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PROMOTION AND DEVELOPMENT OF AGRO-RELATED METALWORKING INDUSTRIES (PHASE I)

US/RAS/92/072

BHUTAN

Country Report*

Prepared for the Royal Government Bhutan
by UNIDO in co-operation with RNAM/ESCAP

Based on the work of Reynaldo M. Lantin
UNIDO Expert

United Nations Industrial Development Organization
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SUMMARY

I. INTRODUCTION

The Special Programme for the Industrial Development of Asia and the Pacific, launched by the Third General Conference of UNIDO in 1989, has focused on two industrial subsectors supporting the vital agricultural sector of the least developed countries of the region: agro-related metalworking and food-processing industries. This approach has been endorsed by the policy making organs of UNIDO (GC.4/Res. 8 and 9, GC.5/Res.14) and funds have been allocated from various sources in support of preparatory activities in these fields. The priority areas to be addressed in the agro-related metalworking industries were identified in 1990 through a process of desk research and country consultations and a UNIDO/ESCAP Regional Workshop with representatives from most of the LDCs in the region. Subsequently a project was launched, in close cooperation with the ESCAP-executed Regional Network of Agricultural Machinery (RNAM) in Bangkok, with financial support from Italy and assisted by Associate Experts financed by Germany and the Netherlands, to achieve the following outputs by early 1994:

(a) National Focal Points in participating countries strengthened to be capable of providing a continuous flow of technical information and advice to enterprises in agro-related metalworking industries.

(b) Detailed proposals for **prototype exchanges** and assistance in the establishment of a **service for raw material procurement**, concrete **policy guidelines**, and concrete mechanisms for the **improvement of cottage-scale agro-related metalworking industries**.

(c) Detailed plan for the preparation of technical cooperation project documents in agro-related metalworking industries in areas requested by the concerned governments.

The countries participating in the process are Bangladesh, Bhutan, Cambodia, Lao PDR, Myanmar, Nepal, Solomon Islands and Western Samoa. The UNIDO expert visited all relevant production units, training and support institutions and ministries in these countries and, in addition to providing on-the-spot advisory services, prepared very detailed reports on the state of the industry in each country, constraints, potential areas of development and proposals for regional and national technical cooperation. As a result of this comprehensive analysis involving all relevant parties in the private and public sector, and bearing in mind ongoing and planned activities by the governments and the donor community in the participating countries, a thematic programme was formulated for the further promotion and development of these industries building on the successful implementation of the first phase and fruitful partnership with RNAM and the national focal points.

This Country Report on Bhutan is one of the outputs of the UNIDO-assisted Project, US/RAS/92/072, Promotion and Development of Agro-related Metalworking Industries in Least Developed Countries (Phase I). This report provides an account of the problems to be addressed, linkages with other programmes to reach the target groups, and a matrix of proposed responses by UNIDO with donor support. The overall objective of this thematic programme is to promote rural development in the least developed countries of Asia and the Pacific through the promotion of indigenous manufacturing of agricultural tools, implements and post-harvest processing equipment thus, providing a subsectoral and technical dimension to national efforts to promote and develop cottage, small- and medium-scale industries.

II. DESCRIPTION OF THE SUBSECTOR

The agro-related metalworking industry subsector in the LDCs of Asia and the Pacific region has merited due attention and priority considerations for development in view of its impact on agriculture and the rural sector communities of these countries. Since agriculture is the mainstay of the LDCs, self-sufficiency in food for the increasing population which brings pressure to the constant land area and the environment, increased productivity of land and labour and hence, of agricultural production and income of farmers, are among the primary development objectives in these countries. The development of an agro-related metalworking industry for the manufacture of hand tools, single-animal-drawn implements and small mechanical powered machinery through developing capabilities of the private sector mainly through provision of institutional support from the public sector, provides a promising growth potential in and supportive role for agriculture and the agro-based processing industries. This is in view of the past neglect resulting from a state enterprise approach in agricultural mechanization which has proven to be unsustainable especially in the socialist countries. Most of the State-owned and large-scale enterprises declined in operation and viability with the collapse of the Council for Mutual Economic Assistance (CMEA). This situation is particularly prevalent in Cambodia, Lao PDR and Myanmar.

All the LDCs have now taken the new approach of letting the private sector take over the former government function of supplying tools and implements to farmers in the current efforts of privatisation of State-owned enterprises along with the adoption of the policy from centrally planned to liberalized market economy. The private sector is therefore, expected to take the initiative and to produce the required tools and implements on a commercial basis. However, due to their lack of experience and prior success cases in the private sector, the hesitation on the part of the private sector needs to be overcome by adequate infrastructure and institutional support with less of government intervention and restrictions but with due encouragement, such as allowing their products to develop a competitive edge over imports during the early stages of the enterprise.

In most of the LDCs the village blacksmiths are the primary suppliers of basic hand tools and animal-drawn implements being used by farmers. In general however, no institutional support has been given to blacksmithing which may be classified as a metalworking cottage industry but which performs an important role in agriculture

and rural development. Small-scale entrepreneurs in the LDCs have so far been timid in investing in agro-related metalworking enterprises, that is, production of more modern, efficient and higher capacity machines than those which can be produced by blacksmiths. Thus, the small-scale enterprises need basic machine tools in their fabrication or foundry workshops as well as technical assistance in product design, manufacturing, quality control and information on business management, including the financial and marketing aspects.

In LDCs where small-scale agro-related metalworking enterprises exist, typical owners are those who have had experience as former workers in other shops and started out to venture on their own. They simply train their own workers initially as apprentices, then given on-the-job training. Very few owners have engineering background and most workshop owners rely on their own creative and mechanical talents to produce machines which they perceive as having some market. Ideas usually come from existing prototypes or commercial machines which are copied or improved. Some medium-scale workshops may have engineers on the staff who would be assets in product development and improvement of machines being copied or adapted from sources abroad, normally as suggested or ordered by some international non-government organizations (NGO) for their projects in the country.

As the governments in the LDCs have adopted the open-market policy, any products to be marketed by the agro-related metalworking industry subsector has to compete with imported counterparts. The tariff structure, in the LDCs where it exists, often favours the imports in that finished goods are less taxed that raw materials.

In accordance with the Terms of Reference (Annex), the UNIDO Expert visited Bhutan from 10 October to 2 November 1993 and met with the Government officials concerned with the project and the agro-related metalworking industries. Through arrangements made by the Agricultural Machinery Centre in Paro and the UNDP Office in Thimpu, he also visited relevant institutions, organizations, factories, workshops and farming areas in Bhutan.

This report contains two project concepts, one regional for eight least developed countries in Asia and the Pacific and four country-specific for Bhutan.

Based on the country reports of the UNIDO Expert for each LDC during Phase I of the project US/RAS/92/072, Promotion and Development of Agro-related Metalworking Industries in Least Developed countries, the following status of the industry and the related agricultural mechanization in Bhutan is given below:

There is virtually no private sector agro-related metalworking industry aside from blacksmithing which is the mainstay of the source of tools and implements by farmers, particularly in remote mountain villages reachable only after two to seven days hike from the nearest road head. The only public sector agro-related enterprise is the Agricultural Machinery Centre in Paro under the Ministry of Agriculture and has acted mainly as importer, supplier and distributor of engine-powered machinery for use in a limited number of districts. To its credit, AMC has trained farmers

directly on one-on-one session, particularly the operation and maintenance of four-wheeled tractors and power tillers due to driver licensing requirements. AMC has started manufacturing pedal rice threshers and certain attachments to the power tiller as import-substitute products to reduce costs.

The government policy is to discontinue the fabricating activities of AMC and allow the private sector to take over the function of producing agro-related machinery; concentrate on research and development of machinery and conduct group instead of individual training of farmers. Thus, AMC has discontinued its blacksmithing activities which ceased to supply locally made agricultural hand tools. Its foundry shop was never operated due to lack of operational funds, particularly to buy kerosene fuel and apparently also due to lack of trained personnel.

The private sector mechanics industry however, has so far been limited to vehicle repairs. Potential entrepreneurs wishing to set up and operate machinery fabrication or foundry workshop do not have the technical information as there has been no model of such enterprise in the country. The market is perceived to be small by those who might be potential entrepreneurs and demand surveys are needed.

Importation of tools and implements from India appears to be the trend in view of the cheap costs and less risks in engaging in the trading business than in manufacturing. However, distribution is a costly operation and potential entrepreneurs desire that the government take up this activity.

Blacksmiths have virtually not received any form of institutional support. Without doing much, the government may be a prime buyer of their products in as much as the quality of the imported goods is low and virtually not suited for the users in Bhutan. A possibility of supporting the blacksmithing enterprises is for the Government supply blacksmiths with steel materials through the district administrative offices or ministries which will contract the local blacksmiths for the supply of tools and implements needed by government field workers, such as road repairs, forest guards and school gardening requirements. This is instead of instead of supplying finished tools and implements for the same purpose. It is estimated that altogether the amount of tools and implements needed by them is quite sizable to keep all the blacksmiths occupied in making all sort of hand tools needed in their districts. Administratively, the government only charges the kind of product it procures, that is, raw materials (blacksmithing steel or even scrap vehicle springs and high-carbon steel) rather than finished tools, the quality of which turn out to be inferior and are often not usable.

The Ministry of Industry and Trade, currently implements a project on essential oil production utilizing lemon grass which grows wild in certain areas and which give villagers, particularly women opportunities for raising income by engaging themselves in raw materials gathering and perhaps, later, production and in oil extraction which has export market provided that the oil products meet the quality standards. There is an opportunity for fabricating stainless steel or aluminium-lined distillation units by small-scale metalworking shops.

III. CONCLUSIONS AND RECOMMENDATIONS

A. Machinery prototypes and drawings needed

Based on the government development programmes in agriculture and agro-related industries as well as on the current constraints in the production of agricultural crops which need machinery, a list of prototypes and drawings of machinery for adoption from other countries and for a programme of exchanges among them and other developing countries was drawn up and is shown below. Both activities will result in the acquisition of prototypes and drawings of machinery which are to be starting points of testing, fabrication and modification for their adaptation in the R&D institutions in co-operation with manufacturers and farmers. The list is a reference for the proposed regional project concept (Section VI) whereby machinery prototypes will be provided for local adaptation of design, testing and introduction to farmers.

(a) Micro-hydro turbine for mills and electricity generation from Nepal;

(b) Axial-flow thresher from IRRI;

(c) IRRI power tiller;

(d) Single-animal drawn plough from the Philippines and Thailand;

(e) Animal-drawn potato digger;

(f) Hydraulic ram from India;

(g) Rubber roll paddy huller/polisher;

(h) Paddy field row marker from IRRI (drawing);

(i) Manual maize sheller from the Philippines;

(j) Mustard oil expeller from Nepal or India;

(k) Cast-iron mouldboard ploughshare and mouldboard from Myanmar;

(l) Oakwood punch and hammer for mushroom growing and

(m) Solar drier for fruits, vegetables and spices.

B. Machinery prototypes and drawings for exchange with other LDCs

There is no machinery prototype developed in Bhutan since agricultural machinery have essentially been imported from Japan and India. At best, AMC's experiences in the training of farmers in operation, repair and maintenance of

machinery as well as its successful introduction of some types of machinery can be obtained. For example, AMC introduced an oil expeller from Japan. With good foundry technology, the oil expeller could be made locally as had been done in India after some modifications. Myanmar would be most interested interested in such experiences and specifications of the oil expeller as it has a large oilseed processing industry and has the capability of making oil expellers in traditional foundry and machining workshops.

C. Strengthening of national network institutions

There is a need to strengthen the institutions and organizations whose activities relate to or impinge upon agricultural mechanisation as well as agricultural machinery research, design, development, manufacture and commercialisation.

It is suggested that AMC be allowed to continue to promote machines and be involved in the activities of the agricultural extension unit with a view to convincing farmers to adopt improved mechanical technologies along with the other agricultural technologies. Due to lack of human resources, the extension unit alone may not be able to demonstrate and follow up the extension activities requiring certain knowledge of the mechanical techologies involved in the machinery.

D. Policies and strategies

The umbrella economic policy currently prevailing in Bhutan is the liberalized market and a move towards privatisation of government-owned industrial and commercial firms. The following are recommended:

Promotion of agricultural mechanization through custom operation services

Given the low purchasing power of the farmers and their having no access to formal credit because of lack of collateral, a strategy for them to avail of the benefits of mechanization technologies is by promoting the custom work or hire services rendered by those who can afford to buy machinery. This method is already practiced in case of land preparation and field transport using power tillers and tractors and to a limited extent, threshing using engine-powered threshers.

Apart from hand tools and simple animal-drawn implements, the engine-powered equipment are not affordable by small farmers and agro-industrial entrepreneurs in the LDCs. Hence, they are usually left out as beneficiaries of agricultural mechanization programmes, including the design, manufacture and distribution of agro-related machinery and equipment.

Small farmers and agro-processing entrepreneurs, however, can afford custom work or machinery rental services and thus,. avail themselves of the benefits of modern mechanical technologies. While custom work or hire services are practiced to some degree, mostly in ploughing, harrowing, threshing and grain milling operations, the system has not been institutionalized nor promoted as a strategy to

create a market for the more sophisticated machinery. Services could be expanded to water pumping, inter-cultivating, harvesting, drying and food processing.

This custom service scheme may be institutionalized through promotion, demonstrations not only of machinery but also of pilot partially mechanized farming systems in cooperation with farmers and conduct of training in custom work management by AMC. A policy for promoting mechanization is that of giving credit to farmers and non-farmers for investments in agricultural machinery to render custom field operation services.

Group training of farmers in agricultural machinery operation, repair and maintenance include topics in agricultural technology

To enrich the training courses in the operation, repair and maintenance of machinery, modern agricultural technologies should at the same time be included in the training syllabus for farmers. The strategy will add variety to the course, increase their interest and at the same time increase the farmers' knowledge about new technologies. As machinery owners, they could play an important role in technology dissemination and become instrumental in introducing improved farming methods other than mechanization among other farmers in their respective villages.

Mechanization itself should be introduced together with agricultural technologies (agronomy, soil fertility as well as pest and disease control) to ensure improved crop production performance, a reason for using machinery. This strategy would also dispel the common argument that use of machinery per se, does not increase crop yields.

It is recommended that non-machinery agricultural technologies should be integrated with the mechanization training package as the training course might be the only chance for a farmer to be formally exposed to improved agricultural technologies. Similarly, the machinery technologies should be incorporated in the training courses in agricultural technologies which might be organized by the agricultural extension unit of the Department of Agriculture (DA).

Promotion of agro-related metalworking industries

Under a demand-driven economic policy, the creation of a market is the most effective way of promoting a manufacturing industry. Of course, this assumes the existence of necessary conditions and factors not only for the creation of demand but also for the manufacture of the products. Technological knowledge, resources and market information are among the conditions and factors being considered by an entrepreneur trying to engage in the manufacture of agricultural machinery.

Small-scale agro-related workshops and foundries are usually the forerunners of the agro-related metalworking industries. For economic viability of operations, the establishment is normally a diversified one: that is, products which are not agro-related are also being manufactured utilizing common facilities and equipment.

Another reason for understaying the products is the seasonality of demand for [illegible] machinery and overcapacity of facilities because of their lumpiness.

A strategy for promoting blacksmithing as the industry for the supply of simple tools and implements in the remote and almost inaccessible areas of Bhutan needs the co-operation of government agencies. Such agencies could be the supplier of raw materials for blacksmiths who will in turn supply tools and implements to government field workers in the vicinity of the blacksmiths' stations.

An example is the unique and innovative programme by the the Division of Education of the Ministry of Health and Education provides for incorporating in the curriculums of primary, junior high and high schools as well as teacher training institutes, the theoretical and applied aspects of agriculture with the long-term aim of motivating children to like agriculture and apply modern technology. One of the short term aims is to utilize school children as medium for making changes in agricultural technology by influencing their parents. Another is to reduce the dependence of villagers on the World Food Programme and to supplement their diets with vegetables

The programme which is gaining success has been supported by OXFAM since 1981. Revolving funds were provided for garden and piggery projects. Funds were also provided for acquiring garden lands for the school as well as fencing them to protect the crops from wild animals, a major problem. Garden tools are also provided by the government. Yearly, the Division of Education purchases through tender imported tools such as some 600 pieces of spades, 500 pieces of pick axes and other tools to be provided to schools. The tools were reported to be of low quality and the sizes were not fitted for school children.

The schools may, instead, order from the village blacksmiths the needed tools and yet get most appropriate designs with much better quality than the imported ready made ones. High carbon steel materials, instead of low-quality finished products, could be purchased in bulk by usually required tender procedures and distributed to schools for their needs when they order from the local blacksmiths. Local blacksmiths trained in recognizing good quality steel could be involved in evaluating the supplied materials. With this programme wherein UNIDO may wish to assist by training trainers of blacksmiths, upgrading their equipment, supplying catalytic raw materials and giving them better designed tool samples tested by AMC, the village as a whole would be benefitted and an appropriate metalworking industry would be developed.

Improving the traditional paddy harvesting and post-harvest handling in Paro Valley

The rice harvesting and post harvest handling systems in Paro Valley and perhaps also in other places need improvements, if only to save the rice grain already produced over a lengthy period of almost nine months - sowing in February to harvesting in October. An undocumented report by AMC stated that losses range from 20 to 30 per cent of the yield. Observations reveal that perhaps this figure may even be low. The losses start even before harvest. As the grains are harvested at generally overmature state, perhaps to shorten drying time in the field, and because

the variety is the shattering type, grains fall naturally or with slight wind movement. The large losses occur in the harvesting method using non-serrated sickles and in the handling of the unthreshed paddy crop. Field drying for about seven days, collecting the unthresed crop to form bundles and carrying the bundles towards the house for stacking incur large grain losses.

The problem of harvest and post-harvest losses normally lies within the purview of agricultural engineering research of which AMC may have the capability of doing. AMC has previously tried to investigate the perceived problem, but only at an ad hoc basis. AMC is mandated to do research and development.

Subject to further verification of the extent of losses in other rice-producing districts, it is recommended that AMC develop and extend to farmers an improved system consisting of, but not limited, to the following:

(a) Early harvesting or timing it at optimum grain maturity;

(b) In-field threshing using suitable types of threshers with built-in system for preventing or minimizing losses while handling straw with grain, and

(c) Practice of suitable grain, rather than grain-in-straw, drying and storage and

(d) Introduction of efficient rice mills.

Following a verification that losses are above the usually tolerable 5 % of the yield, AMC should formulate a harvest and post-harvest handling system specifying the management actions and the machinery needed to avoid losses.

The final connection of the above research activity with the promotion and development of agro-related metalworking industry in Bhutan is in the fabrication and supply of threshers, dryers and rice mills. Through systems engineering a suitable method accepted by farmers and village folks considering the traditional culture would be developed. Private sector manufacturers would obtain their machinery design information and drawings or prototypes through the AMC with assistance from UNIDO.

E. Promotion of the agro-related metalworking industry

Since the decision has already been made to to privatise the manufacturing activities of AMC simply by ceasing its manufacturing operations and letting the private sector respond by entering the machinery market vacuum, problems should be anticipated and appropriate measures made to forestall them.

Exploiting the comparative advantage for manufacture of machinery

Bhutan has the strong competitive advantage of low-cost electrical power and it may just offset the other disadvantages. Raw materials imported from India are tariff-free, therefore, only the transport costs are added. Sales taxes on imported

[illegible] and could be a mechanism to equalize the competition field [illegible] locally made and the imported products.

If the local private manufacture does not take place, the programme of research and development of agricultural machinery by AMC may turn out to be an end in itself because the the designs of the AMC will not be manufactured. At best, prototypes will be fabricated and demonstrated and perhaps appreciated, but not commercially distributed. It is the kind of trap most R&D institutions in developing countries have gone into and made only displays of their developed machinery without ever serving the farmers.

Therefore, it is recommended that AMC, with backstopping of the Ministry of Agriculture and the Ministry of Trade and Industry (through its industry incentive programme) encourage the private sector to establish small-scale workshops for fabrication of agricultural machinery. Such workshops may initially produce a diversity of products which are in demand according to the season but shall always consider machinery supply support for the agro-based industries, a top priority in the Seventh Plan

It is also recommended that the Ministry of Trade and Industry develop tax mechanisms for imported machinery to establish a fair competition field for the local fabrication industry which ought to compete by having better products than imported ones. For this, it is also recommended that AMC give due technical support in their manufacturing activities. It is important that right from the start, the principles and ideals of good quality control be instilled in the management and workers of the small-scale workshops

Industry incubators at AMC

There is a need to utilise AMC's idle blacksmithing facilities and the foundry facilities which have never been operated. An incentive for a would-be manufacturer is through an industry incubator system to be set up at AMC. This could be either in the fabrication or in the foundry workshop enterprise or both, since a foundry shop needs machining and finishing facilities.

AMC may develop a programme of industry incubator to allow potential workshop entrepreneurs to utilize its own fabrication, blacksmithing and foundry workshop facilities for learning all aspects of the metalworking industry from planning, raw materials procurement and actual manufacturing to marketing of products without incurring large initial capital investment costs.

The industry incubator beneficiary from the private sector can take advantage of the presence of research engineers as well as the skilled technicians at AMC. For the foundry shop, assistance from UNIDO is needed to provide an electrical induction furnace facility and to train trainers in foundry technology.

Agricultural machinery extension to farmers

According to the DA plan, AMC will concentrate mainly on research and development and on group training of farmers. The agricultural extension unit is the mandated entity to extend agricultural machinery technologies to farmers. However, this unit lacks the human resources familiar with or perhaps interested in agricultural machinery and, as in the experience in many developing countries where the extension of machinery is separate from research and development, the adoption of machinery by farmers is slow because of minimal activities by extension workers in this area.

The usual outcome is that the new technologies never leave the display rooms of the machinery research and development institution. Unfortunately, the institution is criticized for not making an impact because only a few or none of their developed machines has ever been adopted by farmers. In the private sector, manufacturers or traders with new machines make promotional drives to create demand for their products.

Unlike other agricultural technologies such as specification of fertilizers, varieties and pesticides, the introduction of machinery needs closer and more sustained follow-up actions such as training in the proper operation and maintenance, otherwise a machine may be rejected because of incorrect operation in spite of its technological advantages.

It is recommended that AMC be supported also in its efforts to demonstrate machinery preferably working as members of a team along with agricultural extension workers.

Alternative strategy for the Agricultural Mechanization Programme

The poorer farmers who have availed themselves of custom services by owners of machinery have been benefitted through getting their operations done on time and with less burden due to shortage of labour during peak labour demand.

Under the liberalised market policy the farmers should be left on their own to decide whether to mechanise or not and the mechanisation direction should be based on their demand. Farmers, however, should be guided through suitable mechanisation programmes and strategies developed from relevant applied R&D efforts. Some guidelines include economic viability, prevention or minimization of harvest losses and productivity features of the technology.

