Appropriate Industrial Technology for Low-Cost Transport for Rural Areas Monograph No. 2

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

MONOGRAPHS ON APPROPRIATE INDUSTRIAL TECHNOLOGY

No. 2

APPROPRIATE INDUSTRIAL TECHNOLOGY FOR LOW-COST TRANSPORT FOR RURAL AREAS

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna

Monographs on Appropriate Industrial Technology
No. 2

APPROPRIATE INDUSTRIAL TECHNOLOGY FOR LOW-COST TRANSPORT FOR RURAL AREAS

UNITED NATIONS
New York, 1979

EXPLANATORY NOTES

A full stop (.) is used to indicate decimals.

A comma (,) is used to distinguish thousands and millions.

A slash (/) is used to indicate "per", for example t/a = tonnes per annum.

A slash between dates (for example, 1979/80) indicates an academic, crop or fiscal year.

A dash between dates (for example, 1970–1979) indicates the full period, including the beginning and end years.

References to dollars ($) are to United States dollars.

References to rupees (Rs) are to Indian rupees. In October 1978 the value of the rupee in relation to the dollar was $1 = Rs 7.90.

The word billion means 1,000 million.

The word lakh means 100,000.

The following notes apply to tables:

Three dots (. . .) indicate that data are not available or are not separately reported.

A dash (–) indicates that the amount is nil or negligible.

A blank indicates that the item is not applicable.

Totals may not add precisely because of rounding.

In addition to the common abbreviations, symbols and terms and those accepted by the International System of Units (SI), the following have been used:

Organizations

ASEAN	Association of South East Asian Nations
ESCAP	Economic and Social Commission of Asia and the Pacific
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association
IIM	Indian Institute of Management

Other abbreviations and symbols

AUV	Asian Utility Vehicle
hp	horsepower (1 hp = 746 W)
R and D	research and development

The concept of appropriate technology was viewed as being the technology mix contributing most to economic, social and environmental objectives, in relation to resource endowments and conditions of application in each country. Appropriate technology was stressed as being a dynamic and flexible concept, which must be responsive to varying conditions and changing situations in different countries.

It was considered that, with widely divergent conditions in developing countries, no single pattern of technology or technologies could be considered as being appropriate, and that a broad spectrum of technologies should be examined and applied. An important overall objective of appropriate technological choice would be the achievement of greater technological self-reliance and increased domestic technological capability, together with fulfilment of other developmental goals. It was noted that, in most developing countries, a major development objective was to provide adequate employment opportunities and fulfilment of basic socio-economic needs of the poorer communities, mostly resident in rural areas. At the same time, some developing countries were faced with considerable shortage of manpower resources; in some other cases, greater emphasis was essential in areas of urban concentration. The appropriate pattern of technological choice and application would need to be determined in the context of socio-economic objectives and a given set of circumstances. The selection and application of appropriate technology would, therefore, imply the use of both large-scale technologies and low-cost small-scale technologies dependent on objectives in a given set of circumstances.

Report of the Ministerial-level Meeting. International Forum on Appropriate Industrial Technology

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Foreword

As part of its effort to foster the rapid industrialization of developing countries, the United Nations Industrial Development Organization (UNIDO), since its inception in 1967, has been concerned with the general problem of developing and transferring industrial technology. The Second General Conference of UNIDO, held at Lima, Peru, in March 1975, gave UNIDO the specific mandate to deal in depth with the subject of appropriate industrial technology. Accordingly, UNIDO has initiated a concerted effort to develop a set of measures to promote the choice and application of appropriate technology in developing countries.

Appropriate industrial technology should not be isolated from the general development objective of rapid and broad-based industrial growth. It is necessary to focus attention on basic industrial development strategies and derive from them the appropriate technology path that has to be taken.

The Lima target which, expressed in quantitative terms, is a 25 per cent share of world industrial production for the developing countries by the year 2000, has qualitative implications as well. These comprise three essential elements: fulfilling basic socio-economic needs, ensuring maximum development of human resources, and achieving greater social justice through more equitable income distribution. Rapid industrialization does not conflict with these aspirations; on the contrary, it is a prerequisite to realizing them. But, in questioning the basic aims of development, we also question the basic structure of industrial growth and the technology patterns it implies.

Furthermore, it is easy to see that the structure of industrial growth that should be envisaged and the corresponding structure of technology flows should be different from what they are today; a fresh approach is called for. This does not mean that the flow of technology to the modern sector and the application of advanced technologies are unnecessary. On the contrary, it is essential to upgrade the technology base in general, and it is obvious that to provide basic goods and services, there are sectors of industry where advanced or improved technology is clearly necessary. It would be difficult to envisage a situation where the dynamic influence of modern technology is no longer available for industrial growth and development in general. However, an examination of the basic aims of industrial development leads to the conclusion that there must be greater decentralization of industry and reorientation of the design and structure of production.

Such decentralized industry in the developing countries calls for technologies and policy measures that often have to be different from those designed for the production of items for a different environment, that of the developed countries. As a result, there is a two-fold, or dualistic, approach to

an industrial strategy. Morever, the two elements in such an industrial strategy need to be not only interrelated but also integrated.

In approaching the question of appropriate industrial technology from an examination of basic development needs, a mechanism is necessary to link and integrate appropriate industrial technology to the overall development process. Through such a process the concept of appropriate industrial technology could be placed in the mainstream of the industrial development effort.

It is hoped that these monographs will provide a basis for a better understanding of the concept and use of appropriate industrial technology and thereby contribute to increased co-operation between developing and developed countries and among the developing countries themselves.

It is also hoped that the various programmes of action contained in the monographs will be considered not only by the forthcoming meetings of the United Nations Conference of Science and Technology for Development and UNIDO III but also by interested persons working at the interface over the coming years.

Abd-El Rahman Khane
Executive Director

Preface

To focus attention on issues involved in choosing and applying appropriate technology, UNIDO organized the International Forum on Appropriate Industrial Technology. The Forum was held in two parts: a technical/official-level meeting from 20 to 24 November 1978 at New Delhi and a ministerial-level meeting from 28 to 30 November 1978 at Anand, India.

In response to a recommendation of the ministerial-level meeting, UNIDO, with the help of a generous contribution by the Swedish International Development Authority, is publishing this series of monographs based mainly on documents prepared for the technical/official-level meeting. There is a monograph for each of the thirteen Working Groups into which the meeting was divided: one on the conceptual and policy framework for appropriate industrial technology and twelve on the following industrial sectors:

Low-cost transport for rural areas
Paper products and small pulp mills
Agricultural machinery and implements
Energy for rural requirements
Textiles
Food storage and processing
Sugar
Oils and fats
Drugs and pharmaceuticals
Light industries and rural workshops
Construction and building materials
Basic industries

The monograph on the conceptual and policy framework for appropriate industrial technology also includes the basic part of the report of the ministerial-level meeting and some papers which were prepared for the Second Consultative Group on Appropriate Industrial Technology, which met at Vienna, 26-29 June 1978.

PART ONE

Issues and considerations

Note by the secretariat of UNIDO

INTRODUCTION

The growth of modern transportation facilities has been marked by significant technological developments, and complex and sophisticated systems have been evolved in respect of land, sea and air transport. Such developments have been extended in the international movement of goods and materials not only between industrially advanced economies but also with most developing countries, to varying degrees. Internally within several developing countries also, there has been considerable resource allocation for transport, particularly for urban transportation including urban road networks and the needs of motorized transport, following the conventional pattern of developed economies. Expenditure in many of these developing countries has been largely concentrated on the construction of roads for conventional motorized transport and greater use of such vehicles, together with the growth of automotive capacity based on the phased manufacture of automobiles and trucks.

In some countries, there has been significant extension of long-distance transportation networks. By and large, however, though the heavy capital outlay on rail lines and equipment has constituted a major constraint, the needs of rural transportation in developing countries have received comparatively little attention and rural areas continue to be dependent on modes of transport which have been in use for several decades. Since most of these countries are primarily agricultural economies, the inadequate growth of this basic infrastructure has been an important factor in the growing imbalance between the rural and urban sectors.

The provision of suitable transportation facilities in the rural areas of developing countries constitutes an essential infrastructure prerequisite for rural economic development. Such transport facilities need necessarily to be designed both for the adequate movement of people and materials in the rural areas and at prices that the rural population in these countries can afford. With the high proportion of rural production in the GDP of these countries and with the majority of the population, mostly the poorer sections, concentrated in rural areas, the provision of adequate rural transport facilities constitutes a basic socio-economic need.

In recent years, increasing recognition has been shown of the need for evolving an appropriate strategy for rural transportation, and emphasis has largely been given to the construction of roads of varying standards and specifications to meet rural needs. Some attempts have also been made to bring

about greater standardization in the design and construction of rural roads adjusted according to the availability of construction materials and movement requirements. However, comparatively little attention has been given to the design and manufacture of alternative and appropriate means of rural transport, both non-motorized and motorized, specifically to meet rural requirements. Such needs consequently continue to be met either by traditional modes of transportation used in these countries for several decades with marginal improvements, or by conventional motorized transport based on models and production techniques from developed economies.

With increased emphasis placed by most developing countries on agriculture and with programmes for integrated rural development–including the development of agro-industries and production of a wide range of rural consumption goods and inputs for the agricultural sector, and light engineering goods and repair and maintenance facilities–the movement of goods and materials is likely to increase significantly during the next few years. Unless appropriate facilities for transport of such goods are provided, programmes for integrated rural development and economic improvement of the poorer sections of the rural population may be severely affected. It is consequently essential for developing countries to give necessary emphasis to the design, production and use of appropriate modes of transport which would be within the economic capacity of the average agriculturist in these countries. The consideration of appropriate modes of rural transport will need to take into account the pattern and construction of rural roads, including standards and specifications, and construction and maintenance costs and appropriate technological alternatives and developments in respect of *(a)* muscle-powered transport, *(b)* animal-drawn vehicles and *(c)* various forms of motorized transport. To meet the needs of countries where water transport, both water-ways and sea, is of particular importance, consideration has also to be given to boat construction and mechanization. Various policy measures and implications, therefore, have to be considered to enable appropriate rural transport facilities to develop to an adequate extent.

The above aspects have assumed much greater significance, not only because of greater dependence on movement by road or by boats for rural transportation but because of rising costs of road construction and maintenance and the greatly increased cost of production and maintenance of conventional motor vehicles and other alternative transportation facilities. The alternative types and patterns of rural road construction must necessarily be related to factor conditions and resources of each country and are under examination at national level. These are not, therefore, discussed in detail in this paper; attention has been concentrated on alternative modes of transportation in rural areas and the categories and types of vehicles that can be used.

I. OBJECTIVES

An appropriate strategy for rural transportation must be primarily geared to provide adequate and cheap means of transport to and from rural areas. The objectives of such a strategy schould be to *(a)* highlight the principal issues and

alternatives in the determination and selection of appropriate modes and types of non-motorized and motorized transport for the rural sector in developing countries, *(b)* define the various policy measures that may need to be adopted, *(c)* identify the main areas of Research and Development (R and D) on which attention needs to be concentrated, and *(d)* evolve an overall programme of action that can be considered at national and international levels.

II. REVIEW OF ALTERNATIVE TECHNOLOGY

The various alternatives must be related to the distance over which goods and materials have to be transported; their size, weight, and the frequency of trips as well as the terrain. Rural transportation should aim to cover short-distance movements either around the farm or between farms and markets and vice versa. Short-distance transport can take place by various means ranging from human porterage and animal transportation to muscle-powered transport, such as bicycles, to motorized equipment of different degrees of sophistication. Since short-distance transport is primarily involved, rail movement need not be taken into consideration, though such transportation may well be most appropriate and economic where rail links to rural areas exist or are developed as part of the railway network. The economics of production and use of alternative types of rural transport, other than human porterage, also need to be taken into account.

The range of alternatives in land transportation in rural areas can be broadly considered under the following headings:[1]

Human porterage
Handcarts and wheelbarrows
Pedal-powered equipment
Animal-drawn vehicles
Light motorized vehicles
Boats and outboard engines

Human porterage

Human porterage continues to be a common form of transport in poorer rural areas where roads do not exist, and is used primarily for bringing small quantities of agricultural and other rural products to village and semi-urban markets. Better alternatives need to be evolved for reducing the burden of such porterage, whether the loads are carried on the head, shoulder or back. Carrying methods have been dictated hitherto largely by local customs and only marginal improvement has been made in some countries. Reference has been made in the background paper[1] to the *chee-ke (cheegay)* of the Republic of Korea, an improved frame for back loading, which can easily be converted to a wheeled carrier.

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[1] More detailed information on each of these categories is contained in the background paper "Appropriate transport facilities for the rural sector in Developing Countries".

