Building Scrap Based Industries; The Potential for Economic Development and Environmental Improvement in the Gaza Strip

by

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ABSTRACT

Scrap based manufacturing can be an effective economic development tool. The feedstocks for these industries are cheap, locally generated and sustainable, capital costs are low, jobs are plentiful, and the end products are competitive. There are other important environmental spinoffs that result from relying on secondary versus virgin materials: depletion of natural resources including water and energy is curbed, waste disposal and negative externalities are diminished, and litter reduction efforts can be advanced.

Such an industrial development strategy bears particular promise in the Gaza Strip. The Palestinians are heading down the road of future statehood. Plans are being laid and tremendous capital is being spent to upgrade the industrial infrastructure and establish systems to protect the environment. While the groundwork for industrial, solid waste, and environmental protection infrastructures is laid, the time is ripe for pursuing a path of economic development and environmental sustainability through recycling. Small iron foundries in Gaza are used as a case study to explore the feasibility, economic development consequences, and environmental benefits derived from building scrap based manufacturing enterprises in Gaza.

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This thesis is dedicated to Palestinians and Israelis.

May the near future bring prosperity and a real peace to the region.

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PREFACE

It is a balmy and peaceful spring day here in Massachusetts as I sit at my kitchen table composing this thesis preface. The stormy, fearful, and angry political situation of the Middle East seems a million worlds away. Yet it is for a hopeful resolution of those tensions that I embarked on this thesis path and that inspires me to write.

The circumstances surrounding collection of thesis research materials are unusual and set an interesting context for this work. My strong, personal attachment to the Middle East and interest in recycling markets made this topic a natural. The signing of the peace accord also sprang up at the moment of decision. I was not sure that this pursuit was doable for me, particularly as a Jewish woman. But the string of contacts onto whom I was lucky enough to stumble were remarkably hospitable, forthcoming, and, most importantly, encouraging.

It became clear that no one had a comprehensive picture of the use of scrap materials in industry in Gaza and the West Bank. A desire for producing a piece that had some practical and useful application would not let me abandon this idea. However, it was not easy. Traveling back and forth between Gaza and Israel was like moving through a war zone: disturbing and terribly scary. The tension at the border hangs heavily with anticipation and dread. I understand and dealt with the perceptions and frustrations on both sides in a way that few people have a chance to. This sensitivity brought me much pain. Many times I asked myself why on earth I was doing something so crazy and heart wrenching.

My working experience in Gaza was positive. People were enormously kind and generous. I had the opportunity to make friends and get around to see how Gazan society lives, works, and functions. Palestinians are a resilient, resourceful, and welcoming people. I will think warmly of the friendships I made and the time I spent there.

During my second trip suspicions began to be aroused about my work. What possible legitimate business in Gaza could a Jewish woman have who was traveling back and forth openly to Israel, asking a lot of questions about the metal sector, visiting scrap yards, and letting a word or two of Hebrew slip occasionally? Visitors are rare, Jewish visitors are rarer, and female Jewish visitors on their own are non-existent. It became potentially dangerous for me to continue my work in Gaza. I had to leave suddenly with no explanation to those whom I had befriended and with my work uncompleted.

I have managed to fill the gaps in research and write a thesis. Whether I will manage to fill the gaps of comprehension in my own head as to how such a thing could happen is another story. My aim was pure and I was a victim of something I barely understood that was so much bigger than the time and place I was in. Perhaps naiveté and an American sense of trust allowed me to attempt this work in the first place and persist. I guess that was unwise.

I wonder, if someone like myself cannot accomplish so relatively small and innocuous a task, what does that portend for fruitful relations in the future? Until both sides let go of the animosities of the past I wonder whether real peace can be achieved. The Palestinians and Israelis need each other. Their economies are so interlinked that a complete separation, as some are calling for and as circumstances are forcing, will cause severe disruptions. At a minimum, these disruptions are so unpracticable as to wreak enormous havoc on Palestinian development plans. I dare not imagine what a breakdown will mean if the Palestinian economy continues to worsen.

Some say that time is needed to forget and heal wounds. But it seems to me that the hostility will deepen as Palestinians see an Israeli economic expansion occurring next door to which they have no access. Both sides will have to work hard and push to overcome natural instincts that drive them apart and maintain the cycle of counter productive animosity of which I found myself a part. This may be an impossible task. But I wish them the strength in the years ahead to rise above their past self-destructive behavior. I pray from the bottom of the heart for a prosperous and peaceful future for both the Palestinians and Israelis.

METHODOLOGY

My intended methodology for this thesis was on-site interviewing leading to a data based account of iron foundries in Gaza; their cost structure, production mechanisms, markets, etc. This would lead to an analysis of where bottlenecks were for this sector. However, as mentioned above, my work was aborted. I could not rely on written materials, as there is very little assembled information or statistics on Gaza's industrial activity. I visited representative firms in each sector, including one foundry and two scrap metal yards, to search for examples of scrap usage in manufacturing. With data from those visits and interviews with local industrial development specialists, I was able to piece together a composite picture of the iron foundry industry in Gaza.

My new tact was then to take a closer look than originally planned at the small scale foundry industries in other developing countries. Studying their experiences gave me enough insight into technology choice and market development for castings to do a prescriptive analysis for the Gazan foundry situation.

INTRODUCTION

The prospects for peace in the Middle East brings possibilities, challenges, and responsibilities in many realms. In particular, the West Bank and Gaza Strip are likely headed towards future statehood. Opportunities of tremendous magnitude lie in that birth; opportunities to avoid some of the devastating environmental predicaments with which many developed countries have found themselves faced. For instance, a network of Palestinian recycling industries could curb depletion of especially precious and scarce natural resources including water and energy, reduce the need for landfilling, and contribute to badly needed litter reduction efforts. Factories that utilize salvaged rather than virgin materials can also be strong economic development tools. Input materials are cheap and locally generated, capital costs are low, and jobs are plentiful. The intent of this thesis is to demonstrate that the expansion and modernization of scrap based manufacturing in the Gaza Strip will contribute to dearly needed economic development and environmental advantages to this region.

The markets for secondary materials in the region are weak. Systems for collecting, capturing, and remanufacturing salvaged materials into new products are underdeveloped and informal. The potential of utilizing waste resources and taking advantage of new trading and economic avenues presents an opportunity for the Palestinians that is well worth investigating. How and with what benefit are the questions that will be answered in this thesis. Small iron foundries will be used as a case study to explore the feasibility and benefits derived from building up scrap metal based manufacturing in the Gaza Strip.

The timing of this thesis complements Palestinian development plans. Palestinian authorities, investors, and international development agencies are moving forward with plans to upgrade the industrial infrastructure and establish systems to protect the environment. Enormous amounts of capital are being spent to hire consultants, conduct studies, build huge public works projects, and finance manufacturing ventures. Let the new housing, construction, industrial, and public works sectors provide the markets for Gaza's new scrap based manufacturing ventures.

CHAPTER ONE: RECYCLING AND ITS IMPACTS IN DEVELOPING COUNTRIES

From mattresses stuffed with discarded clothes in Columbia and roofing tiles created from scrap paper in Ghana to sewage pipes made from scrap iron in the Gaza Strip, examples abound in developing countries of reuse, recycling, and remanufacturing to create new products from waste material. Recycling occurs at home, in cottage scale industries, and large manufacturing firms. Whether on a large scale or small, the positive consequences for both the environment and economy are plentiful.

This chapter will explore the contribution of recycling to economic development and environmental improvement in pre-industrialized societies. The chapter will discuss why and how an industrial development strategy that favors scrap based manufacturing is important. This will be accomplished by defining alternative recycling schemes, describing the industry characteristics and dynamics that shape the realization of these benefits, and describing the implications of these different recycling schemes. The following chapters will explore the positive experiences of several developing nations with one type of scrap based manufacturing, iron founding, and implications those experiences might have for the Gaza Strip.

1.1 Economic Benefits

The use of a waste material feedstock instead of a virgin feedstock in manufacturing is a useful industrial development policy in pre-industrializing societies, like Gaza. Scrap when handled as a waste is a burden to society, when used as an industrial input is an asset. Resources are hard to come by in developing countries where often raw materials must be imported, costing precious foreign exchange. This is the case in Gaza which has no natural resources.

As an alternative, relatively inexpensive scrap can substitute for this imported raw material. Use of locally generated scrap allows more control over that factor of production: input. When a business must buy overseas it is subjected to the volatility of a market over which it has no control. Many factors can interrupt access to imported materials: politics, weather, currency fluctuations, market demand, resource depletion, and more. Using scrap as an input brings the input market closer to home. The closer the supply to home, the less likely those interruptions. Sustainability will result from utilizing scrap materials.

Recycling industries start with an undervalued resource (waste) and add value at each step in the many stage process: collection, separation, cleaning, processing, etc. The demand and capital invested at each stage likewise cause the value of the output to grow creating employment and income generation opportunities. By adding a small value at each level to a large amount of material there is a good profit to be made. "...more productive use of urban waste will affect the value of these items and will draw new actors into the waste arena" (Furedy 1984, p. 168). The following chart exemplifies how the value of cardboard increases as it is readied for utilization as an input in production.

TABLE 1: PRICES PAID FOR CORRUGATED CARDBOARD ALONG THE RECOVERY ROUTE

Country	Currency	Date	Price per Ton at Which:		
			Collector Sells to Small Merchant	Small Merchant Sells to Large	Large Merchant Sells to Final User
India	Rupees	Nov 1979	100-200	900	1,800
Columbia	Pesos (Colombian)	Jan 1980	1,000	3,000	5,500
Mexico	Pesos (Mexican)	Sept 1979	900	1,100	4,000

(Vogler 1984, p. 244)

This chart also demonstrates that recycling industries have positive ripple effects on many associated down and upstream businesses. In this chart, scrap based manufacturing occurs with the "final user" at the last stage. Collection, processing, brokering, etc. are all labor intensive activities required for the preparation of the recycled feedstock. As scrap based industries grow, so must the businesses needed to supply them with input.

The value addition benefits accrue to the economy generally and individually to firms involved in the process. Water and energy savings result from using scrap. This in turn causes lowered production costs. Input is cheaper since salvaged materials usually cost less than virgin. Below is a chart that demonstrates the financial advantages for a paper mill of using waste paper as a percentage of their input instead of 100% wood pulp.

TABLE 2: ESTIMATED COST/BENEFIT VALUE OF PAPER PRODUCTION AT A PAPER MILL IN THAILAND (IN BAHT, THAI CURRENCY)

Raw Material	Cost of Raw Material	Other Expenditure	Total Cost of Production	Value of Finished Product	Benefit: Cost Ratio
100% wood pulp	5640	1642	7280	11,500	1.57
17.5% wood pulp 82.5% waste paper	2440	1642	4080	87,000	2.13
100% waste paper	1880	1642	3520	6900	1.96

(Lohani 1984, p. 189)

Savings to the economy can also be seen in terms of foreign exchange. Importing raw material requires hard currency which is often in short supply. In Egypt, millions of dollars in hard currency were saved by producing local fertilizers composted from waste products, rather than importing artificial, chemical fertilizers (Bakr and Ayman 1992). Municipal solid waste composting, like other forms of recycling, has the tremendous advantage of being a highly effective means of transforming large amounts of waste into a usable end product. There are much higher proportions of organic matter in the refuse of poor countries because expensive, preprocessed, packaging is not widespread and hence spoilage occurs more readily. The Gaza Strip like Egypt has unusually high levels of organic matter in their solid waste (up to 80%) (UNRWA 1993). Additionally, there are fewer contaminants in the waste as poorer people dispose less processed items, making composting an attractive commercial option for organic waste especially where soil quality is poor (Gaza and Egypt, for example).

In the cases of refuse derived fertilizers and compost, there are potential indirect benefits from composting organic debris, as well. In industrialized countries crops grown with organic additives have a higher sales price. Clever marketing tactics need to be employed to profit from this phenomena. Additionally, the use of non-chemical fertilizers have a long list of environmental advantages over the synthetic, petroleum based variety: avoidance of the negative impacts of petroleum mining and production, reduction of water and energy usage, more rapid uptake and distribution by the plants, and reduction of water pollution from runoff. The composting example is instructive. This example has shown how a community can constructively tap its waste resources, add value to create a highly desirable and marketable end product, and protect its environment in the process.

Examination of recycling activities thus far has shown us that refuse can indeed be a resource; scrap based industries can be a boost to the economy. The feedstocks for these industries are cheap, locally generated and sustainable, and save foreign exchange for imported raw materials. Capital costs are relatively low, jobs are plentiful, and the end products can be competitive. Production from a lower value waste material can mean an economic advantage, especially when the cost of labor is low enough to offset the added cost of separation and collection required in scrap based manufacturing. The rapid rate of urban sector population growth in developing nations, combined with the slow expansion of the economy, have created a situation of high unemployment and low wages (Lohani 1984). Under these circumstances, highly labor intensive activities such as recycling are highly desirable.

1.2 Environmental Benefits

It is often felt in developing nations that environmental considerations are a rich country's luxury. This point will not be debated here, but no one could dispute that industries offering reduced environmental impacts are preferable to conventional industries. There are important environmental spin-offs that result from relying on secondary versus virgin materials: curbed depletion of natural resources including water and energy, reduced pollution, diminished landfill needs, and decreased litter.

The significance of reduced resource needs is disproportionately beneficial for the developing world where raw material extraction often has more devastating impacts on the environment than in developed countries. Developing countries bear many scars of mining, timbering, agriculture, etc. Often environmental regulations are not found or are easily avoided with cash. Pre-industrialized countries cannot afford the gentler extraction methods, sophisticated pollution control technology and extensive restorative measures found elsewhere.

Using scrap means, in part, avoiding the need to extract and refine virgin ores or other materials. In the case of iron ore, for example, the production processes involved are ore mining and processing, limestone quarrying and lime formation, coal mining and processing, coke formation from the coal, sintering, and blast furnace. Iron making is highly problematic environmentally. "The production of coke and the production of pig iron [1] in the blast furnace are the stages that cause most of the pollution...During coking operation, approximately one-quarter of the weight of coal is liberated as gases and vapors; over 2000 different chemicals are found in these gases. Fugitive emissions from coke ovens are difficult to control (Tellus 1992)." By using iron scrap as a substitute for virgin iron these processes are eliminated.

Manufacturing with scrap typically requires less water and energy, and hence fewer negative externalities (pollution), than utilizing virgin materials (ores, resins, timber). In Ghana, a reduction from 38 to 1.6 barrels of fuel was achieved per unit of production of aluminum when the switch was made from raw ore to scrap input (Goethe Institute 1989). The following table illustrates to what extent scrap substitution lowers resource costs and externalities.

TABLE 3: ENVIRONMENTAL BENEFITS DERIVED FROM SUBSTITUTING SECONDARY MATERIALS FOR VIRGIN RESOURCES (in percent)

Environmental Benefits	Aluminum	Steel	Paper	Glass
Reduction of:				
Energy Use	90-97	47-74	23-74	4-32
Air Pollution	95	85	74	20
Water Pollution	97	76	35	--
Mining Wastes	--	97	--	80
Water Use	--	40	58	50

(Pollock 1987, p. 22)

These effects are particularly advantageous where resources are dear. Utilities and water provisions are often extremely expensive where the infrastructure is not fully developed and the advantage of an economy of scale cannot be seen. In Gaza, water and fuel are scarce and prohibitively expensive.

[1] Pig iron- Crude, high carbon iron produced by reduction of iron ore in a blast furnace. Considered premium charge because of uniformity of composition and size and lack of undesirable trace elements, good for use whenever there are excessive tramp elements (contaminants).

Waste that is utilized as industrial feedstock need not be disposed or dumped and consequently waste disposal and clean up costs are lowered. Safe waste disposal practices are rarely found in developing countries, so the more diverted from the waste stream the better. While industrial development policies may pursue recycling to cut costs or generate jobs, the environment will also prosper from this approach.