One of the R&D activities by AMC will be towards developing suitable mechanization systems for harvesting rice and for minimizing post-harvest losses. AMC should verify the one time observation that at least in the Paro area, significant losses in paddy occur at the field, along the way to the house yard and at the house yard itself where the grain-on- straw is stored by stacking

[illegible] successful extension of an effective mechanization [illegible] harvest and transport system, AMC can make an impact by saving grain already produced. If the perceived grain losses are verified to be significant, the savings due to mechanization could be a justification for the continuation of AMP, not necessarily in its present form. In a way, the savings is a rationalization that mechanization increases overall production although actually it was just instrumental in saving the grains already produced.

It is recommended that AMC conduct studies to resolve the following issues in consultation with DA and perhaps with assistance from UNIDO and FAO:

(a) Shall the government continue to subsidize apparently uneconomical use of machines by the larger and better endowed "rich" farmers even though such machines benefit also the poor farmers because they can avail themselves of mechanization services at reasonable or market rates? The recommendation is to discontinue the subsidy but continue AMP with a view to seeking alternatives, either by importation of low-cost but good-quality power tillers or assisting in the establishment of a local fabrication industry by the private sector through technical training, incubator practice and provision of designs obtained from other countries through RNAM, IRRI, FAO, UNIDO and other organizations. The latter would need maximum support, short of subsidies.

(b) Granting that the system of tractor and power tiller level of mechanization is not economical to the owner, how can it be made so? If the high capital costs of the machines is the reason for such uneconomical ownership, how will an alternative source of power tillers and attachments, that is, from another LDC or other developing country or locally manufactured, change the economic picture? Will there be machinery spare part supply and repair service support system? Will the pricing structure of the hire services change? Assuming that metalworking workshops with capable manpower are in place will it stimulate entrepreneurship in the manufacture of spare parts? The recommendation is similar to that in (a).

(c) What are the alternative systems to achieve the mechanization level that is self-sustaining, reliable and subsidy-free?

(d) Machinery hiring is a proven means to expand utilization of machinery to earn more for servicing the capital costs. What is the extent by which this could be done throughout the year? Can more machinery attachments be developed to increase the versatility of the power unit so that it could be used almost throughout the year, even for non-agricultural activities?

(e) So far, only the financial position of the owners of machinery has been investigated. The extent by which the non-owners of powered machinery or those who hire powered machinery services benefit from such hire has not been investigated. There is a need to do financial analysis of their own production under the machinery hire system. How much of the subsidy given by the government is passed on to the non-owner of the powered machinery? Is the low hiring rate for machinery which could be an indication of passing on the government subsidies to the ultimate user the

reason for the non-economical ownership? If the rental fee is increased to the theoretical level at which ownership would be economical, will the non-owners still hire the machines?

(f) How does mechanical power level of mechanization increase the net yield, that is, save losses in yield? Have the net savings of grains factored in as one of the benefits? If not, then this should be determined, because grain losses could be as high as or even higher than 30 per cent of the potential yield of the grain for a shattering variety harvested late and with post-harvest operations handled the traditional way.

G. Support services for cottage and small-scale industries

In the LDCs, cottage and small-scale industries play a major role in the industrial development of the country. Agro-related metalworking industries comprise a significant portion of the total industry sector because they provide the tools and implements for agriculture. The support services normally needed by the cottage and small-scale metalworking industries in the LDCs are credit, market development and technical advice, particularly on production operations and management, designs of new products and quality control.

In Bhutan, the support services can be more efficiently rendered through the co-ordination of efforts of the AMC with DI in organizing training programmes for potential owners, supervisors and workers of small-scale workshops. Among the topics for the courses are workshop management, including quality control, workshop layout, safety, finance and marketing. Workers may be given refresher courses on foundry technology, machining and fabrication techniques with emphasis on quality control.

It is recommended that AMC, with backstopping of DI, conduct feasibility studies of establishing and operating small-scale fabrication workshops.

By Bhutan's classification, blacksmithing is the only agro-related metalworking industry which may be considered as a cottage industry. According to the Seventh Plan and by its objectives, blacksmithing would be a top priority of industrial development in the least developed districts since the services of blacksmiths especially in remote areas are almost indispensable. Blacksmiths are the only source of tools for agricultural production in the remote areas. It is therefore, important that blacksmiths are supported through improved technology by providing them training, better facilities, raw materials supply and possibly a market for their products outside of their village. For the latter, the government itself could be the market as departments normally have workers who are issued tools and implements to do road repair and maintenance, forestry work and other jobs requiring small hand tools.

It is also recommended that the Department of Industry coordinate with other government agencies to have a programme of obtaining the hand tool requirements from blacksmiths instead of importing finished tools for use by their respective field workers. A possible mechanism for this is the ordering of the tools through the Dzongkhags which will contract the blacksmiths within the Dzongkhag's jurisdiction

[illegible] needed tools according to specifications. As support to the [illegible], the government agency will supply the required raw materials (e.g., high carbon steel) to blacksmiths through their respective Dzongkhags. Such raw materials are to be purchased by the government in bulk through the usual tender procedures to get the best price and as a start, avoid disrupting the usual government procedures but considering also better alternatives later. The materials will then be distributed to the blacksmiths through the Dzongkhags as the private sector might be hesitant in taking the initiative.

The mechanism may seem to be cumbersome at the start but after some streamlining activities with the help of the Dzongkhags and the blacksmiths, the system will not be any more cumbersome than the present procedure for procuring finished tools. The benefits to the blacksmiths and to their respective communities is expected to offset the initial difficulties.

It is also recommended that DI/AMC organize a blacksmith training programme at the Dzongkhags using mobile blacksmithing facilities.

H. Programme for further development of the agro-related metalworking industry sector

The following programmes may be undertaken by the government authorities and agencies concerned:

(a) Development of capabilities for fabrication of agro-industrial processing equipment which need specialized engineering knowledge. As engineering knowledge is required for the design and manufacture of such equipment, this programme will be confined to small-scale and medium-scale workshops with staff engineers and fairly modern facilities. For example, two or more workshops after they get established, may engage in the fabrication of essential oil distilling units.

(b) Integrating the local development and production of agricultural machinery and agro-processing equipment with agricultural development projects or programmes. The coordination/linkage by the Ministry of Trade and Industry with the Ministry of Agriculture at the inception or formulation stage of agricultural and agro-industrial development programmes is essential for anticipating the needs and identifying gaps in machinery and equipment supply as well as in formulating strategies in the metalworking sector. If necessary, foreign technical assistance will be given for this project or programme component.

Apart from developing confidence and capability of the local agro-related metalworking and engineering industries to supply specialized equipment, this strategy will increase the likelihood of replicating the projects in other areas because the needed equipment can be locally sourced. Bottlenecks in overall development of an industry system, including the production of raw materials from the agriculture side, can be avoided at the outset. Thus, development activities in the metalworking industry sector will not be carried out in isolation of the agricultural production and processing sector to which it has a supportive role of machinery and equipment

The following are examples of programmes for which the agriculture and industry components must have a balanced development to be sustainable:

(a) The food processing industries, like those of citrus, mushroom and asparagus, where appropriate agricultural tools, handling and field-to-factory transport facilities and equipment as well as processing equipment are required.

(b) All crop, livestock, dairy, poultry, fishery aquaculture, forestry production and the related upstream processing industries need equipment and facilities which are to be supplied as much as possible by the local metalworking industries, most of which are small-and medium- scale.

(c) Alternative energy resources development and applications as well as environment and ecological protection measures are mostly agro-related and so are the tools and machinery technologies for carrying them out. Examples are micro- and mini-hydroturbines, windmills, hydraulic rams, agricultural waste handling and utilization equipment and agro-forestry tools and machinery can be supplied by the metalworking industry sector.

LIST OF ABBREVIATIONS

AEU	Agricultural Extension Unit
AMC	Agricultural Machinery Centre
AMP	Agricultural Mechanization Programme
AMW	Agro Mechanical Workshop
ARC	Agricultural Research Centre
BAPC	Bhutan Aromatic and Phyto Chemicals
BCCI	Bhutan Chamber of Commerce and Industry
BDFC	Bhutan Development Finance Corporation
BOIC	Business Opportunity and Information Centre
CARD	Centre for Agricultural Research and Development
CCI	Chambers of Commerce and Industry
DI	Department of Industry
ECDC	Economic Co-operation among Developing Countries
EODP	Essential Oils Development Project
ESCAP	Economic and Social Commission for Asia and the Pacific
FCB	Food Corporation of Bhutan
GDP	Gross Domestic Product
IRRI	International Rice Research Institute
ITC	Industrial Training Centre
JOCV	Japan Overseas Co-operation Volunteers
MHI	Myanma Heavy Industries
MTI	Ministry of Trade and Industry
NFP	National Focal Point
NGO	Non-government Organization
NN	National Network
OPG	Oilseed Processing Group
OXFAM	Oxford Famine
PDF	Pilot and Demonstration Foundry
R&D	Research and Development
RGOB	Royal Government of Bhutan
RNAM	Regional Network for Agricultural Machinery
TCDC	Technical Co-operation among Developing Countries
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization

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Figure 8. Top: Comparative performance testing of the stainless steel distillation unit from the Netherlands (left) and the mild steel goosenecked unit commonly used by small-scale field distillers, at the essential oil nursery at Gyelpsing, Mongar. Bottom: Distilling kettle (left) made of stainless steel adapted by the Bhutan Aromatic and Phyto Chemicals for use with locally designed condenser coils.

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Figure 10. Two types of oil expeller used in Bhutan. Top: The small version of the Hander from Japan. Bottom: The 6-bolt type from India.

Figure CP 4.1. Shattering losses during harvesting and drying of the straw with grains in the field. Clockwise from top left: Cutting the straw with non-serrated (smooth blade) sickles; turning over the partially dried harvest after two days in the field and paddy grains left in the field (losses).

Figure CP 4.2. Sequence of handling field-dried harvested paddy for transporting to house yard. Clockwise from top left: Bundling the straw with grains; strapping the bundle of straw on the shoulders and assisting in getting up with the bundle of straw.

Figure CP 4.3. Shattering losses of paddy during transport and stacking. Clockwise from top left: Woman carrying the straw bundle drops grains along the way; Paddy grains left on the stone ledge where the bundle was laid during rest by the carrier; and At house yard where the straw with grains are to be stacked.

Figure CP 4.4. Shattering losses during transport of harvested paddy. Top: Carriers briskly walking and dropping the grains along the road. Bottom: Sample of grains dropped on the road from the straw bundle.

Figure CP 4.5. Drying and threshing of paddy in Paro Valley. Top: Drying of the harvested paddy in the field. Bottom: Manual threshing by women.

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INTRODUCTION

Bhutan is small and mountainous. Air distance from north to south is only 150 km, but elevations rise abruptly from about 600 m above sea level in the south to about 8,000 m in the north. The east-west distance is 370 km.

An impressive effort by the Royal Government of Bhutan (RGOB) is an environment protection programme, particularly the forests, soils and water resources. Logging activities and tourism are restricted.

The terrain is rugged and picturesque. Cultivation of crops are in small river valleys and in areas where the slopes are gradual and the soil is fertile. These are in patches and a town or village settlement is usually located in or near the limited areas of arable land.

The economy of Bhutan is small with GDP of about US$ 200 million only, almost half of which comes from agriculture, livestock and forestry.

In 1990, areas devoted to crops were 123,200 hectares for foodgrains, 11,200 hectares for annual crops and 14,100 hectares for three perennial crops (Table 1). Maize is a dominant crop in the rainfed areas and shifting cultivation (tsheri) main season cropping. Since it has a high return compared to other foodgrains, there has been a switch in crop production to maize from paddy, wheat, buckwheat and millet. Horticultural crops contribute significantly to foreign exchange currency earnings giving Bhutan a strong comparative advantage over other LDCs. Orange and apple exports to Bangladesh and cardamom exports to Singapore and Japan have risen to US$ 5.2 million. While still at its infancy, mushroom cultivation has a large potential for export and upliftment of the rural women who could be engaged in this horticultural industry.

In remote areas, damage to crops by wildlife, particularly wild pigs, are a major problem cited by farmers as shown in Table 2.

Table 1. Crop area, yield and production estimates in Bhutan, 1983-90.

	1983 Survey	1986 Estimate	1987 Estimate	1988 Estimate	1990 Survey
Area: x1000ha					
Paddy	30.8	32.5	33.2	33.8	26.2
Wheat/Barley	14.4	15.4	15.7	16.0	10.2
Maize	58.4	57.1	58.2	59.4	74.0
Buckwheat/millet	20.6	20.0	20.4	20.8	13.2
Subtotal:Foodgrain	124.0	125.0	127.5	130.0	123.6
Potatoes	4.1	4.9	5.0	5.1	4.2
Chillies	1.0	1.0	1.0	1.0	n/a
Mustard	5.0	5.2	5.3	5.4	7.0
Beans and pulses	3.2	3.2	3.3	3.3	n/a
Subtotal: Four annual crops	13.3	14.3	14.6	14.8	11.2
Oranges	7.9	8.7	8.9	9.1	6.6
Apples	1.6	1.6	1.6	1.7	1.8
Cardamom	8.5	7.8	7.8	7.9	5.7
Subtotal: Three perennial crops	18.0	17.9	18.3	18.7	14.1

Table 1. (Continued)

	1983 Survey	1986 Estimate	1987 Estimate	1988 Estimate	1990 Survey
Yield :Metric tonnes/ha					
Paddy	2.1	2.2	2.2	2.3	2.3
Wheat Barley	1.1	1.1	1.1	1.1	1.1
Maize	1.5	1.5	1.5	1.5	1.6
Buckwheat/millet	0.8	0.8	0.8	0.8	0.8
Potatoes	8.0	8.0	8.2	8.3	7.4
Chillies	3.6	3.6	3.7	3.7	n/a
Mustard	0.7	0.7	0.7	0.7	0.7
Beans and Pulses	0.8	0.8	0.8	0.8	n/a
Oranges	4.9	4.9	5.0	5.1	5.5
Apples	2.2	2.3	2.3	2.4	2.5
Cardamom	0.4	0.4	0.4	0.4	0.4

Table 1. (Continued)

	1983 Survey	1986 Estimate	1987 Estimate	1988 Estimate	1990 Survey
Production: x1000tonnes					
Paddy	65.0	71.5	72.9	74.4	59.5
Wheat/Barley	16.0	17.1	17.6	17.8	11.2
Maize	87.3	84.7	86.4	88.1	100.1
Buckwheat/mi!let	16.8	16.0	16.3	16.6	10.7
Subtotal:Foodgrain	185.1	189.3	193.2	196.9	181.5
Potatoes	32.6	39.1	39.9	40.7	31.1
Chillies	3.6	3.6	3.7	3.7	5.2
Mustard	3.4	3.5	3.6	3.6	5.2
Beans and Pulses	2.6	2.6	2.7	2.7	n/a
Oranges	38.7	42.6	43.5	44.3	36.4
Apples	3.5	3.7	3.6	3.6	4.7
Cardamom	3.0	2.7	2.8	2.8	2.6

Source: Department of Agriculture

Table 2. Crop and food losses due to wild animals in different districts (Dzongkhags), per cent.

Dzòngkhag or District	Paddy	Maize	Wheat	Buck-wheat	Millet	Potato	Food
Tongsa	18	42	21	14	0	23	14
Lhuntsi	13	19	6	0	0	11	13
Chuckha	3	3	4	3	2	3	3
Tsirang	14	29	0	0	2	0	16
Samtse	0	0	0	0	0	0	0
Sardang	2	3	0	2	0	0	2
Punakha	15	11	6	0	0	0	16
Haa	5	3	3	0	0	3	2
Pemagatsel	0	31	12	4	0	4	24
Wangdi	17	5	12	8	0	11	21
Tashiyangtse	18	20	12	0	0	18	23
Dagana	-	-	-	-	-	-	-
S-Jonghar	3	20	0	3	8	0	19

Source: Department of Agriculture, Database for Food Insecurity Indicators, National Food Security Programme.

There are only a few units of water-driven mills and micro-hydro power plants in spite of the abundant hydro-power resources as shown in Figure 1. Virtually the hydro-power resources are still untapped but electricity in major urban areas has been sufficient and cheap since the Chhukha hydropower project came on stream. Electricity production now makes up 10% of GDP. Some electric power is exported to India.

Figure 1. Apart from its exquisite natural beauty and picturesque scenery, Bhutan has an abundance of hydropower resources still to be tapped.

A. Seventh Five-year Plan (1993-1997)

The Seventh Five-year Plan continues to pursue the goals of the Sixth Plan and emphasizes health, education and training. The Sixth Plan aimed to improve self-sufficiency in staple food, per capita income of the rural population, productivity and output and soil and water conservation. A significant development is the focus of the Seventh Plan on the promotion of the private sector which emerged as a central government objective during the course of the Sixth Plan.

The Seventh Plan aims to enhance the net national income by increasing the proportion of net national product from the industrial sector. The industrial development by the private sector will be promoted within a free enterprise economy. Third country exports will be increased; employment opportunities will be improved and the formation of a skilled labour force will be promoted.

B. Industrial Incentive Programme

The following targets, based on the guidelines for industrial development formulated by the Ministry of Trade and Industry (MTI) and which are among those provided for in the incentive programme, are relevant to the promotion and development of agro-related metalworking industries in Bhutan:

(a) Establishment of efficient import substituting industries;

(b) Balanced regional development;

(c) Human resources development emphasizing entrepreneurship and private sector needs;

(d) Promotion of small- and medium-sized industries and

(e) Strengthening and consolidation of existing enterprises.

The industrial sub-sectors which are given priority are the agro-based industries, mineral-based and wood-based industries, service industries and other industries. The least developed Dzongkhags are given priority in investment incentives over the less and the more developed ones.

For the institutional infrastructure support, the Department of Industry (DI) is the key government agency for industrial development. A Trade Institute will develop manpower capabilities and produce skilled personnel. The Integrated Entrepreneurship Development Programme will assist entrepreneurs in every phase of setting up a business. Through its published incentive programme, a potential investor would be able to make financial calculations and decisions in accordance with the government's set policies and programmes. Six industrial estates and 12 industrial service centres will be established during the Seventh Plan period. The Business Opportunity and Information Centre (BOIC) which maintains a library and a computerized information system is already in place at the DI to assist entrepreneurs in obtaining the needed market and technology information.

The Essential Oils Development Project (EODP)

MTI is the implementing agency of the UNDP-assisted project on essential oils development in Bhutan. With the manpower shortage due to the sparse population and limited arable land, RGOB is exploring alternatives for income generation and exploitation of the natural resources without degradation of the environment. The project areas are initially located in the districts of Mongar, Tashigang and Lhuntshi which have elevations of 650 to 1,200 m above sea level and where lemon grass grows in the wild (Figure 2 and Figure 3).

Figure 2. Top: Lemongrass grows wild in three mountainous districts where elevations range from 650 to 1,200 metres above sea level. Bottom: Leaf gatherers, mostly women, supply a medium-size essential oil distilling plant with stainless steel distilling units. Others have their own small-size units made of mild steel.

Figure 3. Part of the medium-size plant for distillation of lemongrass essential oil in Mongar district. All materials are made of stainless steel Right: One of two distilling kettles of 500 kg capacity of lemongrass leaves; Foreground: the florentine or oil separator from water, above which is the plate condenser.

MTI plans to expand the coverage of EODP to other suitable areas in the country. Once the essential oil industry system based on lemon grass has developed further into an export industry, MTI will consider other essential oil plants.

MTI supports the development of small-scale industries and encourages the establishment of private workshops for the fabrication of agro-related tools and equipment for crop and animal production as well as for processing of agricultural products. It however, needs assistance in the development of agro-related metalworking industries, including training of human resources in establishing foundry, machining and fabrication workshops as well as in strengthening of research and development (R&D) capabilities in agricultural machinery and agricultural engineering systems.

C. The Agricultural Mechanization Programme (AMP)

One of the major agricultural projects is AMP which has a projected capital cost of Nu 118 million (about US$ 3.8 million) and a recurrent cost of Nu 27 million (about US$ 875,000). The R&D institution needs to determine the most appropriate mechanization technology for the steep slope farming system. Significant labour shortages have forced the increase in wage rates and share-croppers' remuneration causing a redistribution of income. The labour shortage is one of the reasons for undertaking the AMP.

I. GENERAL STATUS OF THE AGRO-RELATED METALWORKING INDUSTRY SECTOR

A. Public sector industries

The Agricultural Machinery Centre (AMC)

The only public sector manufacturing activity for agricultural machinery is undertaken by AMC in Paro (Figure 4). It has complete workshop facilities which enables it to do metalworking with reasonable quality. The workshop equipment have been supplied through development assistance programmes of Japan and Germany. AMC manufactures some import-substitution items, such as paddle wheels, reversible mouldboard ploughs and trailers which used to be imported from Japan as attachments to power tillers or tractors.

AMC is the only institution in the country which deals with agricultural machinery, including research and development, manufacture and distribution as well as training of farmers in operation and maintenance of tractors, power tillers and their machinery attachments. The research and development activities had been minimal and confined to finding practical solutions to manufacturing problems encountered at the workshop. R&D activities however, will be emphasized after the phase out of manufacturing activities scheduled at the end of fiscal year 1993/94.

The past activities have been largely focussed on the promotion and sales of machinery from Japan and the training of farmers who purchased them from AMC. In 1987, Bhutan received assistance from Japan about Nu 10 million (about US$ 325,000) worth of 35-hp tractors, power tillers and attachments, such as reversible mouldboard ploughs, paddle wheels, trailers and rotary tillers, as well as rice transplanters, cultivators, water pumps, stone pickers, manure/lime spreaders, sprayers, dusters, potato diggers, rice reapers, threshers, oil expellers, flour and rice mills, hoes, sickles and various hand tools.

The Training Division of AMC conducts individual training courses, including a three-month and a one-month course in the operation and maintenance of tractors and power tillers, respectively, which is required for buyers to obtain a certificate for securing a tractor or a power tiller driver's license. The individualized training will be discontinued in the middle of 1994 as directed by the Department of Agriculture. Instead, group training in 12 subjects has been proposed. A volunteer from the Japan Overseas Co-operation Volunteers (JOCV) helps the four staff trainers. Farmer-trainees generally do not want long-duration training because they would be out from work in their fields, especially during the critical periods of land preparation. Hence, proper timing and increasing the intensity of training to shorten the training period would attract more farmers.

The Repair Workshop Division of AMC has been closed down since 1992 in line with the government's privatisation policy. The same thing will happen with the Fabrication Workshop Division by the end of June 1994 to let the private sector undertake the activity on a commercial basis without any subsidies. This division has produced 450 units of pedal threshers and still has 400 units in stock. It is currently winding up operations for the production of wood stoves/heaters after which it will produce animal-drawn ploughs, trailers and paddle wheels.

AMC had produced hand tools, like garden rakes, paddy rotary weeders, hoes, field knives, sickles and axes, some of which were made by the blacksmithing section. As part of the phase out of manufacture by AMC, the blacksmithing activities have been discontinued to allow the village blacksmiths to fully take over the production of knives and sickles. Farmers prefer non-serrated sickle blades because once the serrations get worn out, they would be forced to buy a new one. They prefer the smooth blades which they can easily sharpen. However, the smooth-bladed sickle needs a larger force to effect cutting, thereby contributing to the shattering losses of paddy grains.