Handcarts and wheelbarrows

Handcarts continue to be used in urban and rural areas in several developing countries for short-distance transport. These are usually of traditional design, though steel spokes, bicycle and used automobile tyres have been introduced in some developing countries. Wheelbarrows are also commonly used but these follow traditional Western designs, except in China, where a larger wheel (about 700 mm in diameter) is used.

While the use of handcarts, wheelbarrows etc. will continue amongst poorer sections of the population, greater local research and adaptation would be necessary, by way of improved designs, lighter materials and better components. The production of handcarts, wheelbarrows and similar items is usually undertaken in semi-urban and rural areas. If Rural Workshops and Industrial Centres (RWICs) are set up, improved types could be constructed. Designs and supply of materials not locally available would, however, have to be ensured.

Pedal-powered equipment

Although bicycles have become fairly common in the rural areas of several developing countries, and are manufactured in many of these countries, they are still primarily used for the transport of persons rather than goods and materials, except for light agricultural products such as milk and dairy products. It is necessary to consider, however, whether more robust designs of bicycles could be evolved for rural areas rather than the existing models, which are mostly based on earlier Western designs, as well as a rigid frame which permits both transport of people and movement of goods, together with attachments for the carriage of metal or wood products, and agricultural products such as fruits and vegetables. Various types of attachments used in different countries for the carriage of materials can be considered, together with trailers which can be attached to cycle frames.

An alternative form of pedal power is the tricycle, which is commonly used in Asian cities as a cycle rickshaw; it is rather limited because the light-weight body is often not suitable to rural conditions. The *Oxtrike* which could be considered as a possible improvement with its three-speed gearbox is often not suited to rural conditions because of its light weight. The *Oxtrike* is an attempt to overcome the design deficiencies of traditional tricycles. Suitable for small-scale manufacture in developing countries, it could be fabricated in a small workshop equipped with shearing, bending and welding facilities. The use of such vehicles, with or without carrier attachments in rural areas has, however, been rather limited because the light-weight body is often not suitable to rural conditions.

The use of pedal-driven equipment can be significantly extended. Appropriate designs for the basic frame and attachments could be drawn up by national R and D institutions and manufacturers, and prototypes must be tested in field conditions. While basic frames may need to be manufactured on a larger scale, various attachments and accessories could be produced in RWICs and by rural units and artisans, provided designs, common service facilities and supply of materials can be ensured. With appropriate designs and local production

facilities, purchase loans on easy terms will need to be provided to facilitate extensive use of such equipment.

Animal-drawn equipment

Apart from pack animals which will continue to be used on difficult terrain, animal-drawn carts also constitute a common form of rural transport in several developing countries. In India, for instance an estimated 60 per cent of goods are moved by bullock-carts and whilst bullock-cart designs over the years have improved, further considerable improvement appears to be necessary. Such improvements may take the form of:

(a) The replacement of wooden wheels by wheels with steel rims and rubber tyres;

(b) Designing a new frame to reduce the weight of carts either through redesign or use of other materials;

(c) Redesigning the yoke to reduce the pressure on the neck of the draught-animals;

(d) Evolving a light roofing structure of tarpaulin or local materials.

Animal-drawn carts are used infrequently in African countries; but donkey carts are used, and improved designs are being evolved. These improved designs, however, have been put into practical effect only to a limited extent and traditional cart designs continue to be used. With the high price of petroleum products and consequential impact on costs of motorized transport, the role of animal-drawn vehicles in rural transport will continue to be very significant. Greater emphasis is, therefore, necessary on improvement in designs and ensuring that such designs are tested and then utilized in production. Since production is normally undertaken in semi-urban and rural areas, the results of research in the form of appropriate designs and technical instructions should be transmitted to local units engaged in such production. A specific programme of financial and other assistance, including supply of materials and components which may not be locally available, should also be provided to such production units, which are often in the form of single households, so that design improvements can be applied in actual practice. Credit on easy terms should also be provided for purchase of carts of improved designs, together with financial assistance to production units.

Motorized vehicles

Motorized transport alternatives for rural areas range from motorized bicycles, motor cycles with various attachments, tri-wheelers, basic four wheelers to multipurpose vehicles and modified conventional vehicles.

While medium and heavy trucks will continue to be used for longer distance transport, other alternatives need to be considered and developed for short haul movements by individual farmers or small groups. The pattern of import substitution in respect of transport vehicles has resulted, in most cases, in the

assembly and semi-assembly of conventional motor vehicles, particularly of cars and trucks of various models. This has not helped the growth of integrated domestic production of automotive vehicles and their principal components and spares nor the local production of vehicles suited to rural conditions. Some successful local adaptations have undoubtedly taken place such as the *Jeepney* in the Philippines but there has been little development primarily suited to local rural conditions. A major constraint has been the high cost and consequently low demand for such vehicles and this has to be kept in mind when considering possible alternatives.

Motor cycles and attachments

The use of motor cycles in rural areas is very low because such limited domestic production as takes place is utilized almost exclusively in urban areas. Interesting urban adaptations, which can have varying degrees of rural application are the auto rickshaw in India and the *bermo* in Indonesia. Greater use in rural areas of such equipment or motorized bicycles with attachments can take place if simpler and cheaper vehicles can be designed, together with simple attachments in the form of trailers, side-cars, etc. Such production could be encouraged through financial incentives to manufacturers, including differential taxes and duties.

Multipurpose motorized farm vehicles

Considerable potential exists for the design and production of simple, multipurpose motorized vehicles for use in agricultural operations and for rural transport. In some agricultural communities, light conventional tractors are already being utilized to pull trailers carrying rural products to local markets. The use of conventional tractors for this purpose is expensive and would be beyond the reach of the average agriculturist. Other alternatives that have been developed are the two-wheeled tractors used extensively in China; single-axle tractors with petrol engines developed by the International Rice Research Institute (IRRI) in the Philippines, which are particularly suitable for wet-rice agricultural areas; and a self-propelled cart also developed by the IRRI and other similar vehicles in use in different countries. Other alternatives have been designed for carrying half-tonne loads over difficult ground and while these have not been specifically designed for developing countries, they illustrate the various possibilities for producing multipurpose vehicles.

The use of multipurpose vehicles for farming, together with short distance transport, can provide a challenging solution to rural transport needs, particularly in areas with greater purchasing power. Obviously such production will need to be related to the demand that can be generated, particularly by farmers operating on the basis of joint ownership through co-operatives or similar units. Production of such vehicles will necessitate extensive testing of prototypes in field conditions, acquisition of technology on suitable terms and a programme of financial and other incentives to both producers and users of such equipment.

Modifications of conventional vehicle designs

In some instances, conventional vehicles can be suitably redesigned to meet rural needs. These include vehicles such as modified jeeps or the Asian Utility Vehicles (AUVs) presently produced and used in the Philippines and other South-Asian countries. Another possible alternative that can be considered is the Tractor which can be produced economically in small numbers, as compared to mass production and ensure the production of a large number of common parts and components.

RWICs could play an important role in repair and maintenance of motorized vehicles utilized for rural transport and for production of simple parts and components over a period of time. The use of such vehicles would also greatly accelerate the pace of technological growth and the use of modern tools and equipment in rural areas.

It would appear from the above résumé that there is considerable potential for the design and development of appropriate motorized vehicles for rural regions, either in the form of multipurpose vehicles or modifications of existing conventional vehicles using common basic parts and components. The selection of the appropriate type of vehicles would necessarily be related to factor conditions, resources and needs of each country. Obviously, initial internal demand for motorized vehicles would be limited in view of low purchasing capability and it may be necessary to take up joint production of particular vehicles for groups of countries in case national internal markets are not adequate. Nevertheless, considerable scope does exist for choosing appropriate alternatives and for initiating programmes for production and distribution of such vehicles.

Boats and outboard engines

In many developing countries, water transport is of considerable significance. In Bangladesh for example, a great deal of rural produce is still carried to markets by boats. It is necessary to evolve design improvements for boats and vessels, including attachments such as light outboard engines. Such engines will need to be simple to manufacture and repair in view of the limited facilities in rural areas. An alternative that can be considered in this context is ferro-cement boats, a subject on which a study has been conducted by UNIDO.[2] The development of low-cost boats for water transport, as well as for fishing, needs to be considered where such transport will continue to be of importance.

III. PROGRAMME OF ACTION

It will be seen from the above brief survey that several alternatives exist and can be further developed for providing appropriate rural transport of various categories. The studies and research made in this regard are by no means

[2] *Boats from Ferro-cement* (United Nations publication, Sales No. 72.II.B.23).

comprehensive and considerable additional R and D efforts are necessary, together with the production of prototypes which can be intensively tested in actual field conditions. Nevertheless, there is considerable potential for an effective and realistic programme of action to be undertaken in this regard.

It is essential that adequate emphasis be given to rural transportation at national policy level and that an overall programme be drawn up regarding the economic and technological needs and implications.

It is necessary that national agencies devote greater R and D efforts to identify the issues relating to domestic rural transportation, and co-ordinate the results of R and D that may already have taken place. Specific fields for further study and research should also be defined in respect of different categories of vehicles; designs; substitution of lighter and durable components in existing common modes of transport; use of better materials and components; application of group technology in manufacture of appropriate motorized vehicles etc. Similar R and D efforts can be undertaken in institutions and by manufacturers in developed countries, particularly in respect of alternative designs for motorized rural transport of various types and categories.

National agencies should evaluate alternative designs for various categories of rural transport from a techno-economic viewpoint; assist in production of prototypes and disseminate information and provide technical guidance regarding appropriate alternatives and production techniques to existing and potential production units.

National agencies should compile information on alternative types of vehicles, and improvements and modifications of such vehicles, together with experience of operations. Such information could be compiled both on national and regional levels and be disseminated to other developing countries through international agencies such as UNIDO.

A specific programme of financial assistance should be undertaken to encourage commercial production of the non-motorized and motorized vehicles considered appropriate in particular countries. Such incentives can take the form of long-term loans on easy terms or provision of capital grants for undertaking manufacture of approved types and categories, together with differential rates of taxes and excise duties to production units. Financial assistance will also need to be provided to users of such non-motorized and motorized vehicles and suitable hire-purchase facilities should be provided at the field level to individual and groups of farmers.

RWICs and similar production units in semi-urban and rural regions should undertake maintenance activities, together with production of products, parts and components to the extent feasible and on a phased basis, in conjunction with the growth of local skills and capability. In respect of simpler transport equipment such as improved carts, fishing boats etc., RWICs can effectively undertake production programmes, provide technical guidance, designs and necessary materials can be supplied by national agencies, and the "organized-urban" sector, and necessary financial arrangements can be made.

The role of international co-operation in rural transportation is significant, both in R and D of alternative designs, production of prototypes etc. and in the phased manufacture of appropriate vehicles for rural areas in developing countries, particularly modified motorized vehicles and their attachments.

Report of the Working Group

I. GENERAL CONSIDERATIONS

While a specialized body of knowledge normally exists in developing countries on the planning and building of roads, very little or none exists on the appropriate choice of transportation means and related manufacture. Where rural transportation is considered, it is always from the viewpoint of roads. However, a transportation policy should first consider the people and goods to be moved and the prevalent conditions, which often do not include the existence of roads. In the rural areas of most developing countries and even in urban areas there are no means of transport available to cover the gap between traditional means of transportation and such motorized vehicles as trucks and passenger vehicles.

A choice of transportation technologies applicable to the rural areas stretches like a continuous chain, from human porterage to motorized four-wheelers, the choice being made in accordance with the particular transportation needs and specific environmental conditions.[1] The range should be considered as dynamic in concept, with each option thought of as a stepping stone to the next more sophisticated option, and there should be a continual search for new stepping stones.

In formulating its conclusions and proposals the Working Group took into account the fact that in the rural areas of developing countries the technologies applied in the past have not been fully appropriate to or effective in meeting the transport needs of small farmers.[2]

Expenditure on the transport section has largely concentrated in the construction of roads for motorized vehicles. An essential element in improving the transport capabilities of small farmers must be to provide a graduated choice of vehicles where performance matches need, and where cost is in proportion to income. Some of these vehicles already exist, but their use is at present very localized; others remain technically primitive but their efficiency could be improved radically.

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[1] Lack of time prevented discussion of boats and boat engines. In any case, the use of the waterways for the majority of developing countries is irrelevant to rural development and the related transport needs. However, in areas where such an option is applicable, it definitely should be taken into consideration.

[2] "Small farmer" is used in this paper as representative of the poorest section of the population, particularly of rural communities.

II. ATTITUDES

Development agencies can play an important role in changing the attitudes of those involved in administration, research and education in developing countries by adopting policies and work programmes which encourage the application of appropriate transport technologies. They can also accord it greater importance in their research activities, thereby giving the subject greater visibility and status.

