

Rural Road Accessibility and Development of Agriculture and Social Infrastructure in Ghana

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The question of the impact of road investment on socioeconomic development of rural areas is of interest to developing regions. In Ghana, a study was made to assess the impact of rural accessibility on agriculture as well as the development of social infrastructure. By using a cross-sectional framework rather than a historical analysis, data were collected from 33 villages in the Ashanti region. Accessibility, defined as the cost of moving a head load of produce from each village to Kumasi (the regional capital), was compared with a number of parameters that describe agricultural development. In addition, the location and development of social infrastructure and the trip-making and in-migration of farmers and their household members were examined. The analysis indicated that the range of accessibility considered had little impact on agricultural activity. Considering that increased agricultural production following new investment is dependent on improved farm-gate prices, a minimum degree of vehicle access to inaccessible areas is essential to ensure the realization of significant increases in farm-gate prices. Providing vehicle access to inaccessible areas would then have a far greater impact on income to farmers than improving short lengths of feeder road. Generally, better accessibility resulted in increased tripmaking and the general social development of rural communities, a factor that is relevant in decisionmaking for rural road investment in the relatively more populated rural areas in developing countries.

The impact of investments in transportation (in particular, low-volume roads on the socioeconomic development of rural areas) is of interest to developing regions throughout the world. This is especially relevant, since in most areas of this type development of roads is often to provide for rapid economic development with emphasis on agriculture. Roads are also expected to provide much needed access to rural communities and their social infrastructure.

Hine (1) has reported varied results of a number of case studies, all aimed at determining the impact of road investment on agricultural development. By and large, such studies have shown that agricultural development is often associated with road investment and that areas close to roads are more likely to demonstrate development than areas farther away. However, it is essential that the extent to which this relation is achieved should be established within the particular socioeconomic environment of each country to provide indications on priorities for development.

This paper reports some of the results of a study conducted in Ghana to determine the impact of rural road investment and accessibility on various aspects of agricultural and social development. The study was carried out by the Building and Road Research Institute (BRRI), Ghana, in cooperation with the Transport and Road Research Laboratory (TRRL), United Kingdom, for the Ghana Highway Authority with support from the World Bank. More detailed reports will be produced by BRRI and TRRL.

SURVEY AREA

The Ashanti region, the study area, lies in the south-central part of Ghana and has an area of about 24 000 km² and a population of more than 1.5 million (1970 census). The capital, Kumasi, has a population of more than 400 000, with the rest spread among some 2500 towns and villages. The latter are mainly dispersed in the rest of the region, excluding the Afram plains in the northwest.

The road network shows Kumasi located in the

center of the region as the natural focus of the distribution network. The city is the administrative center of the Ashanti region, and its major market acts as the transport and distribution center for most of the country. Also, Kumasi is located at the apex of the triangular railway network of the country.

In the area that represents some 70 percent of the region, excluding Kumasi and the Afram plains, the total road length (estimated from existing topographical maps) is about 4400 km, including some motorable tracks. The interim report of the BRRI study (2) gave an inventory total of 3006 km of feeder roads in the network of Ashanti maintained at that time by the Ghana Highway Authority. This length of feeder roads represented about 22 percent of the national total. The regional inventory total was the highest for any single region, and their condition varied from good to very poor gravel or earth surface. Broken bridges and culverts made some of the feeder roads impassable.

On the local level, transportation between the farm and the village and often between farms was entirely along footpaths or partly on footpaths that connect feeder roads or vehicle tracks that pass through or end at the particular village. The major means of transportation is by men, women, or children carrying harvested food crops in baskets or sacks, usually on the head (headloading) along the footpaths and the roads. The use of tractors was identified in one village in the savanna region.