The Department of Agriculture plans to strengthen the R&D and the training divisions of AMC to become its core of activities. Since AMC'S workshop facilities are reasonably adequate for research and development except for some test instruments, personal computers, design aids and other research equipment, there is need for training of engineers and technical human resources.

The foundry shop with complete equipment installed through the Asian Development Bank Loan in 1991 has never been operated due to lack of operational funds to sustain it, including that for the kerosene fuel for the melting furnace. Another reason is the lack of human resources trained in foundry technology.

As policy, AMC is not mandated to do extension work which is the function of the agricultural extension unit of the Department of Agriculture. In the case of agricultural machinery however, agricultural extension workers generally lack the capabilities nor the interest in extending machinery to the point of convincing farmers regarding their adoption or teaching them the details of operation, trouble shooting, repair and maintenance. AMC's effectiveness in promoting mechanized farming has been due to its sales of power tillers, tractors and complement equipment at subsidized prices and with personalized training of operators. Farmers are given one-on-one training courses in particular areas.

AMC is the de-facto national focal point for the project on promotion and development of agro-related metalworking industry in the country because no other institution has activities which are as relevant to the project as AMC. It has taken initiatives in proposing for the Royal Government of Bhutan (RGOB) to join RNAM.

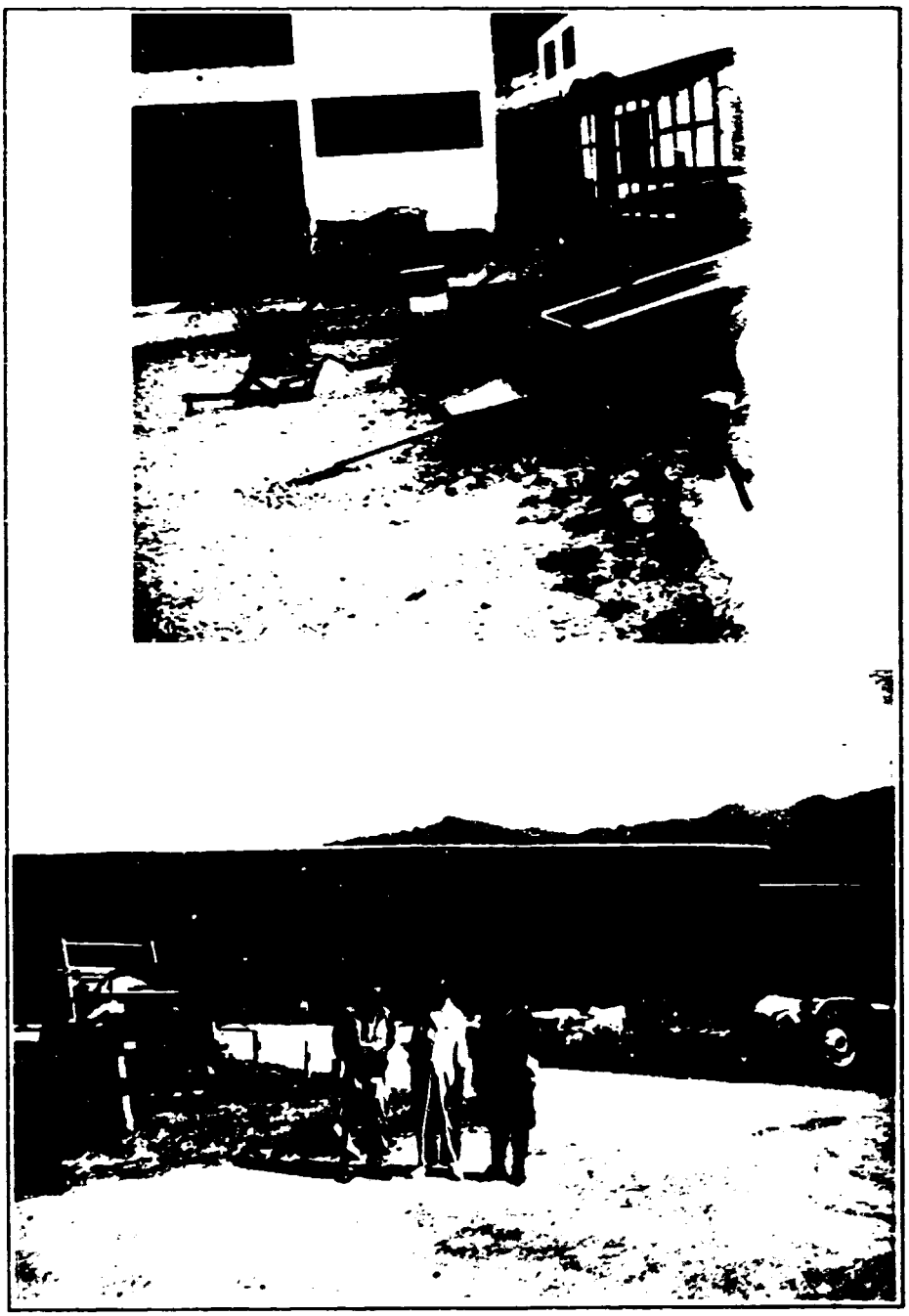

Figure 4. The two major divisions of the Agricultural Machinery Centre in Paro. Top: The R&D Division has a workshop (background) and conducts adaptive design and development of machines such as those from Japan (foreground). Bottom: The Training Division has complete training facilities including machines mostly from Japan;(foreground): three members of the training staff, one of whom (left) is from the Japan Overseas Co-operation Volunteers.

B. Private sector industries

There is one medium-scale sheet metal fabrication workshop in Phuntsholing and a small-scale workshop for sheet metal fabrication and vehicle repair in Bumthang. Other workshops of which there are 18 in Thimphu, are for vehicle repairs only. Some are partly engaged in the fabrication of metal products other than those which are agro-related. There is no private foundry shop and the only one at the AMC in Paro has never been operated. In effect, Bhutan has no foundry industry at all.

The lone workshop in Bumthang in Central Bhutan fabricates wood-fired stoves and heaters out of sheet metal which it makes with reasonably good quality but at a cost much higher than AMC's because of transportation costs to and from West Bhutan.

The owner of the oldest vehicle repair workshop in Thimphu (established in 1987 by the Swiss organization, Helvetas),is keen on establishing a fabrication workshop and even a foundry shop. There is a perceived demand for small tools and simple implements. He needs technical information on foundry technology to help in decision-making and if trained workers are available, he may set up one at the planned Gidkhom industrial area, about 35 km from Thimphu.

In Phuntsholing which is a border town with India, metalworking workshops are strategically located because of the nearness to the source of raw material. The various types of factories in the town enjoy the much lower charges on electrical power compared to those located in India. Labour provided by Indian nationals is cheap, but if factories continue to employ them which they prefer over the Bhutanese nationals, not only in terms of cost but also in terms of company loyalty, the local capabilities could not be developed.

There were doubts expressed by the private sector regarding the viability of branching into fabrication of agro-related machinery primarily because of perceived low demand and the high cost of distribution. The venture might be viable if the government buys the products and takes care of distributing them to the villages, perhaps through the district officers and agricultural extension workers. The government would subsidise distribution. A potential entrepreneur who has long planned to establish such fabricating and foundry facilities could not do so for lack of technical knowledge. A feasibility study is needed before investing in a workshop for fabrication and casting of agro-related machinery as well as equipment for agro-based processing.

The following describes the profile of each workshop and its current activities:

Agro Mechanical Workshop, Bathpalathang, Bumthang

This is the only workshop in the area. It was established originally as a vehicle repair workshop by Helvetas in 1978 but was transferred to the present private owner in 1985. Taking advantage of the modern machine tools in the workshop, the new manager expanded operations to repair of agricultural machinery and fabrication of wood stoves/heaters which are in demand as well as rice cookers for schools. The workshop has 20 workers and an annual turn-over of about Nu 2 million (about US$ 65,000).

About half of the original and mostly Swiss-made machine tools in the workshop are no longer operational because of lack of spare parts. Obviously, some of the equipment had been damaged due to mis-use. For example, a major part of the 2.5-m power-operated sheet metal cutter for 3 mm thickness capacity was broken when a 5 mm plate was attempted to be cut. Other damaged machines needing spare parts are the drill, press and shaper.

AMW has skilled workshop technicians, such as for welding and sheet metal working. A technical staff attended the UNIDO-sponsored in-plant group training programme for engineers in the field of electric welding at the Paton Institute of Electric Welding in Eiev, Ukraine for three months. The workshop has started fabricating a prototype of stainless steel distilling unit based on the one imported from the Netherlands through an essential oil development project.

AMW started fabricating animal-drawn steel ploughs for digging potatoes but gave it up after producing 25 units because of low profit margin. The plough design was copied by nearby village craftsmen who made the plough out of wood. Farmers have found that using the plough for digging potatoes was more effective and resulted in minimal damage to the product compared to using the spade.

Rabten Engineering Workshop, Phuntsholing

This vehicle repair and service workshop, located adjacent to the boundary with India, used to be government-owned and has received assistance from UNIDO for workshop equipment. It is now privatised and has added a vehicle body fabrication workshop. It also participates in government bid offers for the construction of suspension foot bridges where Indian nationals are contracted to provide skilled and semi-skilled labour which is cheaper than that of Bhutanese nationals.

The workshop management is cautious to achieve cost effectiveness and considers market demands in its activities. The general manager is hesitant in fabricating agricultural tools and machinery because of low, if not lack of demand. It cannot take over the soon to be privatised manufacturing and distribution functions of AMC because production costs will be high. Unless suitable government subsidy is granted, products could not be afforded by farmers and the venture would not be viable nor sustainable due to low volume of demand coupled with high distribution costs. Government policies, particularly those of the Ministry of Trade and Industry need to be formulated and affirmed.

The manager, nevertheless, was encouraged to consider manufacturing a diversity of products to make the workshop viable, at least its start up. For example, wood-fired heaters and stoves which are in demand and other products which are not necessarily agricultural may be fabricated. He was also encouraged to set up a foundry shop since the workshop has some machining equipment.The workshop is strategically located near the sources of raw materials and the large market for cast-iron products across the border in India. The nearest foundry shop is about 150 km away in India. If the new foundry has better quality products and high labour productivity, it may get a niche market in India and at the same time serve the farmers in Bhutan.

Kamar Steel Industries, Phuntsholing

This is one of six ventures by the Kamar Group Organization based in Phuntsholing and with liaison office in Calcutta. Management is essentially provided by Indian nationals while labour is supplied mostly by Indian contract workers. It manufactures steel cabinets, tables, chairs, luggage boxes, gates, grills, roll-up doors, wood stoves/heaters, galvanized-iron sheet inner casings of concrete water pipes and other steel products. The covered workshop area totals about 2,000 sq m and contains a complete set of machine tools.

The more than 20 pieces of workshop equipment are mostly of Indian origin and distributed by a trading firm in Calcutta. A pipe bender and a special ribbing machine for fabricating galvanized sheet casing cylinders for concrete pipes are home fabricated as shown in Figure 5. The quality of welding, fitting and other fine craft work finish is mediocre indicating that workers need basic training in craftsmanship and quality control.

Figure 5. Adapted design of ribbing machine for cylindrical galvanized iron sheets which are joined end to end to form as inner lining of a concrete pipe poured in place.

Drukgyal Workshop, Changzamtok, Thimphu

This vehicle repair workshop started in 1992 and appears to be one of the largest of the 18 such workshops in Thimphu. It has a large stock of spare parts and has 35 workers, most of whom are transferees from government workshops. It has a monthly turnover of Nu 150,000 (about US$ 4,900) and a monthly labour expense account of Nu 130,000 (about US$ 4,200). The owner has no plans of venturing into agro-related metalworking industries because of lack of knowledge in this field. Besides, he sees a small business potential in agricultural machinery production.

Sonam Automobile Workshop, Thimphu

This workshop was established by Helvetas of Switzerland in 1986 but was sold to the present proprietor after one year. It is the oldest vehicle repair workshop in Thimphu. The owner expressed keen interest in establishing a fabrication workshop for agro-related metalworks and possibly also a foundry shop. Like other workshop owners, he orders cast parts from India.

Before establishing a foundry shop, he would have to train workers as there are no skilled foundry workers in Bhutan. His available space in the workshop compound is about 750 sq m only but he can have an alternative site at the industrial area in Gridkhom, about 35 km from Thimphu.

He has observed that graduates from the technical Institute generally do not work as seriously as expected and would want white collar jobs, instead. He obtained training in Japan and has trained all his 23 workers himself. Usually, they start as apprentices at age 15 to 20 years. If he had to sponsor his workers for training through an assistance programme, possibly one to be organized by UNIDO, he would require the trainees to each sign a working contract for a minimum of 5 years.

It will be advantageous if any future developments regarding the agro-related metalworking industry project of UNIDO would have a follow-up activity involving the proprietor of this workshop.

Workshops at Lobesa, Wangdiphodrang

Two signs of workshops for repairs of vehicles and agricultural machinery are displayed along the road at Lobesa, about 25 km from Wangdiphodrang. They are the Gangteb Brothers Workshop (Lobesa Mesina) which had closed down since 1992 and the Penjor Engineering Workshop which had never started operations since its sign was put up in 1990. The workshops may have a chance of operating when the manufacturing activities of AMC in Paro becomes privatised and its repair workshop unit at Wangdiphodrang ceases operations.

Potential workshop entrepreneur at Phuntsholing or Paro

A former government official and currently engaged in construction business, expressed interest in setting up a small-scale workshop for fabrication of agricultural machinery. He will consider establishing a foundry shop at Phuntsholing or Paro but informed that he has no knowledge of foundry. He might consider proposing working with AMC to operate its idle foundry on an industry incubator arrangement to enable himself to get the feel of the business and to train personnel, perhaps with assistance from UNIDO. He needs information about foundry technology for his self-study. He was advised to contact the MTI, particularly the Business Opportunity and Information Centre.

He stated that to be cost effective, most establishments in Phuntsholing employ low-wage labour of Indian nationals. While several advantages could be seen in locating the industries at Phuntsholing, any assistance in this regard may defeat the purpose of developing Bhutanese capabilities in industrial operation and management. A suitable policy instrument may be formulated by the Ministry of Trade and Industry. For example, dispersal of new industries away from but still near the city may be considered while still keeping the existing border trade agreements with India. The dispersal will also help minimize industrial pollution and crowding at Phuntsholing.

Bhutan Aromatic and Phyto Chemicals (BAPC), Kurizampa, Mongar

This essential oil distillery is one of the subsidiaries of the Tashi Company. It is a medium-scale distillery established in late 1981 but has ceased operation since 1991 (Figure 6). It has distillation units made of mild steel and buys low-quality oil from farmers who distill lemon grass using mild steel distillation units which the company has distributed to farmers. There are about 500 to 700 units used by farmers in Sherichu, Mongar District, Tashigang District and Auchu, Lhuntshi District.

Field distillers sell their lemon grass oil to BAPC at 90 Indian Rupees per kg. regardless of quality. BAPC collects the oil by the roadside and stores it at the distillery site in 200-litre mild-steel drums which are not inner coated. In 1992,BAPC exported 9 metric tonnes of oil to India. It used to export 30 metric tonnes.

The simple workshop of the distillation plant, although normally for maintenance only, has a technician who is capable of fabricating and repairing distillation units made of mild steel. He has fabricated a prototype of the stainless steel distilling unit which is a modification of the original unit being copied by a workshop in Bumthang . The modifications are in the vapour outlet from the distilling kettle to the condenser, the condenser, the florentine and the support structures. The unit has not yet been tested.

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The dark colour of the weldments in the prototype of the stainless steel distilling unit indicates low-quality welding electrodes and stainless steel materials. To find out which factors cause the dark colour of the weldment, simple welding tests may be conducted on high-quality stainless steel sample strips using different welder settings and comparing the results. The electrodes need pre-heating as instructed by their manufacturer. A final test is to see if the lemon grass oil reacts to the steel and the weldment. The simple test may consist of storing a small quantity of good oil on a crude bowl-shaped container made from the stainless steel scrap with two or three strips of weldments at the bottom for at least one week and analyzing the quality of the oil. The bowl should be well-covered or air-tight to minimize oxidation of the oil.

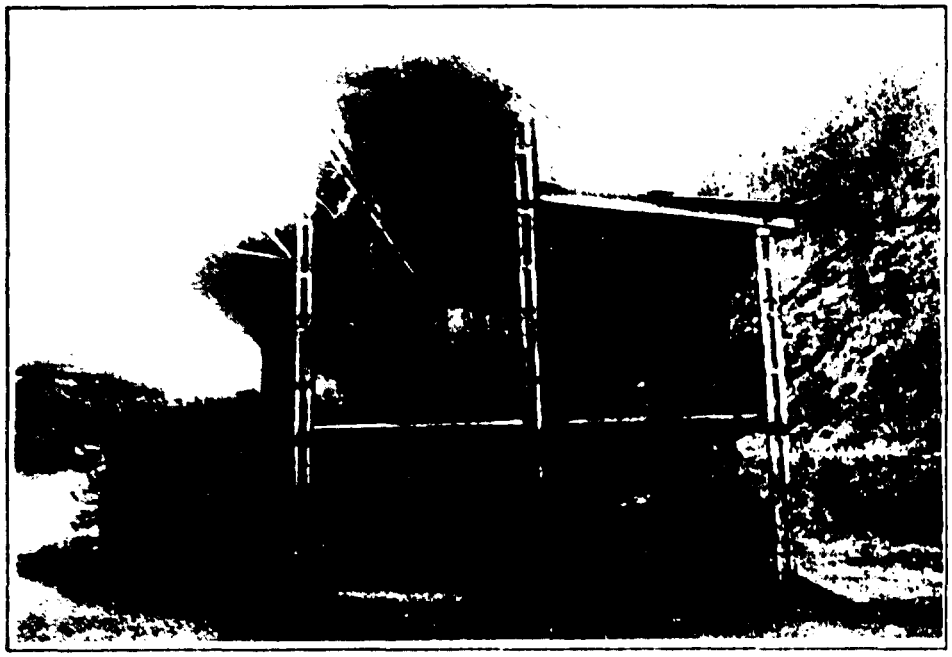

Figure 6. The medium-scale essential oil distilling plant of the Bhutan Aromatic and Phyto Chemicals which is no longer operating. Top left: The plant building showing one of the two large distilling vessels made of mild steel at the middle bay and the active workshop at the right bay. Bottom left: Close-up view of the workshop showing the technician, a welder(to his right) and a mild steel distilling vessel (to his left) submitted by a small-scale distiller for repair. Top: The prototype of a stainless steel distilling unit adapted from the model introduced from the Netherlands.

Micro-scale field distillation units

Lemon grass leaf gatherers distill their collections with their own field distillation units obtained from BAPC affordable payment plan. The boiling units are made of mild steel drums and the condenser coils are made of galvanized iron pipes. The oil product is of low quality due to the rust colour from the distilling units and the contamination of the leaf materials with other plant materials. The only market for the crude essential oil is BAPC which exports it to India for refining. Figure 7 shows a typical installation of a field distillation unit operated by a woman leaf gatherer.

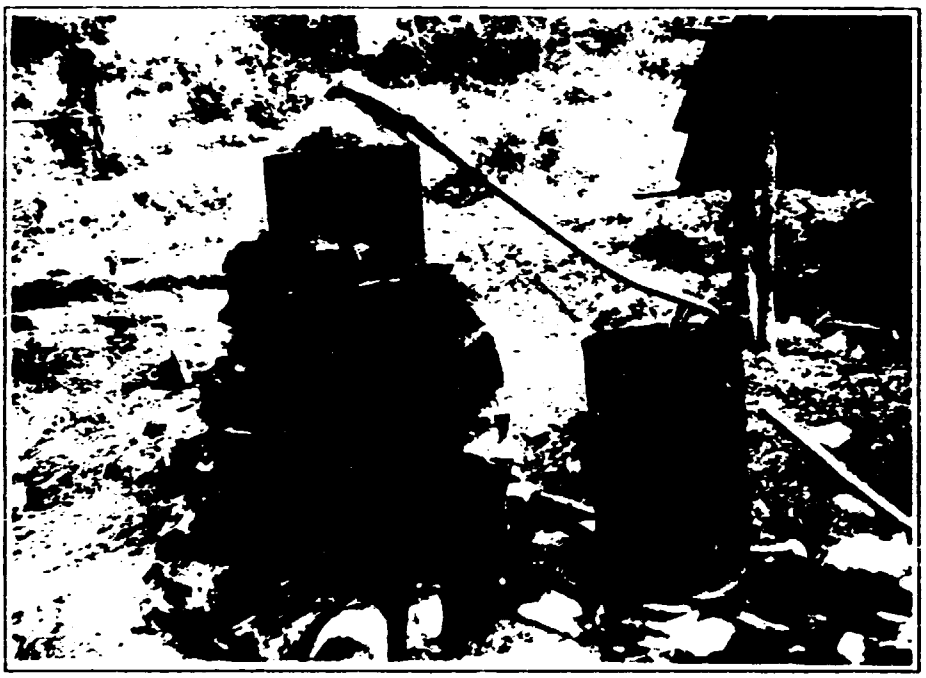

Figure 7. A field distillation unit owned and operated by a woman at Gyelpsing, Mongar district. Left, on the ground: Spent lemongrass leaves or marc, later to be used as fuel supplement; Center: Mild steel distilling vessel which is loaded with leaves through a side port, with gooseneck vapour outlet; Right: Oil drum containing the galvanized iron condenser coil immersed in running water passing through drum. Condensed oil and water mixture exits to a collecting pitcher near the bottom of the drum. Background: Hill which is the source of lemongrass leaves and spring water for the condenser.

There is a need to change the mild steel materials to stainless steel and to train field distillers in quality control of the raw materials gathered and used for distillation. However, the cost of stainless steel is prohibitive.

Figure 8 shows a comparative testing of the two designs of the distillation unit, one made of mild steel and the other stainless steel. The performance of the traditional unit with the gooseneck design for the transition from the boiling and evaporating unit to the condenser is being compared with one design having a straight pipe from the side of the distilling kettle. Also shown is the adaptation made by BAPC on the stainless steel distillation unit from the Netherlands. Preliminary results showed that the oil recovery of the gooseneck distillation units is higher than that from the stainless steel unit where the oil vapours are tapped from the side of the kettle.

The task of gathering lemon grass leaves in the wild is laborious and take so much time because of the distance which has to be covered. There are possibilities of cultivating the lemon grass in marginal areas where pure monoculture of the grass could be practiced.

Penjola Fruit Processing Industry, Bathpalathang, Bumthang

This is a privately owned small-scale and semi-mechanized facility to process apples which are abundantly grown in the area. It has 25 workers and operates only three months per year during the apple harvest season, September to October.

The pasteurization tank made of galvanized iron could be one of the processing equipment which could be fabricated locally. Another is the manual device for putting crowns on bottles containing freshly pasteurized apple juice.

C. Non-government organization

Bhutan Chamber of Commerce and Industry (BCCI), Thimphu

This was established in 1980 and has 350 members. One of its purposes is to enhance and promote private sector trade and industry in keeping with the government's policies and directives. It functions as an information centre for business for its members and for interested parties in other countries. It is a forum for the private sector business to discuss problems related to the development and growth of trade and industrial activities in the kingdom and seek or propose solutions.