1.3 Definition of Terms

The recirculation of waste materials into productive use (recycling) can occur in many ways: scrap based manufacturing, remanufacturing, or reuse. Scrap-based manufacturing is the production of new items from a *secondary* feedstock. Secondary implies that extraction of productive use (as originally intended) from a domestically or commercially produced item has already occurred. This waste is considered "post-consumer" or "post-industrial". The means to circulate post-consumer wastes back into production are complicated due to collection and contamination difficulties.

Therefore, post-consumer waste is considered problematical from a recycling standpoint. Types of secondary materials are only as limited as are the number of things used by a particular society. The list can stretch from the basic (food packaging, paper) to enormous mechanical equipment and machinery. Post-industrial wastes are those resulting from excesses in manufacturing. These wastes are almost always reintroduced back into the manufacturing cycle as the producer is intimately familiar with their composition which matches that of the items produced.

Remanufacturing involves replacing broken and antiquated parts in failed equipment and recreating usable items, thereby upgrading their value. There is an enormous market for these items in impoverished societies where most mechanical items must be imported and the tariffs are high. There is, for instance, a huge, famous second hand motor parts 'suk', or market, in Cairo. *Reuse* means converting secondary goods from a waste product to a salable item with a new purpose and subsequent value. Often times, home prepared items like beer or hot peppers will be sold in salvaged bottles or tins. In Indonesia, for example, charcoal stoves, scales, and other items are made with large tin cans.

The following are some examples of how segregable wastes can be incorporated into new products (this list is far from exhaustive):

TABLE 4: SCRAP BASED PRODUCTS

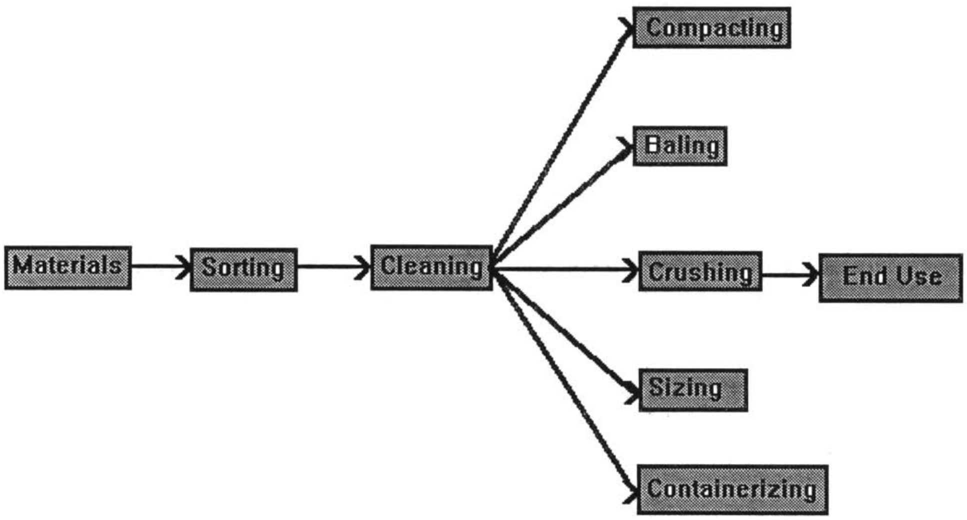
SCRAP	FINAL PRODUCT
Bones	Glue, animal feed
Brewery waste	Animal feed
Glass	Bottles, abrasives, road bed component
Metals	Machine and tool parts, pots and pans, sheet metal
Metallic slag (mining waste)	Aggregate for road making, cement & ceramics, fertilizer ingredient
Organic matter	Animal feed, compost
Paper	Tissue, cardboard, roofing tiles
Plastics	Agricultural products, bags, containers
Sawdust	Fuel briquettes
Textiles	Industrial rags, rugs, paper, roofing shingles, mattresses

1.4 Collection

The systems involved in producing a recycled item are complex and labor intensive: collection, separation, processing, and delivery must occur before the manufacturing stage. (See following diagram describing the recycling process.) Industries require high quality, consistent, and clean material thereby necessitating several steps to prepare the scrap as an industrial input.

The first step in the process of moving waste materials to market is collection. The waste material (input) must be gathered from its source of generation (home or industry) or disposal site (landfill, streetside, trash bin.)

DIAGRAM 1
THE MANY STAGED RECYCLING PROCESS



Refuse must first be separated by material type. Sorting for items like paper, metals, plastics, textiles, vegetative waste, and more obscure items like cinders, coal and coconut shells, takes place at the household level if the material can be sold or reused [2]. Some items are reused directly within the home (containers, vegetative debris as animal food). Office and factory wastes are more easily segregable and will be sorted by material type for recycling if a market exists.

In many cases, waste does not have a high enough intrinsic value to be bought by collectors, but it is worth their while to collect it without paying the generator. They will gather it without payment from the generator of disposal site and sell it to the next actor in the chain, the scrap broker. Usually in developing nations, the job of collecting these materials lies with a complex and intricate scavenging network. The role of scavenger historically has been filled by the most marginalized elements of society. This is evidenced by the designations society has given them: in Latin America 'moscas' or flies, 'bone grubbers' in 19th century London, 'ants' in Tokyo (Vogler 1984), 'gallinazos' or vultures in Columbia (Birkbeck 1979), and 'gypsies' in Istanbul (Vogler 1982).

These large scale scavenging networks provide income for the informal sector while supporting the needs of recycling industries. The debate is heated between those

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[2] ...or deposited into a municipally sponsored recycling program. These programs rarely exist in lesser developed countries so they will not be considered here.

who consider scavenging a lifestyle not fit for human beings and those who see any employment opportunities in a bleak economic landscape as a better prospect than the alternative. These garbage pickers have been described as a "hopelessly poverty stricken group who are scratching out a meager existence from the crumbs of a richer man's existence" (Birkbeck 1979, p.161). Often scavengers live at the dumpsites where whole communities have developed. The most famous of these is the zabaleen in Cairo with similar communities in Manila, Bangkok, Calcutta, Jakarta, and Mexico City (Lohani 1984).

The activities of these communities are critical ultimately to the success of scrap based manufacturing. In so far as promoting a scrap based industrial policy is responsible indirectly for the circumstances of scavengers, their welfare must be considered. Numerous studies have described the living conditions and networks of scavengers. The general conclusion, as will come as no great surprise, is that their living conditions are miserable. The job is highly unpleasant and often dangerous, involving contact with: offensive odors, disease opportunities, pollution impacts (Lohani 1984). Studies have shown the average life span to be less than half of the population at large (Vogler 1984).

The social impacts of this occupation are obvious; they are outcasts. For this reason, often this group lives together frequently near the dumpsite rarely integrating into the community. There are many resultant difficulties for this group.

> Not all scavengers live among such spectacular horror, but almost all are utterly exploited by the merchants who buy waste materials from them. Ignorance, illiteracy, inability to collaborate among themselves, and often heavy indebtedness to the buyers for loans at heavy interest to buy a cart or pay hospital fees, all combine to create a weak bargaining situation in which they are the inevitable losers (Vogler 1984, p. 245).

Income differentials are enormous between those who gather scrap and those who purchase it as demonstrated by the low value of material at the collector's end of the process. The scavenger's disadvantage lies in the small size of his operation, insufficient capital, and lower added values at his stage in the process. Furthermore, there are no barriers to entry into this occupation: no special equipment needs, knowledge or skill. Scavenging can be done by anyone at any time. Entry into this occupation is open and thus competition is stiff. This is yet one more hardship for the scavenger.

In Cali, Columbia a scavenger would receive three times his wages if employed in the paper mill to which he supplies waste paper (Birkbeck 1979). In the Gaza Strip compensation to the picker is roughly comparable to a low skilled worker in the plastics or metal sector there. In Gaza one can earn about 25-30 shekels per day (up to ten dollars) by gathering and selling metal scrap. While the range of compensations range country to country, earnings are universally low for this occupation.

There are many advantages for the end user in this informal supply arrangement. Wages are lower (provided in the form of piece work) because, for example, there is no need for a steel mill to pay workers' compensation or sick benefits to the scavengers who furnish it with scrap metal. (Although in some cases dealers do advance cash or provide housing to the collectors.)

Paradoxically, productivity is increased by utilizing the lower priced informal sector. The incentive to perform is higher when paid per piece versus per hour. Another benefit of this informal system for industry is flexibility in economic hard times. When orders are down, less material is purchased from the providers, obviating the need to keep for a full house of underutilized wage workers. Recycling arrangements can bring economic development activity generally to a community. This recycling system allows the marginalized to turn a liability into an asset, and participate in a chain of production that might otherwise exclude them.

Scavengers tend to be highly scattered and uneducated, therefore measures to improve their situation have been less than successful. Fear and subservience to higher ups interfered with participation in unions and cooperatives (Birkbeck 1979). Other attempted measures include introducing more tools at the sorting stage, increasing access to refuse, and introducing techniques of industriousness among workers. Some multi-faceted approaches seem to be having better success. The Informal Sector Project in Bandung, Indonesia has worked to improve the lot of scavengers by setting up cooperative, garbage industrial estates, improving access to technical information and capital, assisting with marketing strategies, and provision of direct aid for housing, health, education, etc. (Sicular 1992).

1.5 Separation and Processing

Recyclables are brought by the scavengers to scrap yards which separate, upgrade, clean and package the material for delivery to market. The separation and processing stage involves, on occasion, equipment to distinguish material types (magnetic separators), cutters and blowtorches to reduce pieces to usable sizes, and bundling or compacting equipment to maximize density for transport. The equipment can range from the quite sophisticated, expensive, and even automated to the very simple hand held and operated. For instance, the zabaleen in Cairo use basic metal shears to remove seams from tin cans (El-Halwagi 1992). Balers for metal and paper are often used and can be locally made. Human capital is most widely utilized for sorting, carrying, and lifting. Even in the U.S., where access to sophisticated technology is available, one finds a surprising degree of human labor involved in recycling operations.

Equipment and capital are needed at increasingly higher levels at each stage of the process from product generation to recycling to prepare the material until it is in marketable condition. For instance, the scavenger at the dump can operate with virtually no equipment. They identify valued refuse and can transport it with just a bag or container and their own two feet. The more sophisticated (and expensive) equipment they use, from carts to separated trash trucks (in the most advanced, but uncommon, situation), the more effective, safe and comfortable are their jobs.

There is a long chain of dealers and entrepreneurs involved in the recycling process where the profit potential increases as one moves up the chain. Each advanced stage requires an additional infusion of capital, infrastructure and equipment and brings an added value to the resource. The following chart indicates how capital, skill and equipment needs intensify as refuse moves from the dump to recycling site (1982).

TABLE 5: STAGES OF PLASTICS RECYCLING PROCESS SHOWING CAPITAL AND SKILL NEEDED AND JOBS AND VALUE PRODUCED (FOR AN 105 TPY PLASTICS RECYCLING FACILITY IN KINGSTON, JAMAICA)

Activity	Product	Sale Price (US $/ton)	No. of Jobs	Skill Required	Premises Required	Equipment Required	Equipment Cost ($US) Max	Min
Collect			4	None	None	50 sacks or 2 carts	1000	50
Clean			1	None	Sm. Plot	Water Bath & Supply, Gloves	80	40
Sort			2	Training	"	40 Containers	120	60
Size reduce			0	None	"	Hatchet or bandsaw	500	50
Pack			0	None	"	Baling box or press	500	120
	Scrap	Up to 300	7				2200	320
Granulate			1	Training	Shed	Granulator	6000	3000
Bag			1	None	"	Hopper & scale	200	80
	Granulate	Up to 600	9				8400	3400
Extrude & Pelletize			1 + 1	Trained Mechanic & Unskilled	Factory	Extrude, water bath, take off & chopper	20000	8000
	Pellets	Up to 1000					28400	11400
Mold	Objects	Up to 30000	Any	Training	Factory	Injection molders	2400 per person	500 per person

(Vogler 1982, p.119)

1.7 Scrap Prices

This hierarchical system which relies on depressed expenditures at the bottom rung strongly effects scrap prices. International demand for the raw material also is an important price factor. Scrap price is set by the international market with local quality, availability, ease and cost of access to separated materials contributing the local price component. The supplier of scrap charges the buyer a price which is affected by the cost structure and competition of the collecting industry. Competition among scavengers is stiff owing to a lack of barriers of entry. Hence, scrap prices are also kept low for this reason.

The price of scrap is a strong influential factor in the level of recycling activity. A manufacturer is only willing to buy scrap at a price cheaper than the alternative, raw material (often imported). This is because from a production standpoint, raw materials are frequently easier to use as an input than salvaged due to consistent quality and homogeneity. Plus a certain public bias exists against used materials. Contamination and consistency are often a problem with scrap collected from the street. This reluctance translates into lowered prices. For some materials, there can be a production advantage with scrap versus virgin materials in terms of energy and water savings. In any case, there must be a technical or financial advantage for a firm to use scrap and this keeps its price relatively low.

In some parts of the world, markets demand higher prices for scrap than in others.. In Latin America and parts of Asia, for example, there is a enormous demand for scrap materials. In other parts of the world, supply of scrap or raw materials is greater than demand. The infrastructure is not in place to capture and use what are, in other settings, valuable commodities. The lack of demand keeps the infrastructure undeveloped. For instance, in the Caribbean, Africa, and Gaza, tin cans and automobiles proliferate as waste. Elsewhere, these items might be consumed as industrial input (Vogler 1984). Generally, the price of scrap must be monitored as it is an influential determinant of recycling activity in a community.

1.6 The Role of Public Policy

Governmental policies should acknowledge the long and short term economic and environmental benefits that accrue from scrap based manufacturing. Immediate short term savings involve reduction of waste disposal costs and public health benefits associated with eliminating waste piles and their pollution effects. Industries should be rewarded accordingly with governmental policies that encourage the use of secondary feedstocks. Credit opportunities and tax incentives should be provided for enterprises that consume secondary materials.

The government should capitalize on existing disposal and sorting patterns and infrastructure. The government should provide technical assistance to firms and workers in the informal sector to help them upgrade and modernize their operations to expand their intake of scrap. The next step would then be to support and formalize existing collection or processing systems. (Actors within the working system should be incorporated into official plans so as not to disrupt the wage earning occupations of many individuals.) Public institutions can also establish a clearinghouse to apprise firms of another firm's waste, i.e., a potential feedstock.

Governments can also promote policies on a broader scale that discourage the use of virgin materials. Often the state tries to help big business with depletion allowances for mining, subsidization of the use of public lands for resource extraction, differential tariffs that favor the transport of virgin materials, and not taxing pollution. These policies bias firms against using secondary materials. A pollution tax would be a useful policy to encourage scrap based manufacturing. Recycling industries create less pollution than virgin based industries at all stages, from extraction through production and disposal. In any case, these policies are put into place at a later stage in development than found in most pre-industrialized nations. While shaping industrial development patterns these policies should be the long term goal. The public benefits resulting from these governmental interventions will be more sustainable industrial systems in the long term.

1.8 Conclusion

Developing countries have done a better job recycling than their richer counterpart nations. Industrial development policies should capitalize on the traditional practices of recovery and conservation in poorer societies. Resources needed to further encourage these practices at the manufacturing level are not extensive. Equipment needs are few and simple enough that they can be often be constructed locally. Labor needs can easily be met.

Time and increasing recognition on the part of society at large and the public sector are on the side of recycling. Joint efforts by the private sector to pursue production based on scrap and the government to bolster the enabling systems and policies will bring a promising future for recycling and its benefits. The next chapter will begin to explore how this can be accomplished among iron foundries by first looking at the structure of small iron foundries in developing countries.