The concepts should be incorporated into educational courses, particularly those of universities, which will serve the decision-makers of the future.

The fact that basic forms of transport, both vehicles and routes, have not been accorded any official recognition has contributed to their neglect. Information on basic transport is essential both to change current attitudes and to create a basis for planning improvements.

With regard to motorized rural transport, the Working Group endorsed the recommendations of the expert group meeting organized by UNIDO in co-operation with the Government of Australia in 1976. The meeting emphasized that the development of low-cost two-, three- and four-wheeled vehicles in a number of countries and experience in marketing them suggests that these vehicles have a major part to play in economic development. Moreover, the simpler production technologies involved mean that manufacture can be more readily undertaken at lower volumes of production in countries at an early stage of industrial development. This feature can reduce the foreign-exchange cost of providing an adequate transport system and contribute directly to the enhancement of productive abilities and technical skills. To secure these developments, the flow of information on vehicle types and productive techniques should be promoted as a matter of urgency. Governments of developing countries should pay attention to the possible role of low-cost vehicles in their economies and to frame development policies accordingly. There is need for continuing support from the international community, including UNIDO and the United Nations regional agencies, in providing information, training and advice on policy and investments.[3]

The manufacture of motorized vehicles, because of the need for a wider variety of components and related skills, has beneficial effects in other sections of the manufacturing industry, providing a base for the acceleration of technological growth and the use of modern tools and equipment. Rural workshops also play a role in the provision of repair and maintenance services for motorized vehicles utilized for rural transport.

Conventional vehicles can often be suitably redesigned to meet rural needs or to overcome the problems inherent in designs geared to large-scale production. The *Jeepney* in the Philippines is basically a jeep-type vehicle manufactured with almost 100 per cent local content; only the engine is built under foreign licence. Mention should also be made of the work carried out by the *Institut für Produktions-Technik und Automatisierung,* Federal Republic of Germany, whereby frames for mopeds are made from bent and welded sheet metal instead of stampings or tubing.

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[3] *The Manufacture of Low-cost Vehicles in Developing Countries,* Development and Transfer of Technology Series No. 3 (United Nations publication. Sales No. 78.II.B.8).

There is in rural areas considerable potential for the design and development of additional motorized vehicles, either in the form of multipurpose vehicles (for agricultural and transportation uses) or as modified conventional motorized vehicles using common basic parts and components. A multitude of designs and prototypes exists which have not been checked or tested in practice. Many of these do not work simply because they were not designed at the level where they were supposed to operate. Rather than engaging in further R and D work, priority should be given to existing models proven by practice and the improvement of designs presently at the testing stage.

III. POLICY

An essential element in improving the transport capabilities of rural populations must be to provide a selection of vehicles whose performance matches need and whose cost is sensible in relation to income. The achievement of this objective will require a fundamental change in policy to ensure that rural transport planning includes an explicit appraisal of the needs of the small farmer and the constraints within which a choice must be made.

The first step would be a specific analysis of the magnitude, frequency and duration of transport needs and of the distances over which movements are required. The proximity and structure (condition, degree of integration) of all existing routes (footpaths, tracks and roads) and motor vehicle services would be recorded. The consequences in terms of current availability, ease of manufacture and repair, utilizing local resources, as well as employment generation would then have to be evaluated. Finally, a selection would be made of the vehicle-route combination that would best meet local needs.

Existing incomes or credit facilities, and attitudes towards different forms of transport would indicate the likely range of functionally and economically appropriate vehicles.

The crucial elements of this process are: *(a)* an integrated approach to the development of routes, means of transport, local resources and attitudes and employment generation, and *(b)* the direct participation of Government and development agencies in overcoming the problems associated with the provision of appropriate basic vehicles.

IV. PROGRAMME OF ACTION

Main elements

The five main elements in the programme of action are:

(a) A fundamental change in government policies to ensure that transport planning includes an appraisal of the needs of the small farmer and the constraints within which choice must be made;

(b) A change in attitude of those involved in administration, research and education for the transport sector;

(c) The need to collate and co-ordinate information on existing transport devices suitable for the small farmer, on R and D programmes on appropriate transport, and on institutions and individuals with expertise in appropriate transport technology;

(d) Studies of the many aspects of transport for small farmers in urgent need of co-ordinated R and D, for example:

(i) The magnitude, frequency and duration of transport needs at the farm level;

(ii) Methods suitable for the local manufacture of pedal-powered vehicles;

(iii) Improvements to traditional forms of animal-drawn vehicles;

(iv) A basic, low-powered (5–10 hp), motorized vehicle suitable for on-and-off farm transport;

(e) Active government participation in the supply of appropriate vehicles, including assistance to manufacturers and credit facilities for purchasers.

Information

Information is needed on the design, manufacture, operation and effectiveness of such devices as head, shoulder and backloading aids, handcarts and wheelbarrows, animal-drawn carts, bicycle carriers, bicycle and moped trailers, tricycles, carrying containers for pack animals, and basic motorized vehicles.

One function of the international development agencies would be to collate information on existing devices, on R and D programmes, and on institutions and individuals with expertise in appropriate transport technology.

Research and Development

There are many characteristics of rural transport for small farmers requiring R and D. The socio-economic aspects of R and D include the magnitude, frequency and duration of small farmer transport needs at the farm level, as well as other rural transport needs, particularly those associated with industry and with health, educational and other services provided by the community.

The direct and indirect employment characteristics of different needs of land transport are also involved. Of particular significance would be the employment created per unit of capital and the likely proportion of local to foreign resources required per unit of employment.

Of interest also are the economics of basic vehicle operation in relation to loads, distances, short- and long-term load factors, expected vehicle life and maintenance expenditures, terrain, and availability of alternatives.

Many of the items of hardware required need R and D work, for example, wheels and bearings for use on barrows, handcarts, cycles, trailers etc. and bicycles and motor cycles for local manufacture and use.

Production and marketing

There remains a need for field testing and market evaluation in the place where the vehicles will be manufactured and used, such as making the technology known, making credit facilities available for purchasing vehicles, marketing, training and servicing.

Governments can assist manufacturers with the provision of credit and technical expertise through development organizations. There is also a role for development agencies either to provide assistance to specific projects or to reinforce the capabilities of government institutions.

Governments can aid the small manufacturers by assisting with the supply of materials and components and the certification of their quality.

The successful introduction of basic vehicles will depend on the establishment of local manufacture, the provision of institutional credit facilities for purchasers, adequate institutional arrangements for supply and distribution of spare parts, for repair and maintenance of basic vehicles and for the training of operators and mechanics.

PART TWO

Selected background papers

Appropriate transport facilities for the rural sector in developing countries

I. J. Barwell and J. D. Howe***

INTRODUCTION

In considering appropriate transport facilities in the rural areas of developing countries, it can be argued that the technologies applied in the past have been inappropriate to, and ineffective in meeting, the needs of the poorest people. An essential element of any strategy for improving the transport capabilites of rural populations must be to provide a range of vehicles whose performance matches need and whose cost is in sensible relation to income.

All the evidence implies that the facilities available to the poor are few and primitive. Large numbers of people live far from the motor vehicle road system and much of their travel takes place on earth tracks and footpaths; they are also largely dependent upon human- and animal-powered means of transport.

Discussion of appropriate transport facilities for rural communities must be conducted against a background in which:

(a) The number of rural poor is significant and increasing;

(b) Their standard of life is static at best or declining;

(c) Family income is unlikely to exceed more than a few tens of dollars a year;

(d) They live mostly in areas poorly served by public amenities, including transport;

(e) Rural poor generally resist change involving financial risk.

TRANSPORT NEEDS OF THE RURAL POOR

The most significant transport needs as far as the rural poor are concerned relate to agricultural activities, since it is through the generation of marketable surpluses (and thus income) that other goods and services become affordable. They can conveniently be divided into two categories: on-farm and off-farm.

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In most developing countries the small farmers' dwelling and storage facilities are located away from their landholdings, which often consist of a number of separate plots. Transport on the farm is required for a variety of tasks related to crop production and household needs. Movement of seeds or plants, fodder, fertilizer, insecticides, agricultural implements and other inputs, as well as movement of harvested crops, is required each season as a part of normal farming operations. Firewood and water must also be gathered from areas surrounding the farm for household and crop production use. Somewhat surprisingly on-farm transport needs have been almost totally neglected by those concerned with the planning of transport systems to the extent that very little is known about them.

Since the farmer must follow a fairly rigid schedule, on-farm transport should not be so time-consuming as to delay important operations. For example, if some crops are not sprayed on time the results may be disastrous. A World Bank study in Kenya found that although traditional methods of transport such as headloading and donkeys had in some areas been adequate in the past on the farm, introduction of new inputs and high-yielding seed varieties was beginning to strain the available capacity [1].

Off-farm transport

Off-farm transport is conventionally understood to mean movements between farm and market. Many small farmers live remote from the motor vehicle road system and their off-farm transport is between farm and roadside, and between roadside and collection point or market. An example of how large these elements can be in difficult terrain poorly served by roads is given by the definition in a study of Nepalese peasant agriculture of the terms "on road" to mean at the roadside or within a few hundred metres, "near road" to mean up to half a day's walk from the road, and "off-road" to mean more than half a day's walk [2].

Available information does not allow the identification of situations where the farmers' ability to improve their conditions is constrained *inter alia* by lack of transport.

Even farmers operating at or below the subsistence level have to market produce. Surveys in Bangladesh showed that farmers with holdings of less than 1.6 ha market on average 300 kg of paddy each year out of a harvest of 1,700 kg. During a year they also purchase, in paddy and rice, the equivalent of 430 kg of paddy. Thus although their paddy production is below subsistence level, they market a part of their crop to raise cash after the harvest to repay debts, and in any case lack storage space [3].

Small subsistence farmers may need to move nearly a tonne of agricultural goods each year. However, their transport needs could change significantly if they could eliminate debts or obtain storage space. They also have to move a substantial quantity of fertilizer.

Improvements in agricultural practices can significantly increase quantities to be transported. In South-East Asia introduction of a new rice variety increased yields by 5 t per hectare [4]. Assuming that three quarters of this increase was

marketed, a farmer growing 2 ha of paddy would have 7.5 t of additional produce to move, without counting the fertilizer needed to produce the increased yield.

A major factor in determining the frequency and timing of the marketing of produce is the perishability of the crop. Certain crops need to be consumed soon after harvesting, and others require specialized storage facilities. For example, milk has to reach a cooler place very quickly. Perishable crops need prompt and regular transport, either for the duration of harvesting or throughout the year, depending on the type of produce. However, if durable crops can be stored and marketed over a period of months a better price can be obtained.

Some small farmers have no option but to trade at the nearest market, although if they could reach distant markets, they could obtain higher prices. In Rajasthan, India, most of the peasants at harvest time have hardly any option but to offer their produce to the local merchants on such terms as the latter may dictate [...]

The situation can be summarized as follows:

(a) Appropriate transport facilities are necessary if other basic needs are to be met;

(b) The most important needs for the rural poor relate to agricultural activities on-farm and off-farm;

(c) On-farm needs have been totally neglected by planners yet are already a burden if not an outright constraint on small farm activities;

(d) Even farmers at bare subsistence levels may need to market substantial amounts of produce;

(e) The cost and scarcity of hired motor vehicles, the poor terms offered by itinerant traders and the relative lack of success of organized marketing services indicates the need for transport under the small farmer's control;

(f) The transport available to the farmer should not be so slow, burdensome and time-consuming as to limit the amount carried and the distance that can be moved because of the effort or time involved.

TRANSPORT TRENDS IN DEVELOPING COUNTRIES

A major feature of investment in developing countries since the Second World War has been the importance accredited to transport.

This accounted for almost one quarter of World Bank loans and one fifth of International Development Association credit up to 1977 (see table 1). The same emphasis has been reflected in the allocation of public funds by the developing countries themselves (see table 2). The most noticeable transport development has been the growth of motor transport and the construction of roads. In the transport sector highways have dominated investments accounting for approximately a half of all loans and credits (see table 3). Again, priority for investments by international aid agencies has been reflected and endorsed by the developing countries (see table 4).