It has no programme related to the promotion and development of agro-related metalworking industries as it focuses on six major industries declared as priority by the government. However,through its grassroots level network in different Dzongkhags, BCCI helps an entrepreneur seek financing for a proposed viable project. Once a financial institution approves BCCI's recommendation based on financial viability, the chamber monitors the progress of the entrepreneur concerned for proper utilization of funds. It helps the financial institution in a way because of its early reporting in case of misuse of funds by the entrepreneur.

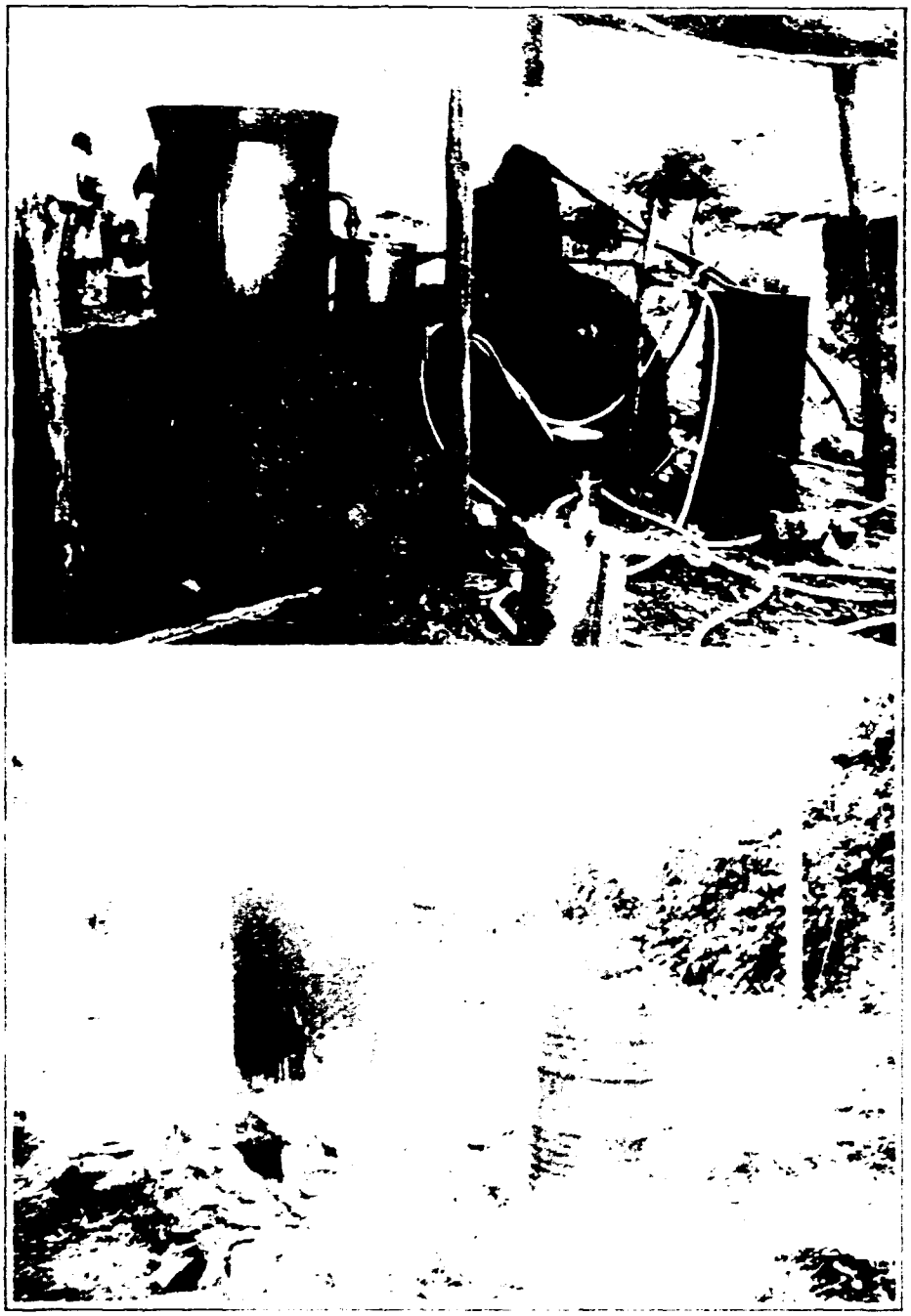

Figure 8. Top: Comparative performance testing of the stainless steel distillation unit from the Netherlands (left) and the mild steel goosenecked unit commonly used by small-scale field distillers, at the essential oil nursery at Gyelpsing, Mongar. Bottom: Distilling kettle (left) made of stainless steel adapted by the Bhutan Aromatic and Phyto Chemicals for use with locally designed condenser coils.

D. Institutional support

Essential Oil Plant Nursery, Department of Agriculture, Gyelpsing, Mongar

This nursery is located adjacent to a re-settlement area. It has two types of distillation units, one made of stainless steel in the Netherlands as part of the FAO assistance in the essential oil development project and another, a smaller unit made of mild steel and commonly used by local lemon grass oil distillers. The initial finding in the comparative tests of performance by the Agricultural Research Centre, Khangma, East Bhutan, is that the mild steel type had an oil recovery of 44 per cent while the stainless steel unit had 28 per cent. While the recoveries may appear both low and the computations were not specified, the difference between the two figures indicate a comparative performance of the two designs of stills. This result, while tentative and not statistically analysed, is corroborated by the observation of BAPC using the Netherlands type of distillation kettle made of mild steel. The condenser and oil separator components are similar to those of the traditionally used mild steel unit. The results need verification based on controlled and statistically analysed trial runs.

The nursery has limited collections of essential oil plants. Among the lemon grass varieties are two kinds from India. The Java type citronella (*Cymbopogon winteriasis*), the oil from which is accepted in the world market, shows promising growth characteristics and is planned to be multiplied and introduced.

It is suggested that the area, including the mountainsides as well as the stony and flat areas where lemon grasses grow wild and have low potential for growing food crops, be used for demonstrating cultivation technologies of lemon grass, palmarosa, citronella and other essential oil crops. Recommended sloping agricultural land technologies, such as alley, contour and hedgerow farming, combined with animal feed grass cultivation, may be practiced and demonstrated. Since a river flows nearby along the valley, some water-lifting device, like a hydraulic ram or a floating water turbine driven by the swift river current, may be installed. Drip irrigation technology may be adapted, especially for sloping land. Sustainability of these mechanical and agricultural engineering technologies or local adaptations thereof, may be studied by the AMC in collaboration with the Agricultural Research Centre in Khangma.

Centre for Agriculture Research and Development (CARD), Wangdiphodrang

This centre concentrates on rice research. Among its experimental field equipment is the axial-flow thresher and one made in India. A necessary improvement of the axial-flow thresher is in having a more robust construction, especially the lower support to withstand the apparently rough handling over the hilly terrain (Figure 9).

Some seven pieces of experimental plot threshers from IRRI are non-operational because of the incompatible electric motor with the 50 Hz power line. As such, they are idle. One such kind of machine was requested by the Agricultural Research Centre (ARC) in Khangma, Tashigang. ARC might as well request the loan of one of the idle machines from CARD but provide the suitable electric motor.

Figure 9. Two kinds of thresher used by CARD, the heavy one from India (left) and the light one from the International Rice Research Institute (right). Shown also are the director of CARD and his son.

Natural Resource Unit, Division of Education/OXFAM Assistance to Schools Programme

This division has an on-going programme of including agriculture subjects in the curricula of primary, junior high and high schools as well as in teacher training institutions. The long-term aim is to motivate the children to like agriculture. The immediate aim is to make them a medium to influence their parents to change their traditional and unproductive practices in agriculture by involving the children in gardening projects, particularly raising vegetables and pigs. It also aims to wean the villagers from reliance on the food for Work Programme which is only temporary. OXFAM has assisted the school programme by buying garden land for the school and providing fencing materials, tools and seed money as revolving fund for the income-generating projects of the children. One school has increased the seed money by 10 times in one year.

The important aspect is not on the profit-making nature of the project but more on the lessons learned and the impact on the attitudes of parents. Apparently the programme is making a headway in most cases.

This success and the on-going activities could be tapped for the promotion of the metalworking industry in the villages. The Division of Education which oversees the Natural Resource Unit annually supplies about 600 spades, 500 pick-axes and other tools to the 175 schools all over the country. The hand tools are obtained through tender which is usually won by commercial giants with supply imported from India. The schools later complain that the tools are usually of low quality, not durable and not appropriate for the size of the children.

Instead of providing ready-made tools to the schools, the Division of Education might buy the quality carbon steel materials in bulk and distribute them to the schools for contracting local blacksmiths to make the tools for them. This has an impact to the local or village economy and may trigger other agro-related metalworking projects with the smithy as the base workshop. An assistance programme is necessary to train trainers of blacksmiths and to provide some blacksmiths with catalytic equipment and raw materials.

National Mushroom Centre, Simthoka, Thimphu

This centre was established in 1989 and has received technical assistance from FAO and the governments of Italy and Japan. The centre's major activity is research and development in the production techniques of shiitake, matsutake, truffles and several other indigenous and high-valued mushrooms. It also does extension work for promoting the production of mushrooms in several villages for income generation.

A bottle-neck in the extension of production is the punching tool and hammer for boring about 13 mm diameter x 25 mm deep holes on oak logs into which the shiitake mushroom spawns are deposited and covered with wax. Mushrooms would emerge in three months if the environmental conditions are right. The market for mushrooms is almost unlimited.

AMC may consider developing low-cost hand tools, such as the log puncher and mushroom solar- or electric-heated drier for fabrication by the private workshops to support the development of the mushroom production and processing industry system.

II. STATUS OF AGRO-RELATED MACHINERY USE

The landholdings in Bhutan are small and range from 0.5 to 1 hectare. Bhutan's own natural setback which limits agricultural production is the ecologically fragile hill and mountain areas with limited arable land. There are no large agricultural landholders although a 5-hectare land ownership is already quite large by Bhutanese standards. The size of landholding and the type of crop produced normally determine the kind of machinery to use. However, with subsidies of the types of agricultural machinery offered in AMP, farmers do not have any other choice.

A. The agricultural mechanization programme

The agricultural mechanization policy statement of 1983 called for the provision of agricultural machinery to substitute for the apparently scarce and expensive labour, provided that this was economic in the long term.

In 1992, the impact of mechanization was assessed by the Ministry of Agriculture. Basically, the assessment concluded that the mechanization of the type and level introduced to the different districts was not economical and it would be difficult to find economic justification for the continuation of the subsidised mechanization programme. It also concluded that labour shortage was not a universal phenomenon, that is, it was mostly critical only during rice planting and harvesting.

The impact assessment observed that there was bias of machinery distribution in that just under 50 per cent of the machinery were for rice production and processing and that over 80 per cent of them were confined to four districts which are easily accessible and near the supply source, that is, AMC in Paro. The four out of seven districts received 90 per cent of the rice specific equipment and nearly 50 per cent of hand tools and improved equipment. The assessment however, made the reservation that the impact of mechanization could not be fully assessed because of

lack of time series data on rural incomes, wage labour rates, crop area and crop productivity As such the pre- and post-mechanization comparisons were difficult to make.

The powered machinery introduced under AMP were mostly of Japanese origin, of one make (Kubota) and mainly for rice cultivation Power tillers and four-wheel tractors and their attachments were sold by the AMC at subsidised prices of 40% of the capital costs. Farmers who owned power tillers and paddy threshers used their machines mostly for their own fields and those who owned tractors with trailers used them for transport on rental basis after using them in their own fields.These equipment were introduced by AMC to farmers in four districts near Paro and in three districts in Central Bhutan where rice is not a major crop. These equipment were particularly attractive to farmers not only because of the subsidy but also because of shortage of labour especially during transplanting and harvesting of rice.

Other machines consisted of rice mills and flour mills. Tools, mainly the spade, were considered indispensable even in non-rice growing areas. As no fabrication workshops exist, the sources of tools are mainly India and the local blacksmiths.

In Paro, the traditional method of harvesting rice is by cutting with non-serrated sickle, laying the cut plants on the field to dry up to seven days, bundling the straw with panicles and carrying them on their backs for stacking at the house yard. Much grain is lost in this process, let alone in storage due to pest damage and in threshing which is done at a much later date when food is needed.

B. Locally made machinery being used by farmers

Before its blacksmithing section was closed down in mid 1993, AMC produced the hoes, sickles, pick-axes and knifes. Its workshop produced hand rotary weeders, garden trowels and pedal rice threshers. AMC has manufactured a total of 450 pedal threshers but only 50 units have been sold as of the end of the 1993 harvest season for rice. No private workshop fabricates any agro-related machinery.

C. Machinery adapted by R&D institutions

AMC started import substitution manufacturing of reversible power tiller-attached mouldboard ploughs, paddle wheels and trailers in 1991. They were adapted from the design of the imported machines from Japan. It also produced two-bullock drawn reversible mouldboard ploughs.

D. Agricultural machinery supply

Data on the agricultural machinery supply were taken from the report of the assessment of AMP by the DA. Tables 3 to 5 show the relevant data transformed from the original data presented in such assessment.

Table 3. Number of tractors supplied by the Agricultural Machinery Centre per 100 hectares of cultivable land per district in Bhutan.

(Units per 100 hectares)

District	Ford 50 hp	Kubota 38 hp	Kubota 16 hp	Power Tiller
Bumthang	0.123	0.074	0.198	0.000
Chirang	0.000	0.000	0.000	0.000
Chukha	0.000	0.000	0.000	0.025
Dagana	0.000	0.000	0.000	0.000
Haa	0.000	0.000	0.000	0.296
G/phug	0.000	0.000	0.000	0.025
L/huntsi	0.012	0.000	0.012	0.000
Mongar	0.000	0.000	0.025	0.012
Paro	0.100	0.025	0.321	2.198
Pemagatsel	0.002	0.000	0.000	0.025
Punakha	0.074	0.000	0.000	1.927
Samchi	0.012	0.000	0.000	0.025
S/gang	0.000	0.000	0.000	0.025
S/Jongkhar	0.000	0.000	0.000	0.025
T/gang	0.000	0.000	0.000	0.000
Thimpu	0.321	0.123	0.247	1.433
Tongsa	0.025	0.000	0.000	0.025
Wangdi	0.161	0.074	0.049	0.106

Source: Agricultural Machinery Centre, Department of Agriculture.

Table 4. Number of hand tools and implements supplied by the Agricultural Machinery Centre, 1983-1993.

District	Units Per Hectare of Cultivable Land	Units Per Household
Bumthang	0.247	1,274.5
Chirang	0.988	315.5
Chukha	0.247	83.0
Dagana	0.494	79.0
Haa	1.161	1,757.8
G/phug	0.074	184.7
L/huntsi	0.222	721.4
Mongar	0.234	564.0
Paro	2.618	5,447.9
Pemagatsel	0.198	709.7
Punakha	0.756	979.6
Samchi	0.012	19.5
S/gang	0.247	412.3
S/Jongkhar	0.148	711.1
T/gang	0.222	1,087.5
Thimpu	1.222	2,037.6
Tongsa	0.408	1,202.9
Wangdi	2.470	3,311.4

Source: Agricultural Machinery Centre, Department of Agriculture.

Table 5. Agricultural machinery supplied by the Agricultural Machinery Centre,1983-1993.

District	Ford Tractor 50 HP	Kubota Tractor 30HP	Kubota Tractor 16HP	Kubota Power Tiller	Kubota Power Thresher	Power Reaper	Power Sprayer	Paddy Trans-planter	Power Chain Saw	Port-able Rock Drill	Port-able Motor Breaker	Kubota Water Pump	Diesel Engine
Bumthang	8	5	0	14	4	2	2	0	8	0	0	0	0
Chirang	0	0	0	3	6	0	2	0	0	1	0	1	0
Chukha	0	0	0	1	0	0	0	0	0	10	4	1	0
Dagana	0	0	0	0	0	0	0	0	0	1	1	0	0
Haa	0	0	0	5	1	0	0	0	0	0	0	0	0
G/phug	0	0	1	4	5	2	0	0	0	0	0	0	0
L/tshi	1	0	0	1	0	0	0	0	0	0	0	0	0
Mongar	1	0	2	1	0	0	0	0	1	0	0	1	0
Paro	5	1	17	114	35	11	10	6	12	0	0	17	11
P/shel	1	1	1	2	1	0	0	0	0	0	0	1	0
Punukha	2	0	0	53	25	4	0	4	0	2	1	5	1
Sanchi	2	0	0	4	1	0	1	0	0	1	0	0	0
S/khar	0	0	1	5	3	0	0	0	0	0	0	0	0
T/gang	1	0	0	10	1	0	1	0	1	16	6	1	0
Thimpu	10	4	8	44	20	1	11	0	9	1	1	9	0
Tongsa	1	0	0	1	0	0	0	0	2	1	1	0	0
Wangdi	6	3	2	39	12	1	4	0	5	3	1	3	2
Total	38	14	32	304	114	21	32	10	38	39	16	39	14

Table 5 (Continued)

District	Water Turbine	Brush Cutter	Rice Mill	Oil Expeller	Winnower	Paddy Thresher	Rotary Paddy	PP Equip-	Garden Pipes	Maize Huller	Shafting Bar	Seed Drill	Tools & Implements
Bumthang	0	0	0	0	4	1	0	0	100	0	0	0	1509
Chirang	0	0	37	5	3	2	4	84	667	0	0	0	1424
Chukha	0	0	3	0	0	0	1	0	0	0	0	0	284
Dagana	0	0	20	1	0	0	18	11	3000	0	0	0	314
Haa	0	1	13	5	0	0	0	17	900	8	0	0	1909
G/phug	0	0	20	2	13	2	25	0	0	0	0	1	1606
L/tshi	0	0	52	2	1	4	23	6	0	2	0	0	1849
Mongar	0	0	33	3	9	5	11	6	4400	0	144	0	2687
Paro	1	7	90	2	65	234	523	339	11031	0	0	0	13598
P/shel	0	0	10	0	0	0	10	0	0	0	0	0	13598
Punakha	0	1	163	8	7	265	634	74	1800	0	0	0	2448
Samchi	0	0	13	2	5	1	5	0	0	0	0	0	140
S/gang	0	0	21	1	1	2	0	29	0	0	0	0	2957
S/khar	0	0	12	1	0	0	10	18	0	0	0	0	3839
T/gang	0	1	189	6	10	29	43	4	9000	10	0	0	8363
Thimphu	0	15	65	4	5	33	137	268	5500	0	0	4	3798
Tongsa	0	0	43	4	0	0	0	16	0	0	144	0	1719
Wangdi	0	0	112	15	30	165	57	64	4200	0	0	0	9040
Total	1	25	896	61	153	743	1501	936	40598	20	289	5	59264

Source: Agricultural Machinery Centre, Department of Agriculture.

E. Demand for agricultural machinery

In a survey conducted by the Ministry of Agriculture, farmers' assessments of their own greatest labour constraints are shown in Table 6. Paddy transplanting and paddy harvest were the major operations having the most labour constraints identified by over 80 per cent of the respondents in the rice growing areas. Dryland crop cultivation was cited as by those in the non-paddy districts as having the most labour constraints. There were no constraints cited for livestock production activities.

In the assessment of AMP by DA, farmers were asked about their views of the programme. Farmers in four rice-growing districts, where most of the machines had been supplied, identified the power tiller powered equipment which had the greatest use to them. The second most useful was the rice mill, followed equally by the thresher and the four-wheel tractor, then equally by the reaper and the flour mill. The hand tools that they thought were most useful were the spade, the sickle and the weeder in that order of popularity. Farmers in the districts where rice is grown but is not a major crop, mentioned also the power tiller and the rice mill as the most useful powered machines. These were followed by the flour mill, the four-wheel tractor and the thresher. Among the hand tools, the spade and the sickle were thought to be the most useful ones.

The reasons given why the equipment is of greatest use included multi-purpose use, labour substitution and income generation. Farmers' proposed solutions to labour constraints consist of mechanisation, exchange labour, hire labour and exemption from compulsory labour in that order of importance. It is striking to note that in the districts remote from Thimphu and Paro, the number of farmers who responded as no idea of proposed solutions, was three times more than in districts near the capital city. This may have to do with exposure to modernisation. Table 7 shows the results of the survey on farmers' assessment of equipment most useful to them.

Table 6. Farmers' own assessments of their greatest labour constraints.

Operation\District	Paro	Punakha	Thimpu	Wangdi	Total	%	Bumthang	Haa	Tongsa	Total	%
Land preparation	1	1	1	1	4	3.2	0	0	0	0	0.0
Paddy transplanting	24	17	7	16	64	51.2	0	0	7	7	24.1
Paddy harvesting	18	8	5	9	40	32.0	0	0	2	2	8.9
Potato sowing	0	0	1	2	3	2.4	0	2	0	2	6.9
Dryland crop cultivation	1	2	0	0	3	2.4	2	6	3	11	37.9
Dryland crop harvesting	1	1	0	0	2	1.6	8	5	0	5	17.2
Vegetable production	0	0	1	0	1	0.8	1	0	0	1	3.5
Livestock production	0	0	0	0	0	0.0	0	0	0	0	0.0
None	5	1	0	0	6	4.8	4	1	2	7	24.1

Source: Department of Agriculture.

Table 7. Farmers' assessment of the individual items of equipment that have been of greatest use.

Machinery\District	Paro	Punakha	Thimpu	Wangdi	Total	%	Bumthang	Haa	Tongsa	Total	%
Power tiller	15	9	4	5	33	50.77	2	2	0	4	18.18
Power thresher	0	1	0	4	5	7.70	0	1	0	1	4.54
4-Wheel tractor	2	0	0	3	5	7.70	2	0	0	2	9.09
Rice mill	2	2	4	2	10	15.38	0	0	3	3	13.63
Power reaper	0	0	0	1	1	1.54	0	0	0	0	0.00
Weeder	0	0	0	1	1	1.54	0	0	0	0	0.00
Spade	0	5	0	0	5	7.70	1	2	3	6	27.27
Sickles	2	0	0	0	2	3.08	0	0	2	2	9.09
Flour mill	1	0	0	0	1	1.54	0	3	0	3	13.63
Several	0	1	0	1	2	3.08	1	0	0	1	4.54

Farmers in all districts wanted more mechanisation and more mechanisation with subsidy. They also wanted that more small tools be distributed and spare parts be made available easily. Training in operation and maintenance of machinery is also needed by the farmers.

The types of hand tools being sold at the public markets are claw weeder, spade, knife with curve end for brush cutting, knife for timber hewing and ax.

F. Production of agricultural machinery

The production of hand tools in Bhutan is done by AMC and by blacksmiths or rural artisans. AMC assembles the partially knocked-down tractors and agricultural machines granted by Japan for distribution at subsidised prices to farmers. The fabrication of some types of agricultural machines is solely done by AMC as no private agro-related metal workshops exist, except for blacksmiths. The production capacity is limited as the workshop facilities have not been geared towards mass production. Rather, fabrication of a few types of items are done during a certain period in anticipation of demand. The assembly of partially knocked-down tractors, power tillers and their attached implements from Japan does not count as a manufacturing activity.

