, from which the figures given the col.2 and 3 of TableA1 are taken. Column 4 shows assumed indirect labour components of each input, and column 5 the percentage of total output value represented by each of the labour components. Labour is found to comprise 36 per cent of the total ex-works value of rolled steel products.

The F.O.R. price at the location where the steel is used also includes excise duty which is taken to have no labour component, and a freight equalisation charge, assumed to have 30 per cent labour component. Table A2 shows this breakdown of the F.O.R. price of steel in 1964, taken from Statistics of the Iron and Steel Industry of India. The labour component of this price is 30 per cent. This figure has also been taken as the labour component of steel supplied to the builder, in the absence of any date on dealer's margins. The whole of this labour component is taken to be in the category L3, labour outside Kerala, although perhaps some small proportion of the transportation cost occurs within the State.

Cement

A similar procedure has been adopted in the case of cement. Table A3, taken from the 1963 Annual Survey of Industries, shows labour costs in manufacture, while Table A4 shows the additional costs in arriving at the F.O.R. price at destination. The information in Table A4 was supplied by the National Building Organisation, and is valid for 1961. The labour component of F.O.R. price is 26 per cent and this again is taken as the labour component of the cost of cement supplied to the builder at town depots, and it is all assumed to be in category L3.

Timber

The labour component of timber costs has been calculated only for one particular case, that of irul rafters, which comprise the main structural element for the tile-on-timber roof considered. Operations in manufacturing these rafters are forestry, including the felling of trees in the forest, and delivery to sawmills and sawmilling.

Table A5 gives the breakdown of the costs of forestry in Kerala in 1965, and is based on information supplied by the Forestry Department. Table A6, taken from the Kerala Government Annual Survey of Industries for 1970, gives the breakdown of costs in saw-milling. Although saw-milling is labour intensive, the value of the trees in the forest is the largest element of the output value, so that the labour component of value after saw-milling is only 25 per cent. This same figure is taken to apply to the cost of all types of timbers used in the construction of the roofs analysed, including cost of formwork for the concrete slabs. In the absence of better information, this labour component has been assumed to be divided in the ratio 2:1 into categories L_1 and L_2, unskilled and skilled respectively.

Tiles

Mangalore pattern tiles are manufactured in Kerala, and the tile industry is covered by the Kerala Government Annual Survey of Industries. Table A7 gives the production cost breakdown, set out as before. It will be assumed that tiles are obtained directly from the factory by the builders and transported to site by trucks. The proportion of labour in the ex-factory price of tiles is 62 per cent and this has been assumed to be divided in the ratio 2:1 between unskilled and semi-skilled labour. Another product of the tile factories is surkhi, and this will be taken to have the same labour component as tiles.

Stone and Sand

Stone quarrying is a small-scale local activity not covered by any survey of industries. The necessary production costs breakdown figures were obtained from survey of local quarries, and are presented in Table A8.

The process is highly labour intensive. Data on sand quarrying were obtained in the same way, but with slightly different numerical results shown in Table A9. By carrying out a direct survey, a better division between unskilled and skilled labour components has been made possible. Both stone and sand are obtained by the builder from the quarry.

Lime

Lime production is also a small-scale local activity, and for this material also, production cost data were determined from a local manufacturer. These are shown in Table A10. Lime shells are collected from the bottom of Kerala's backwaters and lakes by divers and transported by boat to the kiln site. The labour component of cost of limeshell has been taken as 70 per cent. The labour component of charcoal production is taken as 50 per cent of its cost. Labour in all those processes is taken as unskilled.

Transportation

The labour component of truck transportation is very heavily dependent on the distance of the journey, since loading and unloading are labour intensive, while the journey involves very little labour. Two cases have been worked out. The first involves a 10 km. trip returning empty and the second a 50 km. trip, no return journey. Cost breakdown for these two cases are given in Table A11 and A12. Data are taken largely from the PWD Schedule of Rates, which gives vehicle hire rates, as well as loading and unloading rates. Running costs of the vehicle have been estimated from local experience, and 30 per cent of these costs have been taken to be accounted for by labour.

