FROM GARBAGE TO GOLD:
URBAN WASTE MANAGEMENT IN JAKARTA

Presentation at the World Development Report Seminar

The World Bank
Washington D.C.

June 24, 1991

FROM GARBAGE TO GOLD: URBAN WASTE MANAGEMENT IN JAKARTA

Presentation at the World Development Report Seminar
June 24, 1991

INTRODUCTION

1. Opening remarks on the ERCP project in Jakarta.

   Complex project; over 25 people from many different disciplines involved in the project since 1986. Most are in Jakarta; we are the sub-group who are here at present.

2. Introduction of participants.

3. We plan to summarize where we think we are at present, and discuss some of the things we are thinking about for the future. We hope to obtain your input in a variety of ways: your questions, comments, and criticisms, of course, but also any comparative experiences from other countries you may think relevant for our work.

Part I: BACKGROUND

This project is carried out by the Center for Policy and Implementation Studies (CPIS) which is an Indonesian foundation based in Jakarta and funded by the Ministry of Finance. CPIS carries out interdisciplinary research for policy advising and implementation studies on subjects which have included integrated pest management, agricultural and industrial issues, rural banking, the informal sector and education.

The project in which we are involved is currently beginning pilot projects for Enterprises for Recycling and Compost Production (ERCP). ERCPs are designed to process municipal waste from households, markets, and offices, into two products: recycled materials and compost, from the non-recycled organic waste materials. Recycling has been operating in Jakarta for a long time; what is new in this context is the using composting for dealing with municipal solid waste in big cities. The recycling component is, however, essential, since this is how we got into this project in the first place.

The ERCP project originated as a research project, which began in 1986, on occupations which those in the Ministry of Finance refer to as the 'informal sector.'

We started our research with a study of Jakarta's scavengers who were in a particularly vulnerable position as they were classified as gelandangan, an Indonesian term for tramps and beggars. This meant that scavengers were constantly harassed by city officials.

The findings of our 1986 study of scavengers and a 1989 follow-up study show that scavengers are, in fact, part of a developed system of solid waste recycling in Jakarta. While the system has many minor variations, its basic operation is the following. Jakarta's recycling system consists of five levels:

- at the first level, scavengers collect recyclable waste materials (such as different kinds of plastic, glass, paper and metals) from either household garbage bins or city dumping sites;

- these materials are then sold to entrepreneurs, called lapak, who sort and clean the purchased materials;

- the lapak then resell the recyclable materials, in bulk and at a higher value, to entrepreneurs, called bandar, who specialize in one of the recyclable materials and provide transportation of the recyclables from the lapak to the bandar locations;

- the bandar then sell the materials to factory suppliers who, in turn, sell them to the appropriate factories;

- there are also cases in which lapak would sell the recyclable materials directly to factory suppliers; some of the recyclables are also sold to cottage industries.

CPIS was not the only one who recognized the scavengers' contribution to the Jakarta economy. In October 1988, Indonesia's President Soeharto declared that scavengers were not tramps and that their contribution to the economy should be recognized.

Our research findings highlighted the fact that waste, particularly the recyclable components, has value. As the title of this presentation, 'Garbage to Gold,' indicates, there is a resource in the waste stream. The next uestions was: is there value to the rest of the waste? This led us to thinking about producing compost from the non-recycled organic portion of the waste.

While recycling is well-established in Jakarta, composting was not. The key questions we raised were:

- Was composting technically possible under Indonesian conditions?

- If it was possible, could it be justified in economic terms?

In order to answer these questions, in November 1989, an experimental station was established to do three things: (1) to develop a composting technique appropriate for Indonesian conditions, (2) to study the costs of production associated with the techniques being tested, and (3) to provide training on the composting process and the composting technique being used. This was followed by a study on the existing and potential demand for compost. In February 1991, the first Enterprise for Recycling and Compost Production (ERCP) pilot project was started in order to test our findings under real Jakarta conditions.

Part II: Production of Compost from Municipal Solid Waste

A. Waste Management: Present handling of the municipal solid waste stream in the city of Jakarta follows two primary pathways. The first is those recyclables destined for end-user industries that are collected by the scavengers and are routed in various ways through lapaks/bandars/factory suppliers (as was described by Nana).

The second pathway is the rest of the garbage that can be direct hauled to the landfill or first go through an intermediate transfer point known as a temporary dumping site (TDS). These TDS's can have garbage brought into them either by gerobak and/or truck. Some of these sites are managed well, some are under utilized and others are well over capacity and creating health, environmental and nuisance impacts to the surrounding area. The garbage is picked-up from the TDS and transported outside of the city to a landfill site. The garbage once dumped at this site goes through another round of scavenging. What became obvious was that a large portion of the material arriving at this final disposal site was in fact organic in nature and could be captured and utilized as a soil amendment resource.

It should be pointed out that there is a portion of the waste that does not enter this system of disposal. Around Jakarta it is evident that open spaces often become illegal disposal sites. Also, it appears that a substantial portion of this garbage is burned so to mitigate odor, vector and disease problems. The result is an air pollution impact to the local environs.

