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POTENTIAL FOR LIGHT INDUSTRY IN ZAMBIA WITH PARTICULAR REFERENCE TO THE MAIZE MILLING AND OILSEEDS SECTORS

FOR THE ZAMBIA AGRIBUSINESS MANAGEMENT SUPPORT PROJECT

CONTRACT NO. 623-0214-C-00-9045-00

JANUARY - FEBRUARY 1992

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RURAL LIGHT INDUSTRY FOR ZAMBIA WITH SPECIFIC REFERENCE TO MAIZE MILLING AND OILSEED PROCESSING

I. INTRODUCTION

The goal of the Zambia Agribusiness and Management Support (ZAMS) Project is to increase agricultural production, rural incomes and the nutritional status of Zambians through improvements in the agribusiness community in the country.

In the **oilseed** sector, the Project assists in the adoption of technology and the reinforcement of support and marketing systems for small-scale oil extraction enterprises. In the **grain** sector, ZAMS focuses assistance on expanding the rural grain milling capacity, training mill operators in technical and business skills, establishing repair facilities and helping to assure spare parts availability, and supporting the marketing and consumption of hammermill produced maize and other meal.

In both sectors repairs and maintenance of facilities and machinery are of increasing concern. Recently, about 2,000 new small hammermills have been distributed, through a number of programs, to individuals and groups throughout the country. These mills, which have been sold for either cash or on credit, are locally-manufactured hammermills equipped with either electric motors or small diesel engines, both of which are imported. In the oilseed sector, a nascent industry is developing based on small, imported oilseed expellers, hand-operated presses and animal-powered oil extractors. In both sectors, these small processors are intended to complement the large grain millers and oilseed processors found in the larger cities.

Although the technology in the small-scale grain milling sector, based on the use of the hammermill, is well-known and considered feasible, the technology in the small-scale oilseed sector is less certain, and subject to considerable debate among the various advocates of different systems. Therefore, considerable effort continues to be spent on research and design of simple, cost-effective machines for edible oil extraction.

In both sectors, limited attention has been given to determining the need for facilities for the repair and maintenance of existing equipment, or in assuring that spare parts are available when and where they are needed. Even though it is assumed that most of the repair work for the existing machinery can be accomplished in the larger cities of Lusaka and the Copperbelt, it is generally believed that finding adequate spare parts and accomplished workmen outside of these areas is speculative at best. It is also assumed that most of the precision parts, and hard-surfaced wear parts for these machines cannot be produced in Zambia, even in the large cities. Some reports suggest that hammermill operators are forced to rely on local small-town mechanics for repairs, technicians whose skills are often of questionable quality. When rural operators need spares for their machinery, they are forced to spend time and money traveling to the large cities to locate them.

To achieve the objective of the two programs above, within the overall objective of the ZAMS Project, an assumption was made that a critical ingredient was assuring a reliable, convenient, and cost-effective system of repairs, servicing and manufacturing for these small-scale agro-processing enterprises. The consultants were asked to look at these issues to examine the feasibility of ZAMS supporting the establishment of these facilities, particularly in the rural areas, or of providing some other mechanisms or interventions to assure such a system was made available to these agro-processors.

II. STUDY METHODOLOGY

A study team made up of two external consultants, an agricultural economist, and an agricultural engineer, together with the agricultural engineer from ZAMS and agricultural engineers from the Zambian Ministry of Agriculture, undertook investigations in Zambia over a five-week period from early January 1992 to mid-February 1992. The team visited workshops, mill owners and operators, development staff, rural missions, NGOs and government, parastatal and cooperative installations and staff throughout the country. A brief summary of some of the workshops and installations visited is attached to this report.

In addition, the members of the team discussed the programs for hammermills and edible oil equipment as well as other machinery for agricultural production and food processing with several government officials, private businessmen and A.I.D. officials. These visits and discussions were complemented with a review of the literature on both the agricultural production and processing sectors. This included general and agricultural census data, specific crop production and processing studies, research reports, economic and financial studies and a variety of other information.

Visits were made to 4 of the 9 Provinces (including all but one of the major crop producing Provinces), and most of the major cities and towns. Investigations were made in the industrial and commercial zones of the main towns of the Copperbelt and Lusaka, as well as several of the Provincial and District capitals outside of these urban centers.

III. FINDINGS AND MAJOR ISSUES

1. Most of the hammermills have been distributed throughout the country without due consideration by promoters or purchasers for the effective demand for milling services. Often this has led to mills being distributed in areas where it will be difficult to recover the costs of purchasing the mills and operating them. Many will not produce profits for their owners, and many will not make operating costs. In some cases demand could be adequate to support these enterprises, but an excessive number of mills have been placed in the same area, diluting the demand for milling services that should be going to any one single mill.

2. Spare parts and repair services are available in most instances, but this tends to be restricted to the zones along the line of road and rail. This is particularly true in the central corridor from Livingstone to the Copperbelt. A system of linking the central suppliers (i.e., importers and manufacturers) in the major cities to the lesser towns is not well established.

3. Most of the equipment for milling can be easily manufactured in country, even for some of the parts that were reported to be impossible to make, such as the wear parts for expellers. The physical and technical capacity is adequate in Zambia to manufacture parts and entire machines.

4. Poor design or redesign makes many small hand-operated oilseed presses impractical for manufacture and distribution. We found that most of the ram presses have been redesigned to make them less efficient and more subject to excessive wear and breakage than was the case with the prototypes from which the redesigns were made. The spindle press, which had been introduced from a Dutch prototype, has been, in one case, redesigned to make it almost useless.

5. The small motor-driven oilseed expellers that have been imported have not proven very efficient. Most show excessive wear over short periods, and the perceived need to import spares makes their use uneconomical. However, facilities do exist in Zambia for making these spares, which could render some of this equipment serviceable.

6. Repair facilities and workshops in the lesser towns, outside of the major urban centers, experience a great deal of difficulty in generating enough business to keep operating. This is because the local demand for services is extremely limited by the low-level of economic activity in these areas. Off of the main roads, repair services are virtually non-existent except on some commercial farms or at development centers or missions. In the latter two cases, these are heavily subsidized. There is not enough activity to support repair facilities or workshops away from the major transport arteries.

7. Auxiliary activities, outside of the hammermill program, are limited to a few village water pumps, an occasional oilpress and a few pieces of animal traction equipment. Therefore the effective demand for support facilities is too limited to make these investments commercially viable.

8. The low density of population in most of the rural areas, particularly off of the main roads, coupled with the low income of the rural population, means that the demand for services is low, even for such operations as maize milling and oilseed pressing. Thus, the derived demand for support facilities for this equipment is also extremely low.

9. Due, we assume, to a long period of government control of input delivery and marketing, there is a lack of any type of regular marketing network by private businessmen. Thus, there is no way to couple such operations as milling, or repair of mills with a regular

transport and market cycle.

10. Without a regular network of public and private transport to the rural villages and settlements, there is no economical way for servicemen or training staff to reach these areas. Communication between rural areas and larger market towns along the main roads seems to be on an ad hoc basis. Thus, it is also extremely difficult for people in rural areas to transport their machines to workshops when repairs are needed.

11. Because of the difficulty in effecting repairs for machinery off of the line of the main roads, it is extremely important that proper machine installation and maintenance is done to prevent breakdown. However, many machine operators do not do proper maintenance procedures on a regular basis. There are several reasons for this: they have not received adequate training in these procedures; they do not have the spares such as oil and air filters to carry out maintenance; the machine owners are absentees; operators are either not trained or have no means of obtaining the proper spares needed for preventive maintenance; and the original installations were not properly done.

12. Although some training for owners and operators is provided by such services as VIS, this program needs to be strengthened through repeated and regular visits to the operation site by maintenance/training personnel. However, such "circuit rider" trainers would find it difficult and expensive to provide this type of training due to the great distances between installations (due mainly to low population density) and the lack of regular public and private transport among these rural settlements.

13. We concur with other studies (ZAMS) that at least 50% of the hammermills will fail due to lack of milling volume, inability to command high enough unit prices to make operating the mills economical, excessive concentration of mills in some areas, and poor maintenance. This percentage could well increase due to a 30% increase in the price of diesel since the ZAMS study was done, and the likely increase in imported spares due to recent currency devaluations.

14. Where mills are not able to generate enough business and to charge enough per unit to cover costs, owners are likely to deplete their capital asset so that when breakdowns occur, owners will not be able to undertake repairs. We have already seen this occur with cooperatives and other groups, and it appears that is more common among these groups than among individual owner/operators.

15. As hammermills fail, people will travel further distances to have maize ground, which will help to make the surviving mills more profitable. In some cases, we believe that individuals will be able to buy up failed mills and move them to more lucrative areas. However, some finite number of mills is the maximum that can be supported by any given rural population. That number may be soon reached.

16. As the cost of mill operation rises, the fees demanded will have to increase in order for

mill owners to stay in business. However, unless some other income sources are found, many rural residents will be unable to pay the fees.

17. Maintaining any equipment in the rural areas, especially motor driven equipment, is so difficult that we believe efforts to introduce this equipment should be kept to the minimum at this time. Thus, any effort to introduce machines such as oilseed expellers away from the main line of road should be limited to hand operated machines of a design that will give a minimum chance of breakdown.

18. There is a need to connect R&D work with industrial firms to insure that designs can be manufactured economically, and so that the experience of the industrial sector can be drawn upon to insure practical and efficient designs. There is a great deal of isolation among the R&D people.

19. There is also too much R&D being undertaken on equipment that has already undergone extensive design and test elsewhere. This is true for grinding mills, water pumps, oilseed presses, animal traction equipment and other small farm tools and processing equipment. More effort should be made to simply bring in designs that are proven, and find the means to manufacture them locally.

20. There is an enormous capacity for manufacture and repair of all types of machines in the country, both for local use and for export. The physical and technical capacity exists for manufacture of these and other much more sophisticated machines for export. In our judgement, the technical competence found in many workshops is good to excellent. The main concern is management and motivation, and we found that to be quite high in some of the private workshops.

21. In many of the government parastatal workshops we found a tremendous lack of understanding of how businesses should function. Most of these have been given a mandate to generate revenues for operations from outside of government sources. However, management seemed not to understand how to generate business, how to price their services, how to establish incentives for quality and quantity production, nor how to determine priorities in their businesses.

22. It is doubtful if the parastatal workshops can be a viable option for support of the agribusiness sector at this time. In addition to their management problems that result from their need to move to a commercial mode of operation, reports are that they are inefficient and slow, are accustomed to high billing rates (a legacy of their function of supporting other parastatal and government operations), and that many of their best technicians have left for the private sector as their companies have been unable to pay them adequately and on time. Although these workshops have reasonably good facilities and equipment, they lack the motivation to put these to effective use. Unless they become truly private, they will not command much of the private market.

23. The private commercial workshops, foundries and manufacturing establishments, however, are not only anxious to put their capacity to work, they are actively exploring opportunities. However, many have been oriented to production for government or the parastatals, such as the mines, and somewhat lack the experience of finding market niches that they can exploit.

24. The current high interest rates make it difficult for the industrial sector to operate profitably except in assured, rapid turnover, operations. The risks involved in designing goods for production in an unsure market are multiplied when placed against such high interest rates. This alone may prevent these firms from emerging from a command economy to a more competitive market environment.

25. Although technology transfer and development is well established in the large private firms, familiarity with market exploitation may not be as well developed. For export oriented production, these firms will need to develop external linkages in order to exploit the more liberal trade policies and foreign exchange retention schemes now being offered by government and to capitalize on regional markets by utilizing their existing capacity.

26. The current policy of permitting some imports, such as agricultural equipment, to enter free of duties, while placing levies on imported raw materials such as steel, works against the manufacturers for domestic markets. Even rebates of import duties for exported goods is not viewed favorably by manufacturers due to long delays and excessive bureaucratic procedures experienced in receiving the rebates.

27. Even with high interest rates, credit is limited and rationed. Interest must be paid against approved bank overdrafts even if the overdraft facility is not used. This causes an inefficient use of credit facilities and does not permit firms to operate flexibly and rationally.

IV. POSSIBLE ACTIONS OR INTERVENTIONS

The following are recommended actions or interventions that could be undertaken by the ZAMS Project in support of the various agro-industries in Zambia, or in support of light-engineering in general. They are listed in order of the priority that the study team felt they deserved relative to this sector in Zambia. It should be pointed out that this list is relevant within the context of the macroeconomic and policy environment that the team felt existed in Zambia or that the country was moving toward at the time of the study. If that environment should change, that is if new policy directives are approved by government, some of these recommendations may be less valid or the priorities could shift.

1. Develop a compendium or directory of companies that can provide various services such as engineering, machining, manufacturing, repairing, or spare parts importing within the agro-processing and light engineering sector.

ZAMS should initiate a review of workshops, importers, suppliers, services companies and other firms that have the capacity to service or support this sector. Included should be both parastatal and private companies that currently operate in Zambia. These include foundries, machine shops, metal-working shops, engine overhaul and repair shops, spare parts importers and manufacturers, raw materials suppliers and specialty firms. The purpose would be to catalogue the technology and capacity available in-country, and to widely circulate the information so that users will be aware of the availability of services and supplies. This should not just be a listing of companies, but rather a fairly objective assessment of capacities and capabilities.

2. Develop or support training for hammermill operators.

ZAMS, in support of SIDO and VIS is currently supporting the hammermill training efforts in Zambia. However, due to our strong concern that operators off of the main road lines will have tremendous difficulty in obtaining spare parts and repair facilities, we feel that a stronger training effort will need to be done for preventive maintenance so that breakdowns can be kept to a minimum. However, it is not thought likely that operators could afford to pay for this training in most instances at commercial rates, therefore, this effort will have to be subsidized by A.I.D. or the Government. Different models for training might be developed and tested. These should include attaching trainer/maintenance people to the planned VIS workshops, with transport, so that they can follow-up current operators on a regular basis and perform maintenance and do training in preventive maintenance in the field. Other options are attaching mobile maintenance/training people to existing commercial garages, conducting periodic regional refresher training exercises, and working with existing vocational training centers.

In addition to the training for physical operations, installations and maintenance, there exists a great need for training of owners and operators in management of these enterprises. It is clear that a large percentage of these mills are operating without due consideration being given to the true costs of recovering capital investments as well as regular operating costs. In the cases of machinery purchased with loans, recovery of loan funds and interest charges is essential. Also, few, if any of the owners (especially in the case of group ownership such as cooperatives), have put aside reserves against major maintenance and repairs. Thus, when breakdowns occur, funds are not available for equipment refurbishing, and these fund requirements are often very large amounts.

In addition to addressing the training needs mentioned above, ZAMS should also help to develop training materials for the hammermill sector and other agro-business activities. These should include brochures, posters, and possibly video materials that could be used in training and promotional activities.

3. Develop interventions in support of the edible oil subsector.

Interventions should include very small-scale, small- and medium-scale, and possibly

large-scale processors. The latter, which consists mainly of parastatal and cooperative oilseed processors should be included only if their operations become completely commercial, without government subsidy, or if they are privatized.

Continuing development of small, hand-operated oilseed presses should continue, with the aim of finding or developing equipment that can operate in rural areas with the minimum chance of breakdown or wear. Such systems as the KIT process, or the more simple spindle press should be prime candidates, and they should be thoroughly tested with small commercial enterprises. We recommend a controlled pilot program that finances the establishment of small oil processing enterprises in prime oilseed growing areas. Attention to the production, marketing and management would be included. If these prove successful, then linkages to manufacturers should be sought so that they can be produced for distribution through agricultural or hardware equipment suppliers.

For the small to medium scale processors, some efforts should be made to help set up edible oil manufacturing firms in areas where road or rail transport is available as well as other infrastructure such as electricity and water exists. The findings of the team are that facilities exist in Zambia to repair these higher performance machines, and replacement parts could be produced in-country. Thus, the larger, commercial and semi-commercial machines can be tested. These should be promoted in regions where oilseeds are currently grown or could be grown. The objective would be, in the first instance, to supply edible oil in smaller towns, where supplies are less assured from the large firms. It would also help to stimulate production of oilseed crops in these areas.