In table A13, the ex-works and transportation costs of each material is shown, along with the labour components of each. The sum of these gives the on-site cost and hence the labour component. In the case of most materials a 10 km. journey has been assumed. In the case of surkhi, a single 50 km. journey to site is assumed. In the case of tiles a two stage truck journey is assumed, consisting of a 50 km. journey to the town depot followed by a 10 km. journey to site.

The on-site costs and labour components derived from Table A13 are those used in Table 1.

Table A1: Production cost breakdown for steel, 1963

Item	Value		Labour	
	(Rs. in million)	% of total	% of col (2)	% of total
(1)	(2)	(3)	(4)	(5)
1. Inputs				
1.1 Fuel, electricity	497	13.3	30*	4.0
1.2 Materials	1688	45.1	40*	18.1
1.3 Depreciation	456	12.2	-	-
1.4 Others	169	4.6	50*	2.3
2. Wages, salaries	502	136	100	13.6
3. Other value added	375	10.2	-	-
4. Total, output value	3686	100.0		38.0

* assumed percentage

Source: Government of India, Annual Survey of Industries, 1963 Industry 341-1.

Table A2: Breakdown of F.O.R. price of steel, 1966

Item	Value		Labour	
	Rs/tonne	% of total	% of col(2)	% of total
(1)	(2)	(3)	(4)	(5)
1. Ex-works value	492	71.0	38.0	27.0
2. Surcharge	1	-	-	-
3. Freight equalisation	75	10.8	30*	3.2
4. Excise duty	125	18.0	-	-
5. F.O.R. price at destination	693	99.8		30.2

Source: Statistics for Iron and Steel Industry of India, 1969, Table 11.308, Light Structurals 5.11.66.

Table A3: Production cost breakdown for cement, 1963

Item	Value		Labour	
	Rs. in million	% of total	% of col(2)	% of total
(1)	(2)	(3)	(4)	(5)
1. Inputs				
1.1 Fuel, electricity	202	25.8	30*	7.8
1.2 Materials	303	38.4	40*	15.4
1.3 Depreciation	52	6.6	-	-
1.4 Other inputs	31	3.9	50*	2.0
2. Wages, salaries	79	6.2	100	6.2
3. Other value added	120	15.2	-	
4. Output value	785	100.0		31.4

Source: Government of India: Annual Survey of Industries, 1965, Industry 334.

Table 44: Breakdown of F.O.R. price of cement, 1971

Item	Value		Labour	
	Rs./tonne	% of total	% of col(2)	% of total
(1)	(2)	(3)	(4)	(5)
1. Ex-works value	100	66.0	31.[illegible]	20.8
2. Packing charges	37.50			
3. Freight equalisation charge	36.45	17.4	30*	5.[illegible]
4. Excise duty	34.75	16.6	-	
5. F.O.R. price at destination	208.70	100.0		26.0

Source: National Building Organisation, Journal of National Building Organisation, Vol.XVIII, No.2, p.10, New Delhi

Table 45: Breakdown of production costs in forestry, 1965

Item	Value		Labour	
	Rs. in million	% of total	% of cost(2)	% of total
(1)	(2)	(3)	(4)	(5)
1. Inputs				
1.1 Standing trees	103.5	46.8	-	-
1.2 Other inputs	28.1	12.7	50*	6.[illegible]
2. Wages, salaries	24.2*	11.0	100	11.0
3. Other value added	65.2	29.5	-	-
4. Output value	221.0	100.0		17.[illegible]

Source: Government of Kerala, Forestry Department, private communication.

Table A6: Breakdown of production costs in sawmilling

Item	Value		Labour	
	Rs. in million	% of total	% of col(2)	% of total
(1)	(2)	(3)	(4)	(5)
1. Inputs				
1.1 Materials (timber)	738	71.0	17.4	12.4
1.2 Other inputs	46	4.4	50*	2.2
2. Wages and salaries	109	10.5	100	10.5
3. Other value added	150	14.4	–	–
4. Output value	1043	100.0		25.1

Source: Government of Kerala, Annual Survey of Industries, 1970.