Shortfalls in production of certain items, mostly simple hand tools, like spades, hoes, shovels and pick axes are filled up by imports from India which are much cheaper than those imported from Japan. Village blacksmiths supply most of the more simple and easy to make tools, like sickles, knives and other small domestic utensils and are usually crude because of meagre blacksmithing tools and facilities.

The operation of the blacksmithing section has been stopped, in line with the government's policy of phasing out AMCs' manufacturing activities to give way for the private sector.

The following are being manufactured in the AMC workshop:

(a) Pedal rice threshers - 450 units manufactured of which only 50 units had been sold as of the end of the rice harvest season in 1993;

(b) Field knives - number produced not available;

(c) Garden rakes - 300 pieces produced;

(d) Sickles - number produced not available;

(e) Hand-pushed rotary weeder for rice - 750 produced and sold in 1992 but sales went down in 1993 and

(f) Trowels, design copied from Japan- number produced, not available.

The agro-industrial metalworking industry, being non-existent in Bhutan and the mountainous conditions as well as the widely scattered farming areas, needs a unique

strategy for its promotion and development.

G. Custom hiring of machinery

In the assessment survey of the Ministry of Agriculture, data showed that machinery owners use their machinery for hire purposes. Most of this hire, such as that of rice mill, hand-operated winnower and oil expeller, is for non-agricultural purposes. However, both hand and power operated threshers were used more on the owner' farm than for hire purposes as shown in Table 8. The assessment found that the rate of utilization of the machines was low which was attributed probably to the high density of the machines on a district basis.

Table 8. Use of machinery on owner's farm and for hire purposes, 1993.

(Mean, in days per year)

Machine	Owner's Farm	Hire	Total	Per cent of Use on Owner's Farm
Tractor	28.5	69.8	86.6	32.8
Power tiller	14.8	20.2	35.3	38.8
Power thresher	11.2	14.7	18.5	60.4
Power reaper	10.2	14.8	22.0	46.4
Paddy transplanter	3.7	3.4	7.0	52.9
Rice mill	13.9	52.1	68.4	19.4
Oil expeller	2.0	74.4	75.2	1.1
Winnower	18.7	41.6	53.3	35.0
Paddy thresher	14.9	12.4	17.1	61.3
Paddy weeder	10.3	14.0	12.0	85.4

Source: Department of Agriculture.

The assessment survey of the Department of Agriculture showed that few farmers are actually meeting the capital costs of tractors and power tillers with income derived from machine rental. Only half of the owners of power threshers and rice reapers are meeting their annual capital costs. Only the rice mills appear to be economically viable at both the subsidised and unsubsidised capital costs. The data are shown in Table 9.

Table 9. Number of farmers by district and power machine who generate sufficient annual income from hire of machinery to meet annual capital costs.

(Samples in parentheses)

Machine		Paro	Punakha	Wangdi	Thimpu	Bumthang	Haa	Tongsa	Total
Tractor, 35 hp	s	0(2)	-	0(3)	-	-	-	-	1(8)
Tractor, 16 hp	s	2(2)	-	-	-	-	-	-	2(2)
	ns	0(2)	-	-	-	-	-	-	0(2)
Power tiller	s	4(2)	2(9)	1(5)	0(2)	0(3)	0(2)	-	7(43)
	ns	1(22)	1(9)	0(5)	0(2)	0(3)	0(2)	-	2(43)
Power thresher	s	3(6)	0(2)	-	-	-	-	-	4(9)
Power reaper	s	2(7)	-	1(1)	-	-	-	-	3(8)
Transplanter	s	1(1)	-	0(1)	-	-	-	-	1(2)
Engine, 7 hp	s	7(9)	5(7)	5(6)	4(7)	-	-	1(2)	22(31)
	ns	7(9)	5(7)	3(6)	4(7)	-	-	1(2)	20(31)
Engine, 10/14 hp	s	3(3)	-	1(2)	-	-	-	-	4(5)
	ns	3(3)	-	1(2)	-	-	-	-	4(5)
Oil expeller	s	-	0(1)	1(3)	-	-	-	-	1(4)
	ns	0(1)	1(3)	-	-	-	-	-	1(4)

Source: Department of Agriculture.

H. Oil expellers

Bhutan imports about 70 per cent of its edible oil requirements which amount to about 2,000 tonnes per year. The sources of edible oils are Malaysia for palm oil and India for other edible oils. One-fourth of the oils is imported by the Food Corporation of Bhutan (FCB), one-fourth by the World Food Programme from Malaysia and the remaining one-half by private entrepreneurs from India.

The main source of edible oils is mustard which is a subsistence crop. Only a few farmers produce a marketable surplus. Pangtshi seed is another common source of edible oil but extraction is essentially by the laborious traditional method as the screw type expellers cannot be used.

The two types of expellers used in Bhutan are the 6-bolt type manufactured in India and a small version of the Hander oil expeller from Japan (Figure 9). There are about 60 units of expellers installed by AMC. Some 20 to 30 units have been imported directly from India. A German Komet press is operating in Jakar, Bumthang.

A study of oil expellers in Bhutan does not recommend any particular type of expeller but states that the 6-bolt expeller can be operated profitably in many locations. It specifically recommends discontinuation of promotion of the table oil expeller which is not reliable since spare parts are not available. It also recommends the formation of an Oilseed Processing Group at the Centre for Research and Development (CARD) at Wangdipodhrang comprising an agricultural engineer (preferably from the AMC field station located at the same compound as CARD), an agronomist from CARD and a mechanic. One of OPG's functions is to test oil expellers and recommend one oil expeller which will be supplied and supported.

The local manufacture of oil expellers is highly dependent on the development of the foundry industry as well as on the capabilities in machining and heat treatment, like in Myanmar where manufacture of the large version of the 6-bolt type is most common or in India where the current need is the supply of spare parts for the existing oil mills. Small-scale foundry and fabrication shops should be able to develop capabilities in making and repairing some parts which are easily worn out like the wormshaft.

III. ECDC/TCDC POTENTIALS

Bhutan has no developed technologies in the area of agro-related metalworking industries which can be transferred to other developing countries. However, it has a lot of experiences in the promotion of power tillers and mini-tractors along with their complement implements. The power tiller has been introduced in the rice-production districts and are highly accepted by farmers. Bhutan has also limited experiences in essential oil production which apparently benefit women and which exploit the renewable natural resources without harmful effects to the environment.

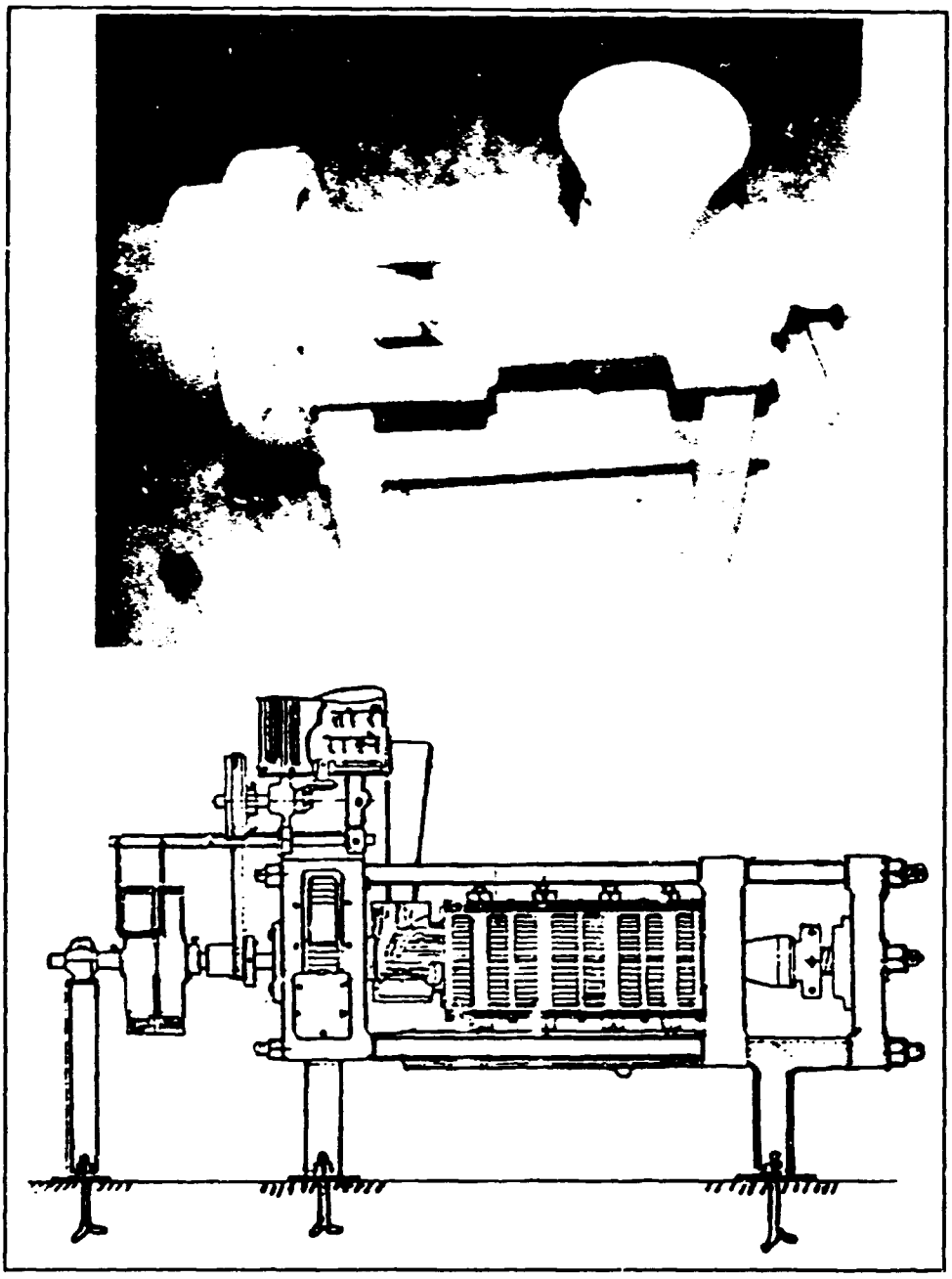

Figure 10. Two types of oil expeller used in Bhutan. Top: The small version of the Hander from Japan. Bottom: The 6-bolt type from India.

Bhutan has a large scope for accepting technologies from other countries. Among them are the foundry and the machinery fabrication technologies. Bhutan can benefit from experiences of other countries in fruit, vegetable and spice production, harvesting and handling, grading, packaging and expanding markets to third countries. Examples are acquisition of horticultural production and post-production technologies for apples, oranges, asparagus, mushrooms and cardamom for which Bhutan has a comparative advantage.

A. Agricultural mechanization programme of AMC

The experiences of the AMC regarding the introduction of engine-powered machinery technologies at subsidised rates could be a lesson for other countries. There is controversy regarding the assessment and the farmers' desire for tractors and power tillers. On the one hand, economic assessments point out the uneconomic use of such equipment because of the limited number of days used per year. On the other hand, farmers say that power tillers and other powered machinery are most useful to them and wish that the mechanisation programme be continued. They, of course wish that subsidies be also continued which is the crux of the matter since government will essentially subsidise a non-economic system.

Alternative solutions which satisfy the economic viability requirements and at the time solve the labour shortage problem may exist in other developing countries. For example, they may be producing cheaper power tillers, the technology of manufacture for which may be transferred to Bhutan. In this field, Bhutan could be a benefactor of TCDC but certainly has mutual activities in ECDC.

B. Essential oil production

The present field and decentralized distillation of lemon grass to extract essential oil for export is an established system in Bhutan. However, it is meeting problems of quality control which renders the value of the product low and limits its exportation to India only which refines the oil for re-export or utilize it domestically. Improvements are possible in cultivation, harvesting and post-harvest processing techniques, including sorting and grading of the raw materials, in the use of distillation units which are non-reactive to lemon grass oil vapours and liquids and in quality control of the distillation process (e.g. avoidance of dirt contamination and improved oil separators). In one year, the above system is expected to take place through the UNDP-assisted project on the development of the essential oil industry in Bhutan.

Nepal has a similar essential oil industry but more advanced than Bhutan's. Nepal's experience is in the distillation of wintergreen gathered from the wild. Lemon grass is unexploited in Nepal and wintergreen is unexploited in Bhutan. Nepal has a workable centralized and farmer- contracted field distillation and product marketing system for wintergreen while Bhutan has a similar one for lemon grass.

The above is a potential field for ECDC/TCDC between Bhutan and Nepal, particularly in the manufacture of stainless steel or aluminium-lined distillation kettles and oil storage tanks and in the manufacture of epoxy-lined shipping containers.

C. Horticultural production and processing

The comparative advantage of Bhutan in horticulture has not yet been fully exploited. In fact, there is a large scope for improvement in both production and processing techniques for which tools and machinery are needed. For example, pruning shears for apples and oranges, hillside cultivating and harvesting tools for

asparagus, efficient and environment friendly field driers (e.g. cooperative or community solar and hydro-electric driers) for cardamom and mushrooms, oakwood punchers for shiitake mushroom spawn inoculation and light ropeway transport system may be manufactured/installed locally if the R&D institutional support system and the private sector small-scale fabrication, foundry and blacksmithing workshops are in place. Developing countries possessing these technologies could exchange them with Bhutan, perhaps with the horticultural products which are produced efficiently and cheaply as a result of the technologies received by Bhutan and of its natural comparative advantage.

IV. PROBLEMS AND CONSTRAINTS

A. National network

In general, linkages among the few institutions and organizations which could possibly have some activities related to the manufacture of agro-related machinery need to be strengthened. Effective communication and co-ordination of activities among them would result in mutual benefits and in the more effective implementation of activities. The mechanism for this is a national network (NN) of institutions and organizations whose activities are relevant to agro-related metalworking industries. The following are the major problems and constraints identified:

Need for linkages among R & D institutions, extension units, manufacturers, blacksmiths and farmers in the development of agricultural machinery

There has been minimal co-ordination and working relationship between the AMC and the Agricultural Extension Division (AED) of the Department of Agriculture. Extension workers could assist in AMP by giving information on machinery needed by farmers.

In the assessment of the AMP being implemented by AMC, the economics of the use of tractors, power tillers and engine-powered equipment is being questioned. However, farmers' perceptions are different. They would still want to own power tillers and rice mills or at least have machinery hire services available to them.

It appears that because there is no economic justification for the continuation of subsidies in some cases, the continuation of AMP itself is threatened. However, no alternative solutions or ideas have been proposed. Then, the labour shortage problem is back to its original situation for which AMP was thought to be the best solution. The direction for AMP needs to be resolved by defining its role in the development and delivery of agricultural support activities. It can continue to have a supportive role not only in agricultural mechanization but also in post-harvest technology such as in prevention of harvest and post-harvest losses, increasing the efficiencies of rice mills, promotion of repair services for oil mills by local manufacture of cast-iron spare parts and building up of worn out parts. It can also play a role in the processing of cardamom and mushroom by developing low-cost and energy efficient driers.

Need for utilizing idle facilities and excess capacities of AMC

As a result of the phasing out of AMC's repair services and manufacturing activities, certain facilities have become idle or are not being fully utilized. The idle facilities are the repair workshop, the blacksmithing and the foundry shops. In June 1994 when manufacturing activities are phased out, the fabrication workshop would be either idle or have excess capacity since it would take time before R&D activities could be fully undertaken.

Need for sharing of information

One way of activating the NN is the sustenance of the flow of information between the national focal point (NFP) and the members. It would be helpful if the NFP maintains a newsletter containing, among other information some new designs of machines requested from RNAM headquarters and other sources. Small- and medium-scale workshops, after getting established, could be assisted by giving them information about new design ideas. They may be able to fabricate their own prototypes adapted from such ideas quickly because of their market orientation and flexibility. As co-operators in design and development, these workshops should be on the list of those to be provided with materials received from RNAM, like newsletters and catalytic assistance.

AMC will need to disseminate information about the results of its research and development efforts to the private workshops yet to be established. It will need also to disseminate information to farmers the improved technologies it has developed for their adoption. For this, simple illustrative pamphlets may be published and distributed through school children with assistance from the OXFAM programme of the Division of Education, Ministry of Health and Education. This activity is related to the proposed project concept for involving blacksmiths in the supply of tools for the schools as given in Section VI.

Weak linkage of R&D institutions with machinery manufacturers

The design and development of a machine in the R&D institution is often a long-drawn process because of lack of pressure unlike in the case of manufacturers who are motivated by profit or by the prospect of loss. Thus, to accelerate the development process towards the commercialisation of a machine which should be its goal, the R&D institution in each LDC should work hand in hand with the private sector manufacturers.

AMC can start off promoting the manufacture of tools and implements it finds suitable and acceptable to farmers by working with potential workshop entrepreneurs.

There is apprehension that the vacuum which will be created by the stoppage of fabrication activities by AMC by the end of Fiscal Year 1993-1994, will not be filled in by the private sector due to their lack of experience in the metalworking fabrication industry. Instead of private sector manufacturing, trading m ay take place instead especially with the attractive low cost hand tools and machinery from India.

While the above scenario may be regarded as a natural consequence of an open market economy, the agricultural and industrial planners may consider favourable alternative scenarios which may occur when appropriate strategies are formulated. Time should be given to AMC to promote machinery manufacturing by small-scale fabrication and foundry workshops.

It may be safe to assume that in the long-run, it is always better to develop manufacturing industry capabilities than not at all. Unemployment may take place in a few more years when population would have increased and it might be too late to start from then. The conditions created then might be irreversible.

What might be overlooked in considering a bias for importing cheap tools and machinery from India rather than locally manufacturing them is the fact that electrical power in Bhutan is much cheaper and more abundant than in India. This comparative advantage may offset transportation costs of raw materials which are tariff-free. The cheap labour cost in India may be offset by greater productivity of the Bhutanese workers through training and efficient manufacturing techniques. Quality production, certainly not impossible to achieve, is another competitive edge for Bhutan. Simple-designed power tillers and threshers which are two types of machines cited by farmers as most useful to them can even be manufactured locally at much cheaper cost than the imported ones.

A review, therefore, of the present plans and policies regarding the agricultural mechanisation programme should be made by RGOB, taking into consideration the above points and the drive to work towards self-reliance in the manufacture of agro-related machinery.

Need for fabrication and testing of essential oil distillation units

It was observed that the quality of the stainless steel materials used and the welding finish were lower than those of the original distillation unit being copied. The dark finish, unlike other stainless steel units may affect the quality of the essential oil which would be processed by the unit. The quality of oil produced from this distillation unit needs to be tested under controlled conditions.

Aluminium sheet lining for the mild steel kettle may not affect oil quality, yet will considerably reduce the cost of the distillation unit making oil distillation an economically viable venture for the farmer. However, the use of aluminium has not been commonly used by essential oil distillers. A test distillation unit may be fabricated and tested first before mass producing any design of a particular model. AMC in Paro which undertakes research and development in agro-related metalworking industries may be requested to undertake the above exploratory fabrication activities. A successful system using aluminium as material for distillation will have the advantage of reduced costs compared to stainless steel and good quality oil compared to that produced using mild steel.

Need for technical information on foundry technology

A reason for the hesitation of one vehicle repair workshop to invest in establishing a foundry workshop is the lack of knowledge in foundry technology.

It is suggested that UNIDO assist the private sector in Phuntsholing in the conduct of a feasibility study of a privately owned and operated small-scale foundry and fabrication workshops and that UNIDO provides literature in foundry technology.

High cost of machinery distribution in Bhutan

Both the managers of the Rabten Engineering Workshop and the Kamar Steel Industries showed concern about the small market demand of agricultural machinery. However, the became interested when informed of the pending privatisation of the machinery manufacturing activities by the AMC and the prospect of introducing improved machines to farmers through its research and development as well as extension activities. Nevertheless,they cited that the major problem is the high cost of distribution of machinery to farmers. The company would not be prepared to distribute machinery over widely dispersed areas because the costs would be too prohibitive to have a viable business. They suggested that if the government could continue with its distribution activities through the agricultural extension workers of government agencies, small-scale agricultural machinery production might be viable.

If given assistance by UNIDO in the conduct of feasibility studies, the entrepreneurs might establish a foundry shop at Phuntsholing. A market could be developed in the area because of its strategic location in terms of its nearness to the additional niche market in India, the low cost of electricity and the proximity to the source of raw materials.

Lack of suitable model of oil expeller

Based on the recommendation of a study of oil expellers in Bhutan, an OPG has yet to be formed to run tests on oil expellers and a suitable machine is to be identified. Meanwhile, if spare parts for the existing oil expellers could be made locally, their reliability could be increased. Downtime is decreased because expellers will be easily repaired. Most of the idle oil expellers could be rehabilitated. Since most of the parts are made of cast-iron the local shops can do the repairs. If suitable skills and facilities are available, othe parts could be made in the same shops. The constraint however, is that the required repair service system is non-existent.

B. Private sector industries

The agro-related metalworking industry in the private sector is practically nil. A diversified workshop in Bumthang operates as a vehicle repair workshop and at the same time fabricates wood-fired stoves/heaters and rice cookers for schools. The same workshop may develop capabilities in fabricating stainless steel distillation units for essential oils extraction from lemon grass.

A constraint which causes hesitation among potential investors to venture into agro-related metalworking enterprises is their lack of information about the demand or market for agricultural machinery, scarcity of trained manpower for shopwork and limited technical knowledge of fabrication and foundry works. There are no existing private workshops on which potential investors could model their own in case they decide to put up one. At best, they could refer to AMC or to the vehicle repair workshops in Thimphu.

V. CONCLUSIONS AND RECOMMENDATIONS

A. Machinery prototypes and drawings needed

Based on the government's development programmes in agriculture and agro-related industries as well as on the current constraints in the production of agricultural crops which need machinery, a list of prototypes and drawings of machinery for adoption from other countries and for a programme of exchanges among them and other developing countries was drawn up and is shown below. Both activities will result in the acquisition of prototypes and drawings of machinery which are to be starting points of testing, fabrication and modification for their adaptation in the R&D institutions in co-operation with manufacturers and farmers. The list is a reference for the proposed regional project concept (Section VI) whereby machinery prototypes will be provided for local adaptation of design, testing and introduction to farmers.

(a) Micro-hydro turbine for mills and electricity generation from Nepal;

(b) Axial-flow thresher from IRRI;

(c) IRRI power tiller;

(d) Single-animal drawn plough from the Philippines and Thailand;

(e) Animal-drawn potato digger;

(f) Hydraulic ram from India;

(g) Rubber roll paddy huller/polisher;

(h) Paddy field row marker from IRRI (drawing);

(i)Manual maize sheller from the Philippines;

(j) Mustard oil expeller from Nepal or India;

(k) Cast-iron mouldboard ploughshare and mouldboard from Myanmar;

(l) Oakwood puncher (hand tool) for mushroom growing and

(m) Solar drier for fruits, vegetables and spices.