In the case of the small- to medium-sized operations, consideration should be given to importing some oilseed expellers and attempting to have local manufacturers duplicate them in Zambia. These might include some of the older British or Indian expellers for which the patents are no longer in force. At the least, manufacture of the main wear parts of these machines should be attempted locally.

Within the oilseed sector there is a need for some vertical integration. To stimulate production, basic inputs such as improved seed varieties (sunflower) will need to be made available and markets assured. One processor is now undertaking some contract growing, and expansion in this area should be considered with other processors. With current interest rates this may be difficult, and innovative ways to do this may need to be explored. Other options might be helping to set up intermediate contracts to buyers or assemblers/bulkers who would work with farmers by supplying seed and contracting to deliver their production to processors. For some processors, direct retail sales of oil and cake may be possible. One processor indicated that this was administratively too complicated and he preferred to sell wholesale. If this is the case, then assured market outlets will need to be developed. In some cases it may be necessary to encourage establishment of marketing arrangements with grocery wholesalers.

4. Develop, on a pilot basis, a program to assists private workshops in the smaller rural towns, particularly to service the hammermill program.

Although we are not advocating any massive program to build rural workshops in support of the hammermill program, mainly because we strongly question their commercial viability in areas where there currently are few facilities, we think it would be worthwhile to include some support in this area. However, we think this support should be linked to existing private businesses, and not to new workshops.

The approach we recommend is to look at 1-2 geographic areas where a sizeable number of hammermills (and hopefully other machines) are located. Next, survey the owners of these machines to determine what repairs are need (welding for example) and where they go for these repairs (it is possible that this information can be extracted from the on-going hammermill survey). A distinction will have to be make between repair of the mills or other metal parts (mill frames or cyclones for example) and repair of the diesel engines. Based on some consensus of the existing owners as to the best workshops or technicians, both from a point of view of quality and cost of work, identify one or two workshops in the targeted area. Then the identified workshops should be assessed by ZAMS to determine what (if any) improvements might be needed to strengthen the ability of the workshop to backstop the program. Possible actions that could be taken by ZAMS in this regard might be:

- Providing training to the management and technicians in the workshop on either metal working or engine repair;
- Providing FOREX for the procurement of better tools or workshop machines;
- Developing linkages between these rural workshops and the manufacturers of the hammermills and the importers and suppliers of spare parts;
- Helping to develop linkages to the workshops that can manufacture special spares (hard surface parts for example, or bearings);
- Helping the workshop to obtain raw materials supplies, probably through arrangements with larger supply houses; and
- Providing encouragement and ideas on expanded business opportunities, probably through diversification by learning new skills, becoming a small manufacturing or retail outlet for hardware and supplies needed in the area.

It should be stressed that this would be a pilot effort, and should be closely monitored to determine if a feasible model can be developed that could be extended elsewhere.

5. Bring in machines for duplication and manufacture locally.

This was suggested above for small oilseed expellers. However, it should be considered for a variety of other items such as animal traction equipment, water pumps, wheelbarrows, seed decorticators, seed cleaning equipment and many other items that may currently be imported or for which a local market might be developed. Many of these items are out-of-patent, but the technology contained in the machines is still valid and useful. At the same time, some of the spares for machines that are currently operating in Zambia could be imported so that local manufacturers could duplicate them, either under royalty to the patent holders to in the case where patents have expired, without legal penalty. Because duplication and manufacturing of these items may pose a great deal of risk, particularly where the technology may be difficult or the market for the output is not evident, the Project should help to support this by contracting with different firms in the country in the initial stages.

6. Support the private sector agricultural machinery and agricultural processing equipment manufacture for export-oriented industry development.

In conjunction with number 1 and number 5 above, a greater emphasis can be placed on assisting local workshops and small factories to produce for export as well as domestic needs. The major effort should be in helping these companies identify and market products within the region of Southern and Eastern Africa, including Zaire. The development of a directory of capacity and ability as suggested in #1 above can be used in this effort. Copies of any directories can be disseminated throughout the region. In addition, replications of machinery suggested in number 5 above should be done in consideration of potential export markets.

It appears that in many cases, local Zambian private industrial firms have not developed the skills in marketing that are required. This is particularly true in the export markets. A main reason for this is that the local companies have generally functioned within a "command" economy where production was generally for government, parastatals or the mining sector. As the marketing opportunities in these sectors diminish in importance, the local firms will have to develop new markets. To the extent that local enterprises emerge from privatized parastatals or new ventures are created by local investors, or that foreign investors are encouraged, knowledge about existing technical capacity will be an essential way of promoting existing workshops. It seems that market development skills have not been acquired to the degree necessary under the previous industrial environment. This is particularly true for the export markets, although it may be almost as much of a handicap to these firms in shifting to production for Zambian markets.

ZAMS can help in the marketing process in several ways:

- Hold seminars in Zambia for local manufacturers on marketing potential in the region. Potential clients from other countries would be asked to attend so that

manufacturers and potential purchasers could be brought together.

- Representatives of local Zambia industry could be encouraged to attend many types of trade or industry fairs or shows held in the region.

- ZAMS could organize a trade show in Zambia which would display the machines and equipment that local manufacturers now produce. This would allow local firms to display their goods. These shows would be widely advertised through Chambers of Commerce or Associations of Manufacturers or Food Processors Associations in the region.

- Undertake an information gathering process to review the requirements for shipping, handling and billing, as well as banking requirements for exports. In addition to providing information to companies unfamiliar with these procedures, it would provide a basis to urge changes where streamlining is merited.

- One technique that can be used is to ship prototypes of machines or parts to potential customers within the region or to regional trade shows. This could be coordinated through other A.I.D.-financed projects in neighboring countries, or through UN organizations. Financial and technical support, in addition to market identification, might be needed to assist Zambian manufacturers.

7. Help link R&D work with industry.

It appears that a great deal of research and development or design (and redesign) work is being undertaken in non-industrial technical workshops. In some instances it is not at all evident that the redesign or modifications on this equipment offers any improvements to the original design. In some instances it appears modifications were made for ease of manufacturing without respect to the technical specifications that had been built into the original design. Here it appears that ease of manufacturing concerns were more from the point of view of the Research Centers rather than the capabilities within the country. In other cases, existing equipment has proven robust and durable enough so that modifications have seemed superfluous. If R&D centers were more closely linked to industry, they could draw on the considerable expertise of these firms in both design and manufacturing considerations. They would also gain from the experience that some of these firms have already had in manufacturing and marketing of similar products.

8. Continue to support efforts to find or design simple, durable equipment for rural areas that are less dependent on fuel, spare parts or external expertise.

This was previously suggested for simple hand-operated oilseed presses, but is equally valid for some other items such as rice hullers and seed decorticators. It is recommended that this design work be done in conjunction with private manufacturers whenever feasible, so that in the process of doing the design work, the practicality of manufacture

of the items, and their true manufacturing costs, can be built into the design.

9. Use the efforts of VIS to establish maintenance and repair workshops as pilot cases to determine the economics and management realties of their model.

Although we have been somewhat skeptical about the potential for establishing new workshops in rural areas, particularly as commercial enterprises, the VIS workshops can provide an excellent opportunity to monitor the impact of rural workshops on the local community and to determine the real volume of demand, and the types of services needed, in these rural areas. They will also provide an opportunity to develop, modify or test the management system, including the need for and responsiveness to incentives for workers and sales people in these types of establishments.

A major concern that should be addressed in the monitoring of these VIS workshops is the extent to which they affect, either negatively or positively, the other firms in the vicinity or the VIS workshops. Due to the fact that VIS will receive equipment and support as a grant and will not be required to pay taxes in most instances, there may be a tendency to practice predatory pricing, or not to calculate costs completely. This would be akin to the pricing policies that are often practiced by the parastatal workshops, and should not be supported.

10. Support any efforts that are made by the parastatal workshops to move to commercial operations.

Currently we are somewhat skeptical about the ability and willingness of the parastatal workshops to convert to full commercially-operated enterprises. However, in cases where there is a willingness to do so, ZAMS should support those efforts. It would be preferable if these workshops were completely privatized, i.e., sold, but barring this, help could be given in instances where these firms are at least attempting to function as commercial establishments, in fair competition with other, private, workshops.

11. Support those policy initiatives that will strengthen the ability of private workshops and manufacturing entities to compete.

a. USAID should encourage more equitable import duties for raw materials destined for production of equipment used in the manufacture of items needed in local production and processing.

At the moment, for example, raw materials like steel used to manufacture agricultural equipment like ox-plows, are subject to duties while ox-plows imported from Zimbabwe are allowed in duty-free.

b. USAID should encourage policy efforts to remove discriminatory practices favoring parastatal firms over private firms.

The parastatal firms have had duty-free import privileges allowing them to import tools, raw materials and other items for local production while private firms have not. In addition, parastatals have not been subject to income and sales taxes. Further, they are often given subsidized, or no-interest loans, for their operations. These practices tend to discourage the development of private sector firms which cannot obtain these privileges.

12. USAID should support policy initiatives that further encourage the full privatization of parastatal-owned workshops, manufacturing entities and food processors. Consideration should be given to using debt-for-equity swaps to move these firms to the private sector. Other possibilities might be to use PL 480 generations to help refurbish and privatize these entities.

13. Other policy concerns are foreign exchange retention and market liberalizations.

The current policy is for allowing 100% FOREX retention for non-traditional exports. In order to support this policy, and to help local businesses take advantage of this opportunity, ZAMS should encourage diversification. To this end, ZAMS will need to consider several options in crop production, processing, and in support activities like equipment manufacturing.

As the country moves toward a full market-generated pricing system, market opportunities will develop that may not be readily apparent at the moment. In order to support these activities, ZAMS will need flexibility, and USAID should encourage and support more flexibility in the Project. A FOREX fund for supporting this flexibility will be needed.

V. THE HAMMERMILL PROGRAM.

A. General

The hammermill program which was launched in Zambia about 2 years ago, had 3 main objectives:

- To provide grinding facilities for food like maize in rural areas that were not served by large central mills;
- To ease the work load of rural women which was particularly heavy due to hand milling operations; and
- To improve the nutritional regime of rural populations, especially children.

The first objective was both a response to an effort to decentralize maize milling operations and

to remove the dependence on central mills' deliveries to rural areas, which was often interrupted. Easing the work load of women was supported not only to remove an arduous task, but also to free up women for more productive work. Nutritional improvement was believed possible from 2 effects of mechanical milling. First, households would have a constant supply of flour on hand for preparing meals. This would allow for more frequent meals, especially important for children. Second, it was hoped that reducing the workload on women would give them more time to grow a wider variety of crops, thereby improving the diet of the family and increasing the income of the household.

The extent to which these objectives are being met is being evaluated and monitored by ZAMS through separate on-going studies and monitoring activities.

The hammermill program consisted of encouraging local manufacturers to design and build hammermills, mainly by contracting through government agencies and NGOs for large numbers of machines. The machines were then sold, usually on credit with 10% down payment and relatively low (and subsidized) credit terms. The buyers were to repay the loans through proceeds derived from payments for milling services or from profits made when millers sold flour ground from maize bought on their own account. Milling operations were also to generate the cash flows needed to cover operating and maintenance costs of the equipment.

A major concern emerged after the initiation of the hammermill program. That was the perceived lack of support services and workshop facilities that were required to insure that mills could be kept in working condition. That concern has increased as already over 2,000 hammermills have been distributed, many on credit, throughout the country, and more of them are being manufactured for distribution. The concern that maintenance, repair and supply of spare parts facilities were lacking was the major reason that this study was requested by ZAMS.

Some organizations, such as SIDO (Small Industry Development Organization) and VIS (Village Industry Services) have established training components so that mill owners and/or operators can be given instructions in the physical aspects of operating and maintaining their machinery and to a very limited extent, the management aspects of their new business. In the majority of cases the mills are powered by small diesel engines, so training in maintaining these engines in the rural areas was very important.

Maintaining equipment like hammermills and diesel engines is closely linked to the environment in which this machinery is operated. Therefore, some attempt was also made to design a proper installation guide. In general this included secure mounting of the machinery on concrete bases, venting engine exhaust fumes outside, away from operators, drawing combustion air from outside, away from dirt and dust, shielding the engine from the mill's own generated dust, and providing an atmosphere conducive to air circulation around the engines, most of which are air-cooled.

The location of the mills was left up to the buyers, and it appears that little, if any, guidance was provided on the most feasible sites for mills. These decisions were left to the market, as was the fee structure for milling operations. The distribution of the mills, by institutions is given in Table

1 by Province and District as of mid-1991.[1] Considerable numbers of additional mills have been placed since that time. Few of the mills sold by private companies are listed. Of these, ZAMS staff estimate that "institutionally" distributed mills may constitute only 40-50% of the total that have been placed throughout the country in recent years.

B. The Demand For Milling Services.

The demand for repair facilities and spare parts for hammermills as well as other equipment found in any area is a derived demand. In the case of hammermills, it is derived from the demand for milling services. That demand will be determined by the volume of material to be milled, which is a function of the consumption requirements of the rural population for flour and the price they can, and will pay, for grinding services. Therefore, it is useful to review the factors making up the demand for milling services.

The demand for milling services in the rural areas of Zambia is considered quite high. Most rural Zambians prefer grinding their cereals with a mill as opposed to the traditional method of using a mortar and pestle. This is particularly the case with maize, which is a very hard cereal to grind, and people will walk great distances to have maize machine-ground. The demand for milling services for other commodities, such as millet, sorghum, cassava or pepper (*piri piri*) is less important given the much lower volume of these commodities used in the diet. These commodities could, however, be important items in the demand for mechanical milling in some areas of the country.

The demand mentioned above is physical demand. This refers to people's desire to have access to the facility, and it was mainly the expression of these desires that led to the launching of a nation-wide hammermill program. This can be translated into an aggregate demand for milling services when population is taken into account.

C. Population

Data from the 1990 census[2] show an overall population for Zambia of 7,818,447 as of August 1990. This compares with a population of 5,668,801 in 1980, an increase of 2,156,646 persons. The increase represents an annual average growth rate of 3.2%. If this growth rate continues, Zambia should have a total population of about 8.2 million by mid-1992.

The distribution of population by urban - rural was estimated at 42% urban to 58% rural in 1990. Urban population, defined as people living in those centers with 50,000 or more people, most of whom are involved in non-agricultural activities, had increased from 39.9% of the total in 1980.

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[1] The data for the Eastern Province is as of February 1992.

[2] Preliminary Report, December 1990.

The urban areas are also more endowed with infrastructure, and have common facilities like piped water, electricity, post offices and police stations. They will also have banking facilities and both government and private retail outlets. Other services, such as petrol stations, markets and garages or workshops are also generally available.

Overall, population densities have increased from 5.3 persons per square kilometer in 1969 to 7.5 in 1980 and 10.4 in 1990. However, population density is uneven throughout the country. Outside of the Copperbelt and Lusaka, only 6 Districts show population densities in the 20-40/Km^2 bracket, out of 57 Districts in the country. While 9 are in the 10-20/Km^2 bracket. Twenty-one Districts have population densities of 5/Km^2 or less, and 11 have between 5 and 10/Km^2.

Table 1 shows the population by District and densities per square kilometer. These data have been combined in Table 1 with the distribution of hammermills under institutional programs in Zambia. Although some data are included in the table for "private hammermills", referring to those mills sold directly by manufacturers or their representatives to private individuals without going through any of the government institutions or NGOs, the data are incomplete. The ZAMS Project staff felt that "non-institutional" or "private" hammermills represented 50 - 60% of the total mills in the country. Thus the mills listed in the table may represent only about ½ of the hammermills in the country as of mid-1991. Recognizing that distributions are only through mid-1991, and that the program was accelerating up through the fall elections, the number of hammermills distributed is large. Again, the distributions are uneven, with some Districts receiving considerably more than others as can be seen in the population/hammermill figures. An additional column has been added which divides population by 2,000 to arrive at a hypothetical maximum number of hammermills that can be supported, referred to as "hammermill requirements."

