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FINAL THESIS REPORT:

"SOLID WASTE MANAGEMENT IN PAKISTAN"

CHALLENGES, OPPORTUNITIES AND INTEGRATED MANAGEMENT APPROACH

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Dedication

'I dedicate this thesis to my parents. Without their prayers and support I would not have achieved this goal'

Acknowledgements

I am thankful to respected teacher Sir Bilal Ahmed Chohan. His all-time appreciation has been the motivating force behind the successful completion of this report. He has been very kind and cooperative during the whole process of report writing. Above all I owe my success to my loving parents. Without their prayers, true encouragements, and financial support I would have never achieved this goal.

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Executive Summary

With a population exceeding 180 million Pakistan's annual waste generation is approximately 20 million tonnes a year. The estimate of waste management shrinks in comparison to the humongous amount of waste being generated. With increase in population coupled with expansion of urban settlements waste management has become a problem which authorities are struggling to solve. This case study establishes the current waste management challenges being faced at global level. The facts are provided according to each region of the world including the estimates of waste generation and collection. Keeping global waste management figures as a comparison the next section of case identifies the waste management issues being faced by Pakistan.

One of the potential long term waste management solution being implemented in Pakistan is the business model of partnership between Lafarge, a cement manufacturer and Saif Group through Lahore Compost, a waste processing unit. The partnership was established to process municipal solid waste (MSW) to produce refused derived fuel (RDF) which was consumed as an alternative fuel by Lafarge. This joint venture, albeit an important one is only a small fragment of the economy which could be used as a model for future partnerships at a larger scale.

Building upon the partnership model the case study then expands the scope by introducing an integrated approach of waste management where the partnerships are not merely between two actors of the economy. The partnerships and collaboration will start from the grassroots level up to industrial involvement and eventually the authorities. Considering the extent of waste generation the first step is to address the generation sources. Therefore, there is a need of perceiving waste as a sensitive element of everyday activity which requires first reduction in its generation and second appropriate management. Once the individuals are being sensitized, the other actors of the economy come into play. The study proposes 7 such actors namely; communities, informal sector (waste pickers and scavengers), institutions, private sector, NGOs, donor agencies and governmental authorities.

The challenge is lack of foresight to completely involve and hold responsible all economic agents of the country. The way forward can only be systemic procedures, collaborations and partnerships among individuals, businesses, industries, government and other economic agents to turn this problem into a sustainable industrial system.

1. Introduction

Lafarge is a multinational industrial organization specializing in cement, construction aggregates and concrete production. With headquarters in France and operations in 61 countries, the company has become a world leader in building materials. Lafarge business foundations are laid on four priorities namely; health & safety, people development, innovation and performance. In 1977 Lafarge focus intensified on sustainable development and environmental performance, building upon the philosophy of making a positive contribution towards society and nature.

This philosophy directed focus towards reduction in environmental footprint. Becoming a pioneer in the industry, Lafarge built a strategy to fight against climate change and sustain the environment. One major achievement in this regard is 26.4% reduction in CO2 emissions per tonne of cement production (Building Better Cities, 2015). Another decisive step which cemented Lafarge as a trend setter in sustainable development was the establishment of Industrial Ecology function.

Cement Manufacturing is an energy intensive process which requires non-renewable raw materials i.e. limestone and clay as ingredients of cement mix and fuel for heating the kiln i.e. coal, petcoke or other fossil fuels. The cement manufacturing has two major impacts on our environment. First, the consumption of non-renewable natural resources; that takes millions of years to form which leads to depletion of valuable earth reserves. Second, due to high percentage of carbon component in fossil fuels, CO2 emissions during heating process of cement manufacturing result in endangering the earth environment. (From waste to resource, 2008). Amid these two challenges, we are also faced with a flawed industrial model, whereby the manufacturing industries function independently from each other, consume raw materials and produce finished products and waste. This close ended model limits possibilities where manufacturing industries can rely on each other using waste of one process as a raw material input for another.

To address these issues, Lafarge through its Industrial Ecology function set goals to reduce the consumption of non-renewable resources and to replace them by alternative fuels in the form of industrial, agricultural and municipal waste. This substitution not only makes one industry's waste valuable for another but it also has far reaching positive impact on the environment. Furthermore, it also seeks to replace raw materials with the byproduct of another industrial process for example slag from steel manufacturing is used as an additive to the cement mix (When waste becomes resource,

2007). Worldwide the Lafarge group utilizes agricultural waste i.e. rice husk, poultry shed waste, sugar waste, tyre manufacturing waste etc. and municipal waste with the cooperation of local municipalities.