Table A7: Breakdown of production cost for tiles, 1964

Item	Value		Labour	
	Rs. in million	% of total	% of col(2)	% of total
(1)	(2)	(3)	(4)	(5)
1. Inputs				
1.1 Fuel, electricity	5.2	18.5	30*	5.6
1.2 Materials	5.3	18.9	60*	11.3
1.3 Depreciation	1.2	4.3	–	–
1.4 Other inputs	2.1	7.5	50*	3.8
2. Wages, salaries	11.6	41.2	100	41.2
3. Other value added	2.7	9.6	–	–
4. Output value	28.1	100.0		61.9

Source: J.T. Chirayath, A study of the tile industry in Kerala, Bureau of Industries, Government of Kerala.

Table A8: Breakdown of production costs for stone quarrying, 1975

Item	Value		Labour	
	Rs./load*	% of total	% of col(2)	% of total
(1)	(2)	(3)	(4)	(5)
1. Inputs				
1.1 Materials	2.5	2.9	–	–
2. Wages, salaries				
2.1 Unskilled	56.0	65.9	100	65.9
2.2 Skilled (supervision)+	15.0	17.7	100	17.7
3. Other value added	11.5	13.5	–	–
4. Output value	85.0	100.0		83.0

\+ In owner-supervised industries, there is no easy distinction between supervision costs and profits; some nominal cost of supervision must therefore be assumed.

* A load in this case is 200 ft^3 or 5.5 m^3

Source: Information supplied by a Trivandrum quarry-owner.

Table A9: Breakdown of production costs for sand quarrying, 1975

Item	Value		Labour	
	Rs./load*	% of total	% of col(2)	% of total
(1)	(2)	(3)	(4)	(5)
1. Inputs	0.50	1.4		
2. Wages, salaries				
2.1 Unskilled	25.00	71.0	100	71.0
2.2 Skilled (supervision)+	3.75	10.5	100	10.5
3. Other value added	5.75	16.4	–	
4. Output value	35.00	100.0		81.5

\+ See note below Table A8

* See note below Table A8

Source: Information supplied by a Trivandrum sand haulier.

Table A10: Breakdown of production costs for lime, 1975

Item	Value		Labour	
	Rs./bag*	% of total	% of Col(2)	% of total
(1)	(2)	(3)	(4)	(5)
1. Inputs				
1.1 Fuel (charcoal)	0.75	12.5	50*	6.3
1.2 Materials (limeshells)	2.15	36.0	70*	25.2
2. Wages, salaries				
2.1 Unskilled	1.00	16.7	100	16.7
2.2. Skilled (supervision)+	0.17	2.8	100	2.8
3. Other value added	1.92	32.0	-	-
4. Output value	6.00	100.0		51.0

+ See note below Table A8. All other labour assumed unskilled
* One bag has volume 36 dm^3 when filled.

Source: Information supplied by a Trivandrum lime manufacturer.

Table A11: Breakdown of truck transportation costs, assuming a 30 km journey, no return journey

Item	Value		Labour			
	Rs./tonne	% of total	% of col(2)	% of total		
				$L_1 + L_2$	L_1	L_2
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Inputs						
1.1 Vehicle runningcosts+	15.0	44.0	30*	13.2	8.8	[illegible]
1.2 Depreciation+	2.0	5.9	-			
2. Wages, salaries						
2.1 Unskilled (loading)	1.32	3.9	100	3.9	3.9	
2.2 Semiskilled (driver)	2.00	5.9	100	5.9		5.9
3. Other value added	13.68	40.0	-			
4. Output value (vehicle hire cost)	34.00			23.0	12.7	10.[illegible]

+ Running cost calculated at Rs.1.50 per km., vehicle depreciation costs calculated at Rs.0.20 per km.

Source: Public Works Department, *Schedule of Rates*, 1974, Government of Kerala.