CHAPTER TWO:

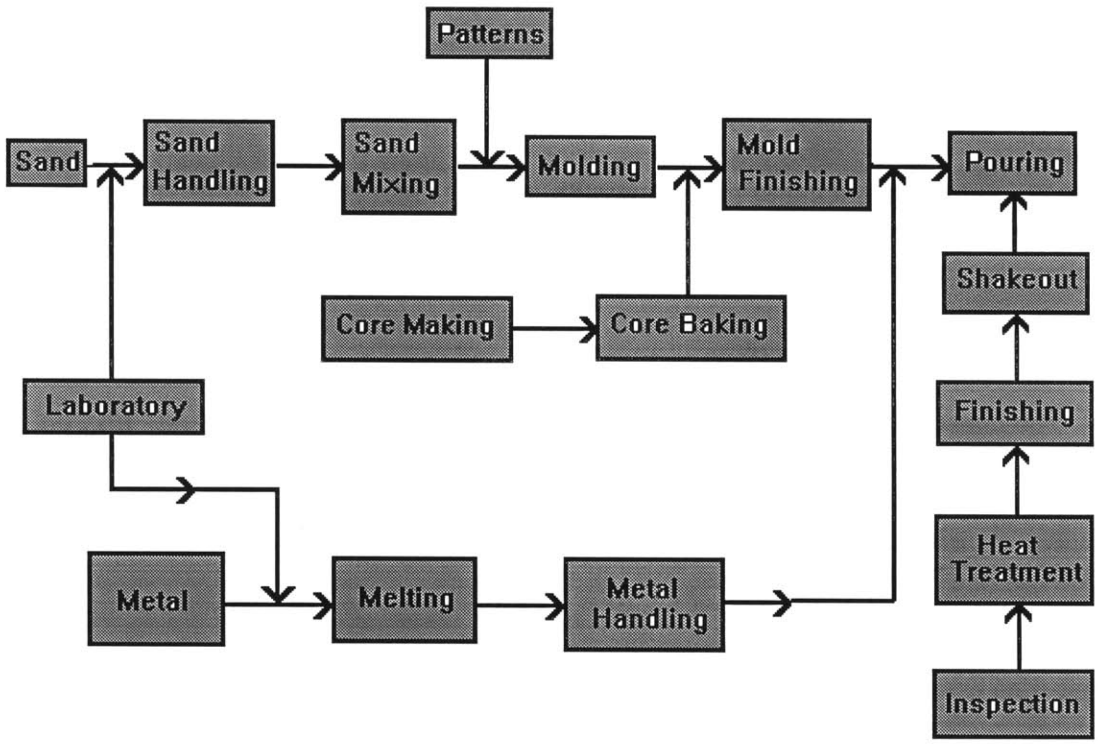
SCRAP BASED IRON FOUNDRIES IN DEVELOPING COUNTRIES

The materials and ways that salvaged materials can be remanufactured into new goods is practically limitless. The casting of metals is one example of scrap based manufacturing. Casting takes place in foundries where metal parts and objects are formed by the pouring and hardening of molten metal in molds. This process will be studied as a common method of recycling in developing countries, more closely examining the difficulties this industry faces on the road to modernization and expansion.

2.1 History of Iron Production

The history of steelmaking and iron production are closely intertwined. Iron ore is a material (iron oxide with many other minerals) extracted from the ground by mining and then reduced into metallic iron with economic value (pig iron). (Reduction removes the other minerals which are contaminants in metal making.) The iron then goes to foundries to be cast or to be made into various types of iron and steel objects as evidenced by the following flow chart. Steel is an iron based material with the carbon removed giving it qualities preferable to iron for some applications. Steel is easier to cut, less brittle and stronger than iron (Vogler 1981).

DIAGRAM 2: FOUNDRY PROCESS FLOW CHART



(Gunasekera 1976, p.25)

The industrial revolution in the early nineteenth century caused tremendous strides in steel and iron production technologies. The rates of goods production and manufacturing was increased to such a degree that expanded sea and rail systems to transport products and raw materials were required. Steel ships and rail lines were needed in tremendous quantities as were supporting cast iron products.

However, the production of steel was still quite expensive due to rather rudimentary furnaces in use at the time. By 1870 a technique was developed to significantly bring the price of steel production down to the point where it could replace rather brittle cast iron for widespread use as a structural material (United Nations 1964). In the 1920's "metallurgists got involved with iron, before that it was looked upon as the poor cousin to steel" (Perkins 1995). Adjustments were made to the metallurgical quality of cast iron such that it became a widely useful material.

2.2 Demand and Customers

Iron and steel together enjoy enormous use in every conceivable form: "for a host of products from very small, such as hypodermic needles and paper staples, to very large, such as bridges and giant pieces of equipment" (Bureau of Mines 1993, p.27). Indeed, virtually every machine or mechanical item is largely made of iron and steel. Most manufacturing, engineering, electrical, construction, municipal water and sewer, agricultural and transportation systems depend heavily on these metals directly as one of their (often primary) components or indirectly through the mechanical processes that contribute to their production. Indeed, metal use is so closely coupled with activity and productivity that a standard measure of economic welfare is steel consumption rates.

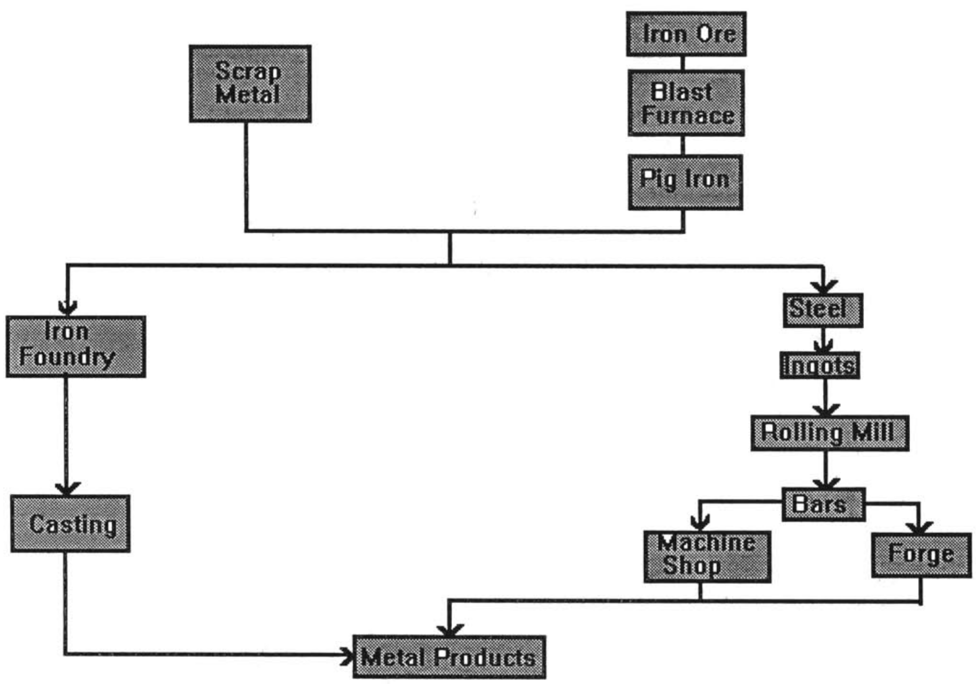
The size of a foundry industry is often linked to how advanced industrial development activities are in an area. "In the case of Brazil, between 1963 and 1974, ...this growth in the foundry industry is of course to be expected as a country moves from a state of complete underdevelopment with virtually no engineering industry to a state of development where the engineering industry accounts for one-third of the total value added in manufacturing output (Bhat and Prendergast 1984, p.19)".

Metal casted parts are frequently the essential components of equipment and machinery. Casting is a cheap means of manufacturing sophisticated and elaborate parts and is therefore a popular production technique (Gunasekera 1976). In fact, more than 90% of manufactured items contain castings (Kanicki 1988). And, according to U.S. Department of Commerce statistics, metal casting remains one of the ten largest industries when rated on a value-added basis (Kanicki 1988). The following is a chart illustrating which economic sectors utilize metal castings and the industries to which they are linked:

TABLE 6: CASTINGS AND THEIR LINKAGES TO INDUSTRY			
POTENTIAL CUSTOMER- SECTOR	**PLANT AND EQUIPMENT**	**REQUIREMENT FOR CASTINGS**	**LINKAGE INDUSTRY**
Basic metal industries Iron, steel, copper, aluminum	Iron & steel making, melting plant, metal forming and rolling	Spares, replacements, and consumables, ingot molds, rolls, furnace doors, guides, apron plates	Metal sections for fabrication industries, reinforcement bar for construction and building industry
Manufacturing industry Food, beverages, cocoanut, tobacco, rubber, rice, sugar refining, rice milling, soft drinks, dairy products, fish processing, tobacco manufacture	Process machinery and equipment	Spares, replacements, e.g., mixer parts, pinions, trash plates, cane knife bosses, rollers, hullers	Food processing for general consumption.
Clothing, footwear, leather goods	Production machines-sewing machines, leather tanning	Tools, machine parts	Export and domestic consumers
Cement and other building material manufacture	Production equipment, crushing and grinding media, quarrying, brick making	Grinding media, liner plates, feed pipes, kiln parts, breaker bars, brick and tile presses, hammers, grates	Construction: Infrastructure development, housing, hospitals, irrigation
Public Utilities Electricity/ generation	Power station/hydro electric	Lamp post sockets, inspection covers	Municipal authorities, construction industries
Transmission/distribution	Transmission equipment	Coupling boxes, manhole covers and frames	Industry and domestic sectors and development projects
Water Sewerage Processing	Water treatment equipment	Pressure pipes, fittings, manhole covers	Industry and domestic sanitation
Distribution	Water distribution	Gratings, sanitary ware, radiators, fire hydrant boxes, stop valve housings	Any infrastructure development
Telecommunications	General line equipment	Telegraph post sockets, inspection covers, manhole covers and grates	Government, industry, public communication
Construction Industries Major construction contractors	Heavy equipment, dredging equipment, quarrying equipment, road making machinery, earth moving equipment	Diggers, traction links, bucket teeth side cutter, breaker bars, bucket lips, crusher spares, shackles, scaffold fittings	Road making, graphite production, installation of public utilities, tourism
Transportation Road vehicles	Cars, lorries	Engines, gear boxes, spare parts	Public transport, transportation
Ship repair/marine engineering/sea ports	Vessels/on board equipment/port handling equipment	Anchors, bollards, lifting gear, propellers, stabilisers, steering equipment	Export/import handling, external transportation, tourism
Domestic Domestic appliances/furniture & fittings	Sewing machines, irons, cookers, cooking utensils	Sewing machine parts, sole plates, gas rings, hinges, locks, bolt handles, baths, taps, pots, pans	Industry, domestic, housing, hospitals, restaurants, hotels, tourism
Leisure	Golf clubs, weightlifting	Heads, weights	Sport and tourism(UNIDP 1988, p. 12)

Iron is the most widely used of all metals with castings the most popular form of metal working. Other types of metal working methods include machining, forging, welding, and stamping. Most finished metal products include parts formed by different methods. Of all these methods, casting involves "the shortest route from liquid metal to the metal shape. This avoidance of intermediate stages contributes, at least in some degree, to the economic attractiveness of castings" (Bhat and Prendergast 1984, p.2). (See following diagram). Since steps in production and capital equipment needs are simple, casting workshops are an especially popular business venture in newly industrializing societies.

DIAGRAM 3: COMPARISON OF SOME ROUTES AVAILABLE FOR THE PRODUCTION OF METAL PRODUCTS



(Adapted from Bhat and Prendergast 1984, p. 3)

Another appealing characteristic of these metals, and indeed the reason iron foundries are considered here as a case study, is that virtually all iron and steel is recoverable and can be made from scrap. Where scrap can technically be substituted for ore and is available, it is used because the cost of scrap is significantly lower than virgin material. Thus, the scrap metal business (collection, separation, processing, transport, commerce, recovery) is one of the world's largest industries in terms of the size of the labor pool, number of establishments involved, metal weight, and the equipment value

(Vogler 1981). Scrap is a critical component in steel and iron production. Technological advances now mean that scrap has overtaken ore as an input in steel and iron making. Many iron foundries rely heavily, if not exclusively, on waste metal as a feedstock.

2.3 Advantages of Casting

There are other characteristics that favor iron casting as a production mechanism in developing countries. One small foundry can accommodate a wide range of shapes and weights of the finished product (Vogler 1981). As well, a good variety of skills are required in the process. This means many jobs of different varieties are needed. Rather complex, three dimensional forms can be cast relatively cheaply and easily. Many different types of metals and items can be cast from one casting workshop. For instance, it is not uncommon to find alloys, non-ferrous metals, and iron all cast in one foundry. This gives the producer tremendous marketing flexibility. For many applications iron casts hold up very well. When a high degree of tensile strength or ductility (bendability) is required steel is generally preferred.

There is very little waste involved in casting. Virtually every drop of molten metal is transformed into final product. Mistakes and rough edges which are removed in the preparation of the final product can be recycled. Even sand, which is very often employed as a molding material, can be reused many times. As well, cast iron objects can be manufactured with up to 100% scrap as an input. This is critically important for the success of foundries in developing societies where access to foreign exchange and, consequently, raw materials is limited. The secondary feedstock is cheap and readily available (Bhat and Prendergast 1984).

Foundries are discovered extensively throughout the developing world as the need for cast metal goods is ubiquitous and a small casting operation can be a profitable business. This used to be the case in industrialized countries. It is said that every small town in New England had a foundry (Gregory 1994); there are far now fewer foundries, and they tend to be larger. According to Charlie Perkins of Henry Perkins Company, a ferrous foundry in West Bridgewater, Massachusetts, during the early part of the century there were more than one hundred foundries in New England, now there are only thirty to forty. Environmental regulations, increased competition from overseas where labor costs are lower, the technological advance of other cheaper, replacement materials like PVC plastic (polyvinyl chloride), automation and mechanization have contributed to the consolidation of the foundry industry.

Despite the trend towards higher production facilities, there is a need for smaller, specialized foundries which can produce customized parts for their customers' special mechanical or engineering needs. Smaller foundries are more flexible because they can switch production output and capacity to meet market demand. Smaller foundries can also provide castings not required in quantity which is frequently the case with customers. Single specialty parts are often needed for machinery. Thus smaller foundries still maintain a competitive niche [3]. The majority of iron foundries in developing countries are small [4].

Larger (often state owned) foundries in developing countries, however, typically furnish a substantial portion of the casting production. It has been noted that there is a steady, but slower, move towards larger scale operations in pre-industrialized settings as well. Newly instituted environmental and safety regulations are contributing to this direction (Bhat and Prendergast 1984). The cost of installing environmental control and safety equipment can only be sustained by a firm with a large resource base.

To produce a cast iron object, a mold is made from a replica of the object to be cast called a pattern. The pattern is used to form an impression in a sand mold. The charge (metallic material of which the final product is composed) is fed into a furnace. There it melts and is poured into sand molds where the molten metal hardens. After cooling the mold is removed, imperfections are corrected, quality is verified, and the cast piece is sold. Very simple. All casting operations from the most complicated, computerized, automated to the most rudimentary follow that basic formula. The next section will document the structure and production processes of small foundries and the scrap businesses in certain developing countries and the commonalties and problems that they face.

2.4 Scrap and the Scrap Business

A key component in casting production is the scrap metal and how it is processed. The content and quality of the charge vary depending on the specifications of the final castings. No matter what sophistication of castings is produced, composition of charge must be controlled. The level of control is related to the product's sophistication. For instance, simple grey iron castings made for water or sewer lines do not have high performance specifications in terms of strength. These pipes and elbows essentially direct liquid towards its destination. Therefore, grey iron castings have a fairly high tolerance for impurities in the metallic charge and can be derived almost entirely from scrap.

Foundry returns are considered the most preferable scrap charge as their composition is assured. Automobile parts, construction debris, and worn machinery are

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[3] Classification scheme: small foundries produce less than 100 tons per year (tpy) iron cast products, medium foundries 100 to 500 tpy, and large foundries produce more than 500 tpy (Bhat and Prendergast).