Goods movement by truck, and passenger movement by bus and taxi have become major new elements in the system. Most railways are carrying more

TABLE 1. APPROVED IBRD AND IDA CUMULATIVE LENDING OPERATIONS TO 30 JUNE 1977

Sector	*Bank loans*		*IDA credits*	
	Amount (millions of dollars)	*Fraction of total (%)*	*Amount (millions of dollars)*	*Fraction of total (%)*
Agriculture and rural development	6 780	17.6	3 644	32.0
Development finance companies	4 012	10.4	302	2.7
Education	1 224	3.2	648	5.7
Electric power	8 455	21.9	949	8.3
Industry	3 653	9.4	495	4.3
Non-project	1 855	4.8	2 011	17.6
Population	120	0.3	76	0.7
Technical assistance	31	0.1	55	0.5
Telecommunications	934	2.4	470	4.1
Tourism	247	0.6	40	0.4
Transport	*9 588*	*24.8*	*2 251*	*19.7*
Urban development	368	1.0	128	1.1
Water supply and sewerage	1 344	3.5	329	2.9

Source: World Bank, *Annual Report, 1977.*

than ever before, but they are losing short-haul business and much of the higher-valued manufactured goods to road transport. The result is that with the exception of those used exclusively for mineral extraction, railways are in a state of decline [6].

The scale of investment has produced considerable changes in the road systems of most developing countries. Yet, with one or two exceptions, most of them still lag far behind the rest of the world in density and quality of road networks.

Past road investments have favoured the construction or improvement of major rural highways rather than urban or minor roads. The World Bank has stated that until about 1970 its overall lending for road and highway construction was disproportionately oriented to major roads, but increasing emphasis is now being given to rural roads (low-volume, low-cost feeder or tertiary roads). The proportion of "rural roads" in the total length of rural roads and inter-urban highways expected to be built under World Bank projects rose from 38 per cent for those approved in 1965 to 52 per cent in 1969/1971 and 93 per cent in 1975/1977 [7]. The Bank's policy change is, however, less radical than it sounds since, in many developing countries, the end of the 1960s saw the completion of a basic trunk road network and attention naturally turned to the provision of more extensive secondary and feeder road networks.

Despite the shift away from major highway construction, given present trends, it is unlikely that the density of roads directly serving the rural poor will increase very rapidly in the future. This is because of the high cost of road construction and limited resources at the disposal of the poorer countries.

Table 5 showing expenditures on road construction in a number of developing countries is drawn from the International Road Federation World Statistics for 1976.

TABLE 2. SECTORAL DISTRIBUTION OF PLANNED PUBLIC SECTOR INVESTMENTS

(Percentage)

Sector	*Barbados[a] 1973–1977*	*Botswana[a] 1973–1978*	*India 1974–1978*	*Kenya[a] 1974–1978*	*Malawi 1971–1980*	*Nigeria 1975–1980*	*Pakistan 1970–1975*	*Philippines 1971–1974*	*Senegal 1973–1977*	*Sierra Leone 1973–1978*	*Sri Lanka 1972–1976*	*Sudan 1970–1975*	*United Republic of Tanzania 1969–1974*	*Thailand 1972–1976*	*Uganda 1971–1975*	*Zambia 1972–1976*
Agriculture	5.4	7.7	20.1	22.2	19.3	6.5	13.7	21.7	21.0	25.6	26.0	38.3	10.5	13.7	22.2	9.6
Natural resources	–	4.2	–.	1.8	–	–	–	–	6.0	–	–	–	–	–	–	–
Mining	–	–	24.0	–	–	7.0	1.2	–	–	3.8	–	–	0.1	1.5	11.1	3.2
Industry	6.1	5.6	24.0	3.0	–	19.0	9.0	–	2.0	7.2	19.0	13.2	13.4	1.5	11.1	8.4
Commerce	1.2	5.6	0.8	3.0	–	–	–	–	3.4	0.7	–	–	1.3	0.9	1.7	3.5
Tourism	0.7	–	–	2.9	–	–	–	–	9.0	0.9	–	–	4.4	–	1.6	1.2
Transport	*28.6*	*26.2*	*19.2*	*40.6*	*34.8*	*27.5*	*16.1*	*57.5*	*17.5*	*21.3*	*25.0*	*14.8*	*28.9*	*19.5*	*28.2*	*29.7*
Power	–	35.4	16.3	–	7.5	5.0	11.9	9.[illegible]	4.9	12.5	10.0	6.4	7.8	7.9	–	15.6
Water	8.4	35.4	2.8	–	3.7	5.0	20.7	–	7.8	1.7	–	6.5	4.1	–	5.2	–
Housing	18.9	35.4	1.6	5.9	4.0	–	7.7	3.3	–	2.5	3.1	–	6.8	–	1.2	11.5
Construction	4.7	35.4	0.1	2.2	13.4	–	–	–	–	0.4	0.9	–	–	–	–	–
Education	15.0	9.4	4.6	3.2	5.3	7.5	7.6	3.4	8.0	4.9	8.4	7.3	7.0	32.8	8.1	9.0
Health	1.8	3.9	4.6	4.9	5.3	2.0	6.4	1.9	2.8	5.4	8.4	4.2	1.5	6.3	6.0	2.9
Social services	0.4	3.9	2.0	–	–	–	–	–	–	6.9	8.4	–	2.9	2.5	3.4	–
Public administration	4.0	7.8	0.3	5.8	–	15.0	–	–	1.9	3.0	–	–	2.9	–	9.8	–
Economic services	–	–	–	5.8	–	–	–	–	7.3	3.2	–	–	–	–	–	–
Urban development	–	–	1.5	–	–	–	–	–	8.3	–	–	–	–	15.1	–	–
Rural development	–	–	–	–	–	–	–	–	–	–	–	–	–	15.1	–	–
Other	4.8	–	2.1	1.7	6.7	10.5	5.7	2.5	–	–	7.6	9.3	8.4	–	2.6	5.4

Source: Country development plans.

[a] Government ministries only.

TABLE 3. APPROVED IBRD AND IDA CUMULATIVE LENDING OPERATIONS IN THE TRANSPORT SECTOR (TO 30 JUNE 1977)

	Bank loans		*IDA credits*	
Transport mode	*Amount (millions of dollars)*	*Fraction of total (%)*	*Amount (millions of dollars)*	*Fraction of total (%)*
Airlines and airports	173	1.8	16	0.7
Highways [a]	4 371	45.6	1 171	52.0
Pipelines	357	3.7	–	–
Ports and shipping	1 597	16.7	300	13.3
Railways	2 994	31.2	764	34.0
Other	95	1.0	–	–
	9 587	100.0	2 251	100.0

Source: World Bank, *Annual Report, 1977.*
[a] Including major highways and minor roads.

Despite past emphasis on investment in roads, large numbers of people still live far from the motor vehicle road system. In Mexico, at the end of 1970 there was permanent access by land to only 15,000 of the almost 100,000 centres of population. More than 12 million people were without permanent access [8].

At least since the Second World War the rural transport problem in developing countries has been seen as one of providing or improving the quality of access. The term access has meant almost exclusively "road access". The only concession to special problems has been the effort devoted to low-cost roads. Since 1951 the Permanent International Association of Road Congresses (PIARC) has held four-yearly conferences on low-cost roads. Until 1976 there were no parallel internationally organized discussions of low-cost vehicles or indeed any other type particular to developing country needs [9, 10].

The most obvious and influential element underlying transport trends has been the increasing commitment to conventional motor vehicles. Although the stock in developing countries has increased substantially since 1945, the current absolute level per head is still extremely low in relation to the developed countries. The rural situation is even worse than available figures suggest since most private vehicles are owned by the relatively small urban population. The expectation is that the numbers are unlikely to increase very rapidly.

Government involvement in the provision of motor vehicles has by and large been regulatory: either permitting reasonably free import or making it very difficult where foreign exchange has been an acute and continual problem. Although some have participated in capitalizing production ventures the bulk of the capital has come from the international suppliers. By 1972 some 47 developing countries had already established motor vehicle industries, although;

(a) Most had not progressed far beyond the assembly of kits of parts imported from the licenser's parent factory;

(b) They were concentrated in the wealthier developing countries: of the 28 countries with a *per capita* annual GDP of less then $200 only India had progressed to full manufacture and five had varying forms of vehicle assembly [11].

TABLE 4. DISTRIBUTION OF PUBLIC SECTOR TRANSPORT INVESTMENT

(Percentage)

Transport mode	*Botswana 1973–1978*	*India 1974–1978*	*Kenya 1974–1978*	*Mauritania 1970–1973*	*Nigeria 1975–1980*	*Pakistan 1970–1975*	*Philippines 1971–1974*	*Sierra Leone 1973–1978*	*Swaziland 1973–1977*	*United Republic of Tanzania 1969–1974*	*Thailand 1972–1976*	*Togo 1971–1975*	*Uganda 1971–1975*	*Upper Volta 1972–1976*
Roads:														
Main	60.5	...	21.5	29.5	...	...	...	...	34.7	29.9	34.7	22.6	20.6	38.5
Secondary	23.6	...	7.3	30.2	...	...	...	...	–	7.7	27.5	–	12.2	–
Minor	3.3	...	8.4	–	...	...	...	...	10.4	2.7		6.1	2.6	–
Urban	–	...	–	–	...	...	...	...	–	0.3	5.1	2.6	1.7	35.9
Other	–	...	–	–	...	...	...	...	–	6.1		7.1	0.3	–
Total	87.4	25.8	37.2	59.7	73.1	24.2	80.3	61.2	45.1	46.7	67.3	38.4	37.4	74.4
Road transport industry	–	4.1	–	–	–	3.5	–	3.7	–	–	1.5	–	–	–
Railways	–	37.1	25.0	–	12.1	21.4	3.6	–	1.6	40.0	8.0	7.7	19.1	7.6
Ports	–	5.1	7.1	20.1	4.4	6.7	4.5	13.0	–		3.7	40.9	–	–
Shipping	–	3.8	–	–	1.7	4.9	–	1.2	–	0.6	–	–	–	–
Other water transport	–	1.0	–	3.4	1.3	–	–	–	–	–	–	–	–	–
Civil aviation	5.1	–	10.1	10.4	6.5	16.7	6.6	6.1	26.8	5.2	3.4	4.1	13.1	3.4
Airlines	–	5.7	–	–	0.7	5.5	–	0.2	–	–	–	–	13.8	–
Other transport	–	0.9	6.0	–	–	–	–	–	–	4.0	0.3	–	4.4	–
Posts and telecommunications	7.4	17.1	14.7	6.5	–	17.1	5.1	14.8	26.6	3.6	15.9	7.1	12.2	14.6

Source: Country development plans.

TABLE 5. ANNUAL EXPENDITURE ON ROAD CONSTRUCTION

Country	*Year*	*Total amount (millions of 1976 dollars)*	Per capita *amount (1976 dollars)*
Benin	1973	4.8	1.5
Botswana	1975	7.4	11.0
India	1974	64.8	0.1
Malawi	1975	9.0	1.8
Mali	1974	1.4	0.3
Mauritania	1971	4.9	3.7
Niger	1974	15.6	3.4
Sierra Leone	1975	1.6	0.5
Sri Lanka	1975	5.8	0.4
Thailand	1975	4.1	0.1

[a] Including maintenance expenditure.

ROADS, VEHICLES AND THE RURAL POOR

For most of the rural poor the predominant method of goods movement is head or backloading with the shoulder pole as a less common alternative. Bicycles, hand-carts, wheelbarrows, animals and animal-carts are used to a lesser extent. Although all these means of transport are used in rural areas their

TABLE 6. PREVAILING TRANSPORT MODES IN SELECTED ESCAP COUNTRIES

	Type of road on which used		
Country	*All-weather road*	*Fair-weather road*	*No road at all*
Afghanistan	Truck	Truck Tractor Animal-drawn vehicle	Camel Horse Donkey
Bangladesh	Truck Rickshaw Headload Pushcart Animal-drawn vehicle	Animal-drawn vehicle Headload Rickshaw Pack-animal	Shoulderload Headload Pack-animal
Indonesia	Truck Jeep Pick-up Delivery van Animal-drawn vehicle	Jeep Delivery van Animal-drawn vehicle	Bicycle Pack-animal Human transport
Sri Lanka	Truck Tractor Cart	Tractor Cart	Pack-animal
Thailand	Motor vehicle Motor cycle Tractor	Motor vehicle Tractor Animal-drawn cart	Bicycle Manual carriage Animal-drawn cart

Source: Questionnaire circulated by the secretariat of ESCAP.

existence, and indeed importance, is yet to be acknowledged in the statistics of most developing countries.

Surprisingly few statements exist of what strategy is being, or should be, pursued in the improvement of rural transport. Of necessity, transport strategy has to be inferred from trends. In most developing countries transport has generally received more resources than any other sector, yet the rural poor have increased in number and their conditions of life have deteriorated. For this reason it is important to determine how past strategy might be modified to better serve their needs.

RURAL TRANSPORT STRATEGY

The continuing importance accredited to transport investments in almost all national plans is the clearest possible indication of the strength of the belief in transport's ability to foster development. Yet numerous case studies have shown some rapid economic growth following improvements in transport, but there are other cases in which no such change occured.