Table A12: Breakdown of truck transportation costs, assuming a 10 km journey, returning empty

Item	Value		Labour			
	Rs./tonne	% of total	% of col(2)	% of total	L_1	L_2
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Inputs						
1.1 Vehicle running costs+	6.0	55.0	30*	16.5	11.0	5.5
1.2 Depreciation+	0.8	7.9	-			
2. Wages, salaries						
2.1 Unskilled	1.3	11.5	100	11.9	11.5	-
2.2 Semiskilled	0.6	5.8	100	5.5	-	5.8
3. Other value added	1.2	11.0	-	-	-	-
4. Output value (vehicle hire cost)	10.95	100.0		33.8	22.5	11.3

+ See note below Table A11

Source: Public Works Department, Schedule of Rates, 1974, Government of Kerala.

Table A13: Breakdown of on-site costs of building materials and Labour components

Material	Unit	Value at town depot		Transportation cost		On-site cost				
		Rs.	Labour (%)	Rs.	Labour (%)	Rs.	Labour(%)	L_1	L_2	L_3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Cement	tonne	280.0	26.0	11.0	34	291.0	26	-	-	26
Steel	tonne	2,500	30.2	10.0	34	2510	30	-	-	30
Timber (frul rafters)	m^3	591.0	25.1	5.6	34	596.6	25	8	17	-
Stone(13 mm)	m^3	29.0	83.0	11.7	34	40.7	69	16	53	-
Sand	m^3	5.0	81.5	11.7	34	16.7	51	11	40	-
Tile (M.P)	'000	310.0	61.9	120.0	23	430.0	48	16	32	-
Lime	m^3	85.0	51.0	5.6	34	90.6	51	3	48	-
Surkhi	m^3	80.0	47.2	36.8	23	116.8	45	15	30	-

Source: for col.(3) and (5), PWD schedule of Rates.
for col.(4) and (6), Tables A1 to A12.

Notes and References

There are mainly three decision criteria usually followed in project evaluation. They are: Rate of Return Method, Present Value of Net Returns and Benefit-Cost ratio. Maximum refers to the highest rate of return among the feasible set of projects. Rate of Return tells us the rate of growth of capital invested and can be defined as follows: If the stream of net returns are indicated by B_1, B_2 ....B_t then the Rate of Return is given by the value of that rate of discount (i) which makes the present value of net returns equal to zero. i.e.

$$PV = \sum_{t=1}^{n} \frac{B_t}{(1+i)^t} = 0$$

From among the set of alternative projects, the project which gives the highest value for i will be chosen.

When the value of the rate of discount (i) is given then the present value method is given by

$$PV = \sum_{t=1}^{n} \frac{B_t}{(1+i)^t} > 0$$

Projects with negative present values will be rejected (since they show a net loss) and from among the projects with positive present values, the project yielding the highest positive PV will be selected.

Similarly, the Benefit - Cost ratio will be given by

$$B\text{-}C \text{ ratio} = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+i)^t}} > 1$$

Where B_t and C_t represent the benefits and costs respectively in year t. All the projects with benefit-cost ratio greater than unity will be recommended and the project with the highest B-C ratio will be selected. For a comparative treatment of different decision rules see Howkins, C.J., and Pearce, D.W., Capital Investment Appraisal (Papermac, Macmillan, London, 1971).

2. The determination of a shadow wage rate in situations of surplus labour has given rise to a vast amount of literature in economics and considerable controversy among economists. Basically the arguments for a zero shadow wage rate and a greater than zero shadow wage rate represent two value judgements of growth vs. redistribution. Proponents of 'growth' would argue that since the immediate necessity is increased output, whatever is saved should be encouraged and whatever is consumed should be discouraged. Since labourers are assumed to be consuming all their additional income (i.e. their marginal propensity to save is zero), the social cost of labour should not be nil but greater than zero. Proponents of redistribution would argue that the extreme disparity in income is a grave social problem and therefore whatever redistribution is possible via employment should be encouraged rather than discouraged. They would regard labourers consumption as equally important as the growth of output resulting from saving. Those who take a via media may favour a shadow wage rate greater than zero but much less than unity.

Results of a recent survey of new residential buildings in Kerala conducted by the Centre for Development Studies (unpublished) showed that roofing represented anywhere between 15 per cent and 25 per cent of total construction costs.