B. Recycling: To return to the recycling network previously described, it is important to realize that from a recycling and waste management perspective, one notes that this informal sector activity has the three components necessary for long term successful recycling. The first is quality control; this occurs at the lapak level. The primary activities of cleaning, separating and densifying are all important steps to meet end-users' and/or transporters, specifications.

The second essential activity is to aggregate a lot of material from various sources, or to provide sufficient quantity. Obviously, the scavengers do this by bringing the material into the lapak. However, just as important is the bandars and factory suppliers who collect large amounts of a single type of recyclable which they subsequently sell to the end-users. This allows the end-users to make deals with a few dealers who have large volumes. From a business perspective, it is preferable for the end-user industries to make a few agreements with suppliers of large volumes of material than making many agreements with many suppliers for small amounts of recyclables.

The third component to a successful recycling strategy is transportation. Transportation must be timely for moving material off-site; this is of particular importance in Jakarta due to the high density of population and the lack of space within the city. The scavengers transport recyclables from residences and commercial establishments to the lapaks. Often the bandar will provide the vehicles to pick-up the separated recyclables. In both cases the transportation infrastructure is making it "convenient" to move the material and results in a relatively efficient system.

C. ERCP: It is at the lapak level that the concept for the Enterprise for Recycling and Composting (ERCP) was targeted. The lapaks and their associated scavengers already have the awareness that there are materials of value in what many consider just a waste.

Also, the lapak level seemed an appropriate place to focus because activities such as separation of materials, quality control and "packaging" for shipment, are already well understood. The lapak is also a point in the recycling infrastructure where manual labor is extensively utilized. Finally, these established lapak owners are already experienced entrepreneurs and have demonstrated they can run a successful business. All these factors are important components for developing and establishing the new activity of composting. An activity that would focus on capturing the natural organic resource which made up a large percentage of the post-scavenged garbage being sent out to the landfill.

D. Composting: Composting is not a new activity in Indonesia. In some form or another, it has been an activity that has been around as long as agriculture. There are also specific examples where different components of the municipal and/or commercial solid waste stream has been composted within the country. However, even though most of the techniques already existing in the country are at a lower technology level which utilizes manual labor, they would not be appropriate for a situation that is receiving relatively large quantities of waste, on a regular basis in an area that is densely settled and has very little available space for processing.

In the conceptualization stages of this project, what became apparent is that a composting technology needed to be developed and successfully sited in those densely populated areas where the waste was being generated. Thus taking advantage of the organic resource near the point of generation, and to the greatest extent possible allowing the finished product, compost, to be distributed locally to those that created the waste. In essence, composting in the urban center creates advantages for the waste disposal system. The ERCPs not only reduce the amount of material that must be transported long distances to a final disposal site but also can act to relieve some of the pressure from the over extended temporary dumping site system. All of this can be translated into beneficial economic impacts to the Jakarta waste management system.

Thus, the initial research at our pilot facility, the Ragunan Research Station, was to develop a composting technique that: allows a relatively rapid through-put of garbage; could be sited in densely urbanized and site constrained locations; causes minimal nuisance conditions from odors and flies; produces an environmentally safe product, produces such a product at a cost that allows it to cover production costs and provide a normal rate of profit.

E. Delivery to the ERCP: It must be remembered that the material destined for the ERCP has already been scavenged. The delivery of the material and removal of residue must be arranged prior to start-up of the ERCP. This is critical for a number of reasons. Since the ERCP is carefully designed to handle a specific amount of in-coming waste, it is essential that waste is delivered at the right amounts on a relatively regular basis. It is also important that this waste is not coming from locations where it has been sitting around for any period of time. If it is not "fresh" waste it will arrive at the site already quite odorous and probably full of fly larva. Both of these conditions will negatively impact the surrounding neighborhood and possibly turn those neighbors against the project.

Finally, it is important that the residue is promptly removed. First, due to initial site constraints, an accumulation of residue can hamper maximum production efficiency. Second, just like incoming waste, residue can become a source of malodors and/or an attraction for flies or other pests.

F. Separation: After the waste is delivered, either by truck and/or gerobak, the material is then sorted. The waste at the ERCPs is separated into recyclables, compostables, and the remainder or residue that is then sent to the landfill outside of the city. Because municipal solid waste is so varied from place to place, and from time to time, it is hard to get a definitive break down of the various percentages of the sorted material. However, a rough estimate is that from 1 to 4 percent (by weight) of the incoming waste are materials that are traditionally recycled (this number is relatively low because the waste has already been scavenged). 40 to 70 percent could be utilized in the ERCP's composting process. The remainder would be residue.

It should be pointed out that the residue does contain a percentage of organic material such as coconut husks, banana stalks, wood and brush. This material is not utilized by the ERCP's composting process since it would need to be substantially reduced in size in order for it to decompose within the 35 to 40 day composting time frame. Such size reduction is a very manual intensive and time consuming process, and if employed, would increase the production costs to a level that would not make the ERCP a viable enterprise.