More recent research has gone still further and suggested that under some circumstances transport investments in isolation may in fact be harmful to certain sections of the community. Appreciable benefits, resulting from transport improvements, tend to accrue to those already advantaged. Often there are appreciable disadvantages which affect the poorest groups.

Examples include:

(a) Reductions in labour demands following the replacement of traditional movement methods by motor vehicles;

(b) Cottage industries hurt by urban competition, leading to the partial collapse of the wider rural economy and migration to the towns;

(c) Changes in production towards transport-intensive products which do not necessarily benefit the poor;

(d) Concentration of landholdings.

Appraisal methods used to assess transport improvements need to be broadened considerably. It is argued that the likely effects of roads, and thus a proper assessment of their justification, can be understood only within the context of an analysis of social changes in the rural areas.

The whole package of rural investments must be more appropriate to the needs, including transport needs, of the poor. The critical decisions are to determine the standard of road which is judged reliable, and the balance which should be struck between providing a few routes of high quality and the need to open up new areas to the possibilities of development by means of a large network of lower standard routes.

For many countries both of these decisions have been determined by the need to borrow the funds required from foreign sources, and the necessity of justifying the investment of these funds. Emphasis on expected economic results of transport improvements has had a number of consequences, the most important of which is that it has biased investment towards projects with quantifiable benefits, such as savings in vehicle operating costs and road

maintenance expenditures. Since both are related to the amount of traffic, the process has naturally worked in favour of main roads and led to a tendency to opt for major route improvements–which can usually be credited with user and maintenance savings–rather than new road construction. Research has shown that in promoting development, of first importance is the existence of a route, its quality is a secondary consideration.

The role of conventional motor vehicles

For many years a belief has been fostered in what might be termed the "economies of modernity", a technological equivalent of the well-known economies of scale. Calculations have been made that motor vehicles are more economic than men or beasts. The clear implication is that "primitive is slow and expensive", that "modern is fast and cheap", and that "a road will lead to a better life for a community as a whole" [12]. But of course, figures are true only with other things being equal, which they almost never are.

Has any allowance been made for the fact that it costs society almost nothing for the track over which loads are carried on the head, by mule or bicycle, but a road suitable for motor vehicles will cost several thousand dollars per kilometre to build and several hundred a year to maintain? What, if anything, are the employment consequences of substitution among different modes of transport? In reality, different modes of transport serve characteristically different movement demands, and they are infrequently in direct competition. It is physically impossible for motor vehicles to traverse terrain that a donkey or bullock-cart would do with ease.

Undoubtedly the increasing dominance of the motor vehicle has been assisted by the preoccupation of governments and international lending institutions with the provision of roads to the exlusion of concern for the vehicles that use them. A preoccupation with the unit costs of operation has resulted in the use of larger and larger goods vehicles in many developed countries. Notwithstanding any reservations about the safety and environmental aspects of this policy, it has recently been pointed out that this has given little real gain to the customer. Very few developing countries have attempted to restrict the number and type of vehicles to those considered most appropriate to their stage of development. Restrictions because of foreign exchange considerations or the desire for local manufacture are common: but restrictions because of alleged technological inappropriateness are rare.

Strategies examined

It is not easy to offer any rational explanation as to why in most countries the provision of roads has largely been considered independently of any questions pertaining to the supply or type, of vehicles. Concentration of government resources on roads and lack of government involvement with vehicles means that a crucial part of the transport needs of the rural poor is not being met. Most developing countries lack low-cost private vehicles widely disseminated among

the majority of the population of industrial workers, small businessmen, and in particular, rural farmers. This fact is particularly stark in Africa. Between headloading or walking, and movement by conventional car, bus or lorry, very few alternatives are used.

There has been a progression from major engineered primary, to secondary and only latterly to tertiary highways all built on the basis of design philosophies imported from the developed countries. Equally a reliance on developed country motor vehicles with only very recently a small step in the direction of lower cost, but still motorized, vehicles and the complete neglect of traditional forms of transport. The result is skeletal road networks that in the poorer countries plainly do not serve effectively the majority of the population and vehicles so expensive that they are beyond the means of all but the affluent. For the rural poor it would be difficult to conceive of a more inappropriate technology.

APPROPRIATE VEHICLE TECHNOLOGY

There cannot be a universal vehicle appropriate to all the rural transport needs of developing countries. An essential element of any strategy for improving the transport capabilities of rural populations must be to provide a graduated choice of vehicles whose performance matches need and whose cost is in sensible relation to income.

Basic vehicles may be defined as "the range of devices from aids to goods movement by man himself up to, but excluding, conventional cars, vans, buses and trucks".

Many such basic vehicles already exist in different parts of the developing world, though often their use is localized. Almost all are capable of improvement.

Basic vehicles have been largely ignored by those responsible for the planning and development of rural transport systems in developing countries. That so many basic vehicles are used despite the neglect and despite technical shortcomings which frequently render their operation very difficult implies a strong underlying need for such simple forms of transport. Furthermore, it suggests that there is considerable potential for their wider and more effective application if skilled attention is directed towards their development and use. Some may be described as "two-dimensional" in that they have height and length but no significant width. This makes them suitable for use on footpaths and tracks. All could be operated on roads of a lower standard, and lower cost, than that needed by conventional motor vehicles.

Head-, shoulder-, and back-loading

Head-, shoulder-, and back-loading, or human porterage, is still the most common method of load-carrying in rural areas. Loads can be carried on any surface on which it is possible to walk. Aids can usually be made at token cost by local people using available materials. Human porterage is, however, arduous. It

is also slow. The loads are limited, and can only be moved short distances. The choice between the different modes tends to be dictated by local custom as much as by the loads themselves. In some countries custom decrees that men do not carry loads–although these taboos are less common among the really poor–whereas in others they move only the heaviest of loads.

Head-loads are usually limited to about 40 per cent of bodyweight (25–35 kg) [13], though this decreases as the distance of travel increases or if the terrain is difficult. The load which can be carried is greater than that which the carrier can lift unaided on to his head [14]. Thus the load is further limited if the carrier has no one to assist in loading. In some parts of the world a combination of head- and back-loading is employed using a head-strap from which the load is suspended. Although this considerably increases the load and eases the raising and lowering problem it also imposes considerable strain on the skull, neck and back.

Shoulder-loading is widely used in Asia, most commonly by means of a carrying pole [15]. The usual construction is from bamboo, split longitudinally to give a semi-circular cross section of large radius to spread the load on the shoulder. It is flexible enough to provide springiness which gives a natural frequency of oscillation related to the frequency of trotting in such a way as to minimize the energy expended. A less common form is the rigid yoke which rests on both shoulders simultaneously with a shaped cut-out to accommodate the neck and carrying roughly equal loads on either side.

Back-loading can be used with or without a carrying frame of which there are a variety of different types. In the Republic of Korea and Nepal loads of 60–80 kg are common [2, 16]. This implies that back-loads suspended from the shoulder are the largest which humans are capable of carrying, though it is not clear whether the greater loads result from the efficiency of the method or the physical condition and the attitude of the people involved.

Human porterage is arduous, time-consuming, and it seems likely that it can cause injury or deformity. Yet for the foreseeable future it is likely to remain an important means of rural transport. Therefore, efforts should be made to improve its efficiency and minimize, if they are real, its harmful effects. Studies in developed countries concerning the design of backpacks for military and sporting purposes, might be useful. One notable attempt at innovation is the joint work of the Georgia Institute of Technology, United States of America and Soong Jun University, Republic of Korea, on the Korean *chee-ke (chee-gay)* of the Republic of Korea [16], a traditional form of back-loading frame. Through a programme of R and D involving three professors, farmers, rural blacksmiths, traditional *chee-gay* makers, specialists in farm equipment and engineers an improved *chee-gay* was produced which converts easily to a wheeled carrier.

Handcarts and wheelbarrows

Handcarts[1] and wheelbarrows[2] are not suitable for use on steep gradients since the weight of the cargo then has to be supported by the operator. On a

[1]A wheelbarrow is a single-wheeled load carrier pushed, under normal circumstances, by one person.

[2]A handcart is a two-wheeled load carrier pushed and/or pulled by one or more persons.

smooth surfaced track of sufficient width the handcart is preferred, but on a rough track is difficult to use. The wheelbarrow, which can be used on narrow footpaths, is likely to find wider application. With the exception of China the wheelbarrow does not appear to be widely used for rural goods movement, its major application being in civil construction. However, there is evidence from Africa of a number of attempts to use barrows for rural transport.

The Chinese version has a large diameter wheel (about 700 mm) with the load placed directly above it on a horizontal platform so that the centre of gravity is just behind the wheel axle. The operator wears a strap which passes across his shoulders and is attached to the handles of the barrow.

Consideration of the design indicates that it is more effective than the so-called Western type. One disadvantage is that the load is carried very high so that the barrow tends to tip sideways. This is mitigated by the use of the shoulder-strap. Studies by the World Bank showed that the maximum load was about 180 kg, compared with about 120 kg for the Western type [17]. Investigation to determine the optimum disposition of the load and the diameter, width and type of tyre to minimize rolling resistance would provide the data needed to develop simple designs for Chinese wheelbarrows using locally available materials. The major need is for the development of strong, light, large diameter wheels that can be manufactured in developing countries.

Pedal vehicles

The best estimate of world bicycle production is that it increased by approximately 31 per cent from 1970 to an annual total of 43 million in 1976. In comparison, production of all motor vehicles increased by 16 per cent in the same period to an annual total of 33 million in 1976.

A 1978 UNIDO report noted that a bicycle is owned by approximately one in four among the 100 or so million Indian households [9]. The $24 to $35 cost (1975 prices) of a standard cycle is, needless to say, still substantial in an economy where the *per capita* annual income is only about $100. Cars and motor cycles are used predominantly in urban areas; the opposite is the case for bicycles. The predominating type is typical of a bicycle produced 30 to 40 years ago in developed countries, which remains popular because of its robustness and longevity. Bicycles in developing countries are habitually used to carry passengers or heavy cargo loads, are operated on rough, unsurfaced tracks and paths, and are expected to stand up to arduous use for many years. Yet no bicycle has ever been designed to meet the very different operational requirements or for manufacture in most developing countries. As a result, most existing cycle factories in developing countries are assembly plants, with the majority of the components imported from the parent company.

Bicycle loads can be increased by attaching a trailer [18], which can also be designed for rapid attachment and for auxiliary use as a handcart on the farm. Such trailers are widely used in many rural parts of Europe, but except in French-speaking countries of Africa and South-East Asia their use in developing countries is uncommon. One interesting application, evolved in Malawi [18] and Nigeria [19], is as a rural ambulance.

The utility of pedal power can be extended by the use of a tricycle (initial capital cost $150 to $200), purpose-designed for load-carrying. The tricycle is inherently stable and can carry loads of 150–200 kg on relatively flat terrain. Widely used in Asian cities as a passenger carrier, commonly known as a cycle rickshaw or trishaw [20, 21], it appears to be virtually unknown in Africa. In some Asian cities authorities wish to restrict them either because of their supposed effect on traffic congestion or because they are considered inhumane. However, the effort involved in propelling a tricycle can be significantly reduced by more efficient design, and there is certainly no shortage of people wishing to ride tricycles as they form an important area of employment. In Bangladesh the cycle rickshaw has become an important means of rural transport for passengers and cargo [22]. The more arduous operating conditions highlight the design deficiencies of the traditional tricycle, which has a single gear, the same as, or slightly lower than, on a bicycle. This is quite inappropriate when its loaded all-up weight can be three times that of a bicycle. The construction is crude and excessively heavy. The wheels are not designed to withstand the side-loads and as a result the spokes break easily and the rims distort.

The "Oxtrike", an attempt to overcome design deficiencies of traditional tricycles, incorporates a three-speed gearbox and a simple differential formed from two freewheels [23]. In addition to the standard front brake there are foot-operated inboard band brakes on the rear wheels. A strong, light, box section frame is used and the weight without bodywork is some 15 kg less than an Indian tricycle in the same condition. The Oxtrike is designed to be suitable for small-scale manufacture in developing countries. It utilizes standard cycle components whenever possible, and the frame is formed from folded and welded 16-gauge (1.6 mm) sheet steel. It could therefore be fabricated in a small workshop equipped with shearing, bending and welding facilities.

It is possible to envisage multi-person pedal-driven vehicles which could carry greater loads or operate on more difficult terrain. Pedal power can be applied to agricultural functions such as crop-processing and cable ploughing. A design for a standard "pedal power unit" which, with appropriate attachments could be used for both stationary and transport applications, has been proposed [24].