[4] One noticeable common factor in developing countries is the growth of the foundry industry both in terms of number of foundries and tonnage produced. This differs considerably from developed countries which in recent years have experienced a growth in foundry output but overall reduction in number of foundries. In Peru, for example, one-third of all foundry establishments are less than 10 years old and two-thirds less than 30 years old. In India the growth of the industry has been phenomenal. Considering the period 1919 to 1965, 60.5 percent of foundries established were set up in the period 1961-65. In 1960, there were slightly over 2,000 iron and steel foundries with production of 933,000 tons; by 1964/65 the number was 4,175 and production was nearly 2 million tons (Bhat and Prendergast 1984, p.18).

widely used sources of iron scrap. What is used depends on what is produced; an impurity in one item can be an asset in another. Manganese, sulfur, magnesium, phosphorus, and carbon content vary according to cast iron type. For the simplest of castings, a knowledgeable foundryperson can eyeball the charge to determine metal type. This inexpensive and low tech method has obvious advantages for small foundries in developing countries.

2.5 Markets

There exists a strong global market for many simple cast iron items: manhole covers, grates for drains, pipe elbows, sewer mains, tools, etc. Most foundries in the developing world produce these fairly rudimentary grey iron goods, not precision castings, although this is starting to change. In some cases, the production of these items has shifted from the U.S. to countries like India and China. Usually the metallurgical skills and laboratory facilities required to produce precision castings are not often available in these settings. Subsequently, small casting workshops most often produce castings of inferior quality. For this reason, one finds more captive (vertically integrated) foundries [5] in developing versus developed countries. In a captive foundry quality can be carefully controlled.

Precision castings used for engineering purposes usually have high performance specifications (high tensile strength or ductility, for instance). Exact knowledge of charge composition is required, in this case. Generally, rather expensive spectrometers are used for this purpose. Pig iron or clean, post industrial scrap free of adulterants must be used to guarantee final product composition specifications. For all types of castings, precision or simple, the composition of metallic charge must be ascertained. With more accurate verification techniques higher tech castings can be produced. Nonetheless, simple and good castings can be produced from scrap metal.

Most charge scrap is bought by the foundry from independent collectors or brokers. The availability of scrap depends on many factors, the most important of which is the degree of industrial activity. As was explained earlier, levels of metal consumption and usage correlates closely with a society's rate of manufacturing. Other contributing considerations to scrap availability include: local competing scrap demand, disposal and collection costs, and product durability and type. In developing countries equipment, a good source of scrap, tends to have much longer life. Machinery is used, repaired and used again long after it would have been scrapped elsewhere. Thus scrap is not as readily available as in developed countries. If local supply is not sufficient importing scrap may be warranted. Many Mexican steel mills, for instance, consume imported scrap (United Nations 1964).

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[5] Captive foundry- This type of foundry is owned by a parent company that manufactures an item, e.g., a capital good, which incorporates the cast object into its output. Generally, captive foundries do not produce goods sold on the retail market (Bhat and Prendergast 1984).

Scrap must be collected, sorted and prepared before sold as a feedstock to a casting workshop. This requirement generates associated entrepreneurial, employment and commerce opportunities. Firstly, all contaminants must be removed from secondary feedstocks. Contaminants can include non ferrous metals and non metallic items. In the first world, where capital resources are more readily available, highly mechanized scrap brokers use magnetized separators to sort the ferrous material from everything else. In developing countries sight and small handheld magnets are the tools of the trade for this operation.

The underdeveloped nature of scrap operations in the developing world contributes to limitations on the growth and competitiveness of foundries. Castings are only as good as the metal of which they are made. However, the remedies are straightforward: a technology upgrade. Better separation and processing equipment for the scrap supplier and metal identification and production technology for the foundries will go a long way to producing better castings. What is tricky is that foundries will not modernize their production causing dependence on qualities of scrap unavailable locally. And scrap businesses will not upgrade their classification equipment until they are assured of a steady market to consume it. A carefully planned upgrading program must target both industries simultaneously.

The foundry furnace size and shape dictates to what extent charge pieces must be cut down. The more processing required, the greater the cost of the scrap and the higher the production costs. Large, sophisticated firms employ huge, expensive shredders which can handle items as large as cars and white goods (refrigerators, ovens), shredding them into small pieces. Otherwise, shears, sledge hammers, and acetylene or oxy-propane torches can be used to dismantle cars composed of cast iron engine block and parts, non-ferrous parts, and mild steel body (Vogler 1982).

Contractors often utilize portable equipment such as hydraulic shears to reduce construction steel from demolished buildings (Bureau of Mines 1993). Some scrap processors that deal with large volumes of material find it worthwhile to flatten and bale their scrap. This eases and makes more efficient transport, but certainly balers are not a necessity. Scrap separating and processing facilities can be a profitable venture, only necessitating at a minimum a small capital expenditure and some space. High skill levels are not needed. Workers can be trained on the job, prior experience is not a pre-requisite.

2.6 Foundry Production Structure and Technologies

Casting production facilities are structured either as job shops or repetition (continuous) foundries. Job shops have low volume output and produce customized pieces on order, the specifications set by the customer. Continuous foundries produce an object speculatively and repetitively for the open market. They tend to be more highly mechanized operations, utilizing, for instance, a conveyor belt so that molds need not be poured by hand. This allows the molds to be carried to the furnace, rather than in a manual operation where the molten metal is delivered to the molds laid out on the floor. In continuous operations production time and costs are lower, but flexibility is limited (Bhat and Prendergast 1984). Job shops are more commonly found in developing countries.

The furnace is the largest and most expensive piece of equipment utilized by foundries. It consumes large amounts of resources: charge materials and energy. Since the melting point of iron is about 1300 degrees Fahrenheit and emissions (carbon monoxides and heavy metals) can be released, the potential for accidents is high. Upkeep is substantial. Furnaces must be cleaned of their residue, hardened charge material, which at the end of the day clings to the side of the foundry. The refractory lining must be repaired often. As such, foundry production tends to revolve around the furnace which is closely linked to productivity of the casting process.

Furnace types are varied, but choice is restricted by the availability of charge materials, capital, and fuel type. (See chart below for comparison of furnace choices.) The three principal types of melting furnaces for iron are: *coke fired cupola* [6], *electric induction*, and *oil or gas fired rotary. Crucible furnaces* are rarely used for iron founding.

TABLE 7: FURNACES FOR MELTING FERROUS SCRAP

Type of Furnace	**Fuel**	**Other Charge Material**	**Product**	**Size**	**Capital Cost**
Cupola	Coke or Hard Charcoal	Solid pig iron	Cast iron	Medium	Low
Rotary furnace	Oil	Solid pig iron	Cast iron	Medium	Medium
Crucible	Gas, oil or coke	None	Steel and cast iron	Small	Low
Electric arc furnace	Electricity	None	Steel and cast iron	Small, medium or large	Medium or high
Induction furnace	Electricity	None	Steel and cast iron	Small	Medium or high
Air or reverbatory	Pulverised coal or oil	Molten or solid pig iron	Cast iron	Medium or large	Medium or high

(Vogler 1981, p.66)

Cupolas furnaces are the primary type in use in both developing and developed countries. A cupola is a cylindrical shaft furnace which is alternately layered with charge and coke (E.P.A. 1992). The metal picks up carbon as it filters through the coke beds. Small amounts of limestone are added to the charge for purification and to help slag rise to the top for easy removal. [7] The metal melts into a well which is periodically tapped as needed.

[6] Coke- Metallurgical fuel created by distilling coal in an oven.
[7] Slag- A non-metallic substance created during melting which must be removed before pouring.

Cupola furnaces are appropriate for high production, least cost casting operations. It is the oldest furnace type in use (patented in 1794) and is widely employed both in industrialized and pre-industrialized settings (E.P.A. 1992). Cupolas have efficient melting rates and their operation is economical by minimizing waste. However, maintenance needs on a cupola furnace can be significant. The cupola shaft is lined with refractory material, clay or brick, which breaks down over time with heat and, hence, needs to be repaired or replaced. All in all, ease of use and low costs contribute to the cupolas' popularity as a melting furnace (Gunasekera 1976).

Cupolas do, however, have higher rates of toxic emissions than electric furnaces emitting carbon monoxide, lead, zinc, and cadmium. An electric furnace emits "about 75% less dust and fumes because of the absence of combustion gases or excessively hot metal temperatures" (E.P.A. 1992). Thus, expensive pollution control equipment like baghouses or electrostatic scrubbers is recommended for cupolas, but not for electric furnaces. Electric induction furnaces have replaced cupola furnaces in popularity in places like the United States where emission control requirements are strict.

The next step up from a cupola is a *rotary furnace*. This furnace works by a rotational movement which accelerates the melting process. Consequently, higher temperatures are used and steel can be melted in a rotary furnace. The fuel is typically oil, but coke can be used and is easier to handle. There are some coke-fed rotary foundries in Egypt (Buckle 1995). Higher quality of refractory material is required for a rotary furnace. One advantage of a rotary furnace over a cupola is that small quantities can be handled more easily, leading to greater flexibility (Vogler 1981).

An *electrical induction furnace* is similar in design to a crucible furnace, in that a shell sits over the furnace. The furnace is powered by electricity and therefore the shell sits permanently in the furnace. This furnace allows for excellent control of metal content. Hence, they are often employed in the production of higher quality engineering castings. These types of units can vary widely in size, from less than a ton for research purposes to a 75 ton unit (Vogler 1981). Their disadvantage is high cost at low production volumes and longer melting times.

Emissions are negligible on site, but it can be argued that these emissions are simply displaced to the environment at large via the power plant where the electricity is generated rather than the foundry site. Chances are better, though, that pollutants will be captured at the electric generating station than at individual foundries principally for reasons of scale. In any case, in many developing countries electricity is not available, or only sporadically. A foundry operation must have a constant input of heat to avoid tremendous problems with solidification of the molten charge. Therefore, induction furnaces are not a viable option in many developing country settings.

Another type of foundry furnace is the *graphite crucible furnace*. These are sometimes used for low scale operations and are predominately found in Gazan foundries. Their application for iron founding is not recommended as these crucibles are designed for non-ferrous melting and are not hardy enough to withstand the higher melting temperatures needed for cast iron charge. Thus, they need to be replaced often, which causes graphite crucibles to be the most expensive furnace option. (See Chapter 3, p. 56, for further description of crucible foundries and their problems.)

2.7 Casting Production

The molding process requires specialized skill and is a relatively labor intensive activity. Patterns must first be made (often in wood) duplicating the shape of the desired object. In some cases a pattern maker outside of the foundry is contracted for this task. The pattern is placed in a box filled with molding sand to create half of the mold. The molds are created in two halves in order to facilitate removal of the pattern. If the object to be cast is hollow, a "core" is also utilized. This is a more complex process. The core is a form made of sand that represents the inner shape of the casting. Sand cores can be crumbled out of the final, hardened casting.

The principal necessities of mold and core making are space and sand. Sand is a desirable molding material as it is readily available, cheap, and survives heat well. The finer the sand, the higher quality end product will result. Sand does need to be bound in order to uphold its form during pouring and setting. Clay and water are mixed with the sand as binders. In less sophisticated operations these ingredients are blended by hand, an arduous task.

After molten metal is poured into the molds and setting (solidification) has taken place, the casting is removed. Internal core sand must be withdrawn and external sand must be brushed off. Care is taken to retain as much sand as possible for reuse. The object must then be smoothed with any sharp edges or small bulges removed. In larger shops grinding wheels perform this task. In smaller shops, tools such as hand files, torches, hammers, and chisels will work (Vogler 1981).

The finished product markets can be considered in three categories: direct sale to consumer for direct use, sale to local manufacturer for use as equipment parts, and export for both indirect and direct use. Castings that are used directly include tools, grates, sewer lines, etc. Local industries may produce, assemble, or use manufacturing equipment that calls for casting parts or replacements. Export items must be of the highest quality (Buckle 1995).

"The upper end of this spectrum (of products) is bounded, both qualitatively and quantitatively, by the particular stage in the development of the engineering industry. Thus, in a country with an undeveloped engineering industry there will be a number of foundries producing low grade castings which may well be adequate for the market they serve. In a country with an advanced engineering industry, possibly including a motorcar industry, there will still be a large number of small foundries producing low to medium grade castings and a small number of large foundries producing high grade castings and contributing to a substantial proportion of total output" (Bhat and Prendergast 1984, p. 22).

Productivity figures vary greatly between foundries ranging from 6 tons per person-year for small foundries in Mexico to 19 tons per person-year in Brazil averaged for all foundries sizes. Average productivity in Mexico independent of foundry size is 12 tons per person-year. In the U.S. and Western Europe the numbers run from 33 in West Germany and Italy to 86 tons per person-year in the U.S. In Japan iron foundry output reached as high as 164 tons per person-year (Bhat and Prendergast 1984) [8]. Productivity is influenced by a number of factors: resource availability (fuel, infrastructure), level of technological advance, skill level of employees, complexity of castings, and production time.

It is clear from the figures above that output of foundries in developing countries is considerably lower than in developed countries. This is to be expected given that expanded economies have greater access to raw materials, capital, information, markets, and infrastructure. Despite these significant limitations many experts believe that more appropriate use of technology and better management of available resources would lead to higher rates of output in developing nations. "Gains in productivity do not necessarily require new investment and usually much can be achieved by more efficient use of existing facilities and through better organization of production" (Bhat and Prendergast 1984, p. 21). For instance, a study of India's foundries indicated that there is much existing capacity that was not utilized.

> Information from industry sources in India suggest that capacity utilization is extremely variable across various sections. In some sections of the industry capacity utilization is as low as 15-30 percent. In these cases the sources of underutilization appear to be mistiming of investment and the decline of demand for products of some of the traditional sectors (i.e., railway castings) coupled with the inability to switch to more intricate industrial castings. While from one point of view, all that seems to be required is a re-allocation of resources within the sector, it must be remembered, that even where operations such as moulding are highly labour-intensive and where there are no physical constraints on the utilization of machine capacity the array of managerial and craft skills required to produce one set of castings may differ radically from those required to produce another" (Bhat and Prendergast 1984, p 21).

2.8 China

The metal casting industry in China is huge, one of the oldest industries in the country and one of the most traditional (Miao 1987). There are approximately 10,500

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8 These figures are from the seventies. Productivity figures will presumably be higher now, but not by much. In most cases in lesser developed countries, foundry operations remain as primitive as ever .

production shops which made about 12.5 million tons of castings in 1993, iron foundries representing about 80 percent of the total output. Generally production levels have increased over the years owing to prosperity in the industrial sector and increased export activity (Zhang 1995). Labor intensive practices and cupola furnaces are the standard. Mechanization generally is rare owing to limited electrification outside of major cities. A few foundries in China have begun to use computers to "determine the optimum operating parameters for cupola melting and for the simulation of casting solidification in research work" (Miao 1987, p.35).

The biggest difficulty for Chinese foundries is the quality of their higher line castings do which not reach the standard of those produced abroad. This has led to modernization programs which attempt to address quality control issues such as improved mold and core making procedures, sand treatment, and upgraded technology where appropriate. "...the China foundry industry is in need of 'AA Technology' (Advanced and Appropriate) rather than highly sophisticated technology which may be beyond the industry's present economic status as well as the general technical level of maintenance and repair capabilities" (Miao 1987, p.35).

2.81 India

India has about 6000 foundries producing about 2.3 million tons yearly (Chakraborty 1995). This amounts to 383 tons per year (tpy) per foundry. Compared to China where average output is 1200 tpy, Indian foundries appear to be on the whole smaller and less productive than their Chinese counterparts [9]. Coke fired cupolas predominate with melting capacities of up to ten tons per hour. Labor intensive practices prevail including manual pouring and assembly of molds. Materials (scrap metals, coke, sand, and limestone) are moved from place to place with laborers carrying baskets.

However, there are several large, high tech foundries found in India. These foundries are manufacturing component parts for the transportation, telecommunication, sanitation, and industrial sectors some of which gets exported to the United States, Middle East, and Europe. Indeed one iron foundry from Roxbury, Massachusetts shut down its stateside operations and instead now imports castings like manhole covers from India. The handwork done there, they say, is of a reasonable quality and quite inexpensive (Gregory 1994). Indian castings can cost as little as $0.30/pound achieved in part by a proliferance of scrap iron.