Cocoa farming and food-crop cultivation (maize, cassava, plantain, etc.) are the major agricultural activities in the region and the major source of livelihood. Rearing of poultry, sheep, and goats are only supplementary agricultural activities, except that there is a recent trend toward the development of commercial poultry farming in the vicinity of Kumasi and some of the major urban centers. Other sources of livelihood for a much smaller proportion of the rural population include market trading, rural industry and handicrafts, government jobs, and provision of services.

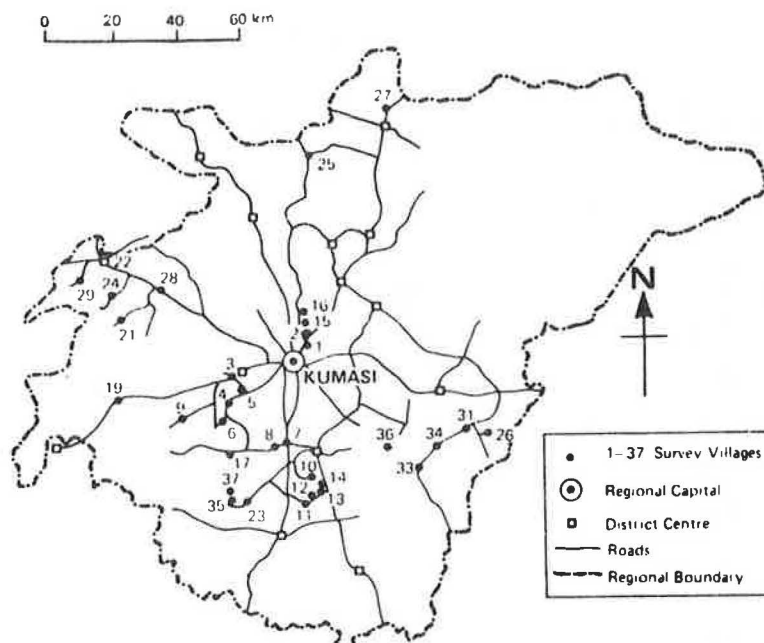
METHOD OF SURVEY

Sampling Frame

Village sampling was based on the existing sample of villages used in a continuing annual agricultural survey by the Ministry of Agriculture. In selecting the survey villages, soil type and fertility, rainfall, terrain, population density, and crop disease (cocoa) were considered to provide some basis for stratification and control. However, final locations were chosen largely in relation to soil type, population density, and accessibility. Seven areas or zones were demarcated based on the previous criteria, and 33 villages that fall within the existing statistical framework were selected for the survey. The village locations are shown in Figure 1.

Socioeconomic data for a total of 491 "holders" (farmer, household head responsible for one or more farm holdings) were obtained by enumerators from the Ministry of Agriculture who were trained for this

Figure 1. Map of Ashanti region, Ghana, which shows location of survey villages.



special survey. The term holder is used as described above throughout the paper.

Parameters of Accessibility

Two key parameters of accessibility were used in the study. These were

1. The transportation charges of moving a unit equivalent to one headload of produce from each village to Kumasi, and
2. The transportation charges of moving a unit equivalent to one headload of produce to its district center.

The transportation charges were found to vary directly with distance traveled. Any apparent leveling effect was found to be an important issue, mainly in cocoa marketing where transportation charges tend to receive a measure of control. However, transportation charges in general were found to be affected by road condition. Trucks that carry goods and people on relatively poor roads charged up to two times or more the charges on roads in better condition over the length of the road. Transportation cost (charge) was found to be one single measure that would account for variation in road condition without requiring a detailed road condition study. The variation in vehicle operating costs with road condition had been determined in an earlier study (3).

In terms of the road network, the definitions adopted covered total accessibility over all links: feeder or main roads. This emphasized the notion that the effectiveness of the development of the low-volume or feeder road component of the network is only as good as that of its connecting main road system to the major consumption centers. All except two of the villages in the sample had direct vehicle access at the time of the study, and they were located between 8 and 102 km by road from Kumasi.