A second point about the residue, the workers have been trained to identify and segregate household hazardous waste from the compostable fraction. Unfortunately, at this point in time, there is no informal nor formal mechanism to divert this toxic material from being landfilled and potentially having an environmental impact on surrounding ground and surface water sources. The first step in any household hazardous waste strategy, separation, has now been realized; what needs to be developed is a transportation component and either a recycling or treatment component.

Sorting is undoubtedly the most important of all the composting activities from a quality control standpoint. It is at this initial phase that those potentially hazardous materials are removed prior to the composting pile formation. Because the initial stages of the composting process creates organic acids, household hazardous waste items must be removed prior to composting. If this were not done, a lot of heavy metals which are potentially toxic (to plants as well as to humans) could be released from these hazardous materials (e.g. batteries, light bulbs, electrical equipment, car parts, etc.) and end up in the compost product. Thus, removal prior to composting insures that a safe, high quality product is produced.

G. Pile Formation: A primary problem which the initial research at Ragunan had to solve was to maximize pile sizes without allowing the piles to overheat due to an over-insulating effect. Pile temperatures in excess of 65 degrees celsius experience reduced decomposition rates. Piles above 70 degrees celsius for an extended period of time can result in dramatic slowing of aerobic decomposition, thus substantially reducing the garbage through-put capability of the ERCP. A second criteria was to build a pile that could be relatively easy to be "turned" by the ERCP workers. After experimenting with a number of techniques, such as plastic pipes with electric blowers, a very simple method using a on-site built bamboo frame "aerators" was developed to provide oxygen to the pile interiors and assist in keeping the compost pile temperatures within the acceptable range of 55 - 70 degrees celsius.

H. Watering: For rapid decomposition, the composting piles in an ERCP must be maintained between 40 - 60 % moisture content. Thus, when choosing a potential ERCP site a water source must be available. The water quality also must not impact negatively on the composting process or the quality of the final compost product. Of major concern in Jakarta, as one moves to the northern parts of the city, especially those areas located near the harbor, is the salt water intrusion of fresh groundwater supplies; this issue must be considered when locating ERCPs and must be taken into account when selling the compost to specific end-users.

I. Turning: Compost pile temperature reflects health and activity of the decomposing organisms. As previously mentioned, in a tropical environment, it is relatively easy to get excessively high temperatures. Turning, along with the use of bamboo aerators, is the primary activity which keeps the pile temperatures within optimum ranges. Temperatures can also decrease below optimum ranges due to the decomposing organisms' need for oxygen, water or "fresh" organic material. Thus, turning, with associated watering, maintains the conditions for rapid decomposition. Turning also moves non-decomposed material from the outside of the pile into the pile interior, thus providing a new food source for those decomposing organisms.

The critical indicator of when to turn is pile temperature. The temperature is monitored with a thermometer and records are kept to see the trends or "direction" of temperature change over time. In essence, the alcohol thermometer (mercury thermometers are not used because of potential contamination of the compost by this heavy metal) is the only "technologically sophisticated" instrument employed at the ERCP. However, it is locally available, and without a doubt one of the most important tools utilized by the ERCP workers.

It should be pointed out that the quality control that began with the initial sorting step continues through the active composting/turning phases of the operation. Workers continually remove those items that are non-compostable and can reduce the quality of the final product.

J. Curing: After about 35 days, the material is resembling soil and the pile temperatures cannot be maintained at the optimum level, above 55 degrees celsius. In essence, decomposition is near completion. Thus, the compost goes into the "curing" phase where the entire pile cools down to ambient temperatures and organisms that normally inhabit the soil environment begin to re-inoculate and spread throughout the piled material. A cured or stabilized compost is one that can be safely applied to plants and soils without adversely affecting the existing conditions. Testing for stability is a very costly process. As such, a safety margin of two weeks curing is employed to address the worse case scenario as far as required stabilization time.

K. Screening: The final stage in the process is screening. Screening serves two major purposes. It is the final quality control step in the process. The screen removes both those non-compostables that were missed in the initial sorting or pile turning phases of the operation. The non-compostables screened out of the end-product ends up being sent with the other residue to the final disposal site at the landfill location. The screen also removes those larger pieces of organic material that did not have enough time to be completely decomposed. This organic material is put back into a newly formed pile to go through further decomposition.

Screening also provides different "grades" of compost product. These are referred to as Coarse, Medium, Fine. The Coarse is that material sent back to be further decomposed. However, there may be potential uses for it, e.g. landfill vegetation stabilization cover. The medium has passed through a screen with 4 cm square openings. The fine has passed through a screen with 1 cm square openings. The particle size grading is in response to specific end-users. It seems the fine compost is preferred for activities such as: turfgrass production and establishment, germination seed beds, potted plants, etc. The demand for medium compost seems to be more for bulk applications, such as park land, crops, roadsides, etc.