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[9] These figures need to be considered with a degree of caution. The China Foundry Association recognizes that it is extremely difficult to ascertain exact figures in an industry where small foundries operate informally and businesses are often shutting down and opening up. Additionally, it is hard to know whether foundry size or productivity accounts for the rather large differential between Chinese and Indian foundry output numbers.

2.9 Case Study: Sri Lankan Foundry Industry

The foundry industry in Sri Lanka is expansive, but underdeveloped. Capacity and technical resources are underexploited and this results in much unnecessary importation of castings that could be produced domestically. Many of the problems that exist in Sri Lankan casting operations are commonly found, and as such the Sri Lankan foundry industry presents a good opportunity for study.

Foundries were known to have existed in Sri Lanka for more than 2000 years. Presently there are over sixty foundries (51 are iron foundries) employing approximately 1500 workers. Sri Lanka's population is approximately 17 million. These shops are producing simple spare parts, and some machine castings for Sri Lanka's rubber, textile and tea industries. This industry's role within the country's developing economy is significant. A modernization of the industry would reduce Sri Lankan dependence on expensive imports, create employment, and cause a similar ripple effect on down and upstream industries that supply foundries with inputs or utilize their outputs (UNIDP 1988).

2.91 Industry Structure

About 60% of the foundries in Sri Lanka are small scale enterprises (0-50 tpy) and 40% are medium scale (50-400 tpy). There is one large, state owned operation that produces 17% of Sri Lanka's yearly output (UNIDP 1988). The movement, however, is toward medium scale shops. In the last twenty years the contribution towards total output of the largest foundry has shrunk from almost 50% to 17% indicating that small and medium foundries have taken a larger share of the market (Gunasekera 1976). The typical foundry in Sri Lanka employs about ten workers, half of whom are considered skilled. Average output (spare machinery parts) is 40 tpy.

Despite positive indications of growth in the industry, Sri Lankan foundries today remain as unsophisticated and unmodernized as they were twenty years ago. For instance, the furnace technology predominantly in use is a cold blast cupola which does not allow for careful control of the charge and utilizes costly, foreign coke. There is virtually no classification and careful identification of the charge material which is so critical to the production of a high quality casting. Often materials are employed which do not meet technical specifications (UNIDP 1988).

Foundrymen rely intensively on scrap iron to feed their furnaces. As in most pre-industrializing nations, scrap is limited because of reduced consumption, longevity of consumer and commercial goods, and stiff competition for salvaged materials. Therefore, the need for scrap iron far exceeds its availability. Availability was such a concern predictions indicated Sri Lanka supplies would dwindle to such an extent as to seriously impair the industry's ability to produce. Limited supply drives up the price of scrap which, nonetheless, remains considerably below that of imported pig iron, the raw material alternative charge material. In 1976 the price of pig iron in Sri Lanka was 2.5 times that of scrap (Gunasekera 1976).

Technical problems constrict the quality of Sri Lankan foundry output. Products manufactured by Sri Lankan foundries are almost all grey iron, of which the lowest quality iron castings are made (UNIDP 1988). There is very limited production with ductile and malleable iron of which higher end objects are made. High performance irons make up thirty percent of the global output, limiting Sri Lanka's ability to compete on the world market. The most rudimentary of the Sri Lankan castings, i.e., manhole covers, grates, brakes, have a reject rate of 17 %. While the iron can be reincorporated into another product there is an associated time and capital loss.

Poor quality products impair the ability of the industry's markets to flourish. Lack of confidence drives purchasers to seek goods from other sources with dependable quality. Many very basic castings are imported, for instance, sluice and gate valves, clamps and joints used for water works projects, although technically Sri Lankan foundries have the capability to produce these items. Therefore many castings used in Sri Lanka are purchased from overseas. Low technical skill levels, lack of metallurgical control, and outdated technology have meant that Sri Lankan foundries do not fabricate castings of sufficient sophistication, complexity, and quality to meet the needs of manufacturers.

Other problems associated with casting production in Sri Lanka are: lack of proper accounting systems, lack of access to technical knowledge, competing administrative jurisdiction between three ministries, closure of public market to private foundries in some sectors, and vertical integration limiting possibilities for commercial ventures (UNIDP 1988).

UNIDO has recommended a rehabilitation program to make Sri Lankan foundries more competitive: Increase the usage of plentiful and cheap scrap steel in charge by adjusting furnace technologies. Usually scrap steel can be easily found where there is not a large, local steel mill to consume it. However, the use of scrap steel in iron casting is presently restricted by the types of furnaces typically employed. A switch from cold blast cupolas to hot blast, electricity fired, or rotary furnaces will allow temperatures sufficient to melt steel. Foundry operations should be modernized. Improving skill levels and upgrading technology will go a long way towards assisting foundries in producing an international quality output. Providing technical training for foundry workers in the areas of metallurgical control and pattern making is critical.

Normalize duties. In Sri Lanka the duties run about 60 % which has the effect of overprotecting the foundries. They do not feel compelled to maintain quality. Duties should be set so as to encourage healthy competition, but not undercut the market by allowing dumping of cheap castings into the local market. Other recommendations for Sri Lankan foundries include a consolidation of oversight and a market development study.

Small scale foundries play a critical role in industrial development activities throughout the world. Backward and forward linkages are particularly strong with castings and therefore an upgrading of casting workshops would have positive beneficial effects on many other industrial sectors. The means to achieve this upgrade are access to information, organization, and capital. Huge investments are not required. A careful study of the bottlenecks these industries face has important implications for Gaza's foundries that will be explored in the last section of this thesis.

CHAPTER THREE:
GAZA'S FOUNDRIES AND THEIR LINK TO DEVELOPMENT

As seen in preceding chapters, iron casting in developing countries is generally confined to small, primitive, and under-capacity workshops. Given access to information and capital, there are many options for the rehabilitation and expansion of these operations to more fully capitalize on available resources and market opportunities. This chapter will evaluate the iron foundry industry in the Gaza Strip and its ability to grow and improve. The most important possible consequences of modernizing are a contribution to a growing industrial economy, utilization for productive use of an otherwise wasted material, and promotion of a sustainable industrial pattern.

The chapter starts with a profile of Gaza's economy and environmental situation, setting the context for the role a flourishing iron foundry trade could play in Gaza's development. Next comes a discussion of the sector's structure and bottlenecks. This leads to proposals for rectification of these problems drawing on comparisons with the practical experiences of other foundries discussed in Chapter Two. The chapter concludes with an evaluation of the potential benefits to the area brought by expansion of this sector.

3.1 Gaza's Economic Situation

The Gaza Strip is a small area, 28 miles long and five miles wide, with a rapidly growing population of more than 800,000 [10] (Roy, "The Gaza Strip...." 1994). There are thirteen cities in Gaza, with approximately one third of the population residing in Gaza City. It is bordered by Egypt to the south, the Mediterranean Sea to the west, and Israel to the north and east. See attached map (p. 45). Gazans have been a people in distress throughout their history. They have never enjoyed the fruits of autonomy. Living conditions in Gaza are very difficult. The population density is one of the highest in the world and unemployment and poverty prevail.

There are now, however, many forces at work trying to correct Gaza's economic disparities. A great degree of international attention has focused on Gaza's situation. The event that precipitated this interest was the signing of a peace accord between the Palestine Liberation Organization (P.L.O.) and Israel on May 4, 1994. Gaza was designated (along with Jericho in the West Bank) the first Palestinian Autonomous Region. The stated intent of the accord is that Gaza and the West Bank will move into a position of full autonomy after five years. The implied intent, and hope of many, is that these Palestinian areas will eventually become a state of their own.

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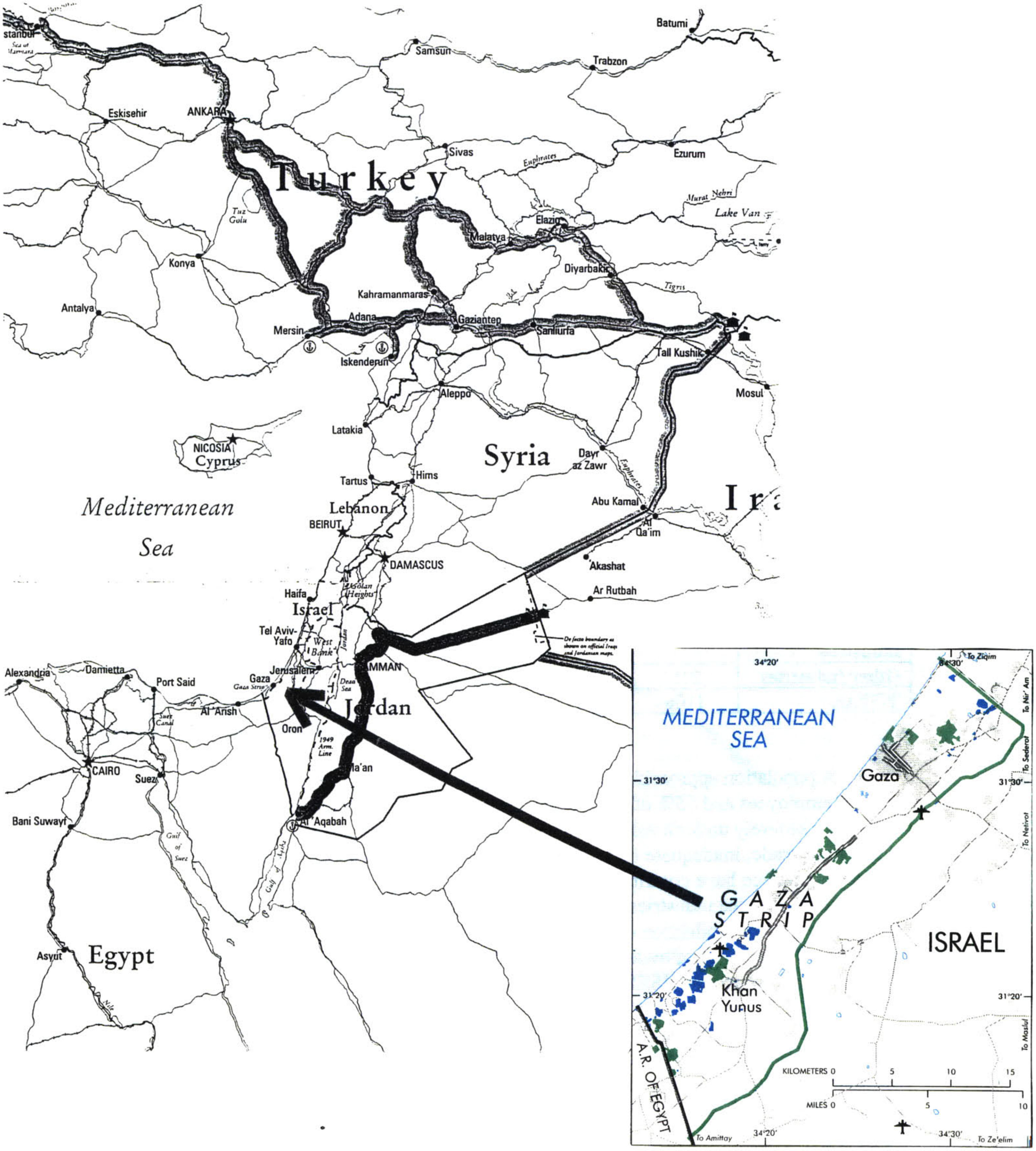
[10] At four percent the population growth in Gaza is one of the highest in the world (Roy, "The Gaza Strip..." 1994).

THE GAZA STRIP



In the meantime, there is much work to be done to raise the standard of living for the Gaza's population. The Gazan economy is dramatically underdeveloped. The disparity between Israel's prosperity and modernity and Gaza's problems of poverty and unemployment aggravate the political tensions that lead to instability in the region. The contrast is illustrated by Gaza's 1991 GNP per capita of $1310, one-eighth that of the Israel's at $10,900 per capita (ISEPME 1993).

Contributing to the weak economy is a small and primitive industrial base. Industrial activity in Gaza has stayed "weak, unsophisticated, and traditional" (Blair 1994) as evidenced by the following chart:

TABLE 8: INDUSTRIAL ESTABLISHMENTS IN GAZA IN 1991

Major Branch	# of Firms w/ 1-3 workers	# of Firms w/ 4-10 workers	# of Firms w/ 11-20 workers	# of Firms w/ 21+ workers	Total # of Firms	# of Workers	% of Total Labor Force
Food, Beverage & Tobacco	75	33	3	5	116	583	8.2
Textiles, Clothing, & Leather Products	245	273	45	8	570	2969	42.2
Wood & its Products	259	55	4	4	322	864	7.6
Metallic Industries	314	60	2	3	378	1465	12.9
Other Industries	215	93	17	1	325	3899	34.4
TOTAL	1106	503	71	21	1710	11337	100.0

(Central Bureau of Statistics 1992)

A population approaching one million people with only 21 manufacturing firms of over 20 employees and 65% of all industrial establishments with less than three workers indicates a severely underdeveloped industrial economy. Restrictions on industrial activity and trade, inadequate infrastructure (power, sewage, water) and an exodus of the educated populace have contributed to this situation. As a result, the economy is dominated by service industries and agriculture. The underdevelopment of the industrial sector, particularly production of exportable quality goods, in part explain Gaza's trading imbalance. The balance of trade is vastly lopsided. The annual rate of import is almost three times that of export (ISEPME 1993).

Another contributing factor to Gaza's poor economic situation is its high unemployment rate estimated to be as high as 55% (Blair 1994). In the past, much of Gaza's income was derived from day laborers working in Israel. Of the total GNP for Gaza and the West Bank in 1991, almost a third derived from salaries of Palestinians working in Israel (ISEPME 1993). Between 1970 and 1987 the numbers of workers in Israel skyrocketed, contributing to economic growth in the region and driving wages up. In 1987, the 'intifada', or uprising against Israeli occupation, began and with it came a squeeze on employment in Israel. The Gulf War followed in 1991 with a reduction in the number of working permits issued.

At its height, about 46,000 workers, close to 46% of Gaza's labor force, held jobs in Israel (ISEPME 1993). Now, on days when the borders are open, 26,000 working permits are issued representing 23% of the labor force (BBC 1995). In the last six months Palestinians jobs in Israel have been replaced by imported labor, thereby eliminating those long term job prospects. Another blow to the Palestinian economy came from the repercussions of the Gulf War abroad. Many Palestinians living and working in the Gulf had been sending remittances home. After the war they became refugees and this sizable injection of income dried up.

In the wake of the peace accord many nations have committed themselves to assisting the Palestinian economy through industrial development projects, infrastructure rehabilitation, housing construction, social programs and more. In particular, the World Bank is working with its counterpart Palestinian organization, PECDAR (Palestinian Economic Council for Development and Reconstruction) which is responsible for doling out aid monies for the following projects: development of road, sewage, solid waste, and water network, reforestation, environmental protection, upgraded housing, and education. The overseas development community plans to spend about $250 million in Gaza reinvigorating opportunities for future economic growth. Discussions are also underway to build a number of industrial parks throughout the Strip. Trade opportunities should expand as a consequence of the new Palestinian-Israeli economic agreement. The economic agreement strives to encourage industrial growth by relaxing barriers to accessing markets and encouraging the free flow of goods.

Immediate possibilities do not yet exist for putting more Palestinians to work in the local economy except as a part of short term infrastructure rehabilitation projects funded by international development organizations. An integral part of the strategy of these organizations is to promote highly visible, labor intensive, public works projects to give an immediate boost to the economy. Longer term strategies include, among other things, promoting the production of goods that fulfill basic needs, are exportable, and substitute for imports (Baskin 1995).

As long as joblessness and shortages prevail peaceful relations between Gaza and its neighbors will remain elusive. As Israelis say, "Hungry neighbors don't make good neighbors" (Kleiman 1995). Jobs and a higher standard of living will increase the likelihood of harmony in the region. And the rewards of peace will be increased economic activity, trade, and tourism. However, conditions are worse than ever at this moment with the Israeli borders shut to most transport and day laborers as a result of the precarious security situation. The Gazan economy has been so closely intertwined with the Israeli economy that these border closings create enormous hardships for Gazans. As well, the Palestinians themselves are seeking distance from the Israeli economy, a consequence of the acrimonious history between the two sides. The need for more indigenous economic activity and industry to generate jobs and income for the Gazan population is now more critically important than ever.