Parameters of Agricultural Development

To measure rural development, no simple unambiguous measure was easily applicable to communities in southern Ghana. Hence, a whole range of social and

economic parameters were surveyed to enable a comprehensive view of the effects of better accessibility to be assessed. Parameters of agricultural development from individual farmer data included farm area, cocoa production, cocoa and maize yields, labor input, finance, crop sales, and the use of modern inputs. Soil samples were collected from the farms and tested for soil fertility in addition to data on local population density, crop diseases, and rainfall patterns.

Social Parameters

Social factors considered in the analysis include the tripmaking characteristics of members of holder's household, education of children of holders, location of schools and length of journeys to school, location of health facilities, and frequency and length of trips for health purposes.

In addition to these, the location of other social infrastructures or services, such as government departments (agricultural extension), administrative centers, public utilities, markets, postal services, etc., were examined to ascertain their relation with accessibility. The location of a total of 35 different social facilities was determined.

RESULTS OF SURVEY

Data Analysis

The study's time constraints did not favor a historical analysis approach and was thus discarded at the initial stages of the study. Instead, a cross-sectional framework analysis was used to determine the identifiable relation between accessibility and the various parameters of social and agricultural development. A regression approach was used to determine the explainable relations. An analysis of variance was carried out for each relation tested together with an F-test of significance. Relations identified and reported in this paper were those that showed reasonable significance and hence less chance of resulting by coincidence.

Agricultural Development and Accessibility

General Holder and Farm Characteristics

The proportion of holders that are male or more than 40 years old rises with distance from Kumasi. More than 50 percent of the holders interviewed were female, while nearly 60 percent were more than 40 years old.

The average total farm area for both cocoa and food crops increased with inaccessibility. The relation was more marked in terms of travel costs to Kumasi rather than the district center. The average size of the household also increases with distance from Kumasi, but the relation was not significant. Average household size was 4.7 people.

The more accessible areas appeared to have a greater proportion of holders with at least the maximum elementary school education.

Principal Source of Livelihood

Cocoa was the principal source of livelihood in the more remote locations, while food farming and non-farming jobs provided the first source of livelihood in more accessible villages. Fifty-nine and 28 percent of holders indicated food farming and cocoa, respectively, as the major source of livelihood. The rest had other sources of income.

Use of Labor

The use of household labor in farming (days worked per person or per holding) rose with inaccessibility. Some further evidence showed that household labor input per hectare declined with inaccessibility, which is a possible indicator of the smaller labor demands of cocoa farming.

No significant simple relation was found to exist between average wage rates and accessibility. However, multiple regression showed the average wage rate to rise with village population, transportation cost to district centers, and population density. Larger isolated villages would thus pay more for labor than the smaller accessible ones.

Use of Modern Inputs

There was no evidence that the use of fertilizers, tractors, or insecticides or contact with extension workers was adversely affected in the less-accessible areas. There was an increased use of fertilizers and other modern inputs in one village in the more remote savanna area north of the region. Thirty-two percent of extension contact, 65 percent of machinery hire, and 75 percent of fertilizer use was in that village. This could also be attributable to the rapidly growing agricultural activity in the area. The village is located on a main road that is generally in a fair condition but showing some signs of deterioration.

The extent of agricultural extension activity generally appears to depend more on direct effects of local management problems of transportation provision and worker enthusiasm than on accessibility.

Holder Finance

The proportion of holders applying for loan finance was higher in the relatively less-accessible areas. More holders more than 40 years old also applied for loans. However, farmers in the less-accessible areas were not as successful as farmers in the more accessible areas in obtaining finance. This also shows the relative advantage of the nearness to the

capital, Kumasi, which has relatively more sources of finance.

Cocoa, Food Crop, and Animal Production

The more inaccessible areas were found to have a higher proportion of farmers growing cocoa, higher average cocoa crop area per holder, and a greater proportion of farmed area covered by cocoa. There was no significant relation between accessibility and cocoa sales per grower or per hectare. In addition, there was no evidence relating variations in food-crop planting density to accessibility. The mixed cropping practice made it difficult to assess this effectively during the survey.