D. Population and Hammermill Requirements

The "hammermill requirements" figure is not just an arbitrary number. It is based on two pieces of empirical data on hammermills in Africa. The first is a study commissioned by the FAO in West Africa[3] which found in the Sahel region from Senegal across to Niger, approximately 1,700 people would need to use the mill to justify a commercial operation. This was based on about 1,200 people on a regular basis, and 500 from surrounding areas on a less-frequent basis. This could rise to 1,500 on a regular basis and 600 on an infrequent basis under some conditions. Factors influencing the number of people needed to support a mill were: location relative to adjoining villages; density of surrounding population and presence of a regular market. The study covered areas that typically had relatively large nuclear villages, with 500-1500 people living in a village, and occasionally up to 3,000, and some with small satellite villages within a few kilometers.

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[3] FAO "Village Mill Institution Programme;" V. Altaralli Herzorg; Rome, December, 1985.

TABLE 1. Distribution of Institutional Hammermills in Zambia, 1991

Province/District	Population Density 1990/km2	Institutional Hammermills mid-1991	Known Private Hammermills	Total Hammermills	Population 1990	Hammermill Requirements [1]	Sq. Kms per Mill Optimum [2]	Population/ Hammermill [3]	Districts with Commrl Mills
CENTRAL									
Kabwe – rural	8.5	95	6	101	219,865	110	235	2,177	
Kabwe – Urban	106	2	1	3	166,619	83	19	55,540	X
Mkushi	4.7	24	17	41	107,264	54	426	2,616	X
Mumbwa	6.1	54		54	127,821	64	328	2,367	
Serenje	4.5	35	1	36	104,042	52	444	2,890	
Total Province	7.7	210	25	235	725,611	363	260	3,088	
COPPERBELT									
Chililabombwe	84.4	2		2	86,637	43	24	43,319	
Chingola	111.3	11		11	186,769	93	18	16,979	
Kalullushi	125	5		5	90,630	45	16	18,126	
Kitwe	448.6	6		6	348,571	174	4	58,095	X
Luanshya	182.2	8		8	147,747	74	11	18,468	
Mufulira	106.9	6		6	175,025	88	19	29,171	
Ndola – rural	7.1	60		60	167,852	84	282	2,798	
Ndola – urban	341.2	13		13	376,311	188	6	28,947	X
Total Province	50.4	98		98	1,579,542	790	40	16,118	
EASTERN									
Chadiza	24.7	15		15	63,539	32	81	4,236	
Chama	3	9		9	52,234	26	667	5,804	
Chipata	24.5	86		86	294,204	147	82	3,421	X
Katete	35	34		34	139,679	70	57	4,108	
Lundazi	12.3	48		48	173,018	87	163	3,605	
Petauke	13.4	50		50	251,144	126	149	5,023	
Total Province	14.1	242		242	973,818	487	142	4,024	
LUAPULA									
Kawambwa	4.3	35		35	82,246	41	465	2,350	
Mansa	8.8	77		77	142,613	71	227	1,852	X
Mwense	12.1				81,277	41	165		
Nchelenge	13.9	16		16	111,736	56	144	6,984	
Samfya	10.5	45		45	108,233	54	190	2,405	
Total Province	10.4	173		173	526,705	263	192	3,045	
LUSAKA									
Luangwa	4.7	3		3	16,300	8	426	5,433	
Lusaka – rural	11.6	74		74	209,318	105	172	2,829	
Lusaka – urban	2728.8				982,362	491	1		X
Total Province	53.2	77		77	1,207,980	604	36	15,688	

Source: ZAMS Monitoring and Evaluation Report July–Sept 1991; Eastern Province, Feb 1992.
Note: Data is not considered complete; most private mills were not recorded.
1: Based on 2,000 persons per mill 2: Area needed to encompass 2,000 persons 3: Population of district divided by total known hammermills

Province/District	Population Density 1990/km2	Institutional Hammermills mid-1991	Known Private Hammermills	Total Hammermills	Population 1990	Hammermill Requirements [1]	Sq. Kms per Mill Optimum [2]	Population/ Hammermill [3]	Districts with Commrl Mills
NORTHERN									
Chilubi	8.6				39,956	20	233		
Chinsali	5.6	30		30	86,852	43	357	2,895	
Isoka	8.8	25		25	121,907	61	227	4,876	
Kaputa	4				51,514	26	500		
Kasama	9.3	65		65	192,046	96	215	2,955	
Luwingu	7.5	26		26	66,763	33	267	2,568	
Mbala	7.5	38		38	138,193	69	267	3,637	
Mpika	2.8	21		21	116,653	58	714	5,555	
Mporokoso	4.5	9		9	53,911	27	444	5,990	
Total Province	1.9	214		214	867,795	434	339	4,055	
NORTH-WESTERN									
Kabompo	3.5	12		12	51,587	26	571	4,299	
Kasempa	1.8	26		26	36,971	18	1111	1,422	
Mufumbwe	1.1	15		15	22,303	11	1818	1,487	
Mwinilunga	3.9	24		24	81,899	41	513	3,412	
Solwezi	4	91		91	120,590	60	500	1,325	
Zambezi	3.8	14		14	69,796	35	526	4,985	
Total Province	3	182		182	383,146	192	667	2,115	
SOUTHERN									
Choma	22.5	48		48	164,387	82	89	3,425	X
Gwembe	2.9	7		7	36,173	18	690	5,168	
Kalomo	5	50		50	154,875	77	400	3,098	X
Livingstone	58.9	2		2	84,116	42	34	42,058	X
Mazabuka	23.1	24		24	157,724	79	87	6,572	
Monze	32.4	30		30	157,451	79	62	5,248	
Namwala	3.8	29		29	83,416	42	526	2,876	
Siavongu	17.5	2		2	45,874	23	114	22,937	
Sinazongwe	12.6	3		3	62,337	31	159	20,779	
Total Province	11.1	195		195	946,353	473	180	4,853	
WESTERN									
Kalabo	5.8	1		1	101,410	51	345	101,410	
Kaoma	4.8	36	10	46	112,747	56	417	2,451	
Lukulu	3.1	5		5	51,016	26	645	10,203	
Mongu	14.1	13		13	142,213	71	142	10,939	X
Senanga	4.5	9	1	10	135,210	68	444	13,521	
Sesheke	4.8	7	13	20	64,901	32	417	3,245	
Total Province	4.8	71	24	95	607,497	304	417	6,395	
Total Zambia	148.5	1,220	49	1,269	6,844,629	3,422	2,130	5,346	

This data would seem to be consistent with that found in a ZAMS study on the Northern and Eastern Provinces[4]. The discussion below looks at the data from that study, and updates it where possible. With that data we have estimated a basic physical market demand for milling services that we find comparable to the estimates made by the FAO in West Africa.

E. Financial Considerations of the Demand Situation

1. Cost Recovery and Operating Costs

The ZAMS study found that the minimum quantity that a hammermill needed to process in order to show a profit (in fact to just break even) was 240,000 kgs per year. This figure was required for cost recovery of investment and operating costs, ***and was based on previous exchange rates and previous prices for parts, fuel and previous interest rates.*** This was based on 30 kwacha per tin (18 kgs) of maize ground. These data, use an interest rate of 20%, which is only about ⅓ of the current interest rate of 52%. Diesel fuel costs were only 23 kwacha/liter compared with the February 1992 price of 46 kwacha.

The interest rate difference is significant. For example, the monthly payment per 1,000 kwacha at 20% interest is
K 50.9 for a 24 month repayment schedule, the schedule that was used in the hammermill program. This totals 1,221.5 kwacha required to repay a 1,000 kwacha loan. At an interest rate of 52%, the monthly payment per 1,000 is K 67.84, and a total of 1,628.3 kwacha will be required to repay each 1,000 kwacha borrowed, an overall difference of 406.76 kwacha.

In the case of the Eastern and Northern provinces, hammermill prices ranged from 200,000 to 400,000 kwacha, depending on manufacture, size and type of power source. Assuming an average price of 300,000, then monthly payments at February 1992 interest rates would be K 20,352 versus K 15,270 at previous rates. The overall effect is an increased volume of maize that would need to be milled to cover the increased interest rate. At 30 kwacha per tin (18 kgs), 73,200 extra kgs of maize need to be milled over the 2 year amortization period to cover higher interest charges; 36,600 kgs per year.

Thus, we now need to mill 276,600 kgs per year to show any profit at all, not counting increased fuel costs. Survey data suggest that about 55 kgs of maize can be milled per liter of fuel. At previous prices that equals 0.594 kwacha per kg. The current price would equal 0.836 kwacha per kg. This increased price is equal to 88,678 kwacha (considering the larger volume required to cover increased interest and higher fuel costs). That means another 2955.9 tins of maize need to be milled to cover fuel costs, or 53,207 kgs. We now are up to 329,806 kgs of maize required to cover current costs.

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[4] "Economics of the Hammermill operation in the Northern and Eastern Provinces of Zambia," ZAMS, Joseph Temba, Elizabeth Phiri, George Nkholoma, March 13, 1991.

It should be pointed out that these calculations were based on good to excellent maintenance of the machines. When maintenance drops, large losses are quickly shown.

2. Relationship of Costs to Physical Demand

Using the above figure of 329,806 kgs of maize milling per year required to cover the owning and operating costs of a hammermill give us a rough picture of the number of people needed to support a mill at a profit. An average consumption per person of cereal grain will usually not exceed ½ kg/day. That means that each person would not be expected to consume more than 182.5 kg/year, and that figure, consistent with others in Africa, is only in rural farm areas. In more affluent and urban areas, consumption of milled cereals is usually less.

At 182.5 kg/person/year, we would need 1,807 people using the services of a hammermill to grind the 329,806 kgs required to cover mill costs. We have not worked through the costs associated with the devaluation from K 95 to K 125 that occurred in February. These costs have been partly taken into account in the increased fuel prices but increased investment costs (for new investors or for machine replacement) and increased costs of spares or repair costs are not included. Considering variations in maintenance, extra distances to transport fuel, lower consumption of maize by some individuals, etc., the figure of 2,000 people needed to support a mill postulated above seems reasonable.

Returning to table 1, we find a column headed "sq. km per mill; optimum". This figure represents the area, given the population density in each District that would be needed to encompass 2,000 inhabitants. It suggest, for example, that a District with a figure of 200 in the column will need to draw people from a 10 km X 20 km area. For a figure of 450, the area will have to be about 30 km X 15 km.

These figures suggest that many Districts would not have enough people on average that could physically travel the distance to the mill. The distance people actually are willing to travel to have grain machine milled will not be known until the ZAMS hammermill study is completed. However, we could postulate that with the exception of large concentrations of populations in towns, Districts with less than 20 persons/km^2 cannot support mills.

It is this primary demand, that is, the amount of maize per person to be ground multiplied times the number of people, that determines the physical volume of demand in any given area. Price per tin of maize ground, as per the ZAMS study, was put at 30 kwacha/tin of 18 kgs (1.67 kwacha/kg). Even this price, the analysts noted, was barely sufficient to cover costs, and 33 kwacha/tin should be charged. However, they also noted that in some areas, resistance to high milling prices was felt, and many mill owners were forced by the community to accept 20-25 kwacha/tin. This situation was especially noticeable among cooperative or community owned mills.

3. Price Elasticity

The elasticity of demand for milling services is unknown, but for purposes of analysis, we have assumed that prices above K30 would meet with stiff resistance, and volumes of maize milled would probably drop drastically if milling prices rose much above K30 per tin. However, we also know from the staff working on the hammermill survey for ZAMS that in some places, notably in the Western Province, prices of K100/tin are sometimes paid. The price people are willing to pay for the service represents a price elasticity and reflects relative preference in use of their fixed household income.

The price level that can be charged will be a function of income in the first instance. The arguments made here are based on the assumption that in the rural areas, cash incomes are relatively low and are not expected to rise significantly in the near future. However, under new economic policies this could change, at least in some areas. For example, if foreign investors come in and encourage new crops for export, a phenomenon that has happened in some other African countries such as Uganda, farmer income could rise dramatically. Under such circumstances, the per unit amount people would be willing to pay for milling could rise, and the level could only be restricted by the cost of owning a personal mill for home grinding of maize, or by the price that would be demanded for commercially milled flour. This represents an income elasticity and reflects how people will shift expenditure as household income changes.

Increases in per unit milling charges means that a lesser quantity of maize needs to be milled to support the mill. If fewer people have to use the milling service in order for the owner to cover his costs, then the geographic area needed to support a given mill will decline.

F. Other Possibilities to Generate Demand for Repair Facilities

The demand for repair facilities for hammermills is a derived demand, stemming from the primary demand for milling. But in rural areas, the demand for repair services must be an aggregate of the demand of several mills, as no individual mill can support the workshop equipment and tools needed to service a small mill. Consider, then, that in many rural areas the geographic area that will support one mill will be great. Thus the demand for repair services from several mills must come from a vast area, unless the demand for services other than mill repair and maintenance is also present.

In our visits to the rural areas off of the main line-of-road, we found little in the way of potential demand for other services that a mechanical workshop or engine repair facility would do. At the best, in certain areas, are plows and other tools for animal powered tillage and cartage. It is conceivable in some areas that manufacture or repair of this equipment could provide an active business for some workshops. However, this will be restricted to metal and wood working. There are no engines, either diesel or gasoline powered in these areas. Only on the main roads does one find a demand for service and repair or engines. This is due to the motorized vehicles, primarily cars and trucks, found on the main roads. In most cases, the towns on the main roads have garages or repair shops for vehicles

Other equipment in rural areas seemed to be extremely limited. The most that we found, outside of mission schools or hospitals, or the larger commercial farms, were some hand water pumps and the occasional vegetable oil press. The latter is quite new, and is addressed elsewhere in this report.

Commercial farming operations would seem to have the greatest possibility of providing business to garages, repair shops and small manufacturing facilities. It is obvious that in the past, most of the commercial farms tried to be self-sufficient in terms of maintaining their equipment. Almost all of the older, established farms have their own workshops and repair facilities. Although they often have to rely on the facilities in larger towns for specialized services, such as boring engine blocks, grinding valves or crankshafts, or machining special parts, commercial farms generally service and repair their own equipment, even up to an including major engine overhauls.

The farms that are of intermediate size, in the 20 to 100 hectare range, many created since independence, have more need for outside facilities than is the case with the large farms. These units, which are often partially mechanized, often do not have a large enough scale of operation to permit equipping workshops to handle all of their repairs. It is these that one finds using the services of local private garages either in the medium-sized towns or at neighboring larger farms. Even here, demand for services is a problem for the local small workshops. Although there is an obvious physical demand for repair facilities, the financial means was inadequate in many situations to translate that into a market demand. We found ample evidence of the inability of tractor, truck or automobile owners to find the money to purchase parts and pay for repairs. Often equipment owners left their vehicles and tractors at the repair garage for months or even years due to shortage of funds, causing serious cash flow problems for garage owners (see the appendix on the garage in Pemba for example).

Generally our conclusion was that in the zones where commercial farming is more prevalent, such as along the line-of-road, line-of-rail from Livingstone to the Copperbelt, repair facilities can be found that can handle most jobs. In fact, we questioned if there was enough work to keep these garages adequately employed. The decline in the operations of the large commercial farms does not seem to have been offset by any significant rise in the operations of medium-sized farming operations that would have a demand for mechanical repair facilities, nor do the small-scale farm operations seem to have increased their demand for such items as ox-drawn equipment. In fact, in the Southern Province the outbreak of "corridor disease"[5] was reported to be having a large negative impact on the use of oxen for cultivation.