3.2 Gaza's Environmental Situation

Gaza's environment, as well as its economy, is in ill health. Contamination and depletion of drinking water sources and inadequate solid waste management practices present the worst environmental risks for the population of Gaza. Piles of rubbish on the street, problematic because they are visually unpleasant and a health risk, signify more consequential and endemic problems.

Of perhaps the greatest concern for the long term, is the despoliation of Gaza's fragile aquifer. Overuse causes salination, as sea water is drawn into these depleted, underground fresh water sources. The aquifer is depleted three times as fast as it is replenished (New York Times 1994). At this rate the U.N. estimates the aquifer will only be potable for another ten years.

Fertilizers and pesticides also leach into the groundwater [11]. Agriculture is practiced widely in Gaza as about two-thirds of this semi- arid land is arable (Safi 1994). Some groundwater corruption comes from the leaching of crude dumps. Toxic groundwater contamination from industrial sources is minimal, not because of capture and treatment, but because industrial enterprises are largely small and their output also modest. Sewage treatment systems do not serve the entire population, are at overcapacity, and in poor working order, so pathogens and biological oxygen demand from human waste compromises groundwater as well.

Air pollution levels are kept low in Gaza by fewer sources of emissions: industry and vehicles. Diminished industrial and vehicular activity correspond to diminished economic activity generally. Vehicles are the primary contributor to Gaza's air pollution. The number of cars in Gaza is growing dramatically daily. It is said that thirty additional cars enter Gaza each day to be bought by the new Palestinian Authority and international workers. As cars there tend to be older models with less efficient engines and lacking modern emission controls, air pollution from these sources is disproportionately high for the number of vehicles. As economic activity in Gaza expands, so will air pollution levels and care should be taken to ensure that it is properly controlled.

The international development community is planning a modern environmental protection program for Gaza. A high priority is placed on fixing sanitation systems as these have the most immediate consequences for human health. Workers have already started to repair existing sewage lines and lay new ones. The construction of sewage treatment facilities is in the works. The Palestinian Authority and various foreign entities

[11] Of the 75 different pesticides used in Gaza, almost 20 were found to be unauthorized for use abroad (Safi).

are devising a solid waste management plan for Gaza. Centralized, modern landfills and systematic and comprehensive garbage collection are part of the plan to replace the 19 existing crude dumping areas and sporadic collection practices.

3.21 Waste Management

Hazardous and municipal waste collection and sewage treatment and disposal have largely been unorganized. The most obvious of these dysfunctions is a lack of proper garbage management. On virtually every corner one finds a steaming, smoking pile of garbage and in every tree a plastic bag. There are sporadic, and often overfilled, waste containers. The collection of this waste, organized at the municipal level, is not systematic or comprehensive.

The rubbish, if gathered for disposal, is piled in open dumps. There are nineteen of these enormous unlined, uncovered, unregulated, unsecured solid waste dumps in the Gaza Strip. They smolder continuously as new batches are burned to diminish volume. All types of waste generated in Gaza are found at the same dumpsites. This includes industrial, hazardous, slaughterhouse, sanitary, and medical wastes. In settings of more sophisticated environmental protection, waste sites are differentiated by type. Different levels of safeguards are practiced dependent on the degree of hazard posed by that waste type.

There are several harmful consequences posed by one landfill for all unsorted wastes. The most immediate is that scavengers (most often children) rummage through these piles exposing themselves to many dangers: fire, sharp objects, disease vectors, odors, pests, toxic contaminants, smoke, etc. Airborne particulates also result from the burning.

While getting garbage off of the streets and into secure landfills is of highest priority for the solid waste management scheme, some thought has been given to recycling waste. Ideally this "waste" could be used as a raw material in local industries, thereby displacing the need for disposal and providing a locally generated feedstock. However, there are difficulties in salvaging waste even in settings of more advanced environmental protection and awareness, and even greater difficulties in Gaza, in spite of the potential for real benefits.

3.22 Solid Waste in Gaza

The greatest impediment for organized waste salvaging efforts in Gaza is the lack of industries based on salvaged materials to consume the material flow. But also low waste generation rates and quality constrict the potential for recycling Gaza's wastes and in part explain the small numbers of scrap based manufacturers. Like other developing cultures, Gaza does not generate as much waste as developed countries, nor is it of as high value from a salvagability standpoint. It is estimated that the average resident of

Gaza disposes of approximately 0.79 kg/person/day (CEU 1994). This compares to 2.5 kgs/person/day in the U.S. and 1.6 kgs/person/day in Israel (Inbar 1994).

The disparity between generation rates is explained primarily by the material consumption habits of richer versus poorer societies. Goods tend to be less heavily packaged in poorer societies. Household items and manufacturing equipment, for instance, are not readily abandoned in a place like Gaza where their use is prolonged through repair and reuse. This is feasible where labor rates are low. There is a booming business in the repair and remanufacture of appliances in the Strip. Many used goods including machinery, vehicles, clothing and more find their way to Gaza from Israel. This type of flow is common from developed country to developing.

Also, the composition of Gaza's refuse is less than desirable from a recyclability standpoint. At the household level many of the higher value items are reused, i.e., metal cans, glass bottle, textiles. A large percentage of the waste composition in Gaza is organic material, over 70% depending on the time of year (CEU 1994). Composting presents an additional opportunities for Gaza to pursue [12]. An unusually high percentage, 20%, of Gaza's waste is unutilizable sand and other inert materials (Muhammed 1984). This matter is scooped up while collecting trash dumped on the ground.

TABLE 9: WASTE COMPOSITION BY WEIGHT

	Gaza	Israel	U.S.
Organics	72.8	52.0	30.9
Paper	12.4	18.5	37.5
Glass	2.2	4.0	6.7
Plastics	11.0	11.0	8.3
Metals	1.7	4.5	8.3
Textiles	---	3.5	---
Other	---	6.5	8.3

(Derived from CEU 1994, p.5; Inbar 1994, p.5; E.P.A. 1990)

Many higher valued materials such as metals found in very low quantities in the domestic waste stream. These ordinarily might come from soda cans, for instance, which are a luxury for lower income households. Factories themselves, which are in short supply in Gaza, typically supply a large portion of the salvaged input material utilized by industry. Industrial waste streams are usually plentiful, uncontaminated, segregated and concentrated and are therefore preferable as an industrial input, from the manufacturer's point of view, to post-consumer waste streams [13]. But Gaza's small industrial base,

12 Large scale composting operations in both developing and developed countries successfully produce a commercial land application material that supplements and can replace fertilizers in some cases. Israel has much experience in this area.

13 From an environmental point of view post-consumer, secondary material content is aggressively sought. Secondary material is important because it is not typically recovered as it is more difficult to

present and past, generates little of this material. "A major source of raw material is the scrapping of obsolete buildings, machines, vehicles and equipment after an average life of some twenty years...(therefore)...the supply of scrap relates to the position (level of investment and industrial activity) twenty years previously..." (United Nations 1964, p. 75).

Another difficulty for Gaza in achieving its recycling potential is the inadequate nature of present refuse collection programs. Usually recyclables collection programs are piggybacked onto solid waste collection. Plus, it is argued, since trash containers are unavailable, Gazan residents are not trained in proper waste disposal habits. Thus, they will not easily be taught to separate their waste by material type.

3.23 Current Recycling Activity in Gaza

Despite these stated hindrances a surprising amount of scrap based manufacturing occurs in Gaza. Systems have evolved to capture the most valuable of the scrap commodities. Gaza has a network of scavengers, collectors, and peddlers. In most cases, the supply of materials is post industrial (primary), not postconsumer (secondary) waste. Scrap flows often come from Israel to supply the inputs necessary to feed industries in Gaza. Rug makers use scrap textiles supplied by clothing workshops which are numerous in Gaza. Shaped pieces are cut from swathes of fabric, leaving behind many smaller pieces and edges. The smaller pieces are sometimes used as mattress stuffing, the longer edges can be woven into carpets.

There is a considerable amount of plastics recycling in Gaza and the opportunity for more. The waste from plastic, woven mat workshops can be used as an energy source. Tubular polyethylene fibers are extruded and cut to the desired length during production. The short ends of these fibers are worthless and are sold as a fuel to Turkish baths in Gaza City. There are a few plastic bag and container manufacturers in Gaza. They use polyethylene pellets bought from Israel or the international market, whichever is cheaper. Sometimes post-industrial, clean plastic film waste is shredded, granulated and substituted for imported pellets. The production of these recycled pellets is relatively low tech. Several factory owners expressed confidence in their ability to utilize locally generated post-consumer plastic bag waste to make recycled pellets if they had the washing equipment necessary to remove contaminants. This seems feasible given the relatively sizable market.

Paper and cardboard use and production are minimal in Gaza. In the city of Ramallah in the West Bank there is a small hydropulping operation that makes egg cartons and fruit trays from 100% waste paper and cardboard. Most of their material is derived from leftovers of packaging operations. Gaza is an exporter of eggs and produce

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gather. Public resources and incentives need to be used to encourage the recycling of secondary waste. Primary (industrial) wastes, on the other hand, are economical and convenient to recycle and market forces, therefore, ensure that they are recycled.

to Israel and, therefore, could likely support such a facility. Lastly, iron scrap is gathered, melted and cast into new items. This will be discussed shortly.

Based on cursory observations there is ample opportunity for the expansion of these efforts and the consequential utilization of excess waste materials by Gaza's industries. In addition to the available refuse generated in Gaza itself, tremendous amounts of primary and secondary waste materials go unutilized in Israel. In some sectors, like textiles, plastics, and metals, there now exists shipments of scrap from Israel to Gaza for use by industry. Israeli recycling programs and markets are remarkably underdeveloped for such a highly industrialized country. The country's recycling rate is only 7.0% (Inbar 1994) and therein presents another opportunity for Gazan scrap based industrial development activity.

3.3 Upgrading Of Gaza's Iron Foundries And Its Benefits

The remainder of this thesis will explore the potential for Gazan waste-based iron foundries to grow by tapping existing resources and opportunities. This sector was chosen based on the particularly primitive state of its operations, the relatively developed state of scrap metal supply networks, the potentially important links between castings and other industrial sectors, and its potential for growth and contribution to Gaza's development.

The most active use of scrap in Gaza is in the metal sector. Approximately 22% of Gaza's factories are metal workshops, one of Gaza's largest industrial employers after the textile sector (see table on p. 46, "Industrial Establishments in Gaza".) The high rate of scrap metal usage can be partially explained by the value of the raw material for which this scrap substitutes: metallic ores. Many metal prices are higher than plastics, paper, and textiles, other scrap materials which can be used in scrap based manufacturing. Equally important to explain the high recycling rates of metals as material values is science. The composition of metal is not degraded during the recycling process as it is for plastics and paper. Thus the process of remelting and casting yields items of comparable metallurgical quality to those made from ores, assuming contaminants can be eliminated. Ease of collection also contributes to higher metal recycling rates. Thus the demand for scrap metals is vigorous and recycling rates are relatively high.

Metal working facilities in Gaza can be divided roughly into six categories: sheet metal working, turning, founding (casting), wire working, bar working, and rebuilding.

TABLE 10: GAZAN METAL WORKING INDUSTRIES

	INDUSTRY DESCRIPTION	SCRAP USAGE
Sheet Metal Working	Produce and remake appliances (primarily refrigerators) and aluminum pots and pans using lathes or machining equipment. Use techniques of metal bending, welding, and soldering.	Used appliances, motors, or parts are adapted for use whenever possible. The aluminum sheets made for the production of kitchenware are produced with aluminum industrial scrap. Aluminum cans cannot be used because of their magnesium content.
Turning (Machining)	Converts steel or copper bars into screws, spare parts	30 - 35% usage of primary scrap bars, rusted or defective.
Founding (Casting)	Iron scrap converted into molten metal which is poured into molds and hardened to produce solid items: machine parts, valves, plumbing parts, sewage pipes, etc.	Almost 100% scrap is utilized.
Wire Working	Steel wires are transformed into screws and nails.	The steel wire used in this process is all new.
Bar Working	Aluminum profiles are cut, soldered, and assembled into door and window frames.	Pre-manufactured, new aluminum profiles are imported for these workshops.
Parts Rebuilding	Automotive spare parts are sand blasted and rebuilt. Screws and shafts are produced for older vehicles and cargo boxes are made.	This industry depends almost entirely on used parts.

(Adapted from Barghout 1994)

3.4 Gaza's Foundries and their Link to Development

The most interesting of these metal working categories, from the point of view of scrap utilization, are the iron foundries. They consume almost 100% iron scrap which includes post-consumer, cast iron items [14].

There are 11 small casting workshops in Gaza. They operate with graphite crucible furnaces of about 100-150 kilograms capacity each. The furnaces are fueled by waste vehicle oil. Waste oil is cheap and readily available since most car owners in Gaza change their oil at automotive shops. The majority of casting is ferrous (iron) with production of up to five tons per month (tpm) per firm. There are approximately five workers per firm (Baskin 1995). Other industries in Gaza are linked to the casting sector, namely the scrap metal business (including scavenging), machine parts manufacture, cement making and gravel quarrying in the West Bank (castings provide the parts for the equipment used in these operations), construction and public works projects.

Gaza's foundries are highly labor intensive enterprises. All operations are manual with molding taking place on the ground. Molten iron is ladled and poured by hand. Sand and charge metals are manually hauled around the premises. These workshops cast

[14] Occasionally expensive, imported pig iron from Turkey or South Africa must be used as a charge supplement to correct metallurgical deficiencies in the scrap. Pig iron use is kept to a minimum because of its elevated cost.

parts for pumps, cars, machinery, motors, grinders, and more. These goods are low quality and only supply the internal market as they do not meet international quality specifications (Barghout 1994). Customers tend to be other small entrepreneurs buying parts (plumbers, mechanics, contractors), individuals purchasing decorative items, and administrative bodies buying parts for their vehicle fleet and infrastructure rehabilitation projects. However, an unfortunately large number of castings from abroad (Turkey, India, the Far East, Israel) supply the local market. Gazan castings cannot compete in terms of quality and sophistication.

3.5 Scrap Collection and Processing Sector

Scrap charge is primarily purchased from Gazan scrap dealers with occasional special orders put in directly to dealers in Israel or the West Bank. Machine shops and foundries are the biggest local customers for scrap dealers. The scrap business in Gaza is vigorous. There are eleven scrap yards which supply local enterprises with the required metal feedstocks. These yards handle steel, copper, aluminum, tin, lead, and iron; about 450 tpm collectively. The scrap comes principally from commercial sources, with some from domestic sources. Every variety of metal article imaginable (appliances, motor parts, decorative items, transformers, radiators, machinery, vehicles) can be found at these scrap yards including, ironically, used Israeli military equipment. Some merchants also supply imported virgin raw materials to businesses.

Foundrymen in Gaza are constricted as to material choice due to the restrictions placed on Gazan dealers doing business in Israel. Most scrap comes from Israel, a source over which the buyers in Gaza have no control. Scrap metal is acquired through collection locally or in the West Bank, Israeli scrap dealers or directly from Israeli construction debris sites. Nearly twenty percent of one dealer's material flow comes from local sources, with that number expected to rise in the future owing to an expanding material economy.

There is a vigorous local trade in scrap metals back and forth to Israel. Generation and consumption are many times greater on the Israeli side reflecting the size of the population, increased GNP, and more advanced state of manufacturing, i.e., steel mills, foundries producing engineering castings, etc. Much scrap metal is collected from Israel, sorted, cleaned, and processed in Gaza, and sent back to Israel for use by industry there. By one estimate, the largest export from Gaza is scrap metal (Goodman 1994). Lower wages make this arrangement worthwhile and the Israeli market can afford elevated prices.