L. Bagging: The final production step is bagging. The compost is sold in two sizes 3 kg and 40 kg bags. Since compost moisture content can vary from ERCP to ERCP and from season to season, it appears that there will be a shift from marketing by weight to marketing by volume. The smaller bags are printed with the "Lestari" label and are sold through retail store or kiosk outlets. The larger bags go primarily to the bulk end-users; that is ,those who want larger volumes of this soil amendment material.

M. Compost: The end-product of the ERCP composting process is a material that can be safely handled, stored and applied to the land. The compost macro-nutrient value is low when compared to animal manures or synthetic fertilizers. Even though this compost should not be considered "fertilizer grade", the compost does have both macro-nutrient and micro-nutrient value.

Analysis of the heavy metal content, pH and other parameters - which could negatively affect plant growth are also being assessed. In comparing the heavy metal levels found in multiple samples of the compost produced to date, one can safely assume that this soil amendment product falls well within the newest US EPA standards (NOAEL levels and section 503 of the Clean Water Act - presently in draft form) for compost products. There have been observed spikes in the Boron and Zinc levels; however, Boron is not presently on the NOAEL heavy metals priority list, and along with the Zinc, both fall well within acceptable limits when analyzed over a large number of composite samples. pH has been on the high side but in most cases well within the ranges found in other MSW composts around the world.

Although, some fertilizer value can be attributed to the compost, the real benefit that this resource provides is as a soil amendment product. Research from around the world has shown that compost has the ability to enhance fertilizer application by increasing plant nutrient utilization, which translates into either less fertilizer use for similar yields or increased yields with similar fertilizer application levels. There is evidence that the resulting nutrient value of the food crops is also enhanced. Similarly, compost has shown to increase water holding capacity of soils; thus, resulting in greater viability during draughty conditions. This especially true for marginal agricultural soils that have high percolation rates. At the other end of the soil spectrum, compost has shown to improve marginal clay or high silt soils by enhancing soil aggregation, soil aeration, water penetration, and enhancement of soil conditions that stimulate root growth. Finally, due to the compost particle structure, erosion potential is reduced with compost application. The compost both holds a slope well and has the ability to cushion the erosive forces resulting from rain drop impacts on the soil.

N. End-use Research: In order to try to demonstrate and eventually quantify both the fertilizer and soil amendment benefits of the compost being produced by the ERCP's, a number of field experiments have been conducted. With time, it is hoped data coming out of these trials will show true agronomic and economic benefits from the use of this product in a number of different applications. Initial indications from these trials are encouraging.

Under the field trials is a set of experiments to determine what benefits compost can play in suppressing root, and possibly other, plant diseases. Previous research in the US has indicated that the compost, and the associated organisms that are enhanced from the application of compost, create soil antagonistic effects that help suppress other soil organisms that contribute to some plant diseases.

Under the field trials is an interesting use for compost, and that is adding this product to shrimp/fish ponds. Theoretically, the compost could stimulate the phyto-plankton growth within these ponds so that the food web, that supports the growth of the harvestable species, is enhanced.

Beyond direct field trials are what are considered "field observations" to see how the compost is being used by various end-users. Demonstration plots have also been begun in order to show potential end-users that this soil amendment product is of benefit to plants. Experiments growing various plants with compost side by side with control plots where compost is not used are now underway. Earlier germination demonstrations pointed to the benefits of compost application to the soils.

These field trials and observations are expected to produce some important scientific data, and to be the basis for enhancing the promotion and sales of this product. Finally, it is hoped the results from this research may point to micro and macro economic benefits that can be transferable to other parts of Indonesia and to other countries.

O. **Training:** As previously mentioned, neither composting nor composting of certain fractions of the municipal waste stream is new to Indonesia. However, small decentralized, labor intensive compost projects in the heart of the urban environment does seem to be a new concept for Jakarta. And because it requires a highly efficient decomposition process that is cost effective, certain techniques developed at the Ragunan experimental station need to be transferred through formal training to potential ERCP supervisors and workers. Thus, Ragunan has developed into more than just an experimental station and the initial ERCP for our overall strategy. Ragunan also plays a very important role as a training center.

Over 35 people have been formally trained in the Ragunan method of composting. New trainees go through a month of formal training within the classroom. Educational material has been developed around the classroom curriculum. The students learn both how to compost and why composting and the resultant compost are beneficial for Jakarta and Indonesia as a whole. These students learn not just the manual procedures of the Ragunan composting process but are taught about the biology of composting and what needs to be in place to optimize biological degradation.

The overriding goal of the curriculum is not to teach a method by rote, but to have the students understand the theory well enough so that they can figure out, by themselves, solutions to new and unexpected problems that will show up in their own ERCPs.

Actual work at the Ragunan composting site complements the classroom instruction. This provides the trainees with hands-on experience and allows them to test some of the ideas presented in class under the watchful eyes of the Ragunan composting staff and the older trainees. After the formal classroom sessions are completed, trainees remain working at the Ragunan experimental station; some participate in new experiments at the station, some are getting experience in selling the end-product and others try to develop new and efficient techniques for producing and/or preparing the compost.