In essence, the demand for commercially-operated repair facilities is already being met in those areas where there exists an adequate commercial demand to support such facilities. In the more rural, isolated areas, where repair facilities are lacking, there is not enough demand to support a commercial repair facility at this time. We will recommend ways to test this assumption and

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[5] East Coast Fever

monitor whether the demand for such facilities exists or can be generated in places where they do not currently exist to the extent found along the main transportation corridors.

G. Recommendations for Support to the Hammermill Sector.

1. The current plans for VIS/VITA workshops could be supported on a pilot basis in certain areas of the country providing the following is done:

   a. Closely monitor the operations of the workshops established to determine the level of demand for services and if that demand is sufficient to operate a workshop, on a commercial basis;

   b. Undertake a preliminary survey of other workshops and artisans in the areas where it is planned to install a VIS workshop, and monitor the impact of the VIS workshop on the business and functioning of the existing facilities after the workshop starts operations;

   c. Undertake a basic survey in the area where the workshops are to be established to get an idea of the density of equipment, locations and type of equipment to be serviced, such as hammermills, oil presses, animal traction or small farm equipment, and the need for other services such as woodworking;

   d. Try to determine where people currently go for servicing of their machines and equipment, and monitor the impact on distance and cost of servicing after the VIS workshop has been created; and

   e. Closely monitor the technical and financial inputs required in the workshops, and determine the ratio of technician to sales and administration required to maintain the workshops operations.

2. A pilot effort can be launched to assess what is needed to improve the service facilities in some of the rural areas. We suggest that 1 or 2 areas be chosen where existing workshops can be assisted. The method would be to find an area where hammermills and other equipment exists, but is off the main road artery. Then the following steps should follow:

   a. Survey the hammermill owners to ascertain how they currently get repairs done. Find which garage or rural workshop is considered the preferred one by consensus of most of the hammermill owners.

   b. Assess the selected workshop to determine the level of skill, availability of equipment and tools, and capacity of the workshop to service equipment in the area.

c. Determine what, if anything, needs to be done to improve the selected workshop's ability to offer quality service to the area. Possibilities could be providing training, helping to provide machine tools or equipment, transport facilities, and infrastructure or management advice and management training.

The intent here is to work with existing workshops as opposed to building or developing new facilities. It is also intended that a private commercially-run workshop or garage be targeted as opposed to a government built or institutional facility. In the case that a facility like an ESCO garage is used, the entity should operate as an independent unit, and on a fully commercial basis.

3. There is a need to create a system whereby spare parts and other materials such as steel and fuel and oil are more readily available in some of the rural areas. For example, we noted that engine spares are generally available in Lusaka for the main diesel engines used on the hammermills. However, parts inventories are not kept outside of the main importer's central facility. This means that spares can only be found in the major cities, requiring expensive travel and delays for the operators. On the other hand, importers and manufacturers feel that there is too much risk involved in intrusting spares to a dealer or factory representative. Usually it is too difficult and costly to collect for these spares. Therefore a cash-and-carry policy has generally been adopted. The Project could assist in trying to find a solution to this problem, although we recognize that the ultimate solution has to be built on trust and experience coupled with a vibrant commercial activity related to these spares. Further study needs to be given to this problem.

4. The most efficient use of funds to keep the hammermills running is to improve the training to operators, owners and people installing machines. Because many of the hammermills are scattered throughout remote rural areas the cost of service workshops or mobile facilities to help keep them running will most likely be prohibitive. Therefore it is imperative that the machines are properly installed and that operators are properly trained in preventive maintenance. It is doubtful if the current VIS and SIDO training programs are adequate, and for machines sold directly by the manufacturer almost no training is provided. We suggest that improvements in training be considered. Some possibilities include:

a. Attaching a trainer/mechanic to the VIS or other garages as a mobile trainer and troubleshooter. He would be given a set of tools and some basic replacement spares such as filters. He would function like a "circuit rider" who would have a set of hammermills in a specific geographic area that he would visit on a regular basis. His assignment would be to help make any small repairs that are needed, help to carry out regular maintenance such as changing filters and oil, checking on installations of the machines and making alterations where necessary, and to do this in a training mode with the owner and operator.

b. Improving and extending the training courses now offered by VIS and others, and include refresher courses. More emphasis has to be made in these courses on proper installation and preventive maintenance.

c. Establishing a course on administration and management for owners so that actual costs and prices can be determined, and so owners recognize the need for sinking funds for major overhauls and amortization of machinery and buildings.

d. Developing visual aids such as posters, brochures, diagrams, etc that can be distributed to those owners and operators as well as garage mechanics who are responsible for maintenance and repair. It may also be possible to purchase old engines and make "cutaway" models for training courses.

VI. EDIBLE OIL EXTRACTION

A. Introduction

Several studies have been undertaken relative to the edible oil situation in Zambia, and the related oilseed production and processing sectors (AID, 1987; W.R. Johnson, 1987; W.K. Kawana, 1991; Barbara Eisinger [Bahia], 1988; ZAMS, 1991; FAO/ADB, 1992). Estimates of the effective demand for edible oil has been put at 46,000 to 60,000 tons. Production of edible oil from local crops is only about ⅓ of demand (Gemini, 1991; AID, 1987), and a total available supply of about 43,000 tons of oil, including local production and imported oil, cannot supply the demand. Of the total supply, somewhere between 20,000 and 34,000 metric tons are imported, about ½ of that as crude, unrefined oil.

The edible oil sector has been dominated by 2 large firms, Premium Oil and ROP, both parastatals. Six medium sized firms, including 2 cooperatives, are also producing edible oil. The output of these 8 firms is destined for urban markets, particularly Lusaka and the Copperbelt (W.K. Kawana, 1991) with at most 30% destined for rural areas.

There are reported about 33 small-scale motor-driven oil mills in Zambia. These are mainly the German-made Komet, the British manufactured Rosedown Mini-40 and an Indian expeller, the Tiny Oil Mill. Some of these are either operating at low capacity or not at all, due to lack of material to process or unavailability of spare parts.

Efforts are now underway by several groups to develop and extend hand-operated or oxen-driven oil presses. These include the ram type presses that were originally developed in Tanzania, and spindle type presses that have been used for a long time throughout the world.

The sector has the potential for meeting the domestic demand for edible oil and soapstock, and possibly for export to neighboring countries. The main oils produced include sunflower,

groundnuts, soybeans, and palm oil. Other oilseed crops include sesame which can be grown for edible oil, and castor which can be produced for industrial and pharmaceutical purposes.

Because of the potential markets for edible oil in Zambia, and the possibilities for export, ZAMS has started a program of development and assistance in this sector. Previously ZAMS worked with medium-sized processors, but now has also turned its attention to aiding in the development of small hand-operated oil presses. The Project has also funded a study (1991) on the "Potential for Small Scale Oilseed Processing in Zambia" that recommended concentrating efforts on the development and dissemination of village level oil processing technologies. The main reasons given by the consultants for concentrating on small village level technologies were related to the issues of improving nutrition in the rural areas, the lack of cost-effective marketing and transport systems that could make oil readily available in rural areas and the difficulty with more advanced technologies in terms of support systems.

Our concern in this sector was related to the potential for rural industry development that would help to create business for any rural workshops that might be promoted, the potential for manufacturing machines and spares, and the current or potential technical and physical capacity of industry and machine and work shops to support the sector. In this respect we make the following observations and comments on the sector.

B. The Small-Scale Village Technology Level.

Small-scale village edible oil extraction now includes mainly four types of oilseed processing technologies (ZAMS, 1991): a ram press developed in Tanzania and modified by TDAU in Zambia; an animal powered oilpress which has imported gears and drive systems; a spindle press with auxiliary equipment for decorticating, winnowing, crushing and use of heat in pre-conditioning; and spindle presses without pre-conditioning equipment. Essentially these systems represent 3 different technologies: a straight ram press based on manual leverage applied to a small ram dimension; a press based on use of a helical screw to increase manual pressure; and an expeller or screw press.

Our concerns over these technologies and the machines developed to use them centered on the problem of maintaining machines in the rural areas, off of the main roads. We had the same concern about any type of motorized equipment for oil production as we had for the motorized maize mills; the difficulty of keeping the motors properly maintained to insure machine longevity. Irregardless of the economics of using a motorized machine in the rural areas, the difficulty of maintaining the motors cautions against their introduction, or at least dictates a go-slow approach. However, the same problems can be found with some of the manual or animal-powered equipment.

The ram presses that we observed in operation in different places in the country all had the same problems: they could not stand up to the immense pressures that they were designed to produce; they had excessive wear when under constant use; they were extremely difficult to operate; and their efficiency of oil extraction was low. We concluded that the modifications made to the

Bilenberg press (that was developed in Tanzania) had not improved the machine for use in Zambia, and had probably, in fact, made the machine less practical. In visiting the workshops of TDAU where the presses had been modified, we could only conclude that an attempt was made to redesign the machine to make it easier to manufacture. This determination must have come from the limitations of the technicians and equipment that were available for manufacturing at TDAU or known by the TDAU designers to be available elsewhere. We could think of no other reason some of the modifications were made, and these modifications did not improve on the original design, and may indeed have resulted in an inferior machine.

The spindle press is a basic, simple old technology using a perforated cylinder and piston arrangement with a threaded shaft used to apply pressure. It works well for extracting oil from material with fairly free-flowing oil. It cannot work on whole-hull sunflower or on soybeans, but is a good technology for decorticated sunflower, groundnuts, sesame or oil palm. A major technical problem with the press is designing strength into the equipment without undue weight and cost. Major problems were observed with a design using a square instead of round cylinder/piston arrangement. Unequal pressure on the side walls caused distortion of the cylinder. Other problems observed were improper cutting of the threads on the spindle and nut, and poor workmanship in manufacture which resulted in distorted equipment which caused uneven pressures and excessive wear. In the case of the square design, the equipment was hardly functional at all.

C. Small, Motor-Driven Oil Processing Equipment.

A study by Deloitte gave the number of small motor-driven oil processing machines as 33 in the country. As noted above, many of these are either not working or are working far below capacity. There are two of these machines, the German made KOMET and the British made Rosedown Mini-40, that have had serious problems with excessive wear. Both machines run at relatively high speeds, and use a design that includes a worm screw to create high pressure on oil seeds to burst the oil cells in the seeds and cause a free flow of oil in the seed mass which then drains through a porous cage. The design and principles are similar to those used in the larger commercial expellers, the main difference is in the considerably higher speed of the expeller shaft that is employed.

A serious problem with these machines has been that excessive wear occurs in the screw shaft and the cage bars. This usually occurs in a very short period of time. For example, on the KOMET, pressing whole sunflower, the screws wore out after only 2,200 liters of oil had been produced, at a cost of K 83,300 for replacement parts (see appendix 1). This means a cost of almost K 38 per liter for spares alone, not including down time, mechanics time, and time and travel to fetch parts. Also, these parts had to be imported, representing a foreign exchange cost of $400.

A similar problem happens with the Rosedown Mini-40. In fact, in the cases where we saw these machines operating, the excessive wear on the screws and cage bars had significantly reduced the extraction efficiency of the machines, in some cases by more than 50%. Thus an additional

cost is entailed in that the raw material for each liter of oil produced is increased. This represents a higher cost per liter of oil for the material and greater wear on the machine in processing.

For the Indian-made, Tiny Oil Mill expellers, the design and operating principles are closer to the larger commercial expellers such as the Anderson, Rosedown, Krupp, etc. However, we observed excessive wear on these machines as well. One conclusion was that the quality of the metal in the wear parts was not high enough for the abrasive use and high pressures that the machine generated. Again parts were not available and were being imported.

D. The Medium-Sized Motor-Driven Oil Processing Facilities

There are currently several medium-sized oil processing facilities in Zambia. These are factory type of installations, and use the screw expeller technology (as opposed to the solvent extraction method usually associated with the larger oil processing facilities). Although most of these would be considered quite small by commercial oil extraction standards, we classify them here as medium-sized by the fact that they are organized on business principles and operate as unique businesses with the major function being edible oil and oilseed cake production. Generally they try to organize product input so as to operate on a continuous basis, and they only operate auxiliary industries when they relate directly and logically to the oil extraction business (i.e., production of soy fortified maize meal). ZAMS has assisted one of these with technical advice and through the foreign exchange funds facility the Project operated previously. Oilseeds processed by these facilities are cottonseed, sunflower seed and soybean.

E. Main Concerns and Problems with Edible Oil Production.

There are several problems in the edible oil industry, including: the difficulty in obtaining a consistent supply of product to process; high costs of operations due to the high cost of commercial bank interest coupled with the need to maintain large stocks of unprocessed seed and processed oil and meal; the sensitivity of the oilseed meal demand function to the demand for meat, milk and eggs; the difficulty in obtaining replacement parts for processing equipment; the competitive advantage of the parastatals who have had access to interest-free operating capital and government subsidies to the parastatals' capital and operations accounts; and uneven imports of both refined and unrefined oil. All of these issues need to be addressed in a comprehensive analysis of the sector and in preparation of any program to assist the sector. Given Zambia's ability to grow oilseed crops (and palm oil) serious consideration should be given to developing the sector not only to meet local demand, but to supply high-quality cooking oil and soapstock to countries in the region. However, such a program will have to take an integrated approach which includes production at the farm level, marketing and processing, including manufacturing and refurbishing of machines and replacement parts, and domestic and export marketing.

While soybeans are the preferred oilseed crop of commercial farms, sunflower has been promoted as the oilseed of choice for the small-scale edible oil production and extraction industry. This preference is not due to any general preference for sunflower oil, but rather because of a

perceived advantage in small-farmer production of the crop, ease of extraction and price advantage. It is assumed that sunflower is easier for small-holder farmers to produce because it is more drought tolerant than most other oilseeds, it can be planted after the labor pressure for maize production has lessened, it will produce a crop with little effort in a fairly short time, and is relatively easy to harvest and handle. Although there are strong agronomic reasons why these beliefs need to be dispelled, they appear to be widely held in the rural areas. The sunflower oil is considered easier to extract than the alternative, soybean oil. Groundnut oil can be easily extracted, but most observers feel that the demand for whole groundnuts for direct consumption or in making sauces renders it too expensive for oil extraction. It is likely that shifting consumers to a partially defatted groundnut cake would be possible, but little effort has been made in this area. The promotion of other oilseeds such as sesame has not been done, and sesame seems to be a localized crop, as is the case with oil palm, production of the latter being limited to the areas where year-around rainfall is sufficient. Therefore most efforts in promoting small-scale or village-level edible oil production has centered on sunflower. This crop also figures importantly in the larger commercial edible oil processing industry, along with soybeans, and therefore a fairly substantial market has developed for this seed.

There are two main problems with small expellers that could be somewhat ameliorated. First, the whole sunflower seed is too abrasive for the machines. Second, the production of quality, hardened wear parts needs to be developed in-country. These are discussed more fully below.

F. The Quality and Condition of the Sunflower Seed.

In the first case, there are several problems with the seed that processors receive from the farmers or the cooperatives. The seed generally has a high-hull, low-oil content, that increases the amount of abrasive hulls that must be processed per liter of oil. This type of seed also requires more power, pressure and heat to squeeze the oil out of the whole seed and the hulls absorb a much larger quantity of oil during processing than would be the case with thinner hulled, higher oil content seed. Much of the seed in Zambia is derived from confectionery types, which are large, thick hulled varieties.

There are two solutions to this problem: (1) introduce higher oil content varieties to the farmers; and (2) promote the process of decorticating, or hulling, the sunflower before processing.

Some attempt has been made to introduce hybrid varieties bred for oil production. This has met with limited success, as farmers seem to be either reluctant to buy new seed each year or the seed is not readily available to them. Also, poor husbandry practices and the lack of, or failure to use fertilizers means that the genetic potential of the hybrids to produce oil is not fully tapped. An alternate solution to the use of hybrids would be to introduce the Zimbabwe variety, *Paradovic*, and the Tanzanian variety, *Record*. Both of these varieties are open-pollinated varieties that have been bred for high oil content. They are thin hulled varieties and in addition to being less abrasive, extracting oil from them requires considerably less power. It is, in fact, the use of the variety Record in Tanzania that made the use of the Bilenberg ram press feasible. It is believed that both of these varieties are derived from Eastern European, Russian and Argentinean varieties

that have been bred up over a number of years for oil production. An added advantage of these varieties is that the oilseed cake will be less fibrous, lower in oil content, and have a higher protein content than will cake produced from whole-seeded, thick-hulled seed.