Poultry, sheep, and goat farming were only on a relatively small scale in the villages studied. No evidence was found to relate ownership of goats or sheep to accessibility.

Accessibility, Transportation, and Marketing

Farm to Village Transportation

The average distance between field and village was about 3.9 km, with about two-thirds of the distance taken up by footpaths. There was no significant relation between distance from field to village and the village's access to Kumasi or the district center.

The principal means of carrying produce from the field in more than 90 percent of the households surveyed was by headload. Fifty percent reported using household labor and 40 percent used either hired labor only or a mixture of hired and household labor. Tractors were used occasionally in the savanna village.

Location of Food-Crop Sales

Fifty-seven percent of holders sold their produce at the house while another 24 percent sold their produce at village markets. For the villages located near Kumasi, direct sales were sometimes made at the market in Kumasi.

There was a slight tendency for the proportion of food-crop sales to rise in relation to total production with inaccessibility, but the relation was not found to be significant at the 10 percent level of significance. The principal means of transportation of food produce prior to sale in any location was headloading. The latter was mentioned by 62 percent of the holders. Hired transportation was used to a significant degree in the savanna village zone.

The farmers sell their food crop to "middlemen" who arrange transportation for sale at other markets. It is usually more expensive for them to arrange for transportation themselves. Cocoa, on the other hand, is purchased by the Cocoa Marketing Board from farmers at buying posts in the villages. Transportation by the farmers would only be by headload from the house to the buying post.

Accessibility and Sale of Crops

Considering the relative frequency of three different crop sales, 55 percent of the holders reported they sold maize. The latter was more widely sold than cocoa. Seventeen and 13 percent reported selling cassava and plantain, respectively.

There was no apparent significant relation between maize sales and accessibility. Cassava sales were more prevalent in more accessible villages, which shows a significant relation at the 5 percent level. Further multiple-regression analysis showed a significant relation between the organic content

of soil, accessibility to district center, and cassava sales.

A significant positive relation was also found between the proportion of holders selling more than 30 percent of their plantain crop and transportation costs to the district center. Multiple-regression analysis again showed that plantain sales may be better explained by noncocoa farm area and the incidence of cocoa growing. Plantain is often grown as a cover crop for cocoa.

In total, accessibility does not readily explain the proportion of farmers in a village selling food crops. Nevertheless, the proportion of farmers selling more than 30 percent of any crop, including cocoa, increases with inaccessibility. However, it is considered that other factors such as increase in farm size with inaccessibility and labor input with accessibility would be contributory factors.

Reliability and availability of transportation as a result of poor road condition did not appear to have adverse effects on the sale of crops. Less than five percent of the holders identified this as a major contributory factor in their produce becoming rotten before it could be sold (3). This could be due to the fact that transportation could be prearranged and hence harvesting could be made to suit transportation availability. However, the chances of disappointment are not completely remote, especially during the rainy season when roads deteriorate faster.

Accessibility and Social Characteristics

The level of tripmaking by holders varied from village to village in frequency as well as purpose. Data from 23 villages were received for the questionnaire dealing with these characteristics. However, only six villages provided details on trips to the nearest district center. It was apparent from those responses that holders made relatively more trips to Kumasi than to the nearest district center.

The average number of trips to Kumasi per holder in a year was 19. As expected, the more accessible villages made more trips to Kumasi than the inaccessible ones. One village very close to Kumasi reported 84 trips, whereas the most inaccessible village had an annual trip rate of as low as 1/year.

Characteristics of Last Vehicle Trip by Holder's Household Members

Occupational Characteristics

Apart from farming and household duties, the principal occupations of tripmakers were market trading (7.5 percent), students (5 percent), and laboring (2.5 percent). Other occupations recorded were artisans or professional drivers, teachers or nurses, and businessmen, with each group representing 1.7 percent, while clerks made up 1 percent.