Part III: Economic and Financial Analyses of Enterprises for Recycling and Compost Production (ERCPs)

A. Introduction.

1. Our economic analysis of composting initially focused on three key questions:

   a. What is the cost of

      (i) extracting recyclable materials from Jakarta's municipal waste, and

      (ii) converting the organic component of the non-recyclable portion of that waste into one or several grades of compost?

      This question has to do with the <u>supply</u> side of these operations, i.e., the cost of production.

   b. How much ERCP compost can be sold in the market at prices that cover production costs and provide a normal rate of profit?

      This question has to do with the <u>demand</u> side of these operations -- in other words, the demand for the output generated by ERCPs.

   c. Will ERCPs generate any social benefits beyond those reflected in the market demand curve for their products?

      There is no reason to think that the social costs of producing compost diverge much from the private costs of production. However, the social benefits may exceed the private benefits for a variety of reasons that will be discussed later.

2. Our answers to the first two questions give rise to a fourth question:

   d. If ERCP compost appears to be profitable from a private point of view, why has the market for non-ERCP compost been so thin (at least prior to this project)?

3. Goals for this part of the seminar:

   a. Report our answers to these questions.

   b. Give the audience some feel for the analyses and thinking that led to those answers.

   c. Convey some sense of the degree of confidence we place in our analyses and answers.

B. Cost of production

1. We estimated the average cost of production per kilogram of compost using data generated from the Ragunan Experimental Station (RES). This was not as simple as dividing total cost by total quantity produced because:

   a. There were other activities taking place at RES (such as research, training, etc.).

   b. We wanted more information than just the average cost of production, such as:

      i. Sensitivity of cost to scale.

      ii. Sensitivity of cost to assumptions about technical and economic parameters, etc.

2. So we devised a model that looked at each step of the recycling and composting operation and computed:

   a. Input requirements.

      i. Time and motion studies were performed to determine labor productivities for each task (but these were not speed runs; we tried to measure typical performance and included time taken for rest breaks).

   b. Input costs.

   c. Outputs, which became inputs into succeeding steps and, ultimately, the final products.

3. The development of this model involved a great deal of interaction with technical people (e.g., Michael Simpson):

   a. Alerted them when certain inputs looked too expensive.

   b. Alerted them when certain process parameters looked like they resulted in excessively costly output.

4. We believe that our cost figures reflect something that is, or is close to, the most economically efficient technology available within a reasonable range of current factor prices. These are not just the costs associated with a particular technique; rather, we think they are the minimum costs of producing compost under Jakarta conditions (especially the waste stream, climate, and land scarcity).

5. Key results:

   a. Average cost varies with size of operation because of some fixed costs; 10 percent difference in average costs if double size of ERCP.

   b. ERCPs can be tucked away on small plots of land: 326 - 632 m^2 (on the order of a 20 m by 20 m plot).

   c. Average cost comes to Rps. 80 - 90 per kg., which is about 4 - 4 1/2 cents (U.S.) at current exchange rates.

   d. Capital requirements range from Rps. 11 to 20 million (U.S. $5,000 - 10,000).

   e. A large-size ERCP can process about 4.5 metric tons of raw refuse a day. Since 4,500 to 5,000 tons of raw garbage are generated each day in Jakarta, a single ERCP would only deal with a fraction of a percent of Jakarta's municipal solid waste stream. If ERCPs can be readily duplicated in large numbers, which we believe is possible, then they can easily begin to make a significant dent in the burden of dealing with Jakarta's solid waste.

f. Cost structure:

i. Labor: 50%

ii. Land: 5%

iii. Rest divided between

(1). Fixed capital costs

(2). Interest

(3). Tools

(4). Supplies

(5). Garbage delivery costs

6. Two additional comments:

a. Land costs:

i. Land is very scarce on Java (it is one of the most densely populated islands in the world).

ii. Rent per square meter varies over a substantial range.

(1). High end: Rps. one million (we do not expect ERCPs to locate in these areas).

(2). Low end: Rps. 1,500 (we expect ERCPs to locate in this range).

(3). Conducted sensitivity analyses at low end of market: looked at effect on average cost if rents ranged from Rps. 2,500 - 10,000; we found that the average cost generally stayed below Rps. 100 per kg.

b. We were careful to use conservative assumptions in our cost model. This implies that the estimates we have reported will tend, if anything, to over-estimate the true costs of compost production.

i. We assumed wages to be in the higher part of the range for similar workers in Jakarta.

ii. We assumed only a five year life for fixed capital.

iii. We included a contingency allowance equal to five percent of our cost estimates.

iv. We expect entrepreneurs to be better than we are (in the Ragunan Experimental Station) at holding down production costs.