In light of the unique opportunity cement manufacturing system presents, Lafarge further expanded its industrial ecology function by providing waste disposal services to governmental and other industrial waste generators. Majority of the industrial waste disposed at the cement plant adds little value to the fuel mix, nonetheless Lafarge believes in being a solution provider and industry leader in preservation of the environment. However, majority of the reliance is on agricultural and municipal waste as these fuels are cost effective alternative to the conventional fuels.

By reducing the usage of nonrenewable resource Lafarge not only limits its carbon footprint but also have a positive impact on local economic activity. Waste that otherwise will be eliminated is introduced back to economic cycle and adds value to the commercial activity of the industrial sector. For the consumer of waste it reduces their expenditure, their dependency on traditional fuels and presents opportunity of sustainable supply stream. In current energy crisis faced by economies the alternative solution only increases the competitiveness of the industrial sector. Waste market also creates employment and business opportunities for the community. The introduction of alternative fuels in energy mix has been implemented across 78 plants worldwide. By 2014 the average alternative fuel usage had reached 30%. The Lafarge Group has the ambition for fuel substitution to exceed 50% by the end of 2020 (Alternative Fuels Chapter, 2014).

If other fuel intensive manufacturing industries shift their inclination towards alternative fuels they can create a market for waste suppliers. The demand for non-conventional fuels depends upon usage and composition of waste. Not every industrial sector is equipped with handling waste as a resource, nonetheless with investment in machinery and industry specific equipment a demand sector can be created. This is an opportunity for waste and by product producers and suppliers provided adequate supply of waste is generated.

In addition to the agriculture waste, municipal waste generation is also a challenge faced by urban developments. The ever expanding cities, increasing population and consequent waste generation coupled with poor waste management procedures has led to full scale crises. If not addressed with strategic goals and procedures it may jeopardize health and even possibly the economy of the state.

It is estimated that the average waste generation per city is 1.3 billion tonnes with the major contribution by developing nations. The figures are expected to increase to 2.2 billion tonnes by 2025 including the increase of waste management costs from $205.4 billion to $375.5 billion by 2025 (Bhada-Tata & Hoornweg, 2012). The estimated volume of waste collected globally is 11.2 billion tonnes. However, from collection to the disposal and recycling the waste market worldwide is estimated at $410 billion a year (Modak, 2011). These figures highlight the importance of waste market as an important economic sector which contributes to 5% urban jobs worldwide notably in developing countries (Courtois, 2012)

As compared to developed countries where waste management procedures are in place to control and appropriately dispose the waste being generated, the situation in developing countries is alarming. According to the study conducted by Ministry of Environment in Pakistan, an estimated 54,888 tonnes of solid waste is generated daily (PEPA, 2005). Considering the humongous amount of waste generation the city municipal councils are overwhelmed to properly collect and dispose the waste in environmentally safe manner. As much as 50% of the waste remains uncollected and poses serious health and environmental threat. Furthermore, the only sound disposal method considered by the officials is either burning or landfilling. Burning waste openly not only releases hazardous gases but also adds to the problem by increasing the pollution. Landfill is an expensive process and it also ends the life of such waste which could be recycled and put to better use. Because of lack of properly established landfill sites some of the collected waste end up in rivers, agricultural lands and forests.

Despite the dire situation and lack of technical capacity this presents an untapped opportunity. Although municipalities do collect and dispose the waste but their objective is merely for the public service and rather dealt as something which a government is obligated to do in order to keep the health and environment protected. The unrealized potential is the economic value of this sector. The figures suggest that there is ample supply of waste generated every day for it to be considered as profitable sector provided the waste streams are directed towards potential buyers. As mentioned earlier if explored properly the supply of waste has demand in the form of manufacturing industry namely cement plants.

The need for shift towards symbiotic relationships between different industries, government and private sector cannot be emphasized more during the current energy crisis in Pakistan. However

studies have been conducted by Ministry of Environment regarding privatization of waste management however realization of this vision has yet to be achieved. The solution of the problem is open industrial ecosystem where interdependency is achieved between different sectors of the economy. The minor progress has been achieved in this regard by pioneering organizations like Lafarge where 41.2% substitution of fossil fuel was achieved in 2014 alone. The alternative fuel mix includes biomass, municipal waste and industrial and chemical waste. Notably, Lafarge required significant investments in plant manufacturing unit for feeding waste into the furnace.

Despite achieving major success in substitution goals, Lafarge faced a pressing dilemma. Waste generation figures do present an impressive supply that could be used as fuel, but majority of this waste is rendered useless by its poor composition. In order to provide burning value to any manufacturing unit, the waste needs to be composed of combustible elements. For example: along with combustible biomass and plastics if major composition of waste in non-combustible ash or sand, the expected heat value cannot be derived from the material. This indicates the need of sorting waste to extract the usable portion for sale. Considering the lack of expertise and poor waste management practices, turning waste into a supply stream only seems impossible. Furthermore, the seasonal flooding, rainy season and long transport routes only add to the problem of volatile supply market.