The variation of hull and oil content in different sunflower varieties is clearly evident from data that is taken from work that the consultants did earlier in Uganda. These data are given in table 2 below, and the varieties given represent similar varietal variations as those found in Zambia.

Table 2

OIL CONTENT ANALYSIS OF OIL BEARING SEEDS SAMPLED AT VARIOUS LOCATIONS IN UGANDA DURING PERIOD FEB TO APRIL 1989.

Sunflower	Oil Content of Kernel	Hull Content of Whole Seed	Oil Content of Whole Seed
Black, small size	53.0%	28.12%	38.09%
Black, Ave size	49.8%	30.0%	34.86%
Mixed, Ave size	50.0%	42.63%	28.68%
Black & White Stripped	47.3%	40.0%	28.38%
Buff stripped	47.7%	41.0%	28.14%
Buff	44.6%	42.1%	25.82%
White	42.7%	40.4%	25.45%
Paradovic	59.0%[6]	25.0%	44.25%

Source: Tests by Derrick Burgess, 1989.

Extremely significant is the data from Table 2 on the hull content of whole seed. The range from 25% to over 42% means that for some varieties, about 17% more hull must be processed[7] per unit of whole seed if the seed is not decorticated. It is also significant that the lower-hulled seed (Paradovic) also contains considerably more oil (6%) in the kernel than the next closest variety. This means oil extraction will be much easier.

By comparison, seed imported for the variety testing program in Uganda were analyzed by Overseas Development Natural Resources Institute (ODNRI) at Abingdon Oxfordshire, U.K. Their report to USAID/Kampala gives the following oil contents of the different varieties:

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[6] The oil content was estimated as complete drying was not obtained due to electricity failure.

[7] To say nothing of purchase, transport and storage.

TABLE 3

SUNFLOWER SAMPLES FROM UGANDA FROM USAID PROJECT (NOV. 28/1989)

Reference (variety or type)	Percent Oil (Moisture Free Basis)	Percent Moisture
Record	46.5	6.0
Kabantolo International		
201	40.7	7.9
202	44.0	7.2
203	45.5	7.0
204	43.6	7.1
211	47.7	6.9
222	45.1	7.2
Mubuku Interstate		
201	48.8	7.1
209	47.7	7.0
210	51.7	6.7
211	42.7	7.9
214	41.3	8.1
Entry IS7000	52.1	6.7
Mubuku International		
203	47.8	6.7
209	49.9	6.9
213	45.9	7.4
214	39.7	8.1
223	44.6	7.3
225	40.7	8.0

Source: Report of Dr. S.W. Head, ODNRI, Jan 5, 1989.

As can be seen, oil content of whole seed ranges from 40% to over 52% among these hybrids. When compared with the local varieties in Uganda the hybrids in general are much superior. It is interesting that the two open-pollinated varieties from Zimbabwe and Tanzania, *Paradovic* and *Record*, respectively, suggested above as possibilities for Zambia, give whole seed yields of 44%

and 46% oil respectively. These yields compare favorably with several of the hybrids tested in Uganda (Table 3). Although the ODNRI data do not give hull content of the whole seed, the Burgess' data show clearly the wide range that can be expected between a variety bred for oil (Paradovic) and the Ugandan land races that had been bred primarily for confectionery uses. Obviously this factor will relate directly to the oil content of whole seed, as indicated in the Burgess' data, but this factor is also extremely important in terms of the seeds' potential to cause wear to processing equipment.

When the oil fraction of the whole seed is the more valuable fraction[8], as is usually the case in Africa, it is obvious that there is a tremendous advantage to the processor to purchase high oil content seed. Not only is the processor buying a higher percentage of a more valuable product when oil content is high, he is transporting a higher value product, handling and storing a higher value product, and, importantly, processing less volume per unit of oil recovered. It is also generally true that the high-oil content seed has a thin, less abrasive hull, causing less wear to the machine. This seed will also process more efficiently with a higher extraction rate, because (1) it is easier to squeeze the oil out, and (2) less oil will be absorbed by the hull fraction.

Sunflower seed should be decorticated, i.e., dehulled, before processing. This is especially true for the large-hulled varieties commonly processed in Zambia, but is advised for all varieties. The main reasons for this are to more easily process the seed, to reduce wear on the machinery during processing, and to increase the extraction rate of oil.

The oil of sunflower is contained in oil cells found in the inner part of the seed kernel. When the hulls are left on the seed, the hulls must be crushed and the oil released from the inner seeds through the entire matrix of the mass. When the hulls are removed, only the softer inner part of the seed needs to be crushed, and because the ratio of oil to seed matrix is higher, the oil can be more easily released and made to flow. Also, the hulls of the sunflower seed are very abrasive. By removing the hulls before crushing, most of the abrasive nature of the seed is removed[9], and wear on the parts of the machine that the seed matrix comes into contact with is significantly reduced. Sunflower seeds are not uniform and can have slightly rough seeds. Therefore small amounts of dust and dirt will adhere to the seed, and this dust is also abrasive. Finally, all of the oil is contained in the inner part of the sunflower seed; none is contained in the outer hull. Therefore, when the whole seed is crushed, the hull portion of the matrix will absorb a certain portion of the oil. This naturally reduces the amount of oil extracted from the seed, thereby significantly reducing the extraction rate of oil.

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[8] i.e., of the gross fractions: hull; oil; and defatted kernel.

[9] With sunflower it is usually necessary to leave a certain amount of the hull in the seed matrix when processing with a screw-type expeller. This is normally about 10% of the total fraction of the material to process.

The obvious solution to the excessive wear caused by the abrasive nature of the sunflower hulls is to remove them before processing. This is the normal practice with any commercial installation. This preprocessing of the seed will also be accompanied by a seed cleaning process to remove dirt and abrasive foreign matter, and heat treatment to help release the oil and improve the extraction rate. It is much less common for the small motorized operations and the hand and animal powered operations to practice seed decortication. A small, locally-manufactured, hand-operated decorticator is available, and could provide a good solution for the hand-operated and very small motorized processors.

Another factor in the longevity of the equipment is the cleanliness of the seed. The ZAMS oilseed study notes that ZATCO had estimated that 15% to 30% of the material delivered was foreign matter, including trash, stones, dirt and sand. Our observations at commercial oilseed processing plants would confirm this. At Southern Africa Oil Mills it was observed that very large amounts of dirt and sand, along with other foreign matter, were included in the sunflower seed. This seed had to be cleaned prior to processing, resulting in an extra processing cost as well as loss of volume and weight. However, by processing clean seed, the wear on the machines was reduced, and the oil was sufficiently purified in one filter press to produce saleable cooking oil from sunflower. It is not only that dirty seed can cause excessive wear to the machinery during processing but it means the processor is buying seed at a high price, paying seed price for foreign matter. Dirty seed also will produce dirty oil, requiring extra refining to produce edible oil.

G. The Problem of Producing Quality Wear Parts in Zambia.

The high pressures generated when processing most seeds for edible oil require extremely robust machinery. When continuous contact is made with the seed, the contact portions of the machine where high pressure is exerted must also be able to withstand wear. The wear factor is compounded when the material being processed is also very abrasive. The edges of the wear parts in processing equipment are hardened, and then they are tempered so that they do not become brittle. Hardsurfacing, although an old technology, requires a relatively sophisticated process. This technology is not wide-spread in Africa. One way to avoid the problem of hardsurfacing and tempering the metal, is to reduce to the minimum the amount of moving surface area under stress. This has been the main reason for the development of such machines as the ram press, which came about as a solution to the problem of getting parts hard-surfaced and tempered.

Because hard-surfacing and tempering has generally been considered too difficult to accomplish in Africa, the small and medium-sized motorized screw expellers were usually not promoted except in the larger commercial operations which had access to imported replacement spares. As we noted above, the cost for the small KOMET expeller screws was $400.00 per screw in foreign exchange for purchase and shipment and K 35,000 for duties, in addition to mechanics costs. These prices could not be supported on a commercial basis at today's interest rates.

Screw expellers requiring hard-surfaced wear parts can be used in Zambia. The solution is to

develop the ability to manufacture these spares locally. Not only would this save foreign exchange, but it would make spares readily available and therefore cut downtime on existing machinery - hence saving on capital investment costs. We believe that this solution is available in Zambia. Not only are there workshops that can provide these services (see appended discussion of BOART in Ndola), but we believe that they are capable of providing technical services to the larger commercial food processing industries as well.

H. Program Actions for ZAMS in the Oilseed and Edible Oils Sector.

There are several actions or interventions that the ZAMS Project could make (or continue to make) in the oilseed and edible oil sector. Although we list these separately, it should be understood that a certain amount of integration of actions from production through processing, including support services for processors, to packaging and marketing will be needed. The suggestions recognize the distinctive problems of the off-the-road rural areas as opposed to the urban, semi urban and small town settings.

1. Continue the development of equipment that offers the people in remote rural areas the possibility of processing their own oilseeds for home consumption and small commercial sales within the rural community. At this point the best equipment would appear to be the KIT process, including the use of decorticator for sunflower seed processing. Without decorticating, only the ram press is capable of processing whole sunflower without motorized equipment. However, if hand processing of whole sunflower seed is to be promoted, it is imperative that improved oil type varieties of sunflower be introduced. This can best be done through the processors who could supply the seed and promote its use with a differential pricing policy based on high oil content of the sunflower seed purchased.

   Although the ZAMS oilseed processing study had strong misgivings about processing groundnuts for oil, we feel that their fears were over-stated in terms of the evidence available on the dangers of aflatoxin. Even if the chance of aflatoxin was as great as they imply, the fact that it generally develops in the harvested groundnuts when they are improperly harvested, dried and stored means that even without processing into oil and meal, consumers can run the risk of ingesting aflatoxin.

   A small amount of sesame seed is produced in the country. This crop could be much more important as an oilseed. It has a high oil content, and the oil is a premium oil. In addition, there is a substantial export market for whole sesame seed, offering an alternative in the event of over-production for local processing.

2. For sunflower production, there is a need to promote better husbandry techniques among small farmers, including use of improved varieties. We think this would be best done in conjunction with the development of small- and medium-scale processing. The most logical system would be for processors to promote the production of improved seed for processing by: (1) establishing contract growing schemes that included some type of

production extension and input supply; and (2) establishing a differential pricing system based on seed quality and oil content. The organizational system would be similar to the type used by horticultural processors and packers where small outgrowers are used. Processors would encourage small producers to grow specific varieties by supplying the seed under repurchase contracts. The processors may need to develop their own extension system in support of their contract growing schemes.

3. The Project should help processors to identify machine shops where spares can be made in Zambia, and then work with processors and machine shops to find solutions to the spare parts problem for the small- and medium-scale screw expellers.

4. The Project should continue investigations into edible and inedible oils other than sunflower and groundnuts for the small processors and sunflower and soybeans for the medium processors. A more thorough investigation into the potential for castor seed, oil palm and sesame seed for oil production for food and industrial purposes should be carried out.

5. For the long-term development of the oilseed sector ZAMS should consider undertaking an in-depth study of the sector, including all aspects of production, crop marketing, storage, processing, and wholesale and retail marketing of the oil and cake. This would also look at the related industries such as livestock feed production and high-protein fortified foods, inasmuch as they are important to the demand analysis of the sector. The study should encompass the entire sector regardless of production or processing scale. It would look not only at supply and demand factors, but also at efficiencies in marketing and processing, degree of industry concentration and fragmentation, and constraints to the further development of the industry and improving its efficiency.

VII. LIGHT INDUSTRY POTENTIAL IN ZAMBIA

In general the study team felt that the capital investment that has been made in machine shops and factories in Zambia far exceeds that found in most other countries in Africa. It is also obvious that the capacity of those establishments is greatly under-utilized. It would appear that the physical and technical capacity found in the country will be increasingly under-utilized as the copper industry declines, unless alternate uses can be found for that capacity.

We felt that there was a general lack of awareness among technicians, and managers of workshops, retail firms, factories, processors and others about the breath and depth of technical services that can be found in the country. In discussions with people in one part of the country we were left with the opinion that they were unaware of the technical capacities elsewhere in the country. Often people looked to the outside; Europe, India and South Africa for services that appeared to be available in Zambia.

This probably stems somewhat from the type of command economy that Zambia operated until last year. With the vast majority of businesses either organized as parastatals or working for parastatals or government agencies, firms were conditioned to wait for business to come to them. Thus management did not look for solutions and opportunities as aggressively as they might have. By the same token, it is probably also true that advertising was very limited. Firms did not feel the need to publicize their expertise and capabilities to the extent that would be needed to become commonly known throughout the country. Without this individual advertising the aggregate knowledge found within the country about Zambian firms' capabilities is limited.

As the economy begins to open up, and all firms are facing the challenge of operating without special dispensation, favor or subsidy from government, the conditions of operating a business will change. We cannot over-emphasize this point. Reportedly the approximately 140 state firms that operated under Zambia Industrial and Mining Corporation (ZIMCO) controlled (and to a great extent still control) 80% of the economic activity in the country. Ingenuity and imagination were neither requirements for management nor were they likely to have been rewarded under this system. In a very real sense management only passed on orders and organized the work output demanded by others. With neither boards of directors nor stockholders watching the financial results, there was no incentive to work efficiently and to capacity. With management now being asked to cover costs within each individual firm instead of passing on losses (if they even knew what their firms losses were) to be absorbed by the generally economy, management is uncertain how to proceed. This is already evident with some of the parastatals such as ESCO, which can no longer depend on a steady flow of work from other parastatals and government agencies. However, it is also being felt even in the private sector, especially in the Copperbelt, where reliance on government subsidized parastatals for work orders is no longer assured.

We did get the sense that many of these firms; government, parastatal and private, were unsure of how to generate business under this new economic environment. Previously these firms responded to orders received for work. Because most work was for the mines or other parastatal companies it was often multiple orders for the same items which permitted firms to set up jigs for continuous runs. The main management concerns were setting up and organizing the workshop. Creation of items and marketing were not major management concerns. Nor has management ever had to concern themselves with cash flows, bank lending, calculating depreciation and amortization, turnovers, accounts receivable, or meeting payrolls. Most managers seem to be only concerned with the volume of work needed to continue business as usual. They will likely find there are other concerns facing management.

At the current time, it is unlikely that sufficient unsolicited orders will come in to justify the capital investment that many of these establishments have. At least the volume of orders is unlikely to fully occupy their current staff and investment in equipment. In order for many of these workshops to operate they are going to have to either (1) develop their own products for manufacture and sale, or (2) go out and find someone who has a design who needs a workshop for production. In the former case management either creates a demand for a product that the workshop has developed or invented or finds a niche and fills it with a product. In the latter case management uses its resources to fill an existing need such as manufacturing parts for a mine or

building hammermills to contract terms and specifications. One is an inventive role for management, the other is a sales role.

The economy of Zambia is undergoing a metamorphosis that will hopefully take it away from a mode of protecting certain groups and industries. As a more competitive economy emerges businesses will have to take on new responsibilities and learn new skills. Some of this will occur naturally as government removes barriers or obstacles to industry and business. However, there is an opportunity for ZAMS to take an active role in helping industry to adjust to this new economic climate and move to more normal business activities. We discuss some of the possible actions below:

1. A first step in working with the industrial and agribusiness sector is to inventory and evaluate the existing capabilities, capacities and technical levels of firms in Zambia.