7. Bottom line:

a. We believe we have a good idea of the level and structure of the cost of compost production.

b. The cost of production does not seem exorbitant on its face.

c. The preliminary evidence from Pak Joko's ERCP (i.e., the first one operated by an entrepreneur) indicates that the actual average cost may be ten percent lower than the cost we projected.

d. Our cost estimates do not include:

i. Cost of CPIS's involvement in the project.

ii. Cost of transporting compost to markets.

C. Demand for compost.

1. Initial observations:

   a. According to agriculturalists (and as mentioned by Michael), compost is beneficial for just about anything that is grown in Indonesia:

      i. It has some fertilizer value.

      ii. More important, it improves soil quality (as an organic soil amendment)

         (1). Enhances ability of soil to hold water.

         (2). Enhances ability of soil to hold chemical fertilizer.

   b. Some compost or compost-like substances were already sold in Jakarta before the establishment of the ERCP at Ragunan.

      i. Non-ERCP compost has been sold in Jakarta at prices well above ERCP average cost estimates plus a normal rate of profit.

      ii. ERCP compost quality appears to be superior to the non-ERCP compost (and compost-like) substances sold in Jakarta.

2. What we do not yet know:

   a. We do not have enough information to estimate the demand curve for compost in Jakarta (e.g., we know little about the price elasticity of demand). Thus, we have no way of knowing what will happen to the market price of compost if compost supply shifts out as the number of ERCPs increases.

   b. On the other hand, we do not know how far the demand curve for compost can be pushed out as a result of:

i. Promotional and educational efforts about the beneficial uses of compost.

ii. Elimination of chemical fertilizer subsidies.

c. In the short run, it is clear that the quantity of ERCP compost demanded at current prices (which we have fixed above average cost in order to ensure a normal rate of profit) far exceeds the quantity currently being produced at the RES and by Pak Joko.

d. Uncertainty about the long run prospects for Indonesia's compost market implies that rapid expansion of compost production capacity may be unwise; therefore, we advise only a gradual expansion. In other words, it would not be a good idea to try to establish 500 ERCPs across Jakarta in the next six months, but 10 - 15 ERCPs should not crash the market.

3. Current demand for ERCP compost production technology:

a. Serpong.

b. Mayor of Central Jakarta.

c. Kalimantan fertilizer producer.

D. **Why might the social benefits of compost production exceed the prices consumers are willing to pay for compost.**

1. Measurable social benefits:

a. Reduction of waste management costs.

i. Conservative estimate is Rps. 20 - 25 per kg. of raw garbage.

ii. These savings are sizable relative to our estimate of the average cost of production of compost (Rps. 80 - 90 per kg.).

b. Land conservation — diversion of land from permanent, exclusive use as a municipal solid waste (and hazardous waste) repository.

i. A medium-size ERCP can save 28 m^2/year (6.5 percent real rate of return).

ii. The entire land area of a medium ERCP can be recouped in about 15 years.

iii. ERCP sites can be used for other purposes if changes in land values warrant dismantling and moving ERCPs. (ERCPs can be quickly dismantled and set up at low cost.)

2. Social benefits not measured by our analyses.

a. We expect ERCPs to lead to a reduction in the amount of garbage burned at dumps, resulting in less untreated emissions of air pollutants.

b. Less damage to groundwater:

i. If we figure out a better way to treat the hazardous materials separated at the ERCPs.

ii. The use of compost may result in a reduction in the amount of chemical fertilizers that leach into groundwater.

E. Why was the Jakarta market for compost so thin prior to this project?

1. It could have been the case that the private cost of compost production exceeded the private benefits of compost production and the social cost exceeded social benefits. This finding would have explained why we did not observe ERCP-type compost being produced in Jakarta. Alternatively, it could have been the case that the private costs may have exceeded private benefits, but social benefits may have exceeded social costs, in which case we still would not observe ERCP-type compost produced in Jakarta. However, it appears that ERCP-type compost production is cost-beneficial from both a private and a social perspective. This leaves us with a puzzle -- why do we not observe the production of ERCP-type compost in

Jakarta?

2. Possible answers to this puzzle:

   a. The incentives for firms to develop and implement composting techniques that are appropriate for Jakarta's economic, climate, and waste conditions have not been that strong.

      i. Chemical fertilizer subsidies diminish farmers' incentives to economize on their use, which is what compost does.

      ii. The ERCP technology is so easy to imitate that there is no way to ensure that the benefits associated with its development would accrue to the firms that conduct the R & D.

      iii. Entrepreneurs would not be able to capture all the benefits of increasing popular knowledge about compost's uses -- advertising externalities.

   b. At best there are weak economies of scale in ERCP compost production.

      i. No particular reason for large operations to be built.

      ii. Small informal sector entrepreneurs may perceive ERCP-type projects as risky because these projects require at least a two month gestation period before they generate revenue; these entrepreneurs also tend to have difficulty raising capital.

Part IV Summary of what we have learned so far and some ideas for the future

A. Summary of key points.

We do not have all the answers to the points raised below, but we discuss here what we think we know so far. Seven questions are raised.

1. Waste has value and Jakarta's recycling system is already carried out extensively and profitably. Can more value be obtained from the waste which is not presently recycled?