In order to establish a sustainable supply stream of waste, Lafarge invested in a joint venture with a local waste processing company. This case study explores how partnership between two private sector companies could lead to complete waste management solution and make a sustainable value chain which could be beneficial for both parties. However, with heavy investment to secure the supply chain the venture was without challenges.

Lafarge with its joint venture directed attention towards a business model of partnership which could be utilized to economize the waste market of Pakistan. However, does small ventures in private sector is the answer of perhaps one of the most pressing issues in the country which has not received significant highlight. Despite the studies being conducted why the problem still persists. And most importantly why does the effort remain on collection and disposal of the waste and not on monetizing the sector. Considering the demand and supply of waste, the market requires more credit than it has received to date.

1.1. Problem Statement

Solid waste management in Pakistan is a neglected sector with little to no focus on financial investment in its management. The issue is far from only management of waste, there has also been negligible research in this area. The municipal data regarding waste generation and management is outdated and inadequate. As the urban population has expanded in the recent decades the municipal authorities are facing challenges addressing the problem. This sector requires attention, investment and research from not only the government sector but every sector involved in waste generation, transportation and any form of management.

1.2. Objective of the Case study

The case study will explore the business model of partnership between Lafarge, a cement manufacturer and Saif Group through Lahore Compost, a waste processing unit. The partnership was established to process municipal solid waste (MSW) to produce refused derived fuel (RDF) which was consumed as an alternative fuel by Lafarge. The investment in joint venture was to secure the supply of RDF in order to achieve the substitution objectives of Lafarge. This joint venture, albeit an important one is only a small fragment of the economy which could be used as a model for future partnerships at a larger scale.

However, to fully address the waste management crises the partnership model requires humongous expansion starting from grassroots level up to the government and industrial involvement. The challenge is lack of foresight to completely involve and hold responsible all economic agents of the country. The way forward can only be systemic procedures, collaborations and partnerships among individuals, businesses, industries, government and other economic agents to turn this problem into a sustainable industrial system.

2. Solid Waste Management

According to United Nations Environment Program (UNEP) waste is any material or object that is discarded after it has served its purpose (UNEP, 2010). Waste can be in any form i.e. solid, liquid or gas emissions. According to United States Environment Protect Agency the solid waste is defined as '*any garbage, refuse, sludge..., and any other discarded material, including: solid or semisolid resulting from industrial, commercial, mining, and agricultural operations and from community activities'*. Specifically everyday items being discarded generally called rubbish or trash are known as Municipal solid waste (MSW).

All the steps involved in complete handling of waste from its generation to its destruction is known as solid waste management and it is the prime responsibility of municipal authorities. The process requires comprehensive planning in order to arrange city wide collection of majority if not all of the waste generated. The next step is organization of transportation of waste to collection sites followed by its segregation either for recycling, for landfill and ultimately destruction of leftover. Despite being the responsibility of municipal authorities, waste management is one of the most poorly rendered services worldwide. In order to establish the basis of solid waste management, its current practices and limitations, the first step is to understand what solid waste entails.

2.1. Characteristics of Solid Waste

In order to formulate a plan for effective management of solid waste and to commit the required resources for the plan it is rudimentary to identify the categories, composition and characteristic of solid waste.

2.1.1. Categories of solid waste

Following are the generally accepted categories of waste depending upon the source of generation. (Tchobanoglous, Theisen and Vigil, 1993)

Table 1: Categories of Solid Waste

Category of Waste	Characteristics
Residential/Household	Domestic areas and dwellings which includes discarded material like leftover food, yard waste, wood, paper, metal and ash etc. This waste is non-hazardous in nature.
Commercial Waste	Waste generated from business establishments like slaughter houses, restaurants, hotels, food markets, stores and shopping malls etc. The waste is usually non-hazardous in nature.
Industrial Waste	Waste of chemical, manufacturing, processing plants or construction sites. This waste can be both hazardous and non-hazardous in nature and it depends upon the industry of origin.
Institutional Waste	The waste produced from governmental institutes, school, college, universities and business offices. This waste is similar in composition to commercial waste and majority is non-hazardous waste.
Agriculture Waste	Spoiled farm yield, waste from farm establishments and animal dung is categorized as nonhazardous. Meanwhile, expired pesticide or used containers are hazardous and require special disposal measures.
Hospital Waste	Includes waste generated by medical centers, hospitals, medical institutions or