   Zambia has skilled technicians and well-equipped workshops, laboratories and factories in a wide range of small businesses and light industries. However these are not well known. We feel that one of the most valuable contributions that the ZAMS Project can make during this period in Zambia's economic restructuring is to acquaint people who need services to the capabilities available. To this end we recommend that a compendium or register of firms be developed similar to the *Thomas Register of American Manufacturers* in the United States. The Register would be organized according to types of skills or technical ability that each company can offer, the capacity of each company, each company's location, and other pertinent information that would assist someone who is looking for a specific service, such as the manufacturing of a spare part, hard-surfacing of metal, or electroplating.

   In order for the register to be useful, and to aid the firms as well as the users, it must be more than a simple listing of the names of firms. To this end we recommend creating a "Registry" in ZAMS which would have technical specialists, editors and printing capabilities. We suggest that expert assessment of the firms be undertaken, so that the registry can make an assessment of each registered firm's capacity and technical and physical competence. This assessment must be enough in-depth and with sufficient accuracy that confidence in the register will be gained both inside and outside of Zambia. Therefore it will be necessary for ZAMS to engage an expatriate technician who is sufficiently knowledgeable about workshops to make such an assessment. The Project should also hire at least one Zambian with similar or complementary skills.

   These people would initiate the process of assembling the register by contacting workshops throughout the country and developing a 1-2 page "proof" sheet of the firm. Working with the firm the ZAMS staff would put the proof sheets into a printable form. The register could be assembled as a loose-leaf notebook so that additions could be made as they become available, and new sheets could be inserted when firms change their ability, or expand into new areas. Smaller brochure-type directories could be produced aimed at specific industries or groups such as the hammermill owners and operators.

The registry could start with one or two areas such as metal machining and woodworking. As the project progressed, other areas should be added such as specific dealers for imported items like farm machinery and spares, shops that rebuild or rewind electric motors, specialists in engineering design and layout and crafts such as leather goods.

The register would be given as wide a circulation as possible. Initially it could be given free to anyone who had a need for it. The register should also be distributed as much as possible in neighboring countries, and advertised through Africa-specific publications like ***African Business*** or ***African Agriculture***.

Initially the register would be produced by the ZAMS Project, but it is logical for such a directory to be taken over by a private publishing firm. If the register is professionally produced it is likely that firms will request to be included, and most would be willing to pay for their listing. It is also possible that users of the register will be willing to pay for the register as is the case in most countries. It should at least be a goal of the ZAMS Project to produce a commercial product and to that end a collaborating publisher should be sought as soon as possible.

2. A natural outgrowth of the inventory of firms will be an assessment of the problems facing the management of these firms. This can lead the ZAMS Project to develop seminars, trade shows, training sessions, or other aids that can help to promote the business of the firms and to assist management in streamlining their businesses or making them aware of opportunities that could be taken.

3. We believe that many of the workshops or factories in Zambia could produce for the Southern and Eastern African regional market. One way to help in this promotion will be the register mentioned in #1 above. Other efforts should also be made. Trade fairs sponsored by such organizations as the Association of Manufacturers, Chamber of Commerce, or the Commercial Farmers Association, together with assistance from ZAMS (and USAID or other donors and government agencies) would offer exposure of local manufacturers with buyers throughout the region. These could be organized on product-specific basis in an area where production of the product is most concentrated - the Copperbelt for example. Other promotional tactics might be used such as assisting Zambian manufacturers to exhibit at neighboring trade shows such as the one to be held in Zimbabwe in April and May (ZITF'92, at Bulawayo).

4. One way for local manufacturers to learn how to produce machinery for sale or export is to copy existing machinery. This technique launched the Japanese industrial expansion after WWII, and is widely used in China and India today. There are several pieces of equipment that can be copied because their patents have expired, yet would find a ready market. Some that come to mind are the medium-sized oilseed expellers that have been on the market since the mid-1940s, animal traction equipment that was developed in the late 1950s and early 1960s, rice threshers and hullers that have been around for over 20 years, grain cleaning and conditioning equipment, and even electric motors and

transformers could be duplicated locally. There is also an immense untapped market for spare parts throughout the region.

Because such manufacturing would pose high risks to firms in Zambia until the manufacturing techniques were mastered and markets fully developed, there may be a need to assist these firms. The length and degree of the assistance should be set according to the learning curve of the manufacturing process and the difficulty and risk in market establishment.

5. Irregardless of the fact that there is considerable unused capacity for light industry in Zambia, the system must be market driven. It would be unwise to produce simply to employ machines and factory investment. For this reason it is essential to put into place a mechanism to help identify markets and match up those market potentials with existing physical and technical capacity. The recommended timing of the interventions suggested here should allow a phased program that permits market identification ahead of manufacturing expansion. As the inventory and assessment of firms takes place, ZAMS will get a clearer idea of the capacities of the firms in Zambia. With that knowledge ZAMS can begin to scout out markets that are consistent with the existing capacity of Zambian manufacturers. Financial and Pricing studies can then be done to sort out which types of things can be made and by whom.

6. At some stage, preferably starting when the inventory and assessment of firms is underway, a study of the constraints to the manufacturing sector should be undertaken. By this we mean doing one or two case studies of firms to determine what things impede their progress toward full market oriented production, and their integration into a wider regional market. This will include looking at banking regulations and policies including the ways credit is allocated and its costs, the government licensing and other regulatory systems affecting manufacturers, tax law and its implications, and informal constraints to business. The aim would be to identify constraints to business development and expansion and recommend policy, legal, tax or other changes that would permit an improved business environment under which industry could operate.

It is the stated aim of the current government to open up the economy, move it to a market driven system, and encourage private sector investment, both local and foreign. However, traditional policies in Zambia since independence have favored an anti private sector economy, heavily centralized in government parastatals, supported by low-cost food policies, insular in orientation with immense suspicion of foreign investment. The extent to which government is able to redirect policy, and the extent to which that redirection will create a strong private sector environment will have immense bearing on how well the light industry sector will perform. It is therefore the recommendation of this study to go slowly until the implications of policy reform are more clearly understood. For example, if foreign investment is permitted and foreign investors are allowed to trade freely in the export market, and foreign exchange retention is fully permitted, the result could be infusions of money into some rural areas that would stimulate

demand for products that could be manufactured locally, like the hammermills and oil presses. If government proceeds in privatizing several government parastatals like the maize mills and oilseed processing factories, as it has stated, local machine shops may be in a better position to work with new owners and managers with factory refurbishing or machine design. If private traders are to take over the marketing of staple foods like maize, there may arise a need for storage facilities that could be manufactured locally. Until we see the legal and regulatory changes needed to improve the business climate and the methods and extent of implementing those changes, we remain cautious and yet optimistic.

ANNEX A

SOUTHERN PROVINCE FIELD TRIP

ROUTE: Lusaka-Masabuka-Magoye-Monze-Pemba-Choma-Kalomo-Zimba and Livingstone (Taken in two separate trips)

MASABUKA - KALAYA ENGINEERING

Kalaya Engineering, a subsidiary of BOART Engineering of Kitwe, is an engineering, machining and manufacturing company located just outside of Mazabuaka in the Southern Province. This area has a concentration of intensive agriculture, the most important being the large sugarcane plantation and associated cane outgrowers. Additionally there is extensive irrigation and recession farming in the region on small and medium-sized farms. Masabuka is one of the larger towns on the line-of-road, line-of-rail. It is situated on the Kafue River, and adjacent to Lake Kafue, the lake created by the installation of the large hydro-electric power dam on the Kafue. It is the urban center for a large concentration of commercial farming activities.

Kalaya's workshops, located just outside of the town, are well-equipped with machine tools. The workshop is capable of undertaking a variety of engineering and manufacturing activities. The company specializes in agricultural equipment for production and processing. Kalaya manufactures hammermills which are fitted with a water-cooled diesel engine from India called the Nulux. Many parts on this engine are interchangeable with the Indian Koliskor and older model Peter engines.

MAGOYE REGIONAL RESEARCH STATION

Magoye Regional Research Station (RRS) is the national center for testing and developing agricultural equipment. The station also carries out crop research in cooperation with Mount Makulu RRS, Lusaka. The agricultural equipment testing and development facilities were set up at Magoye in 1972. These include a well-equipped light engineering workshop with further facilities for vehicle maintenance and woodwork. Unfortunately, these facilities are little used due to the lack of operating funds from the government. The Dutch are currently making considerable inputs for testing of agricultural equipment. Part of that assistance is in the form of a new workshop and importation of various items of animal drawn agricultural implements for testing. For the most part, the existing facilities, which had been constructed with the help of British aid, are used only for storage. Its a pity the existing facilities cannot be upgraded and used rather than the duplication that is going on.

The workshop facilities that exist at Magoye could provide a valuable service to the community in repair, manufacturing and service to engines. Providing service and repairs could also generate valuable and needed income for the station.

MONZE

Monze is a medium-sized town on the main north-south road, about 60 km south of Mazabuka. Monze is situated in a good farming area that includes commercial farms along the line-of-rail. There are several small- to medium-sized farms in the area as well as several near-subsistence farms. Africare's oilseed project is centered here.

The Africare project Women's Club at Tusole - 41km off the tarmac are operating a ram-type oil press supplied free by TDAU.

The handle of their first press broke two months after the machine was supplied in June 1989. A new machine was installed but has had to be repaired several times due to problems with the choke screw. The piston is also showing signs of advanced wear after 9 x 50kg bags of seed (whole sunflower) had been processed.

The output of the press was given as 10 liters of crude oil per 50kg bag of seed. However, this figure is doubtful and 5 liters per bag would be more realistic. The reason for the difference is that the output is estimated from crude oil and not from the actual filtered oil. Also, the output was measured only from one batch of processed seed, using a small quantity. Measuring oil output from continuous pressing and as filtered (useable) oil will considerably reduce output. Oil is sold for K 150 x 750ml (K 200 per liter) whilst the oilseed cake is sold for K 300 x 50kg to dairy farmers.

Groundnuts are also grown in the area, and could provide a potential for oil production. Figures for groundnuts grown in the area are as follows:

- 12 bags at 80kg unshelled per ha.
- 3 bags of unshelled nuts produces one bag of shelled units (by volume)
- 4 bags of shelled nuts are 320 kg, the produce from 1 ha.

The ladies operating the ram press have very little technical or business experience. Any breakdowns of the machine involve a round trip of 80km to Monze. There is no regular transport through the area such as a market truck. Transport of machines as well as saleable produce is on an ad hoc basis.

PEMBA WOMEN'S CLUB

Pemba is a small town on the main north-south road, about 30 km south of Monze. Like most towns on the main road, it is served with electricity and some other utilities, has commercial businesses and some private workshops. It is a relatively important commercial hub for small-farmers and villagers living in the rural area around the town.

Pemba Women's Club is a private enterprise run by 25 women, of which 8 are active in the business. The business operates from reasonable premises on the main street in Pemba, on the main Lusaka-Livingstone road. Activities began in Oct 1989 with bread making, sewing of bed quilts and rental of wedding dresses. With the proceeds from these activities the group decided to expand into oil pressing from sunflower seed.

First choice of equipment was the screw press kit manufactured by Lutanda Ltd. of Lusaka. The kit is made up of four items of equipment - a decorticator, winnower, roller mill and screw press. Processing of sunflower is as follows:

1. The seed is put through the decorticator to release the kernel which contains the oil.
2. The winnower separates the hulls from the kernels and any unbroken seeds.
3. The roller mill machine flattens the kernels and increases their surface area to help absorb moisture and heat.
4. Conditioning - it is necessary to add water and then heat the crushed kernels in order to expel the oil more easily.
5. The material is then loaded into the pressing cylinder and pressed in the screw press.
6. The collected oil is filtered and clarified by heating the oil slowly.

Unfortunately Lutanda Ltd. could only supply the winnower and the screw press. Being unable to complete the process without all the equipment, the ladies returned the two items to Lutanda and purchased two ram type presses from GAMECO in Lusaka at a cost of K 56,000 each.

The women's group constructed a suitable building, which has half-height walls, a metal roof and floor. Operations started in Sept 1991. Six men were employed to operate the presses 6 hours per day (they are now working 2 x 6 hour shifts). At that time oil was sold for k 140 per 750ml. Prices have increased recently due to both general increase in prices and the fact that the small mechanical screw press in Pemba (see Electric Mini Screw Press below) was out of service. The price now is K 180 per 750ml (Jan 92). The ladies claim 30lt of crude oil from 5 bags of sunflower seed. The residue cake is sold for K 680 per 50 kg bag. Again there seemed to be some misunderstanding as to oil output. In this case, the group said that they lost no oil during heating, filtering and clarifying, which could not be true.

Income and expenditure figures for Nov 91 are:

Income

Oil	K 85,000
Cake	K 42,000

(based on a 6 hour operating day)

Expenditure

90 bags of sunflower seed	K 67,500
Salaries @ K1,500/month x 6	K 9,000

Sunflower seed is purchased locally for K 750 per 50 kg bag.

The Pemba Women's Club is an active group who pay their own way. They are now having increasingly frequent mechanical problems with the two ram presses. The handles have broken several times and they had to get them welded at the local garage repair shop. Pistons and pivot parts are showing signs of advanced wear. It is doubtful if the presses can be kept in operation long enough for the capital outlay on the machines to be recovered.

The women are still interested in purchasing the Lutanda kit providing they can raise the necessary capital.

GAMECO - PEMBA

GAMECO, Pemba have supplied 8 small screw presses free to different groups at various out of town location in the area. A women's group in Pemba has been pressing shelled, whole groundnuts without pre-processing with their machine. With much effort about 120 ml of oil is squeezed from 2 kg of groundnuts.

Mr. Derrick Burgess, ZAMS agricultural engineer carried out an on-the-spot demonstration of pre-press processing of groundnuts. This involved crushing the nuts, mixing with a small quantity of water and cooking for a short period to assist in releasing the oil from the nuts when pressed. The result when 2 kg of thus treated nuts was double the amount of oil (240ml).

The GAMECO screw press is not very well constructed. The screw thread is poorly cut and there is a slack fit in the nut. The pressing cage is made from 3mm steel plate drilled with small holes to let the oil out. A major construction mistake with the cage is that it is formed into a box, 100mm square x 300mm long. When pressure is applied the cage tends to bulge on the sides reverting toward a circular cage. However, the pressing piston retains its square shape, and

the pressing is uneven. A cylinder is the only form that will stand the pressures generated when pressing without deforming. The square cage deforms easily.

MACOMBA MENS CLUB

Situated close to a school 17km out of Pemba on the Choma-Namwala road, the group are at present installing a screw press supplied by GAMECO. A thatched shelter has been constructed with a concrete foundation for the press.

This press is of a cylindrical construction, and more robust than the earlier square designs. However, the press suffers from some of the same problems as the one demonstrated in Pemba. Basically poor workmanship in the construction of the press has resulted in the screw being out of vertical. Damage to the frame has resulted through the use of an oversized cage (150mm dia), which requires an extra pressure on the screw. The extra load required for pressing has bent the top member. Modifications and repairs will have to be carried out in Pemba.

JEMBO - HAKANYONA COMMUNITY DEVELOPMENT PROJECT, 40KM S.S. OF PEMBA.

The project is located at a government school and is run by two groups of women that operate a screw press supplied free by GAMECO.

The group is split into two with one group operating on alternate days of the week. Shelled whole groundnuts are pressed without any pre-press processing. The venture is not a commercial one, oil is for local consumption only. Mr. Burgess gave advice on pre-pressing preparation of the groundnuts in order to obtain increased oil output.

ELECTRIC MINI SCREW PRESS - PEMBA

Mr. Armin Scherrer, a young German, started a small sunflower oil pressing business about one year ago. He purchased a KOMET double spindle screw press from Usawa Trading Co. Ltd., Lusaka. The machine is of German manufacture and operates with an electric motor. The machine produces about 5lt (after filtering) of clean oil per hour. Mr. Scherrer is making an effort to grade the sunflower seed he purchases by sampling a small quantity for oil output before purchasing in bulk. Oil output varies from 10+ lt per 50kg to 5 lt per 50kg bag. Some seed deteriorates, giving the oil a bad smell or color. It is clear that proper seed varieties, production techniques, harvesting and storage are needed for promotion of commercial oilseed production and oil processing. Farmers need to be encouraged to improve farming methods when growing sunflower, including using improved varieties with higher oil content and lower hull, and to plant to take advantage of the full rainy season as well as the use of fertilizer. These practices should greatly increase the oil content of the seed, make processing easier and more profitable, and reduce wear on processing equipment. However, it was only at this installation where we found

any attempt to buy seed according to quality. Even among the larger commercial processors this is not done.