A network of collectors furnishes Gazan scrap dealers with the material that is then separated, cleaned, processed, marked up, and sold to the local market. At the bottom end of the chain, young children (boys) scavenge the dump sites, trash bins, and road sides for scrap metal (and whatever else they can find of value). The scavengers also go from door to door in the industrial sector and residential neighborhoods to buy metal waste [15]. They can sell small amounts of easily tradable items, like aluminum cans, to local junk dealers [16]. These merchants then sell the cans to the scrap dealers. Scavengers also sometimes sell their bounty directly to the dealers or in some cases are contracted by the foundries. Usually, though, the scavengers' material is not of sufficient quantity and quality to bypass the dealers and sell directly to the manufacturers.

While working conditions are miserable for these scavengers, their wages are surprisingly good. Four kids on a cart can collect the equivalent of 300 kg/wk of aluminum. They are paid up to two Israeli shekels ($ 0.67) per kilogram and this works out to nearly 25 shekels/day. While this seems low, just over $8.00/day (at present exchange rates), it is on par with what a low skilled laborer in the manufacturing sector in Gaza earns. Skilled workers earn between $10.00 to $17.00/day.

3.6 Bottlenecks in Gaza's Foundries

Iron foundries in Gaza are small and inefficient with outdated production modes and workers of low skill levels. There is much ground for improvement there. Meanwhile, businesses, aid organizations, and Gazan residents are spending tremendous sums on imported castings for manufacturing, infrastructure repair and construction: castings which could feasibly be produced in Gaza. Some of this money, badly needed at home, is unnecessarily exported. A upgrading of Gaza's small foundries present a particularly strong opportunity for import substitution.

There are those who feel that a constrained ability to produce castings of satisfactory quality and price has far ranging repercussions on industrial growth possibilities of a region. A UNIDO analysis of Sri Lankan foundries' inability to successfully meet the needs of the local market concludes:

> The result of this serious deficiency in supply restricts the markets in which local industrial entrepreneurs can operate to produce and develop new or replacement plant and equipment without the necessity to import components or complete units... Unless some changes are made, the present market share will progressively reduce and be dominated by the more advanced overseas foundry industries. If the Sri Lankan industry is not given assistance to increase its technological base and ability to produce volume economically, then the whole local manufacturing base will be progressively eroded, further affecting the Country's balance of payments (UNIDP 1988, p. 26).

With that in mind the next section will focus on the bottlenecks in Gaza's foundry industry. Based on the experience of other foundry industries outlined in the preceding

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15 In Israel today occasionly the call of the scrap merchants can still be heard yelling "alte zachen" ("old stuff" in Yiddish). They comb neighborhoods and sell scrap dealers their bounty.

16 There are numerous little stores in Gaza that sell junk, repaired or repairable household items.

chapter, technical problems will be identified and rectification of the problems proposed. Constraints on foundry production in Gaza can be categorized as follows:

o Outdated, inefficient technology methods.
o Low skill levels.
o Infrastructure limitations.
o Market conditions.
o Poor working conditions.

Outdated, inefficient technology methods: Graphite crucibles are the principal furnace type used in Gaza. Crucible furnaces are essentially stationary or tipping graphite pots lined with refractory brick which sit over the furnace. This process differs from cupola furnaces where fuel and metal are charged together, alternating layers of fuel and scrap. The essential step of carbon addition comes from the graphite which is composed of carbon. One advantage of crucibles, everything else being equal, is that better control over composition and quality is maintained since the metallic charge is kept separate from the coke (Vogler 1981). In Gaza, workers dip ladles into stationary crucibles bringing the molten metal to the mold. The process is labor intensive and efficiency is low.

The major problem with crucibles is their expense. When used for iron casting the crucible does not endure past approximately five to ten melts (Barghout 1994). Crucibles are designed to melt non-ferrous metals (aluminum, copper, zinc and magnesium) at lower melting temperatures than iron. Thus disintegration and accumulated residues shorten the duration of the crucible making it the most expensive method of casting iron. Since crucibles are small in diameter the charge also must be cut down accordingly. Rule of thumb is the size of the charge must be only one-third the diameter of the furnace (Minoff 1995). This added degree of processing contributes to the higher cost of crucible melting. The crucibles cost $300 each and at eight melts per crucible this works out to $20/100 kg. of charge (Barghout1994). Additionally, crucibles can only hold such a small quantity of charge that economy of scale opportunities are ruled out.

The appeal to Gazan foundrymen of graphite crucible foundries is that capital costs are low as each crucible costs considerably less than the initial investment required for a cupola or electric furnace. This makes them attractive for small scale operations which likely have cash flow problems or limited borrowing access, the case in Gaza. However, per unit costs are much higher. Fuel costs are lower than cupolas or induction furnaces where coke or electricity must be used. These are important considerations where coke is hard to get and/or fuel costs are high (typically the case in developing countries, as is true in Gaza). Oil is generally easier to acquire, cheaper, easier to use with a tilting furnace, and heats faster than coke (Vogler 1981). Waste oil is available at moderate costs, but there are potential negative health consequences from burning it. For long term profitably, unit cost per output is most important, not initial capital costs. Nonetheless, Gazan entrepreneurs in the foundry business are not in the position to ignore high capital costs.

Allen Buckle of UNIDO says, "The use of graphite crucible for the production of cast iron casting is a dead end job: the temperature of the molten metal is generally too low, and the quantity is small. The cost of the crucible is very high per kilo of castings as its service life is very short and thus the foundries cannot be expected to compete with those which are only slightly more sophisticated" (Buckle 1995). However, where there is a market for brass or aluminum decorative castings, e.g., benches and door handles, crucibles can be an effective choice. The quality of these types of products must be high to compete successfully on the global market.

Castings made in Gaza are generally of a low quality. This can mean high reject rates which boosts costs for the producer and distrust on the part of the consumer. Poor quality machinery parts can damage equipment and cause downtime which a manufacturing operation cannot afford. Price will not be substituted for quality and therefore many castings used in Gaza are purchased from the overseas market where the quality is dependable. Many very basic castings, for private and public water supply projects for instance, are imported although Gazan foundries have the capability to produce these items. Gazan castings are rudimentary and do not meet international specifications. This keeps many overseas doors shut to them. In the years ahead foundries will not be able to tap into the expected flurry of economic activity without significant product quality improvement. Low quality is in part due to the primitive furnace technology in use in Gaza. One of the first steps for Gazan iron foundries will be to graduate to the next level of furnaces. Financial and technical resources must become available to assist this technology switch. In the past capital was not readily available to Gazan entrepreneurs.

The poor quality factor is in other part due to an inability to assess metallurgical composition of charge or sand type. Foundry workers in Gaza use the eyeballing technique. While some foundrymen have been in the business for many years, there are limits on the human eye's ability to verify precise metal types. Electric spectrometers used for this purpose are prohibitively expensive for an individual foundry, running at about $200,000 a piece.

Testing for molding sand is also important. It is said that a casting is only as good as the mold in which it is cast. However, Gazan foundries do not utilize labs to test their sand. Sand should be tested for strength, compactibility, and moisture. Sand testing is much more rudimentary a procedure than spectrometry. Relatively inexpensive chemical and mechanical tests are available for foundry sand testing.

Low skill levels: Low experience levels among foundry workers is another problem for Gaza. Children of many upper and middle class families tend to study abroad where they remain, joining the Palestinian diaspora. The labor force that is left behind is less educated, experienced, skilled, and equipped with managerial competence. This low level of foundry experience means that the complexity and sophistication of the final castings are limited. Pattern, mold and core making, melting, and pouring all require a good degree of knowledge and practice.

Infrastructure limitations: Electricity rates are prohibitive in the region and provision is sporadic in Gaza. Electric powered furnaces are preferable because of their ability to melt steel, as well as iron, adding to the strength of the casting. Electricity is cleaner at the production site and easier to use. However, at the present time electricity is not a feasible option as the infrastructure is already overloaded, power provision is not consistent, and is prohibitively expensive. An Israeli foundry shut down its electric cupola because it could not sustain the high costs of power (Minoff 1995). Power shortages are disastrous in the foundry business as they cause metal congealing. For this reason, at this time, it would be impossible to switch away from oil as a power source. (Coke also is exceedingly expensive.) Even if electricity were cost effective, an expensive generator would need to be available. Oil seems the most reasonable option at this time.

Market conditions: Gazan businessmen complain of exporting hassles related to security and border closures. This makes it next to impossible for them to rely on long term contracts (Sawaf 1994). The border situation is unpredictable, but hopes are that when the security situation improves so will the movement of goods across the border. Palestinian businessmen are also concerned about the ability of their goods to compete with those produced by their Arab neighbors. Access to the Israeli labor market has driven up wages of Gazan workers. In Egypt, for instance, the average unskilled worker is paid about $3.30/day, as compared to $5.00-$10.00/day for an unskilled Gazan laborer [17]. Wages are only one factor of production, however, usually accounting for substantially under half of production costs in most industrial sectors (Baskin 1995).

Poor working conditions: There are considerable occupational hazards associated with both the scrap and foundry business. People rarely regard the waste pile as anything more than useless discards and therefore often many dangerous items find their way into scrap. In the fall of 1995 a young Palestinian worker was killed by a mine buried in a pile of scrap metal. In Brazil a well-known and tragic incident occurred when highly dangerous cesium chloride was discovered in irradiation equipment at a scrap yard. In the foundries themselves workers breathe the hazardous fumes of burning waste oil. In the summer temperatures are unbearably hot and workers do not usually have safety gear. Poor working conditions lead to low productivity among laborers.

3.7 Gaza's Foundry Industry Upgrade Strategy

Gazan foundries must be ready to tap into the flurry of economic activity of the next few years. A unique opportunity is presenting itself to take advantage of the new markets that housing, sewage, public works, and infrastructure systems rehabilitation

[17] For this reason, some industrial development experts maintain that Gaza must turn to capital intensive industries to maintain competitiveness. Others feel that the strategy should be to utilize Gaza's large and cheap labor pool.

programs will provide. In turn the Palestinian National Authority should leverage aid dollars to invest in homegrown industries and link the spending to a step forward in industrial production advancement.

Gazan foundries are a perfect vehicle to set this industrial development strategy in motion. Foundries have backward and forward linkages to other industries. Therefore the positive repercussions of an industry upgrade would be felt in other businesses. Foundries are a basic industry that are needed to support other industries such as manufacturing, construction, etc. Techniques in the foundry industry can be feasibly upgraded without a major infusion of financial resources. Much of their scrap feedstock can be obtained from the regional market. The markets exist to consume their output. Scrap based manufacturing is a sustainable development strategy that should be pursued in other sectors, as well.

Current constraints on the industry should be addressed in the following ways:

o Do market development study. First survey the potential market. This involves essentially surveying industrial and public sectors (i.e., manufacturing, construction, utility, agricultural) to assess their use of imported castings. A large amount of imported castings are coming from India, Turkey, Eastern Europe, and the Far East (Minoff 1995). New demand from housing and infrastructure projects should also be ascertained. The survey should include the Gaza, the West Bank, Israel, Jordan, Egypt and any other potential market locales.

Next the market share that Gazan foundries might practicably capture would be evaluated. This would be handled by a reverse engineering study which would identify the manufacturing process, metallurgical constituents, investments, input, and financial analysis utilized for imported castings. The last step would identify the capacity of local industry (infrastructure, manpower, input) to manufacture such items with existing facilities or assess what facilities' upgrades would be required (Buckle 1995). (The chart below lists some of the product possibilities available to small foundries.) The availability, quantity, and quality of excess Israeli and Jordanian scrap should be considered in this evaluation. This survey would lead to an evaluation of the potential markets for Gazan foundries given these factors, technological inputs and scale of industry. Consequences for spinoff upgrades of Gaza's scrap business should flow from this analysis.

TABLE 11: PRODUCTS THAT CAN BE MADE IN A SMALL FOUNDRY

Bearings and pedestals	Sand mixers
Bells, discs, and shoes	Shears
Burners	Shelving brackets
Car and lorry parts	Shoe lasts
Coffee grinders and depulpers	Spare parts for industrial, agricultural, & textile machines
Couplings	Stoves and heaters
Defibrilators	Suction pumps
Elevators	Sugar and other food processing equipment
Fans and turbines	Valve bodies
Forging dies	Ventilators
Grinders, vibrators, mortar mixers	Weigh scales
Manhole and drain covers	Weights and counterweights
Millers	Well tops and cover
Molding presses	Wheels
Motor casings	Woodworking machines
Pipes	And much more

(Vogler 1981, p.79)

o Shrink technical gap between local industry and overseas competitors. Modern furnaces, and perhaps mechanization, in some cases, will improve efficiency, productivity, cost of operations, and scrap intake. Productivity varies among foundry operations depending on the many production inputs (as evidenced by the chart below.) For larger foundries in developed countries annual productivity figures can run up to hundreds of tons of output per worker (Bhat and Prendergast 1984).

TABLE 12: SMALL IRON FOUNDRY PRODUCTIVITY RATES

Country	**Mexico**	**S. India**	**Sri Lanka**	**Gaza**
Year	1984	1984	1984	1995
Annual Productivity (Tons/worker)	6	>1	4	>1

(Adopted from Bhat and Prendergast 1984, Clegg 1984, UNIDP 1988, CBS 1992)

It is clear from this chart that the productivity of Gaza's foundries is at the low end of the range. Producing affordable higher quality castings would require a significant increase in productivity rates. However, at this point in time it is unreasonable to propose that Gazan foundries produce high performance castings. That is too great a technology leap and there appears to be a sufficient local market for lower quality grey iron castings in infrastructure and construction. In fact, an iron foundry based on a cupola furnace is opening in Nablus in the West Bank and plans to target this market niche.

A rotary furnace has been recommended for Gazan foundries (Barghout 1994). This furnace rotates to speed up melting and can be fueled by used oil, diesel oil, or natural gas. Oil and gas are the recommended fuels for use in Gaza at this time due to their consistent availability. Coke can also be used (Buckle 1995). A range of production volumes can be handled, from 0.5 to 2.5 tons as well as outputs allowing for growth in capacity (Barghout 1994). For example, in Peru rotary furnaces cast about 50 tpm, but much higher production is possible (Vogler 1981). A rotary furnace can capably handle small volumes, as well. In South India, rotary furnace size is usually about one ton (Clegg 1984).

A rotary furnace is much easier to maintain than a crucible. It needs maintenance only every 80-100 uses, while a crucible needs replacement every 5-10 melts (Barghout 1994). So although its initial capital costs are higher than crucible (a rotary furnace costs about $60,000) its overall per unit production costs are lower over the long term. Construction of this furnace type is relatively simple. Experienced manpower is not a requirement for a rotary furnace (Barghout 1994).

One of the most important advantages of a rotary furnace for Gaza is that because it burns at a high enough temperatures, scrap steel can be used as a charge (Vogler 1981). While the scrap iron supply is tight, mild steel scrap is abundant in Gaza. Steel car bodies litter the sides of Gazan roads. Often this steel skeleton is all that remains after valuable parts are removed [18]. At present in Gaza, scrap steel cannot be used by Gazan foundries because graphite crucible furnaces do not burn at hot enough temperatures to melt steel.

It may be worthwhile to maintain some crucible foundries in Gaza for non-ferrous casting production. A sufficient market in Israel, the West Bank and Gaza may exist for decorative bronze or aluminum castings. This would allow some iron foundries to switch over to a non-ferrous charge while retaining their current production systems and furnaces. A diversity of Gazan made casting products will increase the appeal of this market for buyers who often need a variety of castings. For instance, in constructing a home, iron plumbing castings are needed as well as non-ferrous items like door knobs, faucets, grates, etc.

o Establish a foundry technical center. A centrally located industrial technical center should be situated in Gaza. The foundry industry in Gaza is not large enough to support such a center on its own, so it could be the shared venture of many industrial sectors. This would be a good use of foreign aid and involvement by a governmental body.

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[18] Vogler has shown that a vehicle dismantling operation can be successfully and profitably handled without huge investment in shredding machinery. Just two trained youths with simple, inexpensive equipment (hand hammer, stonemason's chisel, gloves) in one hour could "reduce a car that had been stripped of saleable parts, to pieces small enough for economical transport" (Vogler 1982, p.122).