Yes. We have learned that converting the non-recycled organic component into high quality compost can be carried out successfully in an urban area. The approach, which is labor intensive and can be learned relatively easily, uses only indigenous materials and is remarkably appropriate for Indonesian conditions (and probably for conditions in some other countries).

2. Can private ERCPs operate profitably?

The answer is yes; the question which remains, however, is how many? We have found that converting the non-recycled organic component of the waste stream into high quality compost can be carried out profitably in an urban area. Also, Jakarta costs are high in comparison to most other locations in Indonesia where composting from municipal solid waste might be carried out. Therefore the Jakarta pilot projects should establish upper bounds on the costs of recycling and composting in Indonesia.

There are many types of uses for compost and a large potential demand. However, there is also considerable uncertainty about the precise magnitude of future compost demand. Therefore, our conclusion at this time is that there is sufficient promise to justify further development of ERCPs in tandem with further exploration of compost demand.

3. Is the process environmentally beneficial?

The environmental benefits are twofold. ERCPs provide a method of environmentally sound waste management, thus decreasing the use of other commonly used methods which contribute to environmental degradation (e.g., landfills which diminish the value of the land, and burning which causes air pollution). In addition, the use of the compost produced by ERCPs provides a variety of benefits to the soil.

4. Is the technology available, and how easily can the compost processing techniques be learned?

In the early stages of the project, there were technical problems; the composting process took too long to permit the profitability of the enterprise, given the costs for land and labor in Jakarta. As a result of experimentation, the technology was improved, and a much shorter composting time became possible (from about 100 days to about 35 days); the ERCP project then became economically viable. Training has been highly successful, with the trainees learning both how to make compost and the reasons behind the procedures; skill levels have increased considerably.

5. Can ERCPs be incorporated into urban planning?

Yes, but they can also be carried out independently of the local government. In cases in which they are incorporated into urban planning, successful ERCP development depends upon effective implementation by the local government of such matters as ERCP site selections which are both technically and socially acceptable, and regular delivery of waste and pickup of residual. However, it is not necessary that the local government be involved; waste can be purchased and residual disposed of privately. In some circumstances local governments may want to participate because of the avoided costs and environmental benefits to be gained. In other cases, they may not. One important strength of the ERCP concept is its replicability under different models.

A corollary to this question is whether we envisage ERCPs as a system. The answer is yes or no. They can be systematically instituted; for example the Mayor of Central Jakarta has stated that he would like to see one ERCP in each <u>kecamatan</u> in Central Jakarta. But they can also be developed on an ad hoc basis. The most fundamental point about the ERCP concept is its flexibility. A variety of private-public mixes are possible; these may change and develop over time as well.

6. How much of Jakarta's solid waste could be handled by ERCPs?

This depends on: a) the level of interest in recycling and compost production at the local level; and b) the level of demand. ERCPs are not intended to solve the entire urban waste problem in a large city. They are designed to be complementary to other systems of waste management. If Jakarta's 260 kelurahan had an average of just one ERCP, they could handle about 10 percent of Jakarta's present solid waste; if there could be an average of three, then about 30 % of the waste could be handled in this way.

7. Is a decentralized approach appropriate for this technology?

With the proper quality control steps, compost is what has been called a 'forgiving technology' which allows for a fairly wide margin of error; it is thus particularly suitable for decentralized small scale private entrepreneurs.

The reason for establishing the pilot projects was to establish the process, learn the problems, and work out the solutions. For example, in the early stages of the project, the problems were primarily technical; current problems are related mainly to appropriate site selection and suitable waste delivery schedules. There is also the important problem mentioned by Michael concerning disposal of hazardous waste. We have taken the first steps in the ERCPs by separating such waste, but there is not yet a plan for its safe disposal.

Overall, our experience has been that finding and correcting mistakes, developing new methods, etc. are part of the learning process - which is essential for the planning for ERCP replicability. Suitable technology alone does not guarantee effective replication. Adoption of the process to varied waste streams, appropriate land use, and an understanding of the opportunities and constraints of different types of neighborhoods will be crucial to a successful process of gradual ERCP expansion.

E. Possible options for the future expansion of ERCPs

1. Reasons for Expansion

It appears that significant expansion can occur without the necessity for government intervention except as a catalyst with regard to training and research, and perhaps in helping to established standards related to quality control. The reasons include the following:

a) On the demand side, the decline in fertilizer subsidies increases farmers' incentives to economize on fertilizer use; use of compost increases the efficiency of fertilizer use.

b) Competition from other forms of soil amendments may be decreasing. On the one hand, environmental groups in various parts of the world are increasingly constraining the mining of humus and peat. For example, in Europe now there is an emphasis on the use of non-peat-based compost. On the other hand, animal manure-based soil amendments are becoming less available in and around urban areas. In Jakarta, for example, the horse population has shrunk greatly. While the chicken population is expanding, much of the chicken manure is used for the production of cattle feed. Compost produced from municipal solid waste, however, is both easily available and environmentally beneficial.