Major problems with the machine are wear to the cage and expeller. Cages can be made in Zambia (Kalaya Engineering, Mazabuka) at a cost of K 10,000 per pair. Attempts have been made to produce the screw locally, without success to date and new ones have to be imported from Germany for a total cost each of K 83,300, (US 850) K 34,300 of this total being import duty. Foreign exchange costs equalled $400 c.i.f. Lusaka for each screw ($800 per pair). About 2,200 lt of oil can be produced before an expeller screw is worn out. At a production rate of 50 lt of oil per day, an expeller screw will last 44 days.

With careful seed selection, an extra 400 to 600 lt of oil can be extracted per screw before they are worn out. A cage has 1.5 times longer life than an expeller screw.

The following is a breakdown of Mr. Scherrer's income and expenditure over a period of 4 months based on a 5-day working week:

	Income	Expend.
4,400 lt of oil @ K 200 per lt	880,000	
15,400 kg of seed cake @ K 10 per kg	154,000	
440 50 kg bags of seed @ K 700 each		308,000
Salaries for 3 workers x 4 months		41,600
Electricity		4,000
House rent		10,000
Administration		10,000
Soap, buckets, gear oil		20,000
Two locally made cages		10,000
	1034,000	393,600

It should be noted that allowance had not been made for depreciation of the machinery and plant.

DELO GARAGE - PEMBA

This is the only substantial workshop in Pemba and is typical of others in similar sized towns. The business is 15 year old, major activities being motor vehicle repair. Customers are required to supply their own spares, as the garage owner does not have the capital to supply spares before being paid for work. The mechanic/owner usually disassembles a vehicle or tractor, lists the spares needed and asks the owner to go and buy the spares needed. This has resulted in vehicles being left in a disassembled state on garage property. In some cases vehicles have been left for several months, and sometimes even several years. It is not easy to determine if the vehicles have been abandoned or if eventually the owner will obtain the money needed and purchase

spares. Vehicles at the garage that had been there for prolonged periods included both individual private vehicles and cooperative vehicles. This situation is aggravated by the general lack of spares and foreign exchange. Conditions in the workshop are untidy with equipment dilapidated from many years of use and abuse.

Repairs to agricultural or other equipment is limited to simple cutting, bending, and electric or gas welding. The proprietor is willing to work on small diesel engines from hammer mills etc but would charge in the region of K 200 per km for transport of the engine from site to garage and return.

The owner is also interested in improving his capability for the repair of agricultural and other equipment. However, this would require considerable inputs of tools and technical training. He states that he does not have the finances to purchase the additional tools that he would need to expand his business.

CHOMA

Choma is a relatively important commercial center about midway between Mazabuka and Livingstone. It contains commercial outlets, cooperatives, processing centers, warehousing, workshops, markets and educational facilities. Choma has developed as an important commercial center in the region due not only to its location and transport and communications facilities, but also to the agricultural resources in the vicinity. It is one of the centers targeted for a VIS workshop.

CHOMA TRADES TRAINING INSTITUTE

Choma Trades Institute is a post-secondary technical training institute. Its objective is to prepare students for the technical trades in business and industry. The parastatal sector has been the major potential for employment for its graduates. At various times, the college had received assistance from UK, Germany, and recently Japan in the form of equipment, materials and other inputs and technical assistance. After two years students sit the Zambia Craft Examination, Intermediate Certificate after which they go to industry or Government for one or two years for work experience. The employer reports to the college on the students progress. If satisfactory, a full certificate is awarded. Many graduates are absorbed into Government posts.

The Institute has a well laid-out campus with classrooms, workshops and student accommodation. Six two-year technical courses are offered to 12 students who have completed secondary school. The Institute has a bi-annual intake which has recently increased from 48 to 96 students (16 per course). The courses offered at the Institute are:

- Automotive Mechanics
- Machine Shop Practice
- Engineering Fitting
- Household Electrical Eng.
- Carpentry
- Bricklaying

The courses are run on a basis of 50% practice and 50% theory. Many of the lecturers have the same educational and technical background with experience in industry or government. Nine such colleges exist in Zambia covering disciplines such as: commercial, medical, managerial, and finance.

In a discussion held with the principal, he indicated the college would be willing to assist in training hammermill operators in simple engine maintenance techniques for small diesel engines. The college at present offers a repair service to the public as part of the training courses. Spare parts are supplied by owners. Charges made for labor and wear and tear on tools and equipment are, however not realistic. All work is carried out by students under supervision. Examples of work carried out and charges is as follows:

Service - oil change		K 500
Overhaul	2 cylinder	K 1,000
	4 cylinder	K 2,000
	8 cylinder	K 3,500
Re-bore/honing		K 2,000
Cylinder head truing		K 400
Valve grinding		K 400
Transmission service		K 1,500
Starter motor repair		K 600
Distributor overhaul		K 150
Fuel pump		K 150
Steering		K 350
Ball joints		K 300
Radiator repair		K 150
Wheel balance		K 100

ENGINEERING SERVICES CORPORATION (ESCO) - CHOMA

ESCO-Choma is part of the nation-wide parastatal repair and service garages and workshops. Three levels of these workshops exist: the central such as in Lusaka; secondary in Provincial towns; and District, such as this in Choma. ESCO is going through the painful process of changing from a Government service involved in the repair of GRZ vehicles, to a private enterprise having to operate on a commercial basis.

Vehicles of all types, up to road repair equipment, can and have been repaired but it appears GRZ vehicles or parastatal vehicles still dominate the scene. Engines are overhauled at ESCO's Southern Province main workshop in Livingstone. Full workshops are located in all provinces, with smaller workshops located in other towns.

Work is charged by the hour with ESCO providing the spare parts. Parts that have been in stock for a long time are charged at the original purchase price, inflation and other increases not being taken into consideration.

Mechanics salaries have increased from K 1,030 under Government in 1989, to K 1,895 in 1989 when ESCO was privatized. A 45% per annum salary increase gives a present day figure of K 4,451 of which K 720 is income tax. However, ESCO still reported that they were losing technicians, mostly to the private sector. There is some question of the ability of ESCO to meet its payroll, with reports of long delays in making salary payments. This may have been the main reason for the flight of technicians.

LIVINGSTONE

Livingstone is the Provincial Capital of the Southern Province. It is also a major tourist center due to its proximity to Victoria Falls. Livingstone has gone through several changes in its history, from territorial capital to main center of business and new immigration. It is the first point where the old Rhodesian Railway crossed into the territory. It has been a times a center for commercial logging and sawmill operations, and still boasts some sawmill industry. It has a railway workshop for Zambian railways, and at one time was a main center for coaling steam locomotives. It has the unfortunate problem as Provincial capital of being situated on the southern border of the Province.

ESCO - LIVINGSTONE

ESCO Livingstone is a second-tier facility of the parastatal garage and workshop system at the Provincial level. It handles some of the more difficult work that cannot be performed at District workshops like Choma. ESCO's workshop in Livingstone is a well-equipped facility capable of major engine overhauls and vehicle repairs such as rebores, crankshaft grinding and diesel injector testing. Calibration of diesel injector pumps has to be carried out in Lusaka. ESCO

does have breakdown facilities to collect vehicles or engines but charge a fee of not less than K 150 per km. Repair cost estimates are given after the engine is stripped down.

The workshop is also equipped with a range of machine tools that could be used for the manufacture of spare parts for oil presses, hammermills or other agricultural equipment. The workshop could also be used for small scale manufacturing of complete items.

Large quantities of scrap vehicle parts are available such as springs, shafts and aluminum castings, gear boxes, pistons and clutch housing. These scrap materials are available for sale to the public.

As with ESCO, Choma, there appears to be very little activity; the management and staff not yet having come to terms with their new commercial status. After discussions with ESCO personnel we felt that they were generally eager to move into a more commercial role but that they were unaware about how to proceed. Years of having business sent via Central Government orders has conditioned these managers to wait for work to arrive at their doorstep. There are several things that could be done in order for workshops like ESCO's to move to a commercial basis. Some possibilities are:

- the workshops would have to calculate the value of its facilities and determine a cost per hour of operating or standing idle;

- the workshop management would have to determine what their facilities were capable of producing or doing, and then determine what gaps for services or manufactured goods exist in the communities where they operate;

- the workshops will have to shift to an incentive based remuneration package, either through higher wage packages or through "jobbing" pay systems;

- the workshop management will have to market their facilities and technical abilities through such things as contract service to private transporters, outshop servicing for such things as generators, tractors, etc or through specialized services they can offer to other garages such as crankshaft grinding.

COPPERBELT AND NORTHERN PROVINCE FIELD TRIP

ROUTE: Lusaka-Kabwe-Ndola-Kitwe-Mpeka

KABWE

Kabwe, formerly Broken Hill, is one of the oldest commercial towns in Zambia. The railroad reached Broken Hill in 1906, the center of mining activities in the country. Heavily influenced by mining and the adjacent commercial farming activities that supported the mines, Broken Hill, along with Lusaka and Livingstone contained ½ of the European population by 1921. Although mining activity subsequently shifted further north along the border with Zaire (Belgian Congo) present day Kabwe still has a significant mining presence. Other industrial activities also occur here and it has a major railway workshop for Zambian railways. The neighboring countryside has a significant commercial farming community.

CENTRAL PROVINCE COOPERATIVE UNION (CPCU) - KABWE

From the discussions with Dr. Kilpadi, FAO expert working with CPCU, Kabwe, it would appear that technical repair facilities and engine maintenance workshops do exist in the Kabwe area. The Cooperative Union and ESCO have workshops equipped for vehicle or engine maintenance whilst the railway workshops at Kalaya offer a service of machining, spare parts manufacture or production of complete items. However, service from the railway workshops is said to be slow. The town itself has several garages and small private workshops capable of simple engine maintenance, and general iron and steel work.

Kabwe is also in a zone of fairly intensive commercial agriculture. Several large- and medium-sized farms are found around Kabwe. The region is reasonably well served by a system of secondary roads reaching throughout the commercial farming community. In addition to farm workshops found on most of the larger commercial farms, the town of Kabwe has developed a certain amount of capacity to service the needs of the farming community. Several of the Lusaka based equipment dealers can be found in the town, offering better access to spare parts than is found in many other towns in the country. Its commercial ties are to both Lusaka and the Copperbelt, and transport and communications to both urban areas is good.

Kabwe Transport International (KTI) - Kabwe

According to Mr. B. Kuntawala, GM the company's activities were set up in 1960, as part of nine other companies under the same management. KTI is the operations and repair center for the heavy trucking and haulage business for the firm, which operates throughout Botswana, Zaire, Zimbabwe, South Africa and Malawi. The Kabwe workshops are the center for maintenance of the 50+ vehicle fleet. The workshops are well-organized, and handle everything from routine

servicing to rebuilding of vehicles. For example, wrecked trucks are completely rebuilt at the workshop, from frames, through engines and bodies. A small workshop area is set aside for the repair of private vehicles, and this service has been made publicly available for service and repair since 1991. The company is willing to service small diesel engines as well as other equipment, but it makes it clear that company transport and other company business takes priority when allocating labor, tools and workspace to jobs. The company has mobile workshops that it uses to take care of road service and repair of trucks when needed. Because of the cost of operating the service trucks, however, this service is quite expensive. It makes sense economically for the company when dealing with its own trucks due to the heavy capital investment involved in the trucks and cargo. It would probably be too expensive to use for light engine service and repair. A service may also be available for the transport of engines brought to the main highway from the more remote areas.

Other companies in the group are involved in agriculture, construction, and stone quarrying. The whole business is very impressive and very well run. The Zambian labor force are skilled and active, and excellent organization and management is evident.

MPONGWE MISSION

Mpongwe mission, located near Mpongwe which is situated 40 km west of the main Lusaka - Ndola highway, and about 70 km south of Kitwe. The mission has two small workshops, one capable of simple engine maintenance and metal work, and the other set up for woodwork. It was hoped the facility would be available for the maintenance of diesel engines operating hammermills in the area. However, a change of administration now makes this unlikely. It appeared that the concentration was now on the manufacture of items from wood, with almost no activity in the engine and machine shop. It appears that the latter is used only for maintenance of the mission's fleet and to do repair work for the mission facilities.

MPONGWE - GENERAL

Mpongwe has benefitted from an integrated rural development project financed by the Europeans for a number of years. The project has undertaken a wide variety of activities including road and bridge construction, installation of hammermills, marketing, and most recently the development of rural industrial zones. In the latter case, the Project will install transformers, electric power lines and water systems in an area that will be sub-divided for small industries. There may be a possibility of assisting a repair workshop in this zone. The advantages it offers over other rural areas of the country are:

- a greater density of population due to a fairly fertile region;
- reasonable linkages to the industrial north of the Copperbelt, helping to assure raw material supplies can be obtained, spare parts can be found, and more advanced workshop skills can be tapped;

- a higher than normal level of economic activity that is, at least in part, supported by the relatively high number of people who have retired from jobs in the Copperbelt that have settled in the area;

- a reasonable level of mechanical installations on farms, at mill installations and with road traffic, which should help to create enough business to support a workshop; and

- an apparent level of expertise that is the result of development projects, mission activities and government and private commercial farming activities.

KITWE

Kitwe is one of the main industrial and mining cities of Zambia, located in the Copperbelt. Kitwe is a large urban center, with extensive business and industrial activities. Its main activities are directly linked to mining and most of its business and commerce stems from that sector. Agro-industry and business are mainly involved in transport, transformation, processing and marketing food production for the mining centers.

MAXCOM - KITWE

Maxcom is a mechanical engineering company specializing in steam boilers, stainless steel fabrication, fuel tank manufacture and repairs and engineering services to the copper mines. Maxcom is a Turnpan group company and a member of Lonrho.

Facilities include a large fabrication section, outdoors, undercover and a large well-equipped machine shop. Works manager Mr. Kapungulya informed us that due to the fall of work from the copper mines it may be necessary to reduce the labor force, any reductions would be made in the less skilled areas of the company's operation. This is a problem facing many engineering companies that depend to a large extent on work from the copper mine industry. In order to offset the down turn, Maxcom branched into the manufacture of hammermills and agricultural equipment. This has not proved successful and has been discontinued, the reason being competition from other companies in the same field. However, the company's capacity is very much under-utilized (60%) and management is very interested in any ideas for increased income generation. At present, work is priced on the basis of K140 per hour labor and K250 per hour machining costs. Materials have a 20% import duty and 22% sales duty which is taken into account when pricing jobs.

JUNG & CO - KITWE

Jung & Co. is a light-engineering company managed by Mr. Manfred Jung who started the business over 20 years ago. The company recently amalgamated with another Kitwe engineering company, Lutanda, who market some items of equipment manufactured by Jung: hand-operated oil processing equipment being one example. Other products made by Jung include motor drive

grass cutting machines, block making machines, cement mixers and metal building structures. Mr. Jung estimates the company is only utilizing 20% of its capacity.

The Jung fabrication and machine shops are well equipped to accommodate light to medium engineering work, the 20/25 staff are well trained. Mr. Jung, like many other engineering business operators is concerned over the decline in the copper industry and the general decline in the state of the economy.

NDOLA

Ndola is the second important urban, industrial center in the copperbelt. Ndola, like Kitwe, is equally oriented toward the mining sector. It contains some industry here such as sugar refining and edible oil processing. The efficiency of locating these processing centers here is not certain, and these industrial citing may have been strictly done for political considerations. However, the urban area does contain these and other agro-industries oriented heavily toward the mining sector as is the case in Kitwe.