Trip Purpose

One-third of all the identified trip purposes in the survey were for social reasons (including funerals); selling and buying at the market represented 24 and 14 percent, respectively, of all trip purposes expressed. Health reasons were expressed by 10 percent of the people. The two trips (i.e., 0.4 percent) made for educational purposes were made by a teacher and a student.

Generally, the trip purpose differed for the various occupations and sexes. Sixty-three percent of the respondents were female. The farmers made 40 percent of their trips for social reasons, 24 percent to sell at the market, 12 percent to shop at

the market, and 13 percent for health reasons. Market traders, however, made 80 percent of their trips to sell or buy at the market.

Forty-three percent of the male members made trips for social reasons, 30 percent were connected with the market, and 7 percent were for health reasons. Female members, on the other hand, had 44 percent of their trips for purposes connected with the market, 35 percent for social reasons, and 13 percent for trips to the clinic or hospital. Most of the trips connected with education, business, and work were made by the male members. These characteristics show that women play a dominant role in rural travel and marketing of farm produce in addition to their role as farmers.

Household members between the ages of 20 and 59 made 82 percent of the total number of trips recorded. Eight percent were between the ages of 10 and 19 and seven percent were between 60 and 69. Very few members older than 70 made any trip.

Educational Characteristics of Children

In all the villages studied, 70 percent of the children of holders between 5 and 20 years were attending school. For individual villages, this varied from 25 to 100 percent. However, there was no explainable relation with accessibility at the 10 percent significance level. The number of children in school was significantly explained by the level of education of the holder. Generally, the higher the proportion of farmers with at least a Middle School Certificate, the higher the proportion of their children in school.

Most of the children interviewed attend local village schools as expected, since almost all the villages had at least a primary school located there. In a few cases, children traveled distances that ranged from 1 to 118 km to go to school. In the case of the longer distances, most of the children were either nonresident and attending elementary school elsewhere or attending a higher educational institution in a larger town outside their normal home village. In the case of one of the villages, children had to walk 1 km to attend school in a neighboring village. These characteristics confirm the rather low number of longer-distance educational trips mentioned earlier.

Location of Health Facilities and Frequency of Trips

The third major purpose for rural trips after social and marketing factors appears to be trips for health reasons. Seventy-six percent of such hospital visits were made with vehicle transportation. Forty-six percent of the respondents indicated that they generally go to more than one place of treatment. A few trips were also made to receive native herbal or spiritual treatment.

Generally, since the major hospitals and clinics are located in larger towns and villages, there is a great demand for trips to visit such hospitals outside their village. The distance traveled by any holder for medical treatment ranged between 1.5 and 105 km and averaged about 25 km.

Accessibility and General Location of Social Facilities

The survey revealed that the village population was a key determinant of the number of separate social facilities (e.g., schools, churches, markets, etc.) in the village. For example, out of 33 villages, only 10 villages had 10 or more different facilities, and of these only 1 village with 10 facilities had a population less than 1000 people (1970 cen-

sus), while one other village with a population of about 2100 had only 6 facilities but was so close to Kumasi as to be dependent on the city and its suburbs for most services.

Population stands out as a major determining factor for the location of social infrastructure. However, a strategic location of major social services such as hospitals and clinics, higher educational institutions, markets, etc., is essential to ensure easy access in terms of distance, time, cost, and convenience to the average rural citizen.

Accessibility and Migration Characteristics

Some relation was found between accessibility and the percentage of holders who migrated into their villages, as well as the sex of holders. The areas of relative inaccessibility appear to have more migrant farmers. Sex is also a significant explanatory factor for in-migration, with male farmers having a greater tendency to migrate than female farmers.