4. Government of Kerala, PWD Schedule of Rates, dated 1-7-74. As this is a confidential document it has not been quoted directly.

5. Government of India, Annual Survey of Industries, 1963, and Government of Kerala, Annual Survey of Industries, 1970-71.

6. Local surveys were carried out on brick and lime manufacture and on stone and sand quarrying. The results of these surveys are given in the Appendix.

7. The rates given in the PWD Schedule are always naturally somewhat out of date, since they are based on price information collected from building projects carried out during a period prior to its publication. Nevertheless, the Schedule is the only complete and consistent set of rates available. Moreover the present analysis depends only on relative rates and not on their actual values, so that general inflationary changes in the rates are of no consequence.

8. These figures are again derived from the recent survey of local buildings referred to in Note 3 above.

9. The target cement production figure for 1979, the end of Fifth Plan period, has been set by Planning Commission at 25.0 million tonnes, on the basis of demand projections. But it is already clear (see for instance, Science Today, Jan. 1975) that production in 1970 is unlikely to exceed 20.0 million tonnes, due to delays in commissioning plants and low capacity utilisation.

10. These accounting ratios are based on steel price figures for 23.1.1974, when the domestic stockyard price for mild steel rods was Rs.1749 per tonne, and the CIF price per metric tonne of mild steel rods in the international market was US dollars 355. Shadow exchange rates of Rs.8 and Rs.12 per US Dollar have been used to calculate the accounting ratios given for steel.

11. In a recent report on Forest Resources of Kerala: A Quantitative Assessment, by Chandrasekharan C., (Kerala Forest Department, 1973), Kerala's total timber requirements in 1990 are estimated at between 5.6 and 12.3 million cubic feet, depending on the assumptions made. Moreover, these demand projections assume that substitution of reinforced concrete and steel for timber in buildings will be increasingly common. The shortage of timber is by no means a local phenomenon. There is already a global shortage of structural softwoods and paper-pulp.

12 There is some short-term inelasticity in the supply of both lime and surkhi. But there is no shortage of the basic raw materials needed-limeshell or limestone, and clay - and increase in the demand for these materials can be expected to lead to an increase in the supply in the longer term.

13. The climatic data given in Table 4 are either taken directly from, or calculated using the methods described in Roofs in the Warm Humid Tropics, by Otto Koenigsburger and Robert Lynn, Architectural Association, London, 1965.

14. See Government of Kerala, Report of the Expert Committee on Performance Approach to Cost Reduction in Building construction, Trivandrum, January 1974, page 30. In figure III.I of this report the cost of a 4" tile filler slab is given as 25% less than that of a solid 4" RCC slab.

15. Public Works Department, Standard Data Book, Government of Kerala, 1974. This gives the building materials and Labour inputs required for all items of finished work.

16. Government of India, National Building Code, p.VI-4-14, Table 4.

17. These differences mainly concern setting time and hardening rate, and workability. Setting of the cement mortar is likely to be more rapid than of the other two types. Quick setting may not necessarily be an advantage in brickwork, and though, and cement mortars are somewhat "harsh" in use. Cement/lime or lime pozzolana mortars are more workable, result in a mortar with a higher resistance to water penetration. For these reasons, in European countries where both cement and hydrated lime (but not pozzolana) are readily available, the standard mortar for brickwork is a 1:2:9 cement:lime:sand mortar.

18. The only locally available pozzolana is surkhi, manufactured by grinding down the kiln rejects from tile factories. This is potentially a high-quality pozzolana. But whether or not the surkhi at present available satisfies the requirements specified in the National Building Code (LP40 of IS 4098-1967) is not known, as no test results are available.

19. The ordinance issued by the Government of India sometime back banning the use of cement in such construction as restaurants, guest houses, roads, etc. was a correct measure but, alas, the life of the ordinance was short lived.

20. See Spence, R.J.S., "The Scope for Manufacture of Lime-pozzolana Cement in Kerala", Proceedings of Symposium on Cost Reduction Techniques in Building Construction, March 22 1975, organised by Government Engineering Colleages Teachers Association. (available in mimeograph from Centre for Development Studies, Trivandrum.)