Animal transport

Animals used for transport purposes include the horse, mule, donkey, ox, buffalo and camel. Power output varies, but in all cases is much greater than that generated by human beings. Thus greater loads can be moved, though speeds are slow. Costs of work animals will vary with availability and demand, species, breed, age and condition. Animals play an important role in the agricultural systems of most developing countries, particularly in Asia, and rather less so in Africa where animal draught cultivation methods have developed fairly recently. For the foreseeable future, many small farmers will simply not be able to afford mechanized equipment. Thus while there is likely to be a steady growth in mechanized agriculture, animal draught cultivation will continue to have a significant role.

Pack animals are used in many different parts of the world; their major

application being in steep, rocky or very sandy terrain where wheeled transport is impossible. The load varies according to the route conditions and distance. According to World Bank figures, a pony can carry 100–150 kg at a speed of 3–4½ km/h, a mule 75–100 kg at the same speed, a donkey 70–120 kg at 2–5 km/h and a camel 120–680 kg at 3–5 km/h. The only equipment required–a carrying container or saddle–consists sometimes of cord lashings, though bags or wicker baskets ensure better balancing of the load. More information about these containers should be disseminated.

Animal carts are a major form of rural transport in the Asian region. In India it is estimated that they now number some 14 million, and the Indian Institute of Management (IIM) in Bangalore has estimated that at present more than 60 per cent of all goods are moved from farm to market by bullock cart [25]. In rural areas most are owned by individual farmers and are also used for agricultural activities. Salient features of the traditional cart are common throughout the region. It has two large diameter (1–1.75 m) wooden, usually spoked, wheels, each enclosed in an iron rim. The wheels are mounted on a forged iron axle and run on very loose fitting steel bushes. The axle is contained in a wooden block on to which is fitted a wooden platform. This runs forward to a simple yoke to which are harnessed a pair of bullocks or buffaloes. The cart costs $100 to $180, has a maximum payload of about 1 t and moves at 3–4½ km/h. These carts can operate on very muddy tracks though they cause damage to surfaced roads because of the very high contact pressure at the rim. Because of this, manufacturers in India produce an alternative pneumatic-tyred wheel running on ball bearings, fitted to a specially fabricated steel axle. The cost is approximately twice that of the traditional vehicle [26]. Such carts can carry, on good surfaces, loads of up to 2½ t, yet their penetration of the market has, until now, been very limited; use being concentrated in urban areas and in the affluent agricultural regions with relatively good roads [28].

The use of wheels with pneumatic tyres appears to be more common in Africa than Asia (probably because wooden wheel-building skills are not widely known). They are usually used in conjunction with the discarded rear axles of a motor vehicle. These are excessively heavy since they normally include the useless brake drums and differential assembly and can be difficult to obtain. Maintenance problems are also encountered. Major deficiencies in the design of existing carts mean that the power of the animals is used inefficiently.

A complete reappraisal of design would result in carts with increased carrying capacity and would offer the possibility of using only one animal instead of two. It is likely therefore that the cost of transport could be decreased, with an increase in speed. Because of the range of conditions under which animal carts are operated and manufactured the need is for a number of different designs.

Recently several organizations in India, including the IIM and the National Institute of Design, have made proposals for improved bullock carts [29, 30, 31]. The main reason for this spate of acitivity appears to be the recognition that the bullock cart is not going to be replaced by the truck. "Thanks to the oil crisis people who used to talk about the mechanization of rural transport are now conceding the key role the humble bullock cart plays in transporting men and materials from villages to towns", says a report [27]. However, none of these efforts over thirty years has yet had any significant effect on the carts actually in

use in India. Efforts to develop improved designs have also been made in a number of other developing countries, including Botswana, Malawi, Nigeria, Senegal and the United Republic of Tanzania [32, 33, 34, 35]. A three-pad collar harness introduced in Europe in the 1930s has been proposed as a solution to bullock yoke problems. It is based on the principle of the horse collar, but with no restriction across the front of the neck which would press on the windpipe [26]. Is has been estimated that its use could double the useful work output of bullocks [36].

Motor cycles

Data on motor cycles are more difficult to obtain than on larger motorized vehicles since many countries do not include them in official statistics. A major reason why they are not used in rural areas would appear to be that production is dominated by the developed countries. Trends in design make them increasingly irrelevant to the requirements of rural areas of developing countries. Motor cycles have also become steadily more complex, and more expensive in real terms. For use in rural areas the present requirement for the motor cycle is analogous to that of the bicycle: it must be rugged, simple, easy to manufacture and to maintain locally, suitable for continuous use on rough tracks and capable of being used as a cargo carrier rather than simply as a means of personal transport. In the Philippines some 90 per cent of motor cycles (168,000 in 1975) are fitted with side-cars, the complete vehicle being capable of carrying a payload of 250–400 kg or two passengers plus the driver. The side-cars are usually manufactured in small, independent workshops using elementary metal-cutting and welding equipment. In the rural areas they have been found particularly versatile.

The cheapest device within the motor cycle category is the motorized conversion of the bicycle. A small motor is fixed above the front wheel, which it drives through a friction roller. In India a commercially available conversion kit consists of a small (35 cm^3) engine mounted in the bicycle frame and driving the rear wheel through an additional chain drive. This has proved successful on bicycles, but problems have been encountered with cycle rickshaws [37]. However, with an improved tricycle design such as the Oxtrike [23], there is no fundamental reason why an appropriate conversion should not be successful.

A motorized bicycle costs about $150–200, a moped $250–350, a small motor cycle about $600. The major need, if the potential of the motor cycle is to be exploited, is for the development of design suited to the requirements of, and to small-scale manufacture in, developing countries.

Motorized vehicles

The last few years have seen a growing interest by a number of international and national institutions in basic motorized vehicles for the small farmer. The "single-axle" or "two-wheeled" tractor used extensively in China, has a 7.5 kW single-cylinder diesel engine and in addition to its agricultural functions can be

hitched to a trailer and haul a payload of 1,000 kg at 15 km/h [34]. A 4–5 kW petrol-engined single-axle tractor has been developed in the Philippines specifically to meet the needs of the many small-scale Asian rice farmers. Attachments have been developed for upland and lowland crops, transport and irrigation. The machine was designed to make maximum use of standard components, the engine, roller chains, sprockets, bearings and seals used in the power tiller being imported into most Asian countries for other uses. The remaining components are fairly simple and can be produced by small metalworking shops. The power tiller introduced in 1972 and now produced in six Asian countries is marketed at about $1,000.

The single-axle tractor is not suited to the requirements of dryland cultivation. There have been many attempts since the Second World War to develop "simple", "basic" or "low-cost" tractors, as an alternative to the conventional tractor which is expensive, complex and beyond the means of the small farmer. However, basic tractors have met with only very limited commercial success. A major reason is that in simplifying the design and lowering the cost, power output, weight and wheel size have been reduced, thereby reducing the ploughing performance [35]. An attempt to overcome these difficulties is the "Snail", developed at the National College of Agricultural Engineering, in the United Kingdom. This is a winched, rather than towed, cultivation system, the Snail being, in essence a motorized winch. It can be simply adapted to tow a trailer for transport purposes.

There is also a group of purpose-design motorized transport vehicles for the small farmer. The International Rice Research Institute (IRRI) has developed a self-propelled cart, initially intended for moving a thresher but now generating considerable interest as a general purpose vehicle. It is a three-wheeler with a single, driven and steered front wheel having a payload of 720 kg and a top speed of 15 km/h. In Crete, three-wheeled rigid chassis vehicles powered by single cylinder diesel engines have been developed. Their evolution appears to have resulted from the use of single-axle tractors and trailers for goods movement. The vehicles are produced by small-scale manufacturers [36]. It is evident that these basic farm vehicles will be more expensive than the non-motorized devices described earlier, and require more complex maintenance skills. There is a lack of information regarding the circumstances under which such motorized vehicles can be introduced successfully in a particular area. Much could be learned from a case study in Crete, where the manufacture and marketing of such vehicles seems to have arisen spontaneously.

Lastly, mention should be made of attempts to produce simplified versions of conventional motor vehicles. Several major international manufacturers are now producing Asian utility vehicles (AUVs) [5]. All use major assemblies including engine, gearbox and rear axle taken from the manufacturers' existing ranges, built into a simple, sturdy light-truck chassis with a beam front axle. A cab made up of flat panels–which can be produced without using expensive tooling–is added, and a number of rear bodywork styles are available, including flat-deck, closed-van, and passenger-carrying.

It is intended that these vehicles should be cheap to produce with a significant local manufacturing content, durable, economical to run and simple to maintain.

Since their introduction in the Philippines in 1972 the AUVs have grown rapidly in popularity, with 1975 production estimated at some 12,500 vehicles. They are produced in smaller numbers in other Asian countries, but have not yet penetrated into Africa to any significant extent. While AUVs undoubtedly have a valuable role to play, their retail price is still somewhat above the level necessary to achieve substantial market penetration.

MANUFACTURE IN DEVELOPING COUNTRIES

The evidence from IRRI and Crete demonstrates that basic motorized vehicles can be produced economically on a small scale in low-cost labour economies provided that the product and the production processes are suitably adapted. The approach has been to make use of standard (usually imported) components and assemblies and to fabricate locally the chassis, bodywork and simpler components. Thus there is still a significant imported content in the final product, the major single item being the engine.

The development and wider application of techniques for the low volume production of internal combustion engines would have important implications for the local manufacture of basic motorized vehicles, and for other applications such as power generation, water pumping and water transport. There is one known example of an internal combustion engine being locally produced on a relatively small scale. The Thai Heng Long Co. Ltd. produces 1,500 engines a month in the 10, 15 and 20 hp (7.5, 11.2 and 15 kW) size, with very simple, non-automatic production machines and has started to export to neighbouring South-East Asian countries [37].

The AUVs were developed to reduce the minimum level of economic production and to increase local content. The *Jeepney,* the most distinctively Philippine means of transport, can be viewed as the forerunner of the AUV. When the American armed forces departed at the end of the war they left behind a large quantity of equipment, including many jeeps. Local mechanics converted a number of these to provide a basic means of motorized transport. From these origins the manufacture of Jeepneys has developed into an important local industry in the Philippines. A more comprehensive approach is embodied in the design of the *Trantor,* a new type of work vehicle designed for manufacture by the "Group Technology" production system. The engine and other standard components are bought-in but machined parts, including some gears, are made within the factory. All components are designed to be suitable for manufacture on standard machinery and no special purpose production equipment is used. The *Trantor* can carry out virtually all the tasks and operate with the same attachments as a conventional agricultural tractor, but can, on good road surfaces, be driven at speeds up to 90 km/h and haul trailer loads of 8 t safely at speeds of 55 km/h. The "Group Technology" production concept can be applied to motor vehicles other than the *Trantor.* However, the success of the system is critically dependent upon the vehicle being designed specifically for production by this method.

REVIEW OF EXPERIENCE

There exists a range of basic vehicles whose operational characteristics offer a wide choice for meeting transport needs under different conditions. The technology can be related to basic movement needs and is accessible, available (or potentially so), in sensible relation to income, simple to use and maintain, and utilizes local resources in terms of manufacture, energy, spare parts and operating skills. Factors other than costs are equally important in analysing the suitability of transport modes. To the user, availability of transport at the time required is of great importance and can best be ensured by personal ownership. Comparisons of the operating costs of different vehicles take no account of the cost to society of providing and maintaining the transport infrastructure. All basic vehicles can operate on routes of lower quality than those needed by the use of conventional motor vehicles. They therefore offer the possibility of extending the availability of transport facilities in rural areas, perhaps accompanied by relatively minor upgrading of existing routes. There is much good basic vehicle technology which could be widely applied, but whose use is at present very localized. Where information on such technologies exists it is obscure, uncollated and unknown to those who could make use of it.

Few vehicles have ever been designed specifically to meet the needs of developing countries. Their use in developing countries indicates not that they best meet transport needs but rather that they are better than anything else currently available. Vehicles designed for use in developing countries must also be suitable for local, low-volume production. The system of manufacture envisaged for the vehicle has to be taken into account throughout the design process if the product is to be commercially competitive. The transport needs of the rural poor will only be satisfied if recognition is given to the necessity for policies that result in a balanced approach to transport provision.

POLICY CHANGES NEEDED

The ideas outlined in this paper do not, as yet, enjoy wide currency. Therefore the likelihood of implementing such policies for the provision of more appropriate rural transport facilities is dependent upon substantial changes in present attitudes. If more appropriate transport technologies are to succeed there must be a change in the attitude of senior and middle management in government departments, and by those involved in research and education for the transport sector.