Generally, the larger villages tend to have reduced proportions of migrant farmers. These characteristics tend to indicate that relatively underused good farming land tends to draw migrant farmers to the rural areas of the Ashanti region that are relatively inaccessible from the major urban centers.

Impact of Rural Road Investment on Farm-Gate Prices

An estimate was made of the proportionate change in transportation costs to the transporter following a road improvement to assess the relative change in farmers' prices. Two estimates, one in Ghana (4) and the other in Kenya (5), showed a 32 and 6 percent reduction in transportation costs, respectively, for a light goods vehicle. This type of vehicle in the case of Ghana is a wooden-bodied vehicle nicknamed the "mammy wagon", possibly due to the predominant use by market women (mammies).

Further, two alternative methods that vary in their treatment of standing charges were also used together with the two estimates to provide four estimates of the reduced transportation charges for each selected commodity. Increases in farm-gate prices were predicted for different road lengths and commodities for the estimated reductions in transportation charges. The table below shows the average percentage increase in farm-gate prices following improvements of rural roads (earth to gravel) and footpaths (footpath to vehicle access):

Type of Improvement	Crop Type	Percentage Increase by Following Lengths of Improvement (km)			
		2	5	20	50
Earth to gravel	Maize		0.08	0.29	0.67
	Yam		0.11	0.30	0.50
	Plantain		0.09	0.24	0.37
Footpath to vehicle access	Maize	4.30	11.40	70.60	

It was assumed that the transportation savings would be fully passed on to the farmer (3).

Farm-gate prices, which is the price paid for the farmer's produce in his or her village, were estimated by subtracting the wholesale transportation charge for different distances to Kumasi from the retail market price at Kumasi. Allowance was made for wholesale and retail margins. Relations established between transportation charges and distance from Kumasi were also used in the estimates. More detailed analyses are to be published in reports on the study by BRRI and TRRL.

The estimates indicate that it is in the order of

140 times more beneficial to the farmer to have vehicle access brought 5 km nearer to his or her village than to improve 5 km of existing earth roads and motorable tracks up to a gravel road standard. Nevertheless, with the nature of existing roads in Ashanti, it is important that the roads are given at least minimal maintenance to ensure vehicle access and prevent further deterioration, especially during and immediately after the wet seasons.

CONCLUSION

Within the range of accessibility considered in the study, there was, apart from some difficulty in obtaining financial assistance, little evidence to indicate that agricultural development was adversely affected by inaccessibility. The more inaccessible areas concentrate relatively more on agriculture, while the more accessible areas appear to gain advantage from their location to seek other sources of income. The two villages without direct road access did not show remarkably different characteristics (other than the obvious ones of increased transportation costs) than the other villages.

Accessibility appears to have an important social impact, especially in relation to tripmaking, as a large proportion of it is for social reasons and for health visits. Complete physical inaccessibility would mean reduced social interaction between rural areas and between rural and urban areas. For example, trips to essential health services would be greatly affected by poor accessibility, which could result in poor health and reduced productivity of rural farming populations. In addition to ensuring basic access, population stands out as the most important criteria for decisions on road investment for social development. The strategic location of social infrastructure is also important for ensuring accessibility to as many villages as possible.

On the impact of road improvement on farm-gate prices, the study found that the improvement of short lengths of roads and tracks would have a negligible effect on the prices paid to the farmer. However, replacing a 5-km footpath between a village and the road head by a vehicle track may benefit the farmer through increased farm-gate prices by more than 100 times than by improving the same length of poor-quality road surface to a good-quality gravel road. However, these benefits would have to be carefully weighed against the cost of construction (3).

Essentially, rural road investment, especially in low-volume feeder roads, would require emphasis on minor improvement, especially to drainage structures (in some cases), maintenance of existing roads in passable condition, as well as improving selected footpaths to provide for much needed vehicle access. The main roads, on the other hand, would also have to be adequately maintained to ensure total improved accessibility.