Money spent could be leveraged for technical improvements in many areas. A university would be an excellent location to house this center to tap into existing facilities and other academic resources. Laboratories and equipment would be available (for a small fee to support the center's operations) for foundrymen to test the metallurgical content of their charge and sand quality, and for measurement purposes.

Training opportunities for workers (furnace operators, molders, and pattern makers) would be available in the areas of metallurgical control and pattern making. Technical experts from abroad could provide seminars, technical assistance, industry analysis, and consultancy on upgrade projects not only for casting workshops, but all industrial sectors. Training opportunities can also be provided on site. In South India, foundries have "earn-while-you-learn" programs. Students participate earning some income which can contribute to their tuition or living expenses (Clegg 1984).

Research and marketing studies could be conducted out of this technical center. Importers of castings should be involved in the research. They should be surveyed to understand their specific complaints with locally made castings and assess what product characteristics they seek. Additionally, a new type of furnace should be investigated for transitioning developing economies.

In a region of South India well populated by foundries there are independent laboratories which provide quality control services (Clegg 1984). As well, the local foundrymen's association has established a technical center which makes available consulting services and does research and development work. It is true that this effort is supported by hundreds of foundries in the region. In Gaza, a center would need to provide services to all types of industries. Funds should be provided by institutional industrial development programs to send certain individuals abroad for further studies [19]. According to Allan Buckle of UNIDO, foundrymen need at least one year of university study in metallurgy.

o Introduce appropriate duties on imported castings where possible. In a World Bank study on the potential competitiveness of Palestinian firms, it was determined that they are competitive *at free market prices* (World Bank 1993). This should be the eventual goal of tariff policies. Duties should be gradually reduced so as to provide a period for development of the industry leading to a healthy competitive environment.

The import duties should eventually be set so as not to overprotect the industry and make it lazy in terms of upgrading quality, but not too low to swamp the market with underpriced castings. Currently, there is a free trade agreement between Israel and Europe and the US, so no duties can be imposed on goods circulating in these areas [20]. Current duties on imported castings from the Far East or India range from 5-10%

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[19] This would be promising investment for international aid dollar.

[20] However, in the past the Palestinian territories have not been considered part of Israel for the purposes of the Israel-European Union trade pact. This item will have to be renegotiated in the Palestinians' interest.

depending on the source. Sri Lankan duties are about 60 %. This prices overseas competitors out of the market and foundries, consequently, do not feel compelled to maintain quality. Duties that are too low have the effect of encouraging foreign exporters to dump cheap goods into the domestic market.

o Analyze the possibility of completing the production cycle in Gaza by filling production gaps. For instance, machine tools must go now to Israel for heat treatment. If that could be handled in Gaza the good could be created from start to finish locally with all the value added benefits staying at home. The following are a few investments deemed to be worthwhile: small appliance assembly plants, pipes for water and sewage systems, irrigation equipment (frippers, valves, faucets), heaters and heating equipment, tools, lighting fixtures and equipment, electrical fixtures, plumbing equipment (faucets, drains) (Baskin 1995). Many of these are castings, others are goods that require castings. Building up "customer" industries will generate jobs, income and demand for higher quality castings.

o Consider consolidation of small foundries into one single, cooperative foundry with pooled resources and talents. This assumes a production economy of scale which must be validated (Kleiman 1995). If this is not the case, a networking cooperative should be considered. An information or financial economy of scale may exist that can be tapped through sharing resources, but maintaining separate locations. This method would allow the advantages of local competition to stay within the industry.

o Improve foundry conditions. Workers must be provided with proper health and safety gear. The effects on foundry workers of burning waste oil must be analyzed and rectified if deemed harmful. Many contaminants are retained in used motor oil and emissions are consequently dangerous. Simple measures such as centrifuging, settling, or cloth bag filtering dirty oil to remove some contaminants might improve emissions. More efficient burning through better furnace design with a good chimney updraft would raise temperature, allow for more complete combustion and might alleviate some of these negative effects.

o Provide access to capital. Gazan foundries must do away with crucible furnaces and they will need sufficient financial resources to support this technology switch. A foundry loan program could be supported with international aid offering reasonable lending rates. There must be careful oversight by the authorities to ensure that lenders do not take advantage of over eager capital seekers with usury rates. Tax breaks should be considered by the new Authority for developing industrial sectors.

o Improve working conditions for scavengers. Society tends to pretend this marginalized element does not exist by ignoring them. As long as there is money in garbage, scavenging will persist. Even in well-to-do communities pickers can be found rummaging through garbage cans for aluminum cans. This fact should be accepted and programs should be put into place to improve their working conditions. Based on experience in Indonesia (see Chapter One, p. 23) there are several means to improve the lives of scavengers that have proven somewhat successful. This would include social programs to improve all aspects of their lives.

Scavengers should be given informal training to help them identify dangerous items and identify market opportunities. Perhaps an industrial estate focused on the waste industry would centralize and facilitate their operations. Safety equipment should be supplied (gloves, hats, masks, clothing, shoes) and/or capital should be available at reasonable rates for purchase of equipment. Other equipment (like shears, sledge hammers, torches) will improve the safety and comfort of their jobs.

Conditions at the workplace, in this case the landfill, should be made as safe as possible. Those in charge bear that responsibility if the landfill is left accessible to the public. Burning, if allowed, should be contained to a protected area. Hazardous materials should be segregated and kept inaccessible. Every attempt possible should be made to segregate salvageable materials from the regular garbage. For instance, loads of refuse known to contain metallic industrial waste should be dumped separately at the most convenient site in the landfill for the pickers. To the extent possible, introduce sorting arrangements at the site of major scrap producers, e.g., manufacturers, so as to minimize the necessity to rummage through dumpsites. Scavengers and junk collectors should be encouraged to organize. Funds for social services targeted at this impoverished population would be well spent. They fill a important role in their society and their collective voice will be heard.

o The Gaza Chamber of Commerce, a local industrial development association, or a cooperative foundry group should keep an updated and complete list of foundries for industrial development and marketing purposes.

o The emerging government in Gaza should encourage the use of domestically produced castings. An immediate and important measure would be to require that any castings used for public projects which are made locally be made locally. Israel should do the same for Palestinian products. This would have tremendous beneficial impact. This program would have to be phased in, as many locally made items will not meet specifications. These potential purchasing requirements would help to provide incentive for entrepreneurs to make further investments and would encourage a move towards higher quality goods. Along the same lines, subcontracting to Israeli firms would allow Gazan foundries to leverage Israeli capital and know-how. Subcontracting is a usual practice in the beginning stages of country's industrial development (ISEPME 1993).

Credit opportunities and tax breaks should be given to firms that utilize secondary material feedstocks. In the future when comprehensive billing and tracking systems have been set up, financial encouragement of scrap based manufacturing could be funded through a system where credit were given for every ton of material diverted from the landfill. The handling costs at the landfill saved could stock this fund. Efforts to encourage the overseas iron and steel industries to invest in Gaza should be pushed by the Palestinian National Authority.

3.8 Conclusion

With a relatively small investment in terms of time and dollars, Gazan foundries could be modernized to more efficiently produce better goods. The ingredients are cooperation, training, instrumentation, and slightly better furnace technology. Small iron foundries in Gaza are already an operating industrial network and could form an important, successful base for industrial improvement. Building on an existing entrepreneurial base is much more time and cost effective than starting anew. The potential to link up with other future growing sectors of the Gazan economy is very powerful in the case of foundries.

A stronger foundry industry in Gaza could do the following: fill Gaza's metal parts needs, expand export opportunities, clean scrap off of the streets and from the dumps, bootstrap up the metal businesses, provide jobs that are so critically needed now, increase skill levels of Gazan workers, and provide useful employment for better trained job seekers.

The goal of modernizing Gaza's iron foundries should be to make better, more sophisticated products. This improvement in quantity and quality of Gazan made castings would have a positive effect on other industrial sectors. Many other industries depend on castings either as essential parts for machinery or for providing a market for their material (scrap dealers and scavengers). If other industries can get good, cheap casted parts and equipment from the local market this will have a ripple effect on Gazan entrepreneurial activity generally.

Allan Buckle of UNIDO says:

> The economic impact of the foundry industry must be seen in the light of the destinations of its products. These can be either to other industries, which incorporate the castings into more complex equipment- e.g., water pumps, brake drums for buses and trucks; to construction for manhole covers, drain covers and drainage pipes, and to the general public via shops such, for products such as simple charcoal/coal cooking stoves as used by your great grandmother, skillets and similar. The point to be made is that if castings of sufficient quality are available, this allows others to work at producing the equipment which incorporates them or to install the castings.
>
> There is thus an effect upon downstream employment which would not be the case without the castings. (This argument also applies to many other specialized industrial activities; a group of...industrial services are required for the operation and growth of industry in general. These are...foundry, machine shops, heat

> treatment, surface coating, welding.) There is also an upstream effect in the collection and classification of scrap...and in the preparation and delivery of other inputs such as sand and other (items) for the moulding processes, the manufacture of the foundry patterns, and the import and distribution of other specialized materials" (Buckle 1995).

Other important benefits from a stronger, larger, more modern Gazan foundry industry are the following:

o Control. The use of locally generated scrap will confer a degree of control to the Gazan industrial base. In the past, a reliance on imported raw materials has subjected the factors of production to the volatility of a market that is beyond the producer's control. Volatility is due to fluctuations in consistency of supply and price of imported resources. These patterns introduce subsequent fluctuation into the availability and price of the finished good.

o Resilience. Small firms are resilient. During times of a downturn in the economy they can more readily adjust their operations to accommodate a shift. This was evidenced by the tenacity displayed by many small Palestinian businesses during the intifada (Kleiman 1995).

o Environmental benefits. The use of iron scrap versus pig iron for the production of castings reduces the world's reliance on virgin iron supplies. The elimination of the extraction and refining processes associated with pig iron production will be beneficial as the production of pig iron has some brutal environmental consequences. This is true for the global environment, not Gaza in particular, as there is no iron mining in Gaza. As well, foundries themselves that utilize scrap produce less pollution and utilize less fuel.

More usage of scrap metal waste will mean that fewer metallic goods will end up in Gaza's dumps and on the roadside. This will result in less harmful landfill leachate spilling into the aquifer. Often machinery has harmful liquid components (PCB's, lubricating oils, fuel). Care must be taken to ensure that workers dismantling these items understand and use proper handling and disposal techniques.

o Reduction in steel and cast iron waste leading to reduced disposal costs. An advancement in foundry technique will allow the intake of scrap steel charge. This will create a market for the large quantities of mild steel waste found on every roadside in Gaza. Using scrap steel in Gaza's foundries will avoid the need for a costly clean up scheme to rid Gaza of all its roadside metal debris. The impact on the visual environment in Gaza will be significant. The scavenging network will expand to accommodate the increased circulation of waste materials.

o Reduced production cost. The price differential between pig and scrap iron in Gaza is approximately $120/ton versus the price of pig iron which at minimum runs $600/ton. The resultant price of the finished product are subsequently lowered. Gazan foundries will need to look for ways to keep production costs low to successful compete on the global market. One way is maintain a low input costs through utilizing scrap.

Developing cultures have traditionally done a better job than their richer neighbors of recycling their scrap without government encouragement. Convenience, taste, and policies which aim at subsidizing resource use have in the past shifted manufacturing towards virgin material consumption in industrialized countries. And cheap resources have been readily available. However, now in many western countries the public's awareness of environmental issues is grown, influencing public policy and programs to favor recycling. Nonetheless, there remains a long way to go throughout the world towards reaching sustainable industrial metabolism as evidenced by enormous amounts of untapped waste, overflowing landfills, emphasis on developing virgin material dependent industries, high rates of natural resource extraction, and huge pollutant outputs from industry.

Recycling potential throughout the world has not begun to be tapped. Particularly in newly industrializing societies, the setting is right for vigorous recycling activities and the benefits they bring. Internationally, one finds expanding markets for secondary materials as recycling becomes more common practice everywhere. Markets are pushed on both the demand and supply ends. The strength of the international market for scrap can be an asset for recycling throughout the world.

The use of discarded waste as a manufacturing input holds tremendous potential for developing countries that want to create jobs and build their economies on a stable supply of locally generated materials with less harmful environmental impacts. In lesser developed countries jobs are badly needed, foreign exchange is scarce, imported raw materials are prohibitively expensive, and safe waste disposal capacity is limited. Efforts should be pushed to encourage scrap based manufacturing and other recycling industries, at the same time taking care to ensure that those at the lowest rung of the system are not unfairly exploited.

The foundries in Gaza present a unique opportunity to boost experience with scrap based manufacturing that will have resounding positive implications for the local economy. As such international development organizations should consider a rehabilitation of a modernization program for Gaza's foundries. The costs would be relatively small for all the recommendations proposed (less than a million dollars). As has been seen the impacts of upgrading this sector has far reaching implications on other sectors of the economy. Cooperation between the private industrial sector, the Palestinian Authority, and international aid organizations would set a powerful and badly needed precedent in Gaza.

The purpose of this close examination is to serve as a guide for other scrap based industries in Gaza. There remain opportunities for other segments of Gaza's waste stream (textiles, plastics, paper, organics) to be utilized as feedstocks for industries, rather than burdensome disposal problems.

Gazans are just beginning to formulate industrial development patterns that will shape the economic and environmental health of their society into the future. Now is the time to build scrap based manufacturing into those policies. An important opportunity exists during this period of infrastructure development that should not be missed. While the groundwork for industrial, solid waste and other infrastructures is laid in Gaza, the time is ripe for pursuing a path of environmental and economic sustainability through recycling.

GLOSSARY

blast furnace- tall, cylindrical smelting furnace for reducing iron ore to pig iron, the blast of air blown through solid fuel increases the combustion rate
charge- material introduced into furnace for melting
cupola- shaft melting furnace that uses coke as the principal fuel, metal is melted in direct contact with fuel
drop forging- plastic deformation of hot metal under a falling weight, such as a drop hammer
dross- leftover solids from al production, consisting of intimate mixture of metallic al and al oxide
ferrous- iron bearing
fettling- the operation of rendering a casting ready for machining or direct use
forging- using comp force to shape metal by plastic deformation, dies may also be used
furnace- where pieces of metal are be heated and melted
grey iron- iron with a high carbon content, low quality
jobbing foundry- foundry which is not part of a manufacturing plant and produces castings for sale. Usually makes a wide variety of castings in small lots.
kish- fine, black-gray powder made of graphite and iron oxides resulting from pouring molten iron from ladle to ladle
ore- naturally occurring material from which economically valuable minerals can be extracted
mmt- million metric tons
mold- form, usually sand, containing a cavity into which the molten metal is poured to make the casting
nodular iron- cast iron which has a major part of its graphitic carbon in nodular form
pattern- model of part to be cast made of wood, metal plaster, etc.
pickle liquor- highly acidic cleaning solution, waste product
pigs- crude metal casting prepared for storage, transportation, or remelting
pig iron- crude, high carbon iron produced by reduction of iron ore in a blast furnace or cast iron in form of pigs
refine- to free from impurities
refinery- system of process units used to convert non-ferrous metal ores into pure metals, such as copper or zinc
riser- reservoir of molten metal attached to the casting to compensate for the internal contraction of the casting during solidification
sinter- recycle steelmaking process wastes (particulates too small for ordinary use) by converting to an agglomerated product (sinter) which can be charged to a blast furnace
slag- non-metallic product resulting from interaction of flux and impurities in the smelting and refining of metals (bloom)
slag cement- cement produced by grinding blast furnace slag and mixing it with lime, Portland cement, or dehydrated gypsum
smelting- heating of ore mixtures accompanied by a chemical charge resulting in liquid metal
steel- iron based alloy, malleable under certain conditions containing up to 2% carbon

(Adopted from CSG/Tellus Packaging Study 1992; Vogler 1981; Bhat and Prendergast 1984; and the Bureau of Mines 1993)

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