Present attitudes in developing countries are powerfully influenced by the developed world. The major international companies have the resources and incentive to exert considerable influence and pressure in promoting the transfer of capital-intensive technologies, such as motor vehicles. There is, at present, no pressure group which is exerting a similar and counterbalancing influence to promote the use of more appropriate transport technologies. The bilateral and multilateral aid agencies influence attitudes through the provision of finance, expertise and equipment. They can thus play an important role in changing attitudes in developing countries by:

(a) Adopting policies for the provision of finance and equipment which encourage the application of appropriate transport technologies;

(b) According greater importance to appropriate transport technology in their research activities, thereby giving the subject greater visibility and status;

(c) Taking care, in providing expert assistance, not to impose external standards and procedures which may be inappropriate.

Attitudes will be affected by the priorities accorded to the subject by individual Governments. Part of the process of changing attitudes will involve the development of expertise by those responsible for the planning and provision of facilities. The concepts of appropriate transport technologies should be incorporated into educational courses, particularly those of universities, which will provide the decision makers of the future. The support, by donor agencies, of research institutions, training schemes for government employees and improved information services, all oriented towards more appropriate technologies, will assist in achieving this.

Necessary changes in attitude extend to the collection of information. At present official national and international statistics include only motorized vehicles and, in many cases even exclude motorized two-wheelers. Equally, existing statistics on road networks are based on an arbitrary definition of what constitutes a road and, for the most part, exclude footpaths and tracks not used by motor vehicles. The implication is that the characteristics of more basic forms of transport are not sufficiently important to warrant official attention. For the rural poor nothing could be further from the truth: to them the basic forms may be the transport system.

Undoubtedly the fact that basic forms of transport, both vehicles and routes, have not been accorded any official recognition has contributed to their neglect. Correcting this situation will not be easy since many of the vehicle types do not have to fulfil any registration requirements and the routes are not part of public works maintenance inventories. However, information on basic transport is essential both to change current attitudes and to create a basis for planning improvements. It is vital that the surveys and presentation of results should be integral with existing transport information so that basic facilities are seen to be an important part of the total land transport system.

The most fundamental change required in policy is to ensure that rural transport planning explicity includes an appraisal of the needs of the small farmer and the constraints within which a choice must be made. Two crucial elements of this process are:

(a) Greater flexibility in the methods of route design;

(b) The direct participation of government and aid institutions in overcoming the problems associated with the provision of appropriate basic vehicles.

Developing countries should generate their own road design standards based on local conditions which would incorporate, as appropriate, the requirements imposed by basic vehicles. Road design has been based on the needs of motor vehicles for so long that there is little available experience of designing for anything else, at least in the developed countries. However, some developing countries have experimented with the provision of routes for basic vehicles.

Despite the apparently public nature of track and the private nature of

vehicles, Governments and aid institutions should play as dynamic a role in the provision of basic vehicles as they have done in the provision of roads. If it is in the public interest for Governments to supply and maintain the track why, especially under conditions of great need, should they not also supply vehicles? The most compelling reason for arguing that Governments and aid institutions should intervene in the supply of basic vehicles, is that without encouragement and assistance the private sector is unlikely to do so. Developed country manufacturers appear to be willing to play only a limited role in the development of appropriate basic vehicles (e.g. AUVs). Most local manufacturers who might engage in production lack the resources to carry out the necessary R and D. They require assistance in the form of proven designs, and in initiating manufacture and marketing. It is in these areas that specific actions by Governments and aid institutions can assist in the supply of basic vehicles.

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Rural transport–Philippines

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BACKGROUND AND STATISTICS

The land area of the Philippines consists of 7,000 islands totalling about 800,000 km^2 and a population in 1977 of about 44 million. About one third live in Central Luzon, including Metro Manila, where 80 per cent of the registered motor vehicles are located. About 90 per cent of passenger trips in Metro Manila are with buses, including minibuses or *Jeepneys*. In areas connected by feeder roads, 90 per cent of commuters take the three-wheel motor cycles to reach the main highways. The country has a total road network of 73,000 km of which about 30 per cent, or 22,000 km, are paved; 41,000 km, or 56 per cent, are gravel roads and the rest (10,000 km) are unimproved. The Government infrastructure programmes were heavily directed towards rural areas, especially on feeder-road construction.

Policies can be summarized as:

(a) The transport system should be responsive to the requirement of the planned expansion of the economy and its sectors;

(b) Transport facilities need to be geared to meet regional, urban and rural demands as generated by urbanization and industrialization;

(c) The transport system should link planned cities, industrial bases and agricultural production centres with consumption areas;

(d) Account must be taken of varied requirements due to physical and geographical diversity;

(e) A low-cost market transport system (i.e. feeder roads and cheap vehicles) should complement agricultural production and support agrarian reform.

The motor vehicle fleet at the end of 1977 registered with the Land Transportation Commission reached 986,466 units. These consisted of 440,466 passenger cars; 327,926 commercial vehicles; 200,923 motor cycles; and 17,151 special purpose vehicles. In terms of use, this vehicle fleet can be broken down into: 40 per cent private passenger cars, 6 per cent private *Jeepneys,* 8 per cent taxi fleets, 15 per cent buses and public utility jeeps, 20 per cent trucks and 12 per cent three-wheel vehicles. In other words, one passenger car for every 100 persons, one commercial vehicle for every 130 persons, and one motor cycle for every 220 persons.

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BOT statistics of growth in public transport are:

	1977	*1976*	
Passenger buses	27 213	26 546	2.51
Jeepneys	68 021	45 052	48.00
Taxis	20 205	16 495	23.03
Tricycles	56 161	20 346	176.00
	171 000	109 340	

Translating the above figures into transport needs, 255 passenger seats were available for every 1,000 people in 1977 compared to 167 seats in 1976.

EVOLUTION OF THE AUTOMOTIVE INDUSTRY

Motor vehicles have been imported since 1916. The Second World War wiped out almost all vehicles and until about 1950 replacements were supplied by army surplus vehicles, imports and reconditioned units. Importation was a drain on foreign exchange and in 1949 control was instituted.

In view of the import quota, motor vehicle assembly was introduced for cars and commercial vehicles, but more than 100 different brands or models made development of the industry extremely difficult. Faced with an increasing drain on foreign exchange reserves the Government took steps to rationalize the industry.

The transformation of the industry from assembly to manufacturing began in 1971 when the Board of Investment in co-operation with the Central Bank issued guidelines of the local content programme for the progressive manufacture of passenger cars. This was followed by:

(a) The Progressive Truck Manufacturing Programme (PTMP), implemented on 1 July 1977;

(b) The Progressive Car Manufacturing Programme (PCMP), 1 January 1978;

(c) The Progressive Motor Cycle Manufacturing Programme (PMMP), 1 January 1978;

(d) The Automotive Diesel Engine Manufacturing Programme, set for implementation on 1 January 1979 and the Used Truck Reconditioning Programme set for implementation on 1 November 1978.

The major objectives were:

(a) Dollar savings through domestic manufacture of components;

(b) Increased manufacturing activities, improved skills in various existing small- to medium-scale industries for the domestic manufacture of automotive components, and provision of technological know-how to the domestic manufacturing industries;

(c) Exports of manufactured products regionally;

(d) Development of diesel engine manufacturing technology and expertise;

(e) Development of technical and management expertise in motor vehicle reconditioning.

THE INDUSTRY TODAY

The central body of the industry is the Philippine Automotive Federation, whose constituent members are:

(a) The Automotive Manufacturing Institute (AMI), composed of four-wheeled vehicle manufacturers and participants in PCMP and PTMP;

(b) The Consolidation Automotive Parts Producers Association (CAPPA);

(c) Motor Cycle Manufacturers Institute Inc.;

(d) The Philippine Automotive Association (PAA) of vehicle dealers;

(e) The Parts and Auto Service Association (PASAPI);

(f) Other automotive associations, e.g. the Bus Operators Association, The Hauler Association of the Philippines, The Used Truck/Parts Importers Association etc.

There are 18 motor vehicle manufacturers. Eight of them assemble passenger cars and trucks; four, motor cycles; and the remaining six, commercial vehicles.

The components and parts manufacturers industry expanded considerably as a result of the different local content programmes. From about 50 manufacturers in 1972, the number reached 280 in 1978. Technical assistance from assemblers enabled manufacturers who started as jobbers to produce high-technology components for engine, transmission, engine assemblies, electrical parts, brake systems etc.

Development of the industry brought additional investment and employment, a raising of technical skills, expertise and management ability, plus savings in foreign exchange.

The motorized tricycle

The Government rationalized its long-range programme for the motor cycle industry in the Philippines. The motor cycle has become popular in rural areas and with a side-car has an average seating capacity of two to three persons. The engine size is from 80 cm^3 to 125 cm^3 and prices are $360 to $450. Side-cars cost from $265 to $530.

Sales of three-wheelers reached 42,217 units in 1977 against 31,705 in 1976, an increase of 33.2 per cent. The assemblers and manufacturers have to attain quality standards acceptable to the original makers, who assist in the manufacture of components as well as assembly. Machinery, equipment and special tools are installed with the assistance of technicians either from foreign manufacturers or local engineers. In view of the different models, local manufacturing has not yet established a market base for economic manufacturing. In addition, capital investment and high costs of money are taking prices beyond the reach of average wage earners. Nevertheless demand still grows.

The "Jeepney"

Experience after the Second World War with army surplus vehicles such as jeeps, weapons carriers, and trucks led to locally manufactured *Jeepneys*

becoming popular. They are now regarded as 100 per cent Philippine jeeps since components originate from local manufacturers. From these types evolved the manufacture of *Jeepneys* for passenger transport and cargo, with a seating capacity of 8 to 16 passengers. Manufacture calls for local production of body, chassis, inside and outside trims. Only the engine and transmission are imported. Some manufacturers use reconditioned gasoline or diesel engines. Prices range from $4,000 to $6,000.

Asian utility vehicles and others

Inspired by the success of *Jeepneys,* development of other vehicle types was accelerated. The Asian utility vehicle (AUV) gained market acceptance because of its competitive price and adaptability to terrain and road conditions. Developed by the joint efforts of foreign technical assistance, the body manufacture requires only simple shearing and press operation. The AUV can be used as a minibus, delivery truck for light cargo or a school bus. Models are based on the originals of six foreign firms, and sales, at prices ranging from $2,000 to $4,000, rose from 209 in 1972 to 19,114 in 1977.

Another low-cost vehicle popular in rural areas is the *Sakbayan,* a passenger car with a fibreglass body powered by a 1.6-litre engine, and costing $4,000. Another type used generally for passenger transport is the mini-cruiser jeep, designed by the Philippine army. This is a 100 per cent Philippine-made vehicle and costs about $2,000 with a 1.6-l engine. Some components are purchased from local manufacturers, and the body is metal. The other low-cost passenger car is the Japanese Minicar sedan, with a 360 cm^3 four-stroke engine assembled by Chrysler Philippines.

The minibus

The minibuses are diesel-powered and have a maximum capacity of 45 passengers. The current price is about $5,000 and all components other than the engine and transmission are locally manufactured.

Conclusion

The Philippines has taken the lead among ASEAN nations in developing its own automotive industry, despite the problems of a small market and of marketing conditions dictated by foreign manufacturers. The hope is that the fellow members–Indonesia, Malaysia, Singapore and Thailand–will recognize the need for increased and accelerated co-operative effort. Technical assistance could help in the development of vehicles and increase the local content of models designed for the special conditions of the area as a means of promoting economic development.

The Philippines has acquired experience and manufacturing capability for gasoline engines, besides having diesel engines on the drawing board. Engine

blocks and components including flywheels, manifolds, cylinder heads etc. are in production. Transmissions for passenger cars and light commercial vehicles reached a production capacity of 113,000 units a year, as well as pressing facilities for 70,000 car bodies, truck bodies, rear axles, propeller shafts, brake systems and parts, and under-chassis components.

Modernizing the bullock-cart: a case of appropriate technology for India

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INTRODUCTION

The intention of this paper is to present a genuine case for appropriate technology, which allows facile and widespread implementation. The bullock-cart in the rural transport sector is a case in point. The choice of a technology and its transfer to the rural areas of Africa and Asia is an issue of the utmost importance to the economies of these countries, and it can often make the difference between the success and failure of their projects, programmes and plans.