To ensure increased agricultural development would require the provision of such additional inputs into agriculture that will result in further increases in production and income to the farmer. For example, increased provision of rural banks and their strategic location would improve farmers' finance and hence production and income. The increased demand for transportation from increased agricultural production would provide justification for further investments in low-volume roads in rural areas.

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Economic Evaluation of Pavement Design Alternatives for Low-Volume Roads

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Pavement economics is a very important consideration in the design and management of pavements for low-volume roads. This is particularly true in considering the large mileages that constitute most low-volume-road systems and the sensitivity of total system cost to small changes in pavement design. A pavement management system called the Pavement Design and Management System (PDMS) is used to perform an economic analysis that compares three surfacing types (aggregate, surface treatment, and asphalt) at six different traffic levels for low-volume roads (5-200 vehicles/day in the design lane). Total cost was calculated for each case, which included initial construction, rehabilitation, maintenance, user, and salvage costs. It was found that, for the specific conditions analyzed, aggregate surfacing was optimum for traffic levels of less than five 18-kip equivalent single-axle loads (ESALs)/day, surface treatment was optimum for 5-20 ESALs/day, and asphalt was optimum for traffic with more than 20 ESALs/day. Additional analyses that considered marginal cost, cost-performance ratio, and the effect of terminal serviceability index indicated that a pavement structure that is optimum for a given level of traffic has significantly different costs than a pavement that is not in the optimum range. It is concluded that pavement costs can be greatly reduced for low-volume roads by determining and implementing an optimum design and rehabilitation strategy for a given set of conditions.

The terms "low-cost" and "low-volume" roads are often used together, sometimes interchangeably. However, the term "low-cost," meaning low cost per mile, should not be misconstrued to mean low total cost. Around the world, low-volume roads make up the greater part of the vast majority of road networks. This large road mileage, even when multiplied by a relatively small cost per mile, requires a tremendous annual investment for building and maintenance. The U.S. Interstate Highway System, even though it is costly on a per-mile basis, makes up less than 2 percent of the road mileage of the United States and therefore does not require nearly the resources needed by the United States for its low-volume roads.

Pavement design can be just as important for low-volume roads as for Interstate highways because total pavement costs for low-volume roads are more sensitive to pavement design than costs for Interstate highways. For example, a 1-in change in surfacing thickness for an Interstate highway may increase the cost per mile by 15 percent, but the same design change for a low-volume road could increase

the cost per mile by 50 percent. When multiplied by the large mileage of a low-volume-road system, the effect of pavement design on total cost is very significant.

Because pavement design is so important to the overall cost of a low-volume-road system, every effort should be made by designers to determine the optimum pavement design and rehabilitation strategy for a given set of conditions. This task is made easier by the use of a pavement management system, which can assist the designer in determining optimum pavement management on the basis of total overall cost. This paper summarizes the results of an analysis that evaluated the economic consequences of a range of pavement design alternatives. A pavement management system was used to conduct the analysis, which included the consideration of optimum surface type, marginal cost, and level of maintenance.

BACKGROUND

The U.S. Forest Service operates one of the largest low-volume-road networks under the jurisdiction of a single agency in the world. This system contains approximately 260 000 miles, and 100 000 additional miles are planned for the long-term future. Approximately 11 000 miles are constructed and reconstructed annually, and the annual expenditure for construction, reconstruction, and maintenance exceeds \$0.5 billion.

In an effort to manage this road system more efficiently, the Forest Service and the University of Texas at Austin have developed a pavement management system called the Pavement Design and Management System (PDMS) (1). This computer system optimizes pavement design and rehabilitation strategies on the basis of total overall cost, which includes initial construction, maintenance, rehabilitation, user, and salvage costs. The optimization is completed after the user has supplied information concerning material properties and costs, seasonal conditions, traffic, and road geometry. The PDMS is used in this paper not to optimize under a certain set of