BOART - NDOLA

Boart is a large south African company serving the copper mining and other industries in the manufacture of special parts, spares and providing an up-to-date heat treatment service.

The heat treatment facility is of particular interest because it is one of the technical services that most people we met had trouble finding. Normally most of the other workshops in Zambia, especially away from the Copperbelt, feel they have to send to Europe or South Africa for such services or for repair parts that need to be heat treatment. For this reason we made a special visit to this section of the factory. This facility offers the following services:

Processes:

1. **Carburizing**: to impart a high carbon case on the surface of low to medium carbon steel components to enhance their wear and fatigue resistance.

2. **Through Hardening**: to give the required hardness and toughness through the whole section of a component made from high carbon or alloy steel.

3. **Process or Sub-Critical Annealing**: of forging etc. for easy machining and subsequent operations.

4. **Normalizing**: in order to refine the structure of components and therefore increase the strength and toughness, especially in low carbon steels.

5. **Tempering**: In order to impart toughness and reduce brittleness. This normally follows hardening.

The above processes are carried out at the highest standard by qualified metallurgists, to customer specifications.

Facilities:

Heat treatment is carried out under a protective gas atmosphere with automatic control of gas composition for carburizing.

The heat treatment facility comprises four Wild Barfield furnaces, one Birlec muffle furnace, and two supporting smaller furnaces. There is an endothermic gas generator to produce the endo gas atmosphere, an infra-red gas analyzer for the analysis and control of the gaseous atmosphere in the furnace and a tank containing 42,000 liters of circulated oil for quench hardening.

Work pieces of sized up to 760mm diameter and up to 3,500mm long, weighing up to 2.5 tons can be handled in the plant.

Quality Control:

Strict process control at every stage on every batch is ensured. All components undergo strict testing and inspection in metallurgical laboratory for both microstructural and mechanical properties to ensure that customers requirements are met.

The Boart machine shops are very impressive with up to date equipment, including some CNC machines and a R&D workshop. The company carries out machining work at a cost of K 600 per machine/man hour. Boart will supply special materials, steels, etc., if required. They are also capable of undertaking design or of copying specific pieces from other machines. Their facilities could be particularly in the oilseed extraction industry.

Prices for hardening are:

K 1,000 up to 5kg
K 200 for every KG over 5kg
A reduction of 10% for 50 to 100kg.

TAZARA RAILWAY WORKSHOPS - MPIKA

TAZARA railway workshops are located in Mpika (or Mpeka) which is located about midway on the portion of the Tanzania-Zambia railway that is within Zambia. That is ½ the distance between the border with Tanzania and the Zambian Railways, line-of-rail, at Kapiri Mposhi, 64 km north of Kabwe, and 113 km south of Ndola. Mpika is relatively isolated, being 418 km from the main north-south line-of-rail. There is little business activity in the town, and the area seems to be mainly given over to subsistence and low-commercial agriculture. The

community around the workshops at Mpika have not developed into any thing like a town, and services and amenities in the area are minimal at best. There is a rural development project centered there, along with other foreign funded projects such as the Canadian wheat Project. There is also an agricultural cooperative in the area. High tension power lines now serve the community with electricity from the hydropower sources.

Mr. Charles Phiri, general manager of the TAZARA workshops complex, very kindly gave most of the day escorting the mission over the vast and impressive railway workshops complex. Before leaving the administration building, Mr. Phiri briefed the mission on the background and history of the workshops.

The TAZARA workshops are part of the Tanzania/Zambia railroad, and were built to service that railroad. The railway is jointly owned by Tanzania and Zambia. As with the Tanzanian/Zambian railway, the workshops are Chinese built and equipped to act as a support facility to the railway. It was not clear why Mpeka, an almost non-existent town, was chosen for the workshop installation. Possibly it was done because Mpika is located halfway between Kapiri Mpohsi, start of the railway, and the border with Tanzania. The TAZARA workshops have 500 staff, which includes mechanical engineers, technical workers, administration staff and laborers. Many of the workshops staff were involved in the construction of the railway in the early 1970s and were later absorbed into the workshops on the completion of the railroad in 1976.

The original locomotives supplied are Chinese diesel hydraulic. These locomotives are being updated with the fitting of more efficient German MTU engine units into the original Chinese chassis. USA A.I.D. has donated 17 diesel electric locomotives since 1982. The Zambian side of the TAZARA railway has a total of 43 locomotives.

Mr. Phiri informed us that the workshops are very much under-utilized. Income generation from work carried out for the private sector is a matter being taken very seriously. However, the present administrative structure is not geared to such activities. Revenue earned from private work goes into corporation general funds. Major problems may arise with the organization of private activities in the workshops if these are taking place at the same time as regular corporation railroad work. Presumably the railroad will demand that their work take precedence over any done for non-railroad clients.

Workshops

The workshops are, to say the least, impressive, with major activities as follows:

- Locomotive repair shop
- Carriage and wagon repair shop
- Machine shop
- Heat treatment
- Pattern making
- Foundry-cast iron, cast steel, brass, bronze & alloy
- Forging
- Testing and metallurgy
- Woodwork & coach building

Service and support facilities are:

- Administration
- Oxygen & acetylene
- Compressed air
- Pressurized steam
- Engine testing and calibration

The engineering equipment in the workshops ranges from small machine tools to equipment capable of large machining work. This permits the workshops to handle service, repairs and complete rebuilding of locomotive and rolling stock, and to regularly rebuild items such as wheels and axles. The whole complex is kept in good order. The complex is very much under utilized and is a massive production resource.

LOCAL VISITS - LUSAKA

SARO ENGINEERING - LUSAKA

SARO Engineering is a small, private engineering and manufacturing company located in the Industrial Zone of Lusaka. It has a limited number of tools and machines for manufacture of metal products. It has a good workshop facility for small batch production. At present, Saro is manufacturing hammermills and oil presses. The company imports Koliskor diesel engines from India, which are used on the hammermills it manufactures. SARO also maintains a large inventory of parts for the Koliskor diesel engine, and has an engine rebuilding section for complete overhaul of the small diesel engines.

The company is interested in manufacturing motor driven oil expellers and parts and possibly small oil presses. To that end, it has imported an Indian "Tiny Oil Mill" expeller and installed

it in Lusaka. The manager has visited manufacturers in India to learn how to make parts and do repairs, and has visited oil processors in India to learn how best to operate the expeller he has purchased. A problem with rapid and excessive wear on the expeller and cage was experienced with the Indian expeller. The manager has learned how the Indian manufacturers hard-surface these parts to decrease the wear and increase part life. He hopes to set up a parts manufacturing and repair facility to service these expellers.

SMALL INDUSTRIES DEVELOPMENT ORGANIZATION (SIDO)

SIDO is one of the main institutions promoting the hammermill program. It has contracted for the manufacture of hammermills and sold them through a credit scheme to individuals and groups in the rural and semi-urban areas. It also runs a small training program to teach new owners proper operating and maintenance procedures. Mr. M.C. Kaumba, Project Extension Service Manager, stated that SIDO will operate its future hammermill activities on a commercial basis. He admitted that the speed with which the program of getting 2,000 mills into the field had resulted in many problems, largely due to inexperienced operators and misguided maintenance procedures with the engines, resulting in premature breakdowns. Because operators were unfamiliar with the engines they often tampered with the settings, resulting in engine stoppage or breakdown. Due to this, future activities will involve a stronger training program.

A large quantity of spare parts ($500,000) have been purchased for the Lister engines. A list will be available later. However, Mr. Kaumba did say that the spares had been ordered on the basis of requirements.

TURNING AND METALS

Turning and Metals are engaged in the construction of hammermills for SIDO who supply the license. T&M have 4 branches in Zambia with the parent company based in the U.K. Hammermills are constructed in the T&M factory and are fitted with 15hp Lister diesel engines imported from U.K. Negotiations with the Republic of South Africa (RSA) may result in South African Lister engines being imported from the RSA. T&M does not import large quantities of engine spare parts.

T&M imports 70% of its steel supplies for the construction of hammermills from the RSA. Prices and availability of other sources of steel in Zambia dictate this procedure.

Present steel costs:

Imported from RSA @ K95,000 ($ +/- 1,067) per ton; 8 to 14 weeks delivery.

Local purchase from Zambia Steel and Building Supplies @ K 140,000 ($1,573) per ton.

T&M imports quantities of 150 tons of steel at a time. Any scrap goes to the Copperbelt (Scraw Anglo American) for smelting. Mr. Karanjia, General Manager for T&M, informed us that the company gives some training to prospective mill owners. This consists of 1/2 a day on the maintenance of the engine and mill. A simple 4 page manual is available to assist the owner.

Problems with engines/mills start after 3 to 5 years of use, according to the company, however, a unit well-run and maintained will give 9-10 years of service without serious problems. This difference highlights the importance of training to the overall program, and should demonstrate the cost-effectiveness of any training program.

AFIE - Lusaka

This company is a large agricultural equipment agency with outlets in several of the larger towns in the country in the main commercial agricultural zones. They are dealers for implements such as tractors, cultivation equipment and harvesters for the commercial farming sector. They also provide irrigation equipment and undertake installation. They have fairly large and comprehensive workshops to repair and overhaul agricultural tools and equipment. In addition, they import a line of animal traction equipment from Zimbabwe. The company is also the agent for Lister diesel engines, and they carry a complete line of spare parts for the Lister.

One problem that became apparent when talking with AFIE is that they will not send spares out to the country unless they have been paid in advance. Thus if someone needed a spare part of a Lister engine they would have to come into the company's place of business and pay for the part. The company also carries only a limited amount of spares at their regional outlets, such as in Choma or Kabwe. This situation seems to be common with all of the larger importers and suppliers. Thus, unless some system is found to arrange for dealerships in the smaller towns, the supply of parts will continue to be source from Lusaka and the Copperbelt.

ANNEX B GENERAL OBSERVATIONS ON FACILITIES IN ZAMBIA:

1. WORKSHOP FACILITIES AND LOCATIONS

Shortage of time did not allow the mission to visit the east or western regions of the country. However, a good overall impression has been gained on the availability of technical and workshop facilities.

Along the line-of-road and -rail, an abundance of engineering and engine repair facilities exist. These facilities range from the small backyard garage to medium-sized workshops to large partially or fully integrated companies and the impressive installations of the Tazara railway workshops at Mpeka. Many, due to the decline in copper mining activities and the poor economy, are operating at well below capacity, as much as 60% in some cases. Even the larger, more successful companies report having spare capacity (20% at BOART in Ndola). The mission felt it was only observing the tip of the iceberg. The indications are that facilities in other areas of industry such as woodwork, electrical, and building construction, are available in abundance, and that excess capacity also exists in these areas. We did observe, for example, that at the TAZARA Railway workshop they had the capacity to rewire electric motors of all sizes. However, they were often not working or working only at low capacity due to either the shortage of work or, more often, the shortage of wire for doing the rewiring. This later point is instructional, in that a company has opened in the Copperbelt to produce copper wire for shipment to Asia and Europe. TAZARA im[illegible] all its copper wire for electric motors.

Once off the line-of-road, technical facilities [illegible]dle away to nothing, other than the occasional village blacksmith. Unless electrical po[illegible] is available for upgrading of rural workshop facilities, the village blacksmith can only play a minor role in providing repair facilities for hammermills, engines, and other fairly complex agricultural tools and equipment.

2. HAMMERMILL PROGRAM

The hammermill program now has over twelve NGOs, missions and other organizations installing power driven hammermills throughout the country. Estimates have over 3,000 units[10] in the field by the end of 1992. In most cases, training of operators and provision for engine spares is not adequate. Also there is doubt of the economic viability due to location of many of the hammermills and population density.

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[10] Note that this figure is uncertain. The ZAMS Project has recorded slightly less than 2,000 having been distributed by institutions and NGOs. However, ZAMS staff feel that hammermills private sold may equal or exceed the numbers distributed by institutions. See Table 1.

It is known that a well maintained mill, set up in good conditions, will run for 5 to 9 years without serious mechanical problems. Without reasonable care and under poor working conditions, the units are likely to fail in 2-3 years.

Installation is important to the longevity of the hammermill. The concrete mill base has to be constructed to fit the engine and mill manufacturer's specifications, with good quality concrete and anchor bolts that won't work loose with vibration. Proper anchoring of the mill will reduce breakage due to vibration. In addition, it is extremely important that the engine's exhaust be vented outside to protect the operator from carbon monoxide poisoning. Air intakes for the engines must be placed where the air is as clean as possible. The preferred way is to bring in air from outside of the building where flour is milled. This will prevent intake into the engine of flour laden air. Finally, the mill dust should be exhausted outside of the building where the mill is operating. Where the mill has a cyclone system installed, a vent off of this cyclone to the outside of the building should be connected to the top of the cyclone to vent off flour laden air, thereby reducing the flour load in the air inside of the building. Finally, constructing a barricade between the hammermill and the engine can reduce the amount of dust that is in the air around the engine. Reducing the dust load in any way possible around the engine reduces damage to the engine in two ways: (1) it keeps the engine cleaner which reduces heat build-up as most are air cooled, and excessive dirt and dust deposits on the engine reduces the heat transfer between engine cylinder walls and the air; and (2) it reduces the amount of dust that can enter the engine through air intakes, or seep into bearings.

The maintenance of the mills is not overly complicated but must receive regular care. The engine oil needs to be changed at regular intervals, the frequency depending of the engine and on the conditions under which the engine operates. When installation is improper, attention to oil changes, and oil and air filter changes should be more frequent. The engine should be regularly cleaned to prevent dust buildup and consequent overheating. If bearings are fitted with grease zerks, these must be greased regularly, but not excessively. Regular inspection of air and fuel fittings to prevent loosening and consequent dirt intake must be done. Belts must be checked regularly to assure that they have proper tension, do not have excessive wear or checks or breaks. Inspection must be made of shields and other safety devices not only to protect operators, but also to prevent major breakdowns caused when a shield comes loss and gets into the moving parts such as under belts and pulleys.

With a mill correctly installed and set up, early damage resulting in the engine having to be taken to an urban workshop for repair will be avoided. This is important as transportation costs range from K30 to K130 per km from site to workshop and return. Although these procedures are not difficult, and should be easy for operators to learn, it will not occur in a single training session in most cases. Unless the operator has experience with mechanical devices, particularly with engines, it is unlikely that these facts will be quickly absorbed. Repetitive training is important in teaching these skills and procedures. The increase in longevity of the hammermills, or the reduction in repair costs should make this economically justifiable.

3. VIS WORKSHOPS

The VIS workshop concept is good, providing it can be implemented. To succeed, the workshops will have to have enough income-generating work. Availability of work will be determined by the market demands and the population demographics and competition in the area where the workshops are placed. Market research is required to determine viable products and spare parts for manufacture. Market research should cover a broad spectrum and not be limited to investigations in the rural agricultural sector. Given the amount of workshop equipment planned for the VIS workshops, 6 to 8 staff will be required to run the enterprise commercially.

Even with very good placement of the workshops, the workshop management will have to aggressively market their facility or the products they decide to make. A strong marketing strategy needs to be devised utilizing such advertising outlets as TV, radio and newspapers to tap into the market network. In order to take advantage of the market, a reliable transport system will have to exist. VIS will either have to organize its own transport or utilize existing transport facilities.

4. OIL PROCESSING EQUIPMENT

Mission findings show that suitable workshop facilities exist in Zambia for the production of quality hand or motor driven oil processing equipment for the home market and for export.

Better linkages are required between R&D establishments and the industrial sector to develop equipment that will not only perform its function, but will also be durable enough to work under the harsh conditions found in the rural environment or with continuous use in an urban area. A poor example is the present design of the ram press which is very material intensive but still breaks down after little use.

Users of oil processing equipment have to be trained in the correct methodology for extracting oil and not instructed in shortcut methods (cold pressing or using inferior seed). Improved varieties of sunflower and alternative oil seed crops should be investigated and tested. Again linkages between agricultural research, the grower, and industry is required.