B. Machinery prototypes and drawings for exchange with other LDCs

There is no machinery prototype developed in Bhutan since agricultural machinery have essentially been imported from Japan and India. At best, AMC's experiences in the training of farmers in operation, repair and maintenance of machinery as well as its successful introduction of some types of machinery can be obtained. For example, AMC introduced an oil expeller from Japan. With good foundry technology, the oil expeller could be made locally as had been done in India after some modifications. Myanmar would be most interested in such experiences and in the specifications of the oil expeller as it has a large oilseed processing industry. Myanmar has the capability of making oil expellers in traditional foundry and machining workshops but needs improved designs.

C. Strengthening of national network institutions

There is a need to strengthen the institutions and organizations whose activities relate to or impinge upon agricultural mechanization as well as agricultural machinery research, design, development, manufacture and commercialisation. Informal meetings and communication contacts for inquiries, exchange of notes on activities and significant findings, discussion of policy issues and formulation of strategies and other matters relevant to mechanisation and the agricultural machinery industry are important activities. Such exchanges are critical especially in the R&D circle where technical information can guide the researchers and design engineers in their work.

It is suggested that AMC be allowed to continue to promote machines and be involved in the activities of the agricultural extension unit with a view to convincing farmers to adopt improved mechanical technologies along with the other agricultural technologies. Due to lack of human resources, the extension unit alone may not be able to demonstrate and follow up the extension activities requiring mechanical technologies.

D. Policies and strategies

The umbrella economic policy currently prevailing in Bhutan is the liberalized market and a move towards privatisation of government-owned industrial and commercial firms. The following are recommended:

Promotion of agricultural mechanization through custom operation services

Given the low purchasing power of the farmers and the lack of access to formal credit because of lack of collateral, a strategy for them to avail of the benefits of mechanization technologies is by promoting the custom work or hire services rendered by those who can afford to buy machinery. This method is already practiced in the case of land preparation and field transport using power tillers and tractors and to a limited extent, threshing using engine-powered threshers.

Custom work services in land preparation, water pumping and threshing are already popular in many developing countries. Thus, the target of such high-cost machinery may not be the farmers only but also the non-farmers who may be persuaded to invest in farm machinery for custom work. This may be institutionalized through promotion, demonstrations not only of machinery but also of pilot partially mechanized farming systems in cooperation with farmers and conduct of training in custom work management by AMC. A policy for promoting mechanization is that of giving credit to farmers and non-farmers for investments in agricultural machinery to render custom field operation services.

Apart from hand tools and simple animal-drawn implements, the engine-powered equipment are not affordable by small farmers and agro-industrial entrepreneurs in the LDCs. Hence, they are usually left out as beneficiaries of agricultural mechanization programmes, including the design, manufacture and distribution of agro-related machinery and equipment.

Small farmers and agro-processing entrepreneurs, however, can afford custom work or machinery rental services and thus, avail themselves of the benefits of modern mechanical technologies. While custom work or hire services are practiced to some degree, mostly in ploughing, harrowing, threshing and grain milling operations, the system has not been institutionalized nor promoted as a strategy to create a market for the more sophisticated machinery. Services could be expanded to water pumping, inter-cultivating, harvesting, drying and food processing.

Group training of farmers in agricultural machinery operation, repair and maintenance to include topics in agricultural technology

To enrich the training courses in the operation, repair and maintenance of machinery, modern agricultural technologies should be included in the training syllabus for farmers. The strategy will enrich the course and increase farmers' interest and knowledge about new technologies. As machinery owners, they could play an important role in technology dissemination and become instrumental in introducing improved farming methods other than mechanization among other farmers.

Mechanization itself should be introduced together with other agricultural technologies, that is, agronomy, soil conservation and fertility as well as pest and disease control, etc., to ensure improved crop production performance. This strategy would also dispel the common argument that use of machinery per se, does not increase crop yields. Non-machinery agricultural technologies should be integrated with the mechanization training package as the training course might be the only chance for a farmer to be formally exposed to improved agricultural technologies. Similarly, the machinery technologies should be incorporated in the training courses organized by the agricultural extension unit of the Department of Agriculture (DA).

Promotion of agro-related metalworking industries

Under a demand-driven economic policy, the creation of a market is the most effective way of promoting a manufacturing industry. Of course, this assumes the existence of necessary conditions and factors not only for the creation of demand but also for the manufacture of the products. Technological knowledge, resources and market information are among the conditions and factors being considered by an entrepreneur trying to engage in the manufacture of agricultural machinery.

Small-scale agro-related workshops and foundries are usually the forerunners of the agro-related metalworking industries. For economic viability of operations, the establishment is normally a diversified one by manufacture of non-agro-related products utilizing common facilities and equipment. Another reason for diversifying the products is the seasonality of demand for agricultural machinery and overcapacity of facilities because of their lumpiness.

A strategy is to promote blacksmithing as the industry for the supply of simple tools and implements in the remote and almost inaccessible areas of Bhutan. This strategy needs the co-operation of government agencies. Such agencies could be the supplier of raw materials for blacksmiths who will in turn supply tools and implements to government field workers in the vicinity of the blacksmiths' work stations.

An example is the unique and innovative programme by the the Division of Education of the Ministry of Health and Education which provides for incorporating in the curricula of primary, junior high and high schools as well as teacher training institutes, the theoretical and applied aspects of agriculture. The long-term aim of the programme is to motivate children to appreciate agriculture and apply modern technology in agricutural production suited to their environment. One of the short term aims is to utilize school children as medium for making changes in agricultural technology by influencing their parents. Another is to reduce the dependence of villagers on the World Food Programme and to supplement their diets with vegetables.

The programme which is gaining success has been supported by OXFAM since 1981. Revolving funds were provided for garden and piggery projects. Funds were also provided for acquiring garden lands for the school as well as fencing them to protect the crops from wild animals, a major problem. Garden tools are also provided by the government. Yearly, the Division of Education purchases through tender imported tools which include some 600 pieces of spades, 500 pieces of pick axes and other tools to be provided to schools. The tools were reported to be of low quality and the sizes were not fitted for school children.

The schools may, instead, order from the village blacksmiths the needed tools and yet get most appropriate designs with much better quality than the imported ready-made ones. High carbon steel materials, instead of low-quality finished products, could be purchased in bulk by usually required tender procedures and distributed to schools for their needs when they order from the local blacksmiths.

Local blacksmiths trained in recognizing good quality steel could be involved in evaluating the supplied materials. With this programme wherein UNIDO may wish to assist by training trainers of blacksmiths, upgrading their equipment, supplying catalytic raw materials and giving them better-designed tool samples tested by AMC, the village as a whole would be benefitted and an appropriate metalworking industry would be developed.

Improving the traditional paddy harvesting and post-harvest handling in Paro Valley

The rice harvesting and post-harvest handling systems in Paro Valley and perhaps also in other places need improvements, if only to save the rice grain already produced over a lengthy period of almost nine months, that is, sowing in February to harvesting in October. An undocumented report by AMC stated that losses range from 20 to 30 per cent of the yield. Observations reveal that this figure may even be low. The losses start even before harvest. As rice which is a shattering variety is harvested at generally overmature state, grains fall naturally even with slight wind. High grain losses occur in the harvesting method using non-serrated sickles, handling of the unthreshed paddy crop for field drying for about seven days, collecting the unthreshed crop to form bundles, carrying home the bundles and stacking the bundles of straw with grains.

The problem of harvest and post-harvest losses normally lies within the purview of agricultural engineering research. AMC may have the capabilities of addressing the problem as it has previously tried to investigate it, albeit at an ad hoc basis. AMC is mandated to do research and development.

Subject to further verification of the extent of losses in other rice-producing districts, it is recommended that AMC develop and extend to farmers an improved system consisting of, but not limited to, the following:

(a) Early harvesting or timing it at optimum grain maturity;

(b) In-field threshing using suitable types of threshers with built-in system for preventing or minimizing losses while handling straw with grain, and

(c) Practice of suitable grain, rather than grain-in-straw, drying and storage and

(d) Introduction of efficient rice mills.

Following a verification that losses are above the usually tolerable 5 per cent of the yield, AMC should formulate a harvest and post-harvest handling system specifying the management actions and the machinery needed to avoid losses. The system will include a set of machinery consisting of threshers (pedal-operated or engine-driven), winnowers (manually-operated or engine-driven blowers), tools and mats for sun drying and jute sacks for bagging.

The final connection of the above research activity with the promotion and development of agro-related metalworking industry in Bhutan is in the fabrication and supply of threshers, dryers and rice mills. Through systems engineering and considering the traditional culture, a suitable method accepted by farmers and village folks would be developed. Private sector manufacturers would obtain their machinery design information and drawings or prototypes through the AMC with assistance from UNIDO.

E. Promotion of the agro-related metalworking industry

Since the decision has already been made to privatise the manufacturing activities of AMC simply by ceasing its manufacturing operations and letting the private sector respond by entering the machinery market vacuum, problems should be anticipated and appropriate measures made to forestall them. The most likely channel that the private sector will take is the importation of machines from India rather than local manufacture. In fact, the rationale behind such a decision is the advantage of having low cost machines because locally manufacturing them would not at all be competitive. Raw materials are imported and local labour costs are higher than in India. When this happens, repair shops will be needed near farming areas or villages.

Exploiting the comparative advantage for manufacture of machinery

The above argument however, ignores the strong comparative advantage of the low-cost electrical power in Bhutan which may just offset the other disadvantages. Raw materials imported from India are tariff-free, therefore, only the transport costs are added. Sales taxes on imported machinery at the retail end could be a mechanism to equalize the competition field between the locally made and the imported products.

If the local private manufacture does not take place, the programme of research and development of agricultural machinery by AMC may turn out to be an end in itself because the the designs of the AMC will not be manufactured. At best, prototypes will be fabricated and demonstrated and perhaps appreciated, but not commercially distributed. It is the kind of trap most R&D institutions in developing countries have gone into and made only displays of their developed machinery without ever serving the farmers. A primary cause of this situation is the non-involvement of the private machinery manufacturers. In Bhutan, those manufacturers or agro-related metalworkshop entrepreneurs will yet have to get themselves established.

Therefore, it is recommended that AMC, with backstopping of the Ministry of Agriculture and the Ministry of Trade and Industry (through its industry incentive programme) encourage the private sector to establish small-scale workshops for fabrication of agricultural machinery. Such workshops may initially produce a diversity of products which are in demand according to the season but shall always consider machinery supply support for the agro-based industries, a top priority in the Seventh Plan.

It is also recommended that the Ministry of Trade and Industry develop tax

mechanisms for imported machinery to establish a fair competition field for the local fabrication industry which ought to compete by having better products than imported ones. For this reason, it is also recommended that AMC give due technical support in their manufacturing activities. It is important that right from the start, the principles and ideals of good quality control be instilled in the management and workers of the small-scale workshops.

Industry incubators at AMC

There is a need to utilise AMC's idle blacksmithing facilities and to activate the foundry facilities which have never been operated. An incentive for a would-be manufacturer is through an industry incubator system to be set up at AMC. This could be either in the fabrication or in the foundry workshop enterprise or both, since a foundry shop needs machining and finishing facilities.

AMC may develop a programme of industry incubator to allow potential workshop entrepreneurs to utilize its own fabrication, blacksmithing and foundry workshop facilities for learning all aspects of the metalworking industry from planning, raw materials procurement and actual manufacturing to marketing of products without incurring large initial capital investment costs.

The industry incubator beneficiaries from the private sector can take advantage of the presence of research engineers as well as the skilled technicians at AMC. For the foundry shop, assistance from UNIDO is needed to provide an electrical induction furnace facility and to train trainers in foundry technology.

F. Agricultural machinery extension to farmers

According to the DA plan, AMC will concentrate mainly on research and development and on group training of farmers. The agricultural extension unit is mandated to extend agricultural machinery technologies to farmers. However, this unit lacks the human resources familiar with or interested in agricultural machinery and, as in the experience in many developing countries where the extension of machinery is separate from research and development, the adoption of machinery by farmers is slow because of minimal activities by extension workers in this area.

The usual outcome is that the new technologies never leave the display rooms of the machinery research and development institution. Unfortunately, the institution is criticized for not making an impact because only a few or none of their developed machines has ever been adopted by farmers. In the private sector, manufacturers or traders with new machines make promotional drives to create demand for their products.

Unlike other agricultural technologies such as specification of fertilizers, varieties and pesticides, the introduction of machinery needs closer and more sustained follow-up actions, such as training in the proper operation and maintenance. Otherwise, a machine may be rejected because of incorrect operation in spite of its technological advantages.

It is recommended that AMC be supported also in its efforts to demonstrate machinery preferably working as members of a team along with agricultural extension workers.

Alternative strategy for the Agricultural Mechanization Programme

Certain points have been missed in the assessment of the mechanisation programme implemented by AMC. It appears from the implications of the assessment carried out by the Ministry of Agriculture that the programme is not sound because certain progressive farmers have benefitted from buying subsidised machinery and have derived income from hiring services to the poorer farmers. This implication is not necessarily correct nor is the programme as it is being implemented, necessarily ideal. There may be better alternatives or mid-course corrections other than abandonment of the AMP which means wiping out also whatever benefits, hidden or discernible, are in it.

The poorer farmers who have availed themselves of such custom services might have benefitted also, perhaps at even greater value than what the machinery owners themselves have derived from owning powered machinery. In fact, the assessment of AMP shows that the machinery owners themselves are the losers since calculations would show the non-economic viability of machinery ownership. The hire services resulting from AMP provides small farmers an opportunity which would otherwise be non-existent. Under the liberalised market policy, the farmers should be left on their own to decide whether to mechanize or not and the mechanization direction should be based on their demand. Farmers, however, should be guided through suitable mechanisation programmes and strategies developed from relevant applied R&D efforts. Such guidelines should include economic viability, prevention or minimization of losses and productivity features, among other consideraations.

One of the R&D activities by AMC will be towards developing suitable mechanisation systems for harvesting rice and minimize post-harvest losses. AMC should verify the one time but thorough observation that at least in the Paro area, significant losses in paddy occur at the field, along the way to the house yard and at the house yard itself where the grain-on-straw is stored by stacking.

Through development and successful extension of an effective mechanisation strategy or harvest and transport system, AMC can make an impact by saving grain already produced. If the perceived grain losses are verified to be significant, the savings due to mechanization could be a justification for the continuation of AMP, not necessarily in its present form. In a way, the savings is a rationalization that mechanization increases overall production although actually it was just instrumental in saving the grains already produced.

It is recommended that AMC resolve the following issues in consultation with DA:

(a) Shall the government continue to subsidize apparently uneconomical use of machines by the larger and better endowed "rich" farmers even though such machines benefit also the poor farmers because they can avail themselves of mechanization services at reasonable or market rates? The recommendation is to discontinue the subsidy but continue AMP with a view to seeking alternatives, either by importation of low-cost but good-quality power tillers or assisting in the establishment of a local fabrication industry by the private sector through technical training, incubator practice and provision of designs obtained from other countries through RNAM, IRRI, FAO, UNIDO and other organizations. The latter would need maximum support, short of subsidies.

(b) Granting that the system of tractor and power tiller level of mechanization is not economical to the owner, how can it be made so? If the high capital costs of the machines is the reason for such uneconomical ownership, how will an alternative source of power tillers and attachments, that is, from another LDC or other developing country or locally manufactured, change the economic picture? Will there be machinery spare part supply and repair service support system? Will the pricing structure of the hire services change? Assuming that metalworking workshops with capable manpower are in place will it stimulate entrepreneurship in the manufacture of spare parts? The recommendation is similar to that in (a).

(c) What are the alternative systems to achieve the mechanization level that is self-sustaining, reliable and subsidy-free?

(d) Machinery hiring is a proven means to expand utilization of machinery to earn more for servicing the capital costs. What is the extent by which this could be done throughout the year? Can more machinery attachments be developed to increase the versatility of the power unit so that it could be used almost throughout the year, even for non-agricultural activities?

(e) So far, only the financial position of the owners of machinery has been investigated. The extent by which the non-owners of powered machinery or those who hire powered machinery services benefit from such hire has not been investigated. There is a need to do financial analysis of their own production under the machinery hire system. How much of the subsidy given by the government is passed on to the non-owner of the powered machinery? Is the low hiring rate for machinery which could be an indication of passing on the government subsidies to the ultimate user the reason for the uneconomical ownership? If the rental fee is increased to the theoretical level at which ownership would be economical, will the non-owners still hire the machines?

(f) How does mechanical power level of mechanization increase the net yield, that is, save losses in yield? Have the net savings of grains factored in as one of the benefits? If not, then this should be determined, because grain losses could be as high as or even higher than 30 per cent of the potential yield of the grain for a shattering variety harvested late and with post harvest operations handled the traditional way.

G. Support services for cottage and small-scale industries

In the LDCs, cottage and small-scale industries play a major role in the industrial development of the country. Agro-related metalworking industries comprise a significant portion of the total industry sector because they provide the tools and implements for agriculture. The support services normally needed by the cottage and small-scale metalworking industries in the LDCs are credit, market development and technical advice, particularly on production operations and management, designs of new products and quality control.

In Bhutan, the support services can be more efficiently rendered through the co-ordination of efforts of the AMC with DI in organizing training programmes for potential owners, supervisors and workers of small-scale workshops. Among the topics for the courses are workshop management, including quality control, workshop layout, safety, finance and marketing. Workers may be given refresher courses on foundry technology, machining and fabrication techniques with emphasis on quality control.

It is recommended that AMC, with backstopping of DI, conduct feasibility studies of establishing and operating small-scale fabrication workshops.

By Bhutan's classification, blacksmithing is the only agro-related metalworking industry which may be considered as a cottage industry. According to the Seventh Plan and by its objectives, blacksmithing would be a top priority of industrial development in the least developed districts since the services of blacksmiths especially in remote areas are almost indispensable. Blacksmiths are the only source of tools for agricultural production in the remote areas. It is therefore, important that blacksmiths are supported through improved technology by providing them training, better facilities, raw materials supply and possibly a market for their products outside of their village. For the latter, the government itself could be the market as departments normally have workers who are issued tools and implements to do road repair and maintenance, forestry work and other jobs requiring small hand tools.

It is also recommended that the Department of Industry coordinate with other government agencies to have a programme of obtaining the hand tool requirements from blacksmiths instead of importing finished tools for use by their respective field workers. A possible mechanism for this is the ordering of the tools through the Dzongkhags which will contract the blacksmiths within the Dzongkhag's jurisdiction for the supply of the needed tools according to specifications. As support to the blacksmiths, the government agency will supply the required raw materials (e.g., high carbon steel) to blacksmiths through their respective Dzongkhags. Such raw materials are to be purchased by the government in bulk through the usual tender procedures to get the best price and as a start, avoid disrupting the usual government procedures but considering also better alternatives later. The materials will then be distributed to the blacksmiths through the Dzongkhags as the private sector might be hesitant in taking the initiative.

The mechanism may seem to be cumbersome at the start but after some streamlining activities with the help of the Dzongkhags and the blacksmiths, the system will not be any more cumbersome than the present procedure for procuring finished tools. The benefits to the blacksmiths and to their respective communities is expected to offset the initial difficulties.

It is also recommended that DI/AMC organize a blacksmith training programme at the Dzongkhags using mobile blacksmithing facilities.

H. Programme for further development of the agro-related metalworking industry sector

The following programmes may be undertaken by the government authorities and agencies concerned:

(a) Development of capabilities for fabrication of agro-industrial processing equipment which need specialized engineering knowledge. As engineering knowledge is required for the design and manufacture of such equipment, this programme will be confined to small-scale and medium-scale workshops with staff engineers and fairly modern facilities. For example, two or more workshops after they get established, may engage in the fabrication of essential oil distilling units.

(b) Integrating the local development and production of agricultural machinery and agro-processing equipment with agricultural development projects or programmes. The coordination/linkage by the Ministry of Trade and Industry with the Ministry of Agriculture at the inception or formulation stage of agricultural and agro-industrial development programmes is essential for anticipating the needs and identifying gaps in machinery and equipment supply as well as in formulating strategies in the metalworking sector. If necessary, foreign technical assistance will be given for this project or programme component.

Apart from developing confidence and capability of the local agro-related metalworking and engineering industries to supply specialized equipment, this strategy will increase the likelihood of replicating the projects in other areas because the needed equipment can be locally sourced. Bottlenecks in overall development of an industry system, including the production of raw materials from the agriculture side, can be avoided at the outset. Thus, development activities in the metalworking industry sector will not be carried out in isolation of the agricultural production and processing sector to which it has a supportive role of machinery and equipment supply.

The following are examples of programmes for which the agriculture and industry components must have a balanced development to be sustainable:

(a) The food processing industries, like those of citrus, mushroom and asparagus, where appropriate agricultural tools, handling and field-to-factory transport facilities and equipment as well as processing equipment are required.

(b) All crop, livestock, dairy, poultry, fishery aquaculture, forestry production and the related upstream processing industries need equipment and facilities which are to be supplied as much as possible by the local metalworking industries, most of which are small-and medium- scale.

(c) Alternative energy resources development and applications as well as environment and ecological protection measures are mostly agro-related and so are the tools and machinery technologies for carrying them out. Examples are micro- and mini-hydroturbines, windmills, hydraulic rams, agricultural waste handling and utilization equipment and agro-forestry tools and machinery can be supplied by the metalworking industry sector.

VI. PROJECT CONCEPTS

A. Regional Asia

BANGLADESH, BHUTAN, CAMBODIA, LAO PDR, MYANMAR, NEPAL, SOLOMON ISLANDS, WESTERN SAMOA

Title: Promotion and development of agro-related metalworking industries in LDCs (Phase II)

Duration: Two years

Total UNIDO budget: US$ 818,000

Government inputs: All governments are expected to provide services, counterpart personnel (including their salaries throughout project duration), office facilities and administrative support in kind. Details will be elaborated in the final project document.

At the end of Phase II, the following are expected:

(a) Each LDC has an effectively operating institutional infrastructure consisting of a national focal point, a national institute with workshop facilities (the two may be combined in some LDCs) with strong linkages with relevant institutions and organizations which through that focal point make active use of the regional project and any country specific project relevant to the promotion and development of agro-related metalworking industry;

(b) Each LDC has a functioning national network (NN) for agro-related machinery with members consisting of institutions and organizations from the above institutional infrastructure, private sector organizations consisting of those of farmers' and manufacturers, cooperative societies, national and international NGOs which have relevant projects or activities, banks and other credit or financing institutions, chambers of commerce and industry, and others. The NN have frequent exchanges of information and notes regarding relevant activities and its functioning depends mostly on the leadership of the national focal point or national institute. Involvement of the NN members in relevant seminar workshops exhibitions and other programmes organized by other members is an indication of a working national network. A NN newsletter (produced by the NFP) exchanges members newsletters among the NN is another indication of an active NN.

(c) Selected agricultural and agro-related machines introduced by the project have been tested, modified, manufactured, demonstrated to farmers and promoted for commercial production and use through credit financing, if necessary to farmers, manufacturers and custom service entrepreneurs.

(d) National focal point or national institute in each LDC is closely linked with RNAM and national focal points regarding agricultural machinery and agricultural mechanization.

(e) Human resources in each national institute and focal point strengthened through human resources development programme of the project.

(f) LDC national institutes have adequate facilities to undertake future development projects with or without external assistance.

Development objective

The development objective is to support the agricultural production and processing in the participating countries by improving local capabilities and generating a more conducive environment for local manufacture of agricultural tools, implements and machinery including post-harvest and food-processing equipment.

1. Immediate objective 1

Continue strengthening of national focal point linkages through existing network mechanisms.

Background information

Background information is available in the project document for Phase I and programme summary brief document.

Output

National focal points continuously capable of providing a flow a technical information and advice to small and medium scale enterprises in agro-related metalworking industries and initiate and sustain programmes and project in support of those enterprises.

Activities

(a) Continuation of the information dissemination system between RNAM and the focal points;

(b) Continuation of the promotion of links between the national focal points and public-private enterprises;

(c) Continuation of ECDC/TCDC promotion within the region and

(d) Continuation of managerial and technical advice to the focal points, enterprises and R&D institutions during field visits;

Inputs

CTA-Regional Adviser	To be provided by ESCAP
2 Associate Experts	To be provided by UNIDO

2. Immediate objective 2

To initiate the establishment of an information database through a database for raw materials demand and supply for the agro-related metalworking industries in Bangladesh, Bhutan Cambodia, Lao PDR, Myanmar and Nepal.

Background information

In the LDCs, most of the raw materials needed for the metalworking industries are imported. The quality of the products put out by the industries depend largely on the quality of raw materials used which at the present open economy at least for Bangladesh, Myanmar and Nepal can now be supplied by the private importers and traders.

Most of the small-scale workshops get their raw materials from the private importers and traders because of the quick response to their needs unlike in government-owned trading corporations which had been established to do bulk importation and distribution primarily to state-owned factories and secondly, to private enterprises. Many small-scale workshops face difficulties in procuring raw materials directly from the state-owned trading corporations.

In the open-market system, there is no systematic method of determining by the importers what and how much to import and supply to the metalworking industries. They estimate by experience but most often, workshops make do with whatever raw materials are best and available. Most of the workshops need assistance in specifying the best type of raw materials needed for their jobs and, even if they know, there is no convenient and effective way for their requirements to reach the importers or traders on a consolidated basis for their necessary action or response.

A database which will get the raw materials requirements and process such data for the information of suppliers will be of great help in achieving efficiency in the raw materials market which redounds to benefit the metalworking industries. Measures will be taken to ensure that accurate data is gathered from both users and suppliers.

Outputs

(a) Database headquarters established at the chamber of commerce and industry (CCI) or manufacturers association's office;

(b) Most small-scale workshops responded to the call to submit data requirements to designated collection points which relayed the data to database;

(c) Private raw materials importers and distributors making use of data in their respective operations network and

(d) Data available for exchange among the countries in the region through regular RNAM channels.

Activities

(a) Development of a database for raw material information and prepare necessary software for this database by an international consultant in one of the countries for replication in the others;

(b) Identification of an organization to manage the database. Normally, the CCI or another association with direct private sector participation would be in a position to undertake the activities of the project as it is to the interest of its members. It may have the option to expand the database to other industry subsectors to utilize excess capacity of the computer facility and staff. The database facility could be made self-liquidating by charging service fees from the users or importers who would like to have access to information. The National Focal Point (NFP) will assist the workshops in making specifications through the R&D member institutions in the National Network (NN) since they have the engineering staff who designed or tested the machines or at least familiar with them. Moreover, they are in a position to best consult and coordinate with the standards agency of the government;

(c) Formulate a strategy for obtaining correct and honest information about raw materials needs from workshops. Data gathering is a time-consuming activity which may be eased through the local business association or cooperative. Since small-scale workshop owners are not usually members of the CCI, they should be encouraged to form their own groups and federate them (refer to Immediate Objective 5). The department of cottage and small-scale industries may spearhead the move in collaboration with the NFP. One benefit to be gained by joining the association is the receipt of information through a newsletter. Workshop owners can also cooperate by returning by mail the canvass form sent by the CCI for the purpose. In return they may receive updated information on the material status over a specified period. Linkages will also be established with statistical services and other relevant databases in the country;

(d) Establishment of the database headquarters. The needed facility includes a personal computer set, a database programme, a printer and a photocopier. Only one staff trained in computer operation is necessary. This may be one of the secretaries in the CCI office who will be trained to operate the database as one of the office duties. After all, the work only entails data entries which may be done in batches. If the headquarters decide to expand the facility to other types of raw material requirements, it may have to make staff adjustments. Facsimile facilities would be helpful in getting timely data from towns and cities;

(e) Supply of information to interested parties, particularly importers and suppliers as well as government policy and planning offices. The information may be

sold at nominal cost to recover the cost of operation. The service may be expanded to other raw materials using the same computer facility and personnel;

(f) Monitoring and evaluation. Random field checking of data gathered will be done to detect spurious data. The database established for all small-scale metalworking workshops will be utilized in the monitoring and evaluation. Benchmark information on problems related to raw materials procurement will be gathered prior to the start of the project or before the effect of the project is felt. Data will again be gathered periodically to detect any changes. Data on how the small-scale workshops have been benefitted or adversely affected by the project will be evaluated.

Inputs

International expert for software development (1.5 w/m)	US$	18.000
One computer expert per country (locally recruited)		10.000
One set of personal computers with printer for each country		30.000
Six photocopiers and faxes		24.000
Miscellaneous		10.000
Component total	US$	92.000

3. Immediate objective 3

To upgrade the skills of blacksmith trainers in all participating countries.

Background information

Village blacksmiths play a major role in the supply of tools and implements to farmers in the LDC's. Most of them learned the trade from their fathers and grandfathers and some skills may have improved or deteriorated along the way. Any improvements in their operations are tied up in the kind and quality of basic blacksmithing equipment they have inherited or added to the modest facility.

There is a need to upgrade both skills and equipment to increase the productivity of blacksmiths. Having skilled blacksmiths who are given access to new technologies, such as improved tools and implements redounds to the benefit of farmers they are serving in the villages, who also need the proper tools and implements to be efficient and productive in their farming activities.

Output

A minimum of ten trainers capable of conducting training courses in each province or district per year in each country to enable participants to manufacture hand tools.

Activities

(a) Adoption of the FAO manual in blacksmithing as syllabus for the training course;

(b) Organization and implementation of training courses by the NFP in cooperation with the Ministry of Industry or Department of Cottage and Small-scale Industries and

(c) Monitoring and evaluation of impact of regional and national training courses.

Inputs

Expert in blacksmithing technology from the region (8 w/m)	US$	90,000
Equipment - basic blacksmithing sets for selected blacksmiths		25,000
Group training programme		30,000
Miscellaneous		10,000
Component total	US$	155,000

4. Immediate objective 4

To promote the production of small-scale machinery for agro-based food-processing light industries in Bangladesh, Bhutan, Cambodia, Lao PDR, Myanmar and Nepal.

This objective includes the following sub-objectives:

(a) To catalyze the development of agro-based food-processing industries by making readily available the machinery required in the processing of food raw materials involved;

(b) To strengthen the capabilities of small- and medium-scale metalworking industries in fabricating machinery required by the agro-based food-processing industries and

(c) To strengthen the comprehensive local machinery and equipment support sub-system for the food industrial system covering that from the production and post-harvest processing of agriculture-sourced raw materials to food-processing, packaging and handling for the market.

Background information

A bottleneck in the promotion of agro-based industries, especially the small-scale ones for the rural areas, is the lack of suitable processing machinery. Most often, the needed machines have to be imported although they are simple enough to be fabricated in local small- and medium-scale workshops especially those having engineering staff and qualified technicians. New entrepreneurs may not be aware of the capabilities of the local fabricators who can satisfy their engineering requirements if given the specifications or requirements.

The cost of machinery for a small-scale agro-based processing enterprise represents a large percentage of the total capital requirements. If such machinery could be made to order locally, the potential entrepreneurs will be encouraged to invest in such industries because of the convenience and perhaps, the reasonable cost and readily available repair services.

UNIDO has made a recent (first half of 1993) report each on the development of food-processing industries in Bangladesh, Bhutan, Cambodia, Lao PDR and Nepal. Eventual responses of the governments will lead to the establishment of new industries, most likely small- and medium scale ones and privately owned. In such food-processing industries, particularly oil, sugar and rice milling as well as dairy and fish processing, special machinery are an important component and in fact, itself a major determinant of the scale of each industry type and the quality of the final products. Special food vessels and containers made of aluminum or stainless steel which can be sterilized using heat, are simple enough to be made by the local industries according to specifications and accepted standards.

In Bhutan and Nepal, fruits, vegetables and spices are grown in mountainous, rugged terrain and remote areas. Transporting the raw materials fresh is often uneconomical and discouraging because of bulk, weight, low value and perishability of the horticultural products. Hence, there is a need to process such food raw materials and increase their value per unit volume or per unit weight. Processing such raw materials will create employment in the remote areas, particularly for women. The hygienic requirements in food processing may be assured through the design of the machine, the process involved and training of the processors and handlers of the raw materials.

The project concept calls for a regional cooperative effort in exchanging machinery design information together with the processing technologies involved. For example, designs of driers of high-valued products, like fish, fruits, vegetables and meat pelletizers and mixers of feed for fish, livestock and poultry, and mills for edible oils exist in some countries which are relatively advanced in some areas. If machine exchange is not possible, information on design will be exchanged and given to machinery manufacturers which have engineering design and construction capabilities.

Outputs

(a) At least one machinery design and technical information on the small-scale food-processing involved for raw materials such as fruit, fish, vegetable, meat, oil, sugar, grain, legume and milk, exchanged among the LDCs and other developing countries or adapted from advanced countries;

(b) At least one medium-scale local metalworking manufacturer assisted by the project resulting in its diversified production of specialized machines for small- and medium-scale food-processing industries and

(c) Strengthened national network.

Activities

(a) Identification of food-processing industries which merit high priority for development on account of highest feasibility considering the most likely sustained production of raw materials, ready market, simplicity of processing technology, low investment requirements, mass-base benefits and other criteria; decision to promote or encourage the establishment of the industry will be made in consultation with the private sector and with support of feasibility studies;

(b) Compilation of information on the food-processing technology, including the machinery requirements and sources of their designs or prototypes, costs and other data;

(c) Establishment of collaboration work with 2 or 3 medium-scale metalworking enterprises having at least one design or production engineer on its staff and with fairly adequate machine tools and fabrication facilities for staff.;

(d) Provision of technical advice to entrepreneurs in food-processing industries and maintenance of collaboration work with them to enhance their productivity, maintain quality control and hygienic production conditions, reduce waste, protect the environment and perform other activities for promoting the food-processing industry in general;

e) Training of trainers in small-scale food processing using the locally fabricated food-processing equipment;

(f) Initiatives by the National Focal Point to maintain constant contact with institutions and organizations for co-ordination activities regarding the sustainability of the food industrial system, e.g. promotion of contract growing among farmers for supply of raw materials for the food-processing plant, giving designs or technical advice/prototypes of agricultural machinery to metal workshops for fabrication or replicationand

(g) Organization of a national demonstration workshop for manufactured equipment prototypes to interested entrepreneurs.

Inputs

Expert in food processing equipment manufacture 2 w/m per country X 6 countries = 12 w/m	US$	150,000
National consultants in food-processing to coordinate field activities, 3 w/m x 6 countries		12,000
Preparation of demonstration workshops		12,000
Food processing prototypes		15,000
Materials and supplies for manufacture		15,000
Miscellaneous		5,000
Component total	US$	209,000

5. Immediate objective 5

To promote and develop commercial machinery prototypes for all participating countries.

The immediate objective has the following sub-objectives:

(a) To acquire from LDCs, RNAM member countries and other sources, commercially available machinery identified as needed in the agro-industrial system project for adaptation to local conditions;

(b) To test, modify and replicate the prototypes acquired from other countries and introduce them to farmers, manufacturers and potential entrepreneurs dealing in custom hiring and

(c) To promote the commercial manufacture of the adopted prototype through marketing strategies.

Background information

Often a machine that is suitable for the job in the agricultural production or processing stage in the agro-industrial system is available from other countries. Effort, time and money for R&D to design and develop a machine will be saved if the machine could be acquired through an institutional facility like the Regional Network for Agricultural Machinery (RNAM), a project of 11 Asian countries executed by ESCAP.

The National Focal Point (NFP) in the recipient country turns over the machine to the R&D institution most appropriate for testing, modifying and adapting the machine to work under local conditions. From the experience of RNAM, commercial, rather than experimental prototypes should be exchanged. If no commercial machine is available but R&D efforts have resulted in an experimental prototype, drawings or conceptual designs may be requested as sources of ideas. In all cases of exchanges, proprietary rights have to be respected and permission from the inventor or designer will be obtained.

Output

Entrepreneurs capable of manufacturing the introduced prototypes in respective countries.

Activities

(a) Machinery demand survey of the machines identified under Phase I. The initial list of hand-operated tools and devices, animal-drawn implements and mechanical powered machinery is included in the detailed report prepared for each country. The prioritization of the final list of machinery is to be done by the NFP in consultation with the leaders of various sub-projects, the R&D institution members of the NN and the agro-industrial machinery expert.

(b) Testing, modification and field or factory trials of the machine by the R&D group in cooperation with one or two manufacturer co-operators and the farmers or the processors depending upon the application of the machine. This activity involves the participation of several persons connected with the agro-industrial system project. The NFP who plays a lead role in the machinery NN will coordinate the activities of all the people involved to ensure success of the sub-project which involves perhaps more than one machine to be developed. Typical assignments are fabrication by a co-operating manufacturer of a modified component or assembly, testing of a part for durability by the engineering laboratory of a university, organizing a discussion group to brain-storm on possible solutions to a technical problem, machinery trials in a farmers field or in a processing plant to demonstrate the superiority of the machine over the traditional or existing ones, replicating the machine in one or more manufacturers' workshops, organizing demonstrations for

introducing the machines, conducting trial custom work or renting services in cooperation with an entrepreneur, mapping out strategies with the extension units with technical backstopping by the R&D units, etc. The avenues for collaboration are many.

(c) Monitoring and evaluation by organizing demonstration workshops at the end of the manufacturing process.

(d) Extension and commercialization of the machines. These activities are covered by a strategy suitable for different agro-ecological zones of the country. Farmers, agro-industrial processors, manufacturers and custom work service entrepreneurs are the important targets of the extension activities.

Inputs

Agro-industrial machinery expert from the region (8 w/m)	US$	92,000
National consultants (16 w/m)		30,000
Demonstration workshops		20,000
Procurement of commercial prototypes - At least 3 machines/country x US$ 2,000/ machine for 8 countries		50,000
Replication of prototypes for demonstration		30,000
Miscellaneous		20,000
Component total	US$	242,000

BUDGET SUMMARY	US$
Objective 1 (networking)	
Component total covered by contributions in kind	
Objective 2 (raw material databases)	
Personnel	28,000
Equipment	54,000
Miscellaneous	10,000
Component total	92,000
Objective 3 (village metalworking)	
Personnel	90,000
Training	30,000
Equipment	25,000
Miscellaneous	10,000
Component total	155,000
Objective 4 (food-processing equipment)	
Personnel	162,000
Training	12,000
Equipment	30,000
Miscellaneous	5,000
Component total	209,000
Objective 4 (commercialization of prototypes)	
Personnel	122,000
Training	20,000
Equipment	80,000
Miscellaneous	20,000
Component total	242,000
Common expenses	
Administrative support to RNAM/ESCAP office	30,000
Travel non-UNIDO staff	40,000
UNIDO staff travel	20,000
Equipment for overall project support	10,000
Miscellaneous	20,000
Component total	120,000
Project total	818,000

B. Bhutan country projects

Project No. 1. Development of the blacksmithing industry in support of agricultural development in remote villages

(Note: Training of trainers in blacksmithing is one of the immediate objectives of the proposed regional project in which Bhutan is a participant).

Background

Bhutan's village population is widely scattered among the mountain areas and access of some villages from the nearest road may take up to seven days trekking Villagers rely on the local blacksmith in their area or neighbouring villages for the supply and repair of their farm tools and animal-drawn implements.

Blacksmiths have generally learned and developed their skills from their forefathers. Their own isolation in the mountain villages prevent them from upgrading their own capabilities and making new products. Blacksmiths virtually dictate what kind of tools and the particular design of such tools to be used by farmers within the area of his influence.

Aside from the co-villagers of blacksmiths, local government agencies and instrumentalities are a possible market for the blacksmiths' products For example, labour camps of the Department of Roads, workers of the Department of Forest, employees of the Dzongkhags (District Administration) and the village schools of the Division of Education invariably use simple tools for maintenance, grass cutting, wood clearing, forest tree nursery caring and gardening. As government policy, government purchases of hand tools may be decentralised perhaps at the Dzongkhag or lower level and consider procuring such hand tools from the blacksmiths near the work stations of the field workers.

The Natural Resource Unit of the Division of Education has been implementing the OXFAM School Agriculture Programme (SAP) since 1981. The programme provided assistance in the purchase of land for the school garden, fencing the school compound and providing a revolving fund for operations. It has generally been successful in inculcating in the children the love of work and in teaching the modern methods of vegetable production, thus also influencing their parents and the farming practice in the community SAP now covers 235 primary, junior high and high schools as well as teacher training institutes.

In the programme which is assisted by OXFAM, the Division of Education provides schools with garden tools mainly for vegetable growing projects sometimes with assistance from their own parents. Some 600 spades, 500 pick axes, 200 crowbars, 1,000 weeding spades, 1,000 weeding hoes and a number of other tools are purchased by the Division through the process of bidding by suppliers who usually obtain their articles of bid from India. Normally, the winners of bids are the large commercial traders in the country and because of the bulk purchases, the quality of

the goods delivered are not carefully checked against the samples submitted during or before the bid. In the end, the school children who get the tools suffer because they are inappropriate for children's sizes and they break or get worn out easily. If procured from blacksmiths such tools could be custom made according to specifications.

The first review of the OXFAM programme was carried out in May 1988. One of the recommendations to the then Department of Education was to reconsider the system for obtaining and supplying tools and equipment to schools, indicating that it would be very advantageous for schools to be allowed to purchase appropriate tools locally using money from their agricultural revolving fund. To date, the recommendation has not yet been implemented. The second review was held in October 1992 and proposed, among other recommendations, including reiteration of the recommendation in 1988, that tools and implements already worn out be replaced.

There is a possibility of integrating the SAP further with the overall community development. If the blacksmiths' capabilities are strengthened, they could supply the tools and implements for home food-processing activities which would increase the range of products that blacksmiths could make and develop a viable local market.

Aside from the benefits which the farming community gets by way of subtle influence of the children on their parents, the village blacksmiths could increase their income by making the tools that the local school needs for SAP. Instead of the division of Education purchasing imported tools, it might purchase in bulk the high carbon steel materials and distribute them to the schools. Upon order from the school the blacksmith may custom-make the tools and implements. Not only is the blacksmith relieved of raw materials procurement which increases his cost of production and eventually of the tool or implement he makes for farmers, but also the school children get the correct size and types of tools.

Before the above scenario takes place however, the blacksmiths' capabilities have to be upgraded by training them, upgrading their facilities and providing catalytic assistance in the form of raw materials and samples of improved tools for copying and introduction to farmers.

From the agro-related metalworking industry point of view, this system of procurement of tools and implements from blacksmiths could be adopted by other government agencies. UNIDO will assist towards institutionalizing the system, including upgrading of the capabilities of blacksmiths to supply high quality tools, assistance in the design of new and improved ones from abroad through linkage with the national and regional networks for agricultural tools and machinery and appropriate policy guidelines.

The Natural Resource Unit/OXFAM School Agriculture Programme is in the best position to organize the training modules, which can vary from district to district in view of the widely scattered nature of the schools and the availability of blacksmiths for one school or for a grouping of schools in a Dzongkhag. On an

experimental basis, the blacksmiths in a selected Dzongkhag may be grouped together in a common workplace for training and for fabricating the required tools to be supplied to all the schools in the Dzongkhag, will provide the technical backstopping utilizing the trainers trained through the regional training course.

The Agricultural Machinery Centre (AMC) in Paro has a blacksmithing section which has stopped operations in line with the privatisation policy of the government. It can provide the technical backstopping to the Natural Resource Unit of the Division of Education for training of blacksmiths and later on, to the other government departments in terms of procurement of tools and implements from blacksmiths, including specifications, types most suitable and quality of the products.

Objectives

(a) To upgrade the blacksmiths' capabilities in producing quality and appropriate tools for their respective villages or dzongkhags;

(b) To create an awareness among government agencies of the capabilities of blacksmiths in supplying the simple tools and devices needed by them in rendering public support services and

(c) To develop a system of procurement and distribution of blacksmithing raw materials and other supplies, on the one hand and of marketing some of the blacksmiths' finished products, on the other hand.

Activities

(a) Organization of group training programme for blacksmiths through the Agricultural Machinery Centre in Paro in collaboration with the Natural Resource Unit of the Division of Education.

(b) Formulation of policy guidelines regarding procurement of tools and implements by government agencies at the national, Dzongkhag and village or school levels;

(c) Testing and modification of new designs of tools from abroad, as well as improving the traditional ones and introducing them to the farmers and other users through the local blacksmiths.

Outputs

(a) 50 blacksmiths trained.

(b) Guidelines for policy on tools procurement from blacksmiths and

(c) At least 5 types of introduced hand tools tried and produced by blacksmiths.

UNIDO Inputs

Project budget

Blacksmithing expert (6 w/m)	US$ 78,000
National blacksmithing consultant (6 w/m)	12,000
UNIDO Staff travel	5,000
Blacksmithing equipment, 50 sets x $ 500/set	25,500
Catalytic assistance - high carbon steel raw materials, scrap vehicle leaf springs and ball bearings	7,500
Set of hand tools for trials in vocational training workshops for	
Agriculture Programme trials	2,000
Miscellaneous	5,000
Total	US$ 135,000

Country Project No. 2. Agro-related metalworking industry incubators for foundry and fabrication workshops for the production of agricultural and agro-based processing machinery.

Background

The Agricultural Mechanisation Programme being implemented by AMC has been assessed by the Ministry of Agriculture. Conclusions generally state that the system of mechanisation being used in the programme is not economically viable even under the present system of subsidising the costs of tractors, power tillers and most of the powered equipment used by farmers. Yet the farmers, owners and non-machinery owners alike, indicated a need for mechanisation due to shortage of labour, particularly in planting and harvesting of paddy. Power tillers are much favoured because of their multi-purpose uses and rice mills are considered as the second most useful to them. In the non-rice growing areas, the spade is considered as the most useful tool.

All the above findings indicate that a solution towards an economically viable system of mechanisation is necessary. Apparently, farmers are willing to pay the price for machines to ease drudgery, among some of the non-economic reasons However, both the desire for mechanisation and the economic viability of it might be met through provision of less costly yet as effective machinery through local fabrication even without subsidies.

Exploring alternatives to the present system of mechanization introduced through the AMP lead to meeting both the economic viability requirements and solving the problem of shortage of labour in farming operations. For example, as mechanisation is being viewed from purely economics alone, it is therefore a logical conclusion to import machines from India because of their cheap costs rather than to manufacture them locally. This is based on the comparison that labour in Bhutan is more expensive and that raw materials are also imported from the country where the labour is cheap. However, it seems that some comparative advantages for Bhutan are being overlooked before jumping to conclusions. Power, a critical factor in the costing of any manufacturing industry is many times cheaper and abundant than that in India and can offset the cheap labour inputs in that country. By gearing production techniques toward power consuming and labour-saving techniques, local production of machinery could be cheaper. The extra cost of raw materials is due only to transport and handling since they may enter tariff-free from India. Even if it is not so, there is still a possibility of offsetting costs through better technology.

Established entrepreneurs hesitate to engage themselves in the agricultural manufacturing business because of their perceived lack of market and high distribution costs. The Agricultural Mechanisation Programme has demonstrated that machinery are saleable and more so if prices of the machines offered are even lower than the subsidised prices which could be possible through price cutting techniques, like reduced sophistication of machine designs, efficient manufacturing technologies and cost-effective marketing strategies.

Potential investors or new entrepreneurs in the agro-related metalworking industry are hesitant in investing on workshops primarily because of lack of technical knowledge on agricultural machinery and of the venture itself. There is no local private workshop engaged in the agro-related metalworking industry in the country to serve as model for making decisions. Hence, assistance is needed by such potential agricultural machinery manufacturers.

Objectives

(a) To promote the establishment of agro-related metalworking foundry and fabrication workshops and the local manufacture of agricultural machinery and equipment for small-scale agro-based processing industries;

(b) To introduce the locally designed and adapted agricultural machinery and agro-based processing equipment to potential entrepreneurs utilizing the experience of AMC in the Agricultural Mechanisation Programme and

(c) To formulate policy guidelines towards promotion of self-reliance in the production of agricultural and agro-based processing machinery.

Outputs

(a) Feasibility study report of the market for foundry products;

(b) Redesigned and rehabilitated foundry shop at Agricultural Machinery Centre and

(c) Increased capability of human resources at the Agricultural Machinery Centre.

Activities

(a) Feasibility studies of the market for foundry products in Bhutan as well as in northern India as a possible market;

(b) Redesigning and rehabilitating the foundry shop at AMC to incorporate, among other facilities, an electric induction furnace and to institute efficient production at low capital investments as in a small-scale workshop;

(c) Invitation to and selection of industry incubator participants:

(d) Training of technicians for foundry and fabrication and

(e) Technical and management backstopping to industry incubator participants.

UNIDO Inputs

Project budget

Foundry expert (9 w/m)	US$ 117,000
National consultant (9 w/m)	18,000
UNIDO Staff travel	5,000
Equipment - induction furnaces and controls	10,000
Training materials - scrap and pig iron and other supplies	5,000
Catalytic assistance - machinery prototypes, raw materials for fabrication	8,000
Miscellaneous	5,000
Total	US$ 167,000

Country Project No. 3. Design and fabrication of essential oil distillation units

Background

Phase I of the on-going four-year Essential Oils Development Project (EODP), BHU/92/008/A/01/99, assisted by UNDP in Bhutan, calls for preparatory and research activities leading to the promotion of rural agro-industry based initially on the rural small-scale distillation of lemon grass or the promotion of lemon grass distillation in centralized locations.

Assistance in the design and fabrication of cost-effective and high-oil-quality production of essential oil distillation units suitable for the mountainous terrain and other conditions in Bhutan is needed in connection with the above-mentioned project.

The output number 1 in Phase II is a workshop capable of manufacturing stainless steel, portable, durable, low cost essential oil distilleries after testing the distilleries. The output number 2, to be obtained in Phases II and III, is the introduction of improved, portable, durable, cost-effective, stainless steel essential oil distillery units for the production of export quality lemon grass oil. The success criterion is the ability to produce and distribute improved portable distilleries within Bhutan including the creation of satisfactory financing arrangement with the BDFC.

A bottle-neck anticipated for the project and a reason for the brief assistance sought by EODP through UNDP from the project US/RAS/92/072, promotion and development of agro-related metalworking industries, is the establishment of the distillation equipment support system, namely, a workshop capable of fabricating the suitable stainless steel units which design is still to be determined based on economic and actual financial viability, among other studies, being conducted in Phase 1.

In Bhutan, private fabrication workshops virtually do not exist except for the Karma Steel Industries in Phuntsholing which specializes in sheetmetal office products and the Agro Mechanical Workshop in Bumthang which is essentially a vehicle repair workshop but has branched out to sheetmetal works making wood-fired stoves and heaters. The Bhutan Aromatic and Phyto Chemicals (BAPC) located at Kurzimpa, Mongar and is a subsidiary of the Tashi Commercial Company, fabricates mild steel gooseneck type of distillation units of which it has distributed about 600 units to farmers.

The Bumthang workshop has started the fabrication of one stainless steel distillation unit based on the unit imported from the Netherlands under an earlier two-year FAO project, TCP/BHU/8851, "Development of Essential Oils". While welding workmanship is reasonably good, the quality of the stainless steel used and the welding electrodes used was doubtful, as judged qualitatively on the basis of the darkened colour of the weldments and the low chrome finish of the steel itself. The quality of the steel and the welded joints might affect the quality of the lemon grass oil and this needs verification using simple tests of sample materials with the oil. There are basically two designs of "portable" distillation units in use. One is the low cost unit (1,200 mm height x 570 mm diameter x 1 mm thick mild steel distillation

kettle and a coiled galvanized-iron pipe condenser with 25 mm pipe diameter, 320 mm coil diameter and 6 coils immersed in water contained in 1,280 mm height drum, or one and one-half litre drums joined together). The oil-water mixture is collected in a small mild steel pitcher where oil is automatically but not efficiently separated from the water. This unit is fabricated and sold to farmers by BAPC for Nu 2,000 (about US$ 65)

The other design is the stainless steel model from the Netherlands and introduced during the FAO project. The distillation kettle is 1,260 mm height x 860 mm diameter x 1.5 mm thick and the condenser is of the tube (21 pieces) rather than the coil type. The oil separator or florentine is a more sophisticated one supposed to be more efficient than the pitcher type used with the mild steel unit. The quality of oil extracted is far superior to that from the mild steel unit. The estimated fabrication labour and materials cost by the Bumthang workshop is Nu 129,000 (about US$ 4,160).

Clearly, the stainless steel unit is not affordable by farmers. With mass production methods, the labour cost may be reduced somewhat but the larger portion of the total cost is that of the stainless steel materials and the welding electrodes.

The search for alternative materials which will not degrade oil quality is therefore necessary. Aluminium sheet as inner lining for the mild steel distillation kettle and aluminium pipes for the connectors could be a promising solution. However, a unit has yet to be made and tested.

Another possibility is the double-coating of the mild steel material with epoxy lacquer and curing it at 250 degrees Celsius oven temperature for 10 minutes. Again, this has not yet been done before, except for the storage and shipping containers of essential oils. Whether the water-boiling process to produce steam during distillation will affect the coating or not is still unknown. Also, it is anticipated that the abrasive lemon grass materials might scratch the lining and render its purpose useless. Nevertheless, in a developed essential oils industry which the UNDP-assisted project hopes to develop in Bhutan, epoxy-coated storage tanks and shipping containers are essential and facilities for making them are necessary. This support system has not been anticipated in the UNDP-assisted project which also aims at getting a niche in the export market for essential oils.

Yet another possibility which appears to satisfy both the temperature-tolerance and the abrasion-resistance requirements judging from its wide use in the cooking appliances, is to line the mild steel with teflon. The economic viability has to be explored and the technical feasibility of setting up a teflon lining facility in Bhutan must be studied. Since such facility would require electrical power, Bhutan is in a position to sustain the heating and other requirements of the process which needs electricity. The cheap and abundant electrical power in Bhutan places itself at a comparative advantage in electric power consuming industries and should be exploited as much as possible for development.

Systemwise, the essential oil distillation industry based on stainless steel units may take the path of medium-sized ones which have centralized operations to effect economies of scale and to ensure good quality control. This system is being demonstrated by a private distillation plant where lemon grass leaves are supplied by gatherers who are paid for the quantity of raw materials delivered. This system lacks the value-adding feature of individual distillation units which means more income to the distillers while having also the disadvantage of having a wider material-gathering area which makes transport difficult unless the lemon grass oil is cultivated like any other crop rather than gathered in the wild.

Objectives

(a) To test the available materials (stainless steel and aluminium from India, China, Japan and the Republic of Korea) for their suitability to quality distillation of essential oils and financial viability of their use in the individual field distillation system;;

(b) To study the technical feasibility and financial viability of using heat-resistant and inert non-metal liners, such as epoxy and teflon, for essential oil distillation units, storage tanks and shipping containers;

(c) Following positive results of Project objective (b) and increased capabilities in foundry as aimed in Bhutan Country Project No 2 above, design and fabricate cast-iron or aluminium or mild steel distillation units lined with epoxy lacquer of specified grade or teflon and test their performance as to durability (e.g., scratch resistance of lining, heat tolerance and life span), effect on oil quality, farmer acceptability and other aspects.

(d) Following positive results of either Project objective (a) or Project objective (c), train private sector workshops in the commercial fabrication of distillation units and their distribution in suitable areas.

(d) Following negative results of Project objective (a) and Project objective (b), develop a high capacity central distillation system using high quality stainless steel to effect economies of scale and to simultaneously achieve high grade oil and train private sector workshops in their fabrication and installation.

Outputs

(a) Test results of the effect on oil quality of the available and cheapest stainless steel materials;

(b) Test results of the effect of heat and abrasion on the cured epoxy lining of mild steel, aluminium or cast-iron vessels under simulated distillation conditions;

(c) Fabricated and tested distillation units made of the most cost-effective materials, that is , either stainless steel, aluminium-lined mild steel or epoxy-lined cast-iron, aluminium or mild steel or teflon-lined cast-iron, aluminium or mild steel and

(d) At least one private workshop capable of fabricating essential oil distillation units made either of stainless steel or mild steel lined with either aluminium, epoxy or teflon.

Activities

(a) Testing of the cheapest available stainless steel sheet and welding electrodes for lemon grass oil reaction;

(b) Testing of heat-cured epoxy-coated mild steel and cast-iron materials for abrasion and heat resistance under simulated oil distillation conditions; also of aluminium sheet-lined mild steel under the same conditions;

(c) Financial analysis of fabricated distillation units with stainless steel, aluminium-lined mild steel, epoxy-lined mild steel and cast-iron and teflon-lined mild steel or cast-iron kettle, condenser and oil separator bodies , tubing and couplers;

(d) Training of workshop technicians.

UNIDO inputs

Project budget

Consultant in sheet metalworking (2 w/m)	US$ 26,000
National consultant in oil distillation (2 w/m)	4,000
UNIDO Staff travel	4,000
Equipment for epoxy/teflon spraying and curing	2,000
Laboratory oven with temperature control, maximum 500 degrees Celsius	3,000
Test instruments- thermocouples, scratch or crack detector	1,500
Raw materials- food-grade epoxy lacquer, teflon, thinners, metal cleaners and degreasers, etc.	5,000
Paint-curing oven, electric-heated, maximum temperature 500 degrees Celsius, controllable setting 250 degrees Celsius	8,000
Workshop equipment - stainless steel welder (TIG), grinder, sheet metal cutter, sheet metal roller with capacity 2 mm stainless steel	10,000
Miscellaneous	2,000
Total	US$ 65,500

Country Project No. 4. Joint UNIDO and FAO project. Save grain: minimisation of harvest and post-harvest losses of paddy

Project background:

The rice harvesting and post-harvest handling systems in Paro Valley and perhaps also in other places need improvement, if only to save the rice grain already produced over a period of almost nine months - sowing in February to harvesting in October. Reports by AMC (documentation not available) state that losses range from 20 to 30 per cent of the yield. Casual and qualitative observations, however, revealed that perhaps the above loss figures are underestimates if the harvesting, handling, transporting and storage system used by the field workers during the 1993 harvest season in Paro valley was typical.

The losses started to be incurred even before harvest. The combined effects of shattering variety of rice, delayed harvesting, dry weather and wind caused the rice grains to fall to the ground.

The human factor started physically contributing to the falling off of grains when the rice straw was cut manually with non-serrated sickle and then layed down in neat and thin rows on the field for drying for seven days, as was the case of the particular field observed.

The second disturbance where large losses were incurred came during gathering and piling of the unthreshed paddy crop. After seven days of sun drying, 30-to 40-kg bundles were made. A man or woman transporter carried the bundle on the back and transported it to the house yard where it was neatly stacked to form a cylindrical pile with panicles orientated towards the centre.

Points of disturbance which caused severe grain losses after field drying started at the time of gathering and piling of the harvested crop in the field; tying the bundle round with a carrying rope or strap and helping the carrier stand up from almost supine position in an act to strap the bundle on the back. After standing up with the load, the carrier invariably made a few small jerks to get a comfortable adjustment of the carrying strap. The carrier then travelled toward the house traversing paddy field bunds and small canals across which the carrier made short jumps or long and jerky steps causing more grains to fall. Finally, on the smoother road or trailway, the carrier, depending upon his/her mood and walking habits, unwittingly spreads a thin or thick trail of grains on his/her path. The carrier would make rest stops on a stone step or platforms almost dropping the load each time. All of the above actions cause some grains to drop to the ground.

The above observation of a harvesting system could be typical of the situation in Paro as determined from similar observations of other fields left after harvest. It indicates that the cropping and post-harvest handling management system as practiced entailed considerably large losses which could be prevented. One can estimate that if the system of harvesting and post-harvest handling could be improved to reduce the losses to a tolerable 5 per cent only, rice supply and household incomes will

increase.and the remedy would perhaps have far greater impact than efforts in trying to increase yields through use of better varieties, fertilizers and pesticides and other inputs. Figures CP 4.1 to CP 4.3 pictorially describe the harvesting and handling system as well as the extent of grain losses.

In contrast, post-harvest losses caused by rats, insects and diseases could be less than the harvest and post-harvest losses caused by the handling system (Table CP4). By comparison also, the reported losses due damage by wild animals are lesser (Table 2). Nevertheless, the figures could mean only potential losses as the damage in some cases may have been done on vegetation at the young stage of growth or before the fruiting of the crop.

Table CP4. Rice post-harvest losses in Bhutan.

District	Rat	Insect	Disease	Total
Tongsa	3.8	5.0	0.0	8.8
Lhuntsi	2.0	5.0	1.8	8.8
Chhukha	0.5	2.5	1.0	4.0
Tsirang	1.0	6.0	0.1	7.3
Samtse	0.0	6.9	0.0	6.9
Sarpang	0.0	14.0	0.0	14.5
Punakha	0.3	18.8	5.6	24.7
Ha	-	-	-	-
Pemagatsh	0.0	20.0	0.0	20.0
Wangdi	1.8	12.8	0.3	14.9
Trashiyan	0.4	10.0	0.3	10.7
Dagana				
S'jongkha	0.0	5.0	0.0	5.0
Average	0.9	9.1	0.8	11.4

Source: National Food Security Programme (TCP/BHU/2252), October 1993

Losses of paddy, maize, wheat, buckwheat, millet, potato and food crops by district due to wild animals are shown in Table 2.

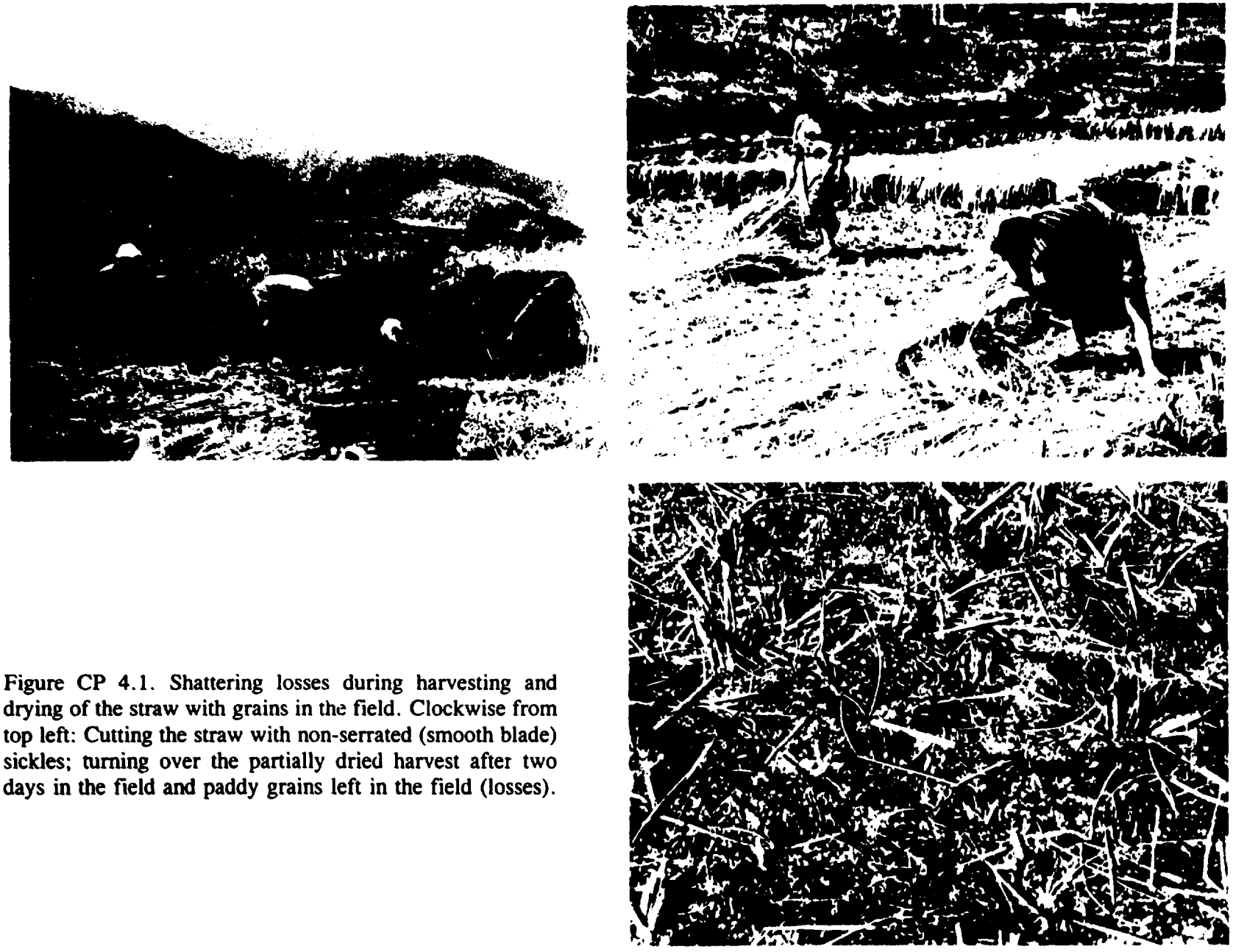

Figure CP 4.1. Shattering losses during harvesting and drying of the straw with grains in the field. Clockwise from top left: Cutting the straw with non-serrated (smooth blade) sickles; turning over the partially dried harvest after two days in the field and paddy grains left in the field (losses).

Figure CP 4.2. Sequence of handling field-dried harvested paddy for transporting to house yard. Clockwise from top left: Bundling the straw with grains; strapping the bundle of straw on the shoulders and assisting the woman carrier in getting up with the bundle of straw.

Figure CP4.3. Shattering losses of paddy during transport and stacking. Clockwise from top left: Woman carrying the straw bundle drops grains along the way; Paddy grains left on the stone ledge where the bundle was laid during rest by the carrier; and At house yard where the straw with grains are to be stacked.

Figure CP 4.4. Shattering losses during transport of harvested paddy. Top: Carriers briskly walking and dropping the grains along the road. Bottom: Sample of grains dropped on the road from the straw bundle.

Figure CP 4.5. Drying and threshing of paddy in Paro Valley. Top: Drying of the harvested paddy in the field. Bottom: Manual threshing by women.

Objectives

(a) To establish a bench-mark information on the amount of losses of paddy during pre-harvest, at time of harvest and during transport, drying, storage and milling of paddy and during storage of rice before final consumption.by the traditional and mechanical methods and by different varieties;

(b) Based on the bench-mark information gathered, to establish and evaluate an integrated system of harvesting, threshing, drying, transporting and handling and storage of paddy as well as milling and storage of milled rice and

(c) Based on the successful or optimum system and utilizing the assistance of RNAM, to develop the appropriate harvest and post-harvest machinery which can be produced by locally.

Outputs

(a) Research report of the extent of harvest and post-harvest losses of rice under the traditional and introduced mechanized methods;

(b) Evaluation report of the performance of alternative harvest and post-harvest for rice in each major rice-growing district.

(c) Developed efficient and minimal grain-loss system of harvest and post harvest system adopted by the rice farming community

(d) At least two manufacturers engaged in the fabrication and supply of threshing, drying and rice milling equipment introduced by the AMC and compatible with the developed system advocated to the rice farmers.

Activities

(a) Statistical data gathering and analysis of paddy pre-harvest, harvest, post-harvest handling and storage losses as well as rice milling and storage losses in major rice producing districts with detailed notes of losses;

(b) Systems engineering analysis of traditional paddy harvesting, handling, drying and storage as well as rice milling and storage in different districts;

(c) Development of alternative harvest and post-harvest systems with a view to reducing grain losses and yet being compatible with traditions and customs;

(d) Development of suitable equipment for local and commercial fabrication with a view to sustainability of the proposed system.

Inputs

Project budget

Post-harvest engineering expert (3 w/m)	US$ 39,000
Agricultural machinery expert, 10 w/m	130,000
National consultant in post-harvest machinery (3 w/m)	6,000
Prototypes of harvester, thresher, drier, rice mill and storage bin	10,000
Catalytic equipment for workshop	10,000
Catalytic raw materials for manufacture of demonstration units of harvest and post-harvest equipment	10,000
UNIDO Staff travel	5,000
Miscellaneous	5,000
Total	US$ 215,000

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ANNEX

TERMS OF REFERENCE

JOB DESCRIPTION
US/RAS/92/072/11-01

Post title: Expert in Agro-related Metalworking Industries

Duration: 10 m/m

Date required: 1 March 1993

Duty station: Bangkok/Thailand, with travel to selected LDC's of Asia and the Pacific Region

Purpose of project:

The purpose of the project is to provide assistance to the Least Developed Countries in the Asia and Pacific Region in terms of technical support to agro-related metalworking industries through fuller utilization of existing networks, technology exchange and promotion of TCDC. Preparation of detailed technical cooperation programmes in the areas of raw material procurement and cottage industries is also envisaged.

Duties:

The duties of the expert will be as follows:

- o collect data on ECDC/TCDC potential through visits to member countries.
- o provide ad hoc technical advice to enterprises and R&D institutions during field visits.
- o identify concrete prototypes needed in the participating countries.
- o establish the final list of prototypes to be exchanged.
- o undertake a preliminary review of needs, in the countries expressing interest, in the following areas:

    1. Raw materials procurement;
    2. Support services for cottage industries;
    3. Concrete programme for the development

- o identify constraints in the agro-related industries, and suggest possible

remedies, including technical assistance projects.

o suggest projects to be formulated by UNIDO, and prepare some project concepts for further development by UNIDO.

Qualifications:

A mechanical engineer with extensive experience in metalworking, specifically related to the production of agricultural equipment, as well as productechniques.

Language: English

Background information: Refer to the project document.