There is no doubt that, for long-distance transportation of goods, capital-intensive technology is unavoidable. But for intra-sectoral transportation on a small-scale in the villages, there is a strong case for retaining carts which use bio-energy as the prime motive power and are economical of capital into the bargain. There are 70 million bullocks on the active list out of a total population of 80 million work-animals. Assuming a power output of 0.4 hp (0.3 kW) per animal, the total is 28 million hp (21 GW), which is 64 per cent of all the capacity that goes into farming enterprises in India. Human labour accounts for 23 per cent of the total energy used and a residual 10 per cent comes from mechanical and electrical sources. There is no alternative to animal-drawn vehicles in certain remote areas and on roads which bypass the small towns or the national and state highways and connect one small village to another. In most parts, bullock-carts and buffalo-carts are the predominant types in use. In sandy terrain, where the drag or the rolling friction is great, the camel-drawn cart is preferred even to the four-wheel-drive jeep, which consumes much more petrol than normal. The total traffic carried by the system annually is of the order of 10 billion t/km. This deliberate underestimate adds to the argument that no alternative carrier can be found for much of the freight.

The bullock-cart and carts drawn by other animals have undergone little change in design over the past several decades. There has been no systematic effort–because of a fatalistic belief in the inexorable passing away of the carts–to transmit the benefits of modern science and technology to the bullock-cart, rural transportation and the communication system as a whole. In transportation technology, some sporadic efforts were made in the past, particularly during and after the 1930s. Introduction of pneumatic tyres during the 1940s increased the

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load capacity of the carts significantly and augmented earnings while reducing overall road damage. But the fruits of such efforts have not been spread widely enough due to the communication gap.

Bullock-carts are bound to remain for at least another 50 years. Long-distance rail transport is cheaper than truck-freighting by road, and official policy has recognized the complementarity between the medium-haul truck and the long-distance capacity of the railway networks by allocating mutually exclusive spheres of operation to the two systems. There is no reason why this logic cannot be extended to cover the counterpart roles of the bullock-cart (short-haul) and the truck (medium-haul).

All types of bullock-cart operations entail varying degrees of cruelty to the animals. Much of it avoidable. The net loading capacity, even with two bullocks, is less than 1 t, and the weight of the cart itself is about one half of the pay-load. Its pulling capacity is low and the drag on the cart retards the animal and thus slows down the system. Though the cart might appear to be well balanced in a stationary position, this is seldom true in dynamic situations, and this increases the vertical load on the animal's neck, a goodly proportion of it being avoidable. Though theoretically the bullocks are required only to haul the load, in practice, they have to both carry it and pull it. The stress vertically on the animal's neck reduces its ability to haul. In most parts of the country, slowing down or stopping the carts is effected by bringing to bear an unbearable strain on the neck or on the snout of the animal, which is strung through with a rein or halter of abrasive rope. No economic justification can be adduced for the conventional cart, yet it has survived into the modern age because, as in the case of ploughs, threshers, and the Persian wheel, which have not changed in centuries, the farmers cannot afford anything better.

It is not practical or feasible to replace the bullock-cart and if we have to live with it, official policy should concentrate on the only feasible course of action: to improve cart and animal technically and genetically, as well as economically, so as to increase their efficiency, reduce cruelty to the animals and eliminate road damage. That this is possible has been conclusively demonstrated by sporadic efforts in the past and by recent but more comprehensive redesign attempts. When the carts are improved, a network of bullock-cart stations operated with ancillary and supporting services will have a pre-emptive share, as they should, in the carrying of freight originating from, or bound for, the rural areas. Such professionally organized servizes could stabilize the entire bullock-cart system as well as the service sector in the rural areas. In certain areas where improved carts are in operation, the earnings of carters have increased two and threefold.

A study of the geometrics of carts in various parts of the country is in progress. Simultaneously the task of developing sets of design improvements to suit various types of carts, incomes, terrain and use has begun. Experiments on the prototypes of the redesigned elements are being conducted in laboratories and under field conditions.

Concern for the animal's welfare has never prompted any of the redesign attempts. The pneumatic tyre eliminated road damage and improved cart efficiency. But it did nothing to relieve the animal of its ancient burden or salve its unhealed wounds.

The principal structural elements that will figure in any major redesign

attempt are a light platform, smooth bearings, wheels designed for dynamic motion, a better harness and a brake, none of which exist now. There will be a variety of designs to suit varying types of terrain and freight–slushy roads in the villages and concrete surfaces in the city; heavy loads, such as construction steel and high-volume and low-density loads like hay or vegetables. While smooth bearings will be universal in all new designs, the large wooden wheel from the traditional country cart will be retained for use on village roads alone. The new designs will be so conceived as to accommodate widely varying sizes of animals.

To ensure the adjustment of design to freight, hard-rubber or pneumatic tyres would be ideal. They commend themselves especially for light loads on smooth city roads. Four-wheeled carts with pneumatic tyres could be used for carrying heavy loads in the cities up to a maximum of 3 t. Single bullock-carts of improved design would be adequate for loads up to 1 t on all kinds of terrain. Many double bullock-carts can be converted for hauling by a single animal. Carts, with interchangeable parts, are also a distinct possibility. Importantly, improved designs will be such that, to the extent possible, they may continue to be manufactured in the non-organized rural sector with a view to ensuring the utmost utilization of rural manpower and local materials.

Half a million carts with tyres now carry loads of 2–3 t, particularly those transporting sugar-cane and construction materials. Most of these improved carts use patented pneumatic tyres. Other improvised versions use worn-out axles and tyres from discarded trucks, particularly in the country areas. Four-wheel carts are commonly seen in Madras and New Delhi and do brisk business. Earnings can be as much as four times the daily earnings from a traditional cart. Animal-lovers will readily appreciate that it is more probable that a hungry man eking out a marginal existence will be more cruel to the animal than another who makes more out of his cart. Thus, it is hoped that when the animal is able to pull the weight comfortably, there will be less need of punishment.

The most pernicious part of the traditional design is its harnessing device, of which the yoke is the most important member. Studies have shown that of the combined weight of the cart and freight, 50–60 kg rests on the animal's neck. This not only tires the animal prematurely in the course of the journey, but has also deleterious effects on its health. Attempts are being made to ensure a balanced load which would reduce the weight on the animals' necks. A number of ideas for yoke designs are being tried out, such as padding for the neck under the yoke, and a two-piece yoke of which only one would rest on the animal and the other would be linked to the harness strapped to the animal's back.

The fitment between the animal and the yoke is the most difficult and challenging part of the design. The concept is easily exemplified from the design of the much lighter and faster horse-cart. The pull beams in the single horse-cart float are secured or lashed to the animal with straps. Even when the pull beams oscillate up and down, the stress or the shock is dissipated through the harnessing. A comparable harness for the bullock-cart and buffalo-cart has not yet been thought of. Steel chains are used to secure the buffalo and the camel to the cart. They may also be as cruel as the yoke and waste energy also.

Another major defect in the traditional cart is that it has no brake. A log of wood hung at the rear is commonly used in hilly areas. Another variation uses

two logs in the front and the rear of the wheels and is worked through a pulley. A further improvement is being tried out whereby a block of wood can serve the same function as the logs, manipulated through a lever system for greater efficiency. The animal's neck is at present used to slow down the cart or to stop it. It is also strained whenever the cart has to be turned sharply, one animal being made to stop and serve as a pivot round which the other animal is made to turn. The bullocks suffer greatly in the process. The law must be altered to make brakes compulsory for bullock-carts. These are technically necessary when smooth bearings are used, but in a sense, smooth bearings are harder on the animal as it has to provide the retro-force to stop the cart.

The Andhra Pradesh variation of the rope reins and the Kerala brake need to be introduced throughout the country, as obvious and inexpensive methods of averting some measure of hardship. IIM has been working on the modernization of the bullock-cart system for some years. Funded by the Department of Science and Technology, a few prototypes incorporating improved design features have been worked out. Trials show that further improvements can be effected, and these prototypes are undergoing field tests under operational conditions. The Ministry of Shipping and Transport is considering a proposal by IIM for conducting a socio-economic survey which will assess the role and importance of the bullock-cart system in the Indian economy.

Annex I

SELECTED DOCUMENTATION PUBLISHED OR COMPILED BY UNIDO RELATING TO THE SUBJECT

Boats from ferro-cement. Prepared by W. Sutherland. Utilization of shipbuilding and repair facilities series no. 1. 1972. 123 p. tables, diagrams, illus. (ID/85)
Sales no. 72.II.B.23.

Establishment and development of automotive industries in developing countries, part II. Proceedings of the Seminar on the Establishment and Development of the Automotive Industry in Developing Countries, Karlovy Vary, Czechoslovakia, 1969. 1970. 117 p. tables, graphs. (ID/36, v. II)
Also published in French and Spanish.
Sales no. 70.II.B.8.

Establishment and development of automotive industries in developing countries, part I. Report of the Seminar on the Establishment and Development of Automotive Industries in Developing Countries, Karlovy Vary, Czechoslovakia, 1969. 1970. 123 p. (ID/36 v. I. corr.1)
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After-sales maintenance in the automotive field. Symposium on Maintenance and Repair in Developing Countries, Duisburg, Federal Republic of Germany, 1970. 1970. 17 p. illus., diagram. (ID/WG.62/27)

A new approach to the manufacture of low-cost vehicles in developing countries. The trantor project. Prepared by G. Edwards *and* W. Taylor for the Expert Group Meeting on Manufacture of Low-Cost Vehicles in Developing Countries, Melbourne, Australia, 1976. 1976. 22 p. table, illus. (ID/WG.224/2)

A transport strategy for development. Prepared by W. Owen for the Interregional Seminar on Industrial Location and Regional Development, Minsk, Union of Soviet Socialist Republics, 1968. 1968. 14 p. (ID/WG.9/15)

Automobile subcontracting with the developing countries. Prepared by E. Bernard for the Meeting on Transfer of Technology to Developing Countries through Subcontracting and Licensing Agreements, Paris, France, 1972. 1972. 31 p. (ID/WG.136/11 and ID/WG.214/3)
Also published in French and Spanish.

Automotive co-operations in Hungary. International co-operation in the automotive industry. Paper prepared by F. Horcher for the Meeting on Transfer of Technology to Developing Countries through Subcontracting and Licensing Agreements, Paris, France, 1972. 1972. 19 p. tables. (ID/WG.136/8)
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Etude du marche des cycles et motocycles en Tunisie. Centre National D'Etudes Industrielles, Tunisia. 1971. 4 v. tables, graphs, diagrams.
Published in French.

Improvement of engineering design capabilities of the developing countries (with particular reference to automotive components). Paper prepared by E. Gibian for the Expert Group Meeting on the Development of Engineering Design Capabilities in Developing Countries, Vienna, Austria, 1970. 1970. 58 p. tables, illus. (ID/WG.56/8)

Maintenance of heavy duty commercial automotive equipment. Paper prepared by W. Eaton for the Seminar on the Establishment and Development of the Automotive Industry in Developing Countries, Karlovy Vary, Czechoslovakia, 1969. 1968. 37 p. annexes, floor plan, summary. (ID/WG.13/4)
Also published in French and Spanish.

Problems related to the production and supply of automotive components. Paper prepared by E. Gibian for the Seminar on the Establishment and Development of the Automotive Industry in Developing Countries, Karlovy Vary, Czechoslovakia, 1969. 1968. 35 p. illus., summary. (ID/WG.13/6)
Also published in French and Spanish.

Quality control on foundry operations for automotive parts manufacture. Paper prepared by L. Komarov for the Seminar on the Establishment and Development of the Automotive Industry in Developing Countries, Karlovy Vary, Czechoslovakia, 1969. 1968. 30 p. summary. (ID/WG.13/1)
Also published in French and Spanish.

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Transport bicycle. p. 182. diagram.
Three-wheeled vehicles. pp. 183–184.
Asian utility vehicle. pp. 185–187. illus.
Ferro-cement boats. pp. 188–189.

Technology–the critical choice for developing countries. The work of the Intermediate Technology Development Group. Paper prepared by G. McRobie for the Meeting of Selected Heads of Research Institutes, Vienna, Austria, 1976. 1976. 21 p. (ID/WG.233/12)
Ferro-cement shipbuilding. p. 6.
Transport. p. 8.

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The use of old and second-hand road transportation equipment. Paper prepared by M. Alth for the Seminar on the Establishment and Development of the Automotive Industry in Developing Countries, Karlovy Vary, Czechoslovakia, 1969. 1968. 25 p. summary. (ID/WG.13/14)
Also published in French and Spanish.

Transportation and storage of fertilizers. Interregional Fertilizer Symposium, Kiev and New Delhi, 1971. 1971. 11 p. tables, summary. (ID/WG.99/51)
Also published in French, Spanish and Russian.

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Copies of these compilations are available to requestors from developing countries only. The reference number must be quoted.

Asbestos. (IIS file no. 8398)
Bicycles. (IIS file no. 6721)
Brake linings. (IIS file no. 5261)
Elevators. (IIS file no. 7039)
Glass micro-balloons. (IIS file no. 8391)
Hermetic compressors for refrigerators. (IIS file no. 5487)

Annex II

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