c) Preliminary results from agricultural trials we are conducting indicate that the use of Lestari compost can provide substantial benefits to some important food crops and other plants. When the research is further along, information about these benefits will be provided. If the early results are confirmed, such information is likely to increase the demand for compost.

d) On the supply side, appropriate technology for the fast through-put needed for profitable composting in urban areas is now available.

e) Previous constraints (lack of information, lack of capital for some potential entrepreneurs, high level of perceived risk to entrepreneurs) can be removed through training centers and bank loans made available at commercial interest rates to potential ERCP entrepreneurs.

f) The considerable interest in ERCPs which has already been generated as a spinoff from the pilot projects (for example, by the Mayor of Central Jakarta, the planning board of the new town of Serpong, P.T Pupuk Kalimantan Timur, the Public Works Department of Kabupaten Kudus, etc.) is encouraging. All of this interest in replicating the ERCP process has come without any publicity from us.

2. Preliminary Ideas about Expansion

a. First Stages

Our plan was to start first with the Ragunan Experimental Station in order to learn the appropriate technology and to learn how to train future ERCP entrepreneurs and workers. This worked successfully and was then followed by pilot projects conducted in Jakarta in order to understand how the process could work with private entrepreneurs. (Unexpectedly during this stage, as mentioned above, others also came to us for training from several parts of the country).

b. Gradual Expansion

We are presently in the process of thinking about gradual expansion of ERCPs both inside Jakarta and outside. The question we are asking ourselves is: how can this be done with little or no government intervention except with regard to research and education (of both producers and consumers)? Encouraged by our successes in training, we are now focusing on the design of training centers which would: 1) train ERCP managers; 2) continue demand-related research; and 3) help ERCP managers to obtain financing at commercial rates where needed.

i. Development of Training Centers

Training centers would need to be developed flexibly in accordance with different local conditions. One example might be a training center with a professional staff of six (coordinator, production manager, assistant production manager, two instructors, and a person who concentrates on marketing and demand). The coordinator would oversee the activities at the training center and would be responsible for maintaining relations with the local government; he would also keep in touch with Ragunan, have responsibility for trainee recruitment, and help the graduates obtain loans if needed to open ERCPs.

In such a model, 8 - 10 new trainees could be trained each month; each trainee would stay for two months. In the first month he would learn the theory and practice of composting and recycling (learning through classes and by producing the compost). In the second month, he would participate in marketing activities, agricultural trials, and would study business and accounting practices. Thus, at any one time there would be 16 - 20 trainees at such a training center.

Another model we are considering is a small mobile training center. It is likely that the best plan would be to have some stationary and some mobile training centers. Meanwhile training at Ragunan could be upgraded to provide advanced and specialized training for staff who would conduct research, consult with the training centers, and conduct occasional workshops.

ii. Employment of Training Center Graduates

Some of the graduates of these training centers would become trainers and others would open ERCPs (some might do both). Potentially there could be three kinds of ERCPs: a) the urban model discussed here which produces compost from municipal solid waste; b) a commercial model which produces compost as a byproduct of the production of commodities with highly organic waste streams (for example, food processing activities); and c) a small city, or rural town model in which land and labor is much cheaper than in the urban model and where other types of organic waste are available at low cost and can be blended to make a low cost compost available for the rural market.

iii. Training Centers Needed for Limited Period of Time

Training centers would be needed only for a limited number of years. The purpose would be to teach the composting technique in such a way that quality control is emphasized, to continue demand research and agricultural trials on the uses of compost, and to disseminate the relevant information. Afterwards the process should spread by itself, and training centers could be gradually phased out.

3. The Goals: Summary

The concept that waste has value and that different kinds of waste can be profitably transformed into useful products of different kinds is an idea which can be disseminated widely. Government interventions are not necessary beyond research and training, and perhaps establishing standards of quality control of compost. Some local governments may wish to provide help, however, because of the avoided costs, environmental benefits and employment generation which result from ERCPs.

The key ideas which we would like to leave you with are these:

a. ERCPs are technically possible: they can be labor intensive; they use only low-cost indigenous materials; and they are easily replicable.

b. The techniques can be relatively easily learned, with a resulting significant improvement in skills.

c. ERCPs are economically feasible and can be profitable for small scale entrepreneurs.

d. Because of the uncertainties about the magnitude of future demand, expansion of ERCPs should proceed gradually, with supply being related to identifiable demand.

e. Quality control of the product, especially an emphasis on sorting out hazardous wastes before the composting process starts, is essential.

f. Flexibility is the key concept to keep in mind when considering ERCP development. ERCPs can develop systematically or on an ad hoc basis, in a variety of environments, and with different public-private arrangements. ERCPs are small and easily moveable; they can take advantage of unused land and can move as the land is needed for other purposes. They can change character as well as location; it is their flexibility which is the greatest strength of the ERCP concept.

g. It is likely that this model can be adapted to some other countries, in addition to a gradual ERCP expansion in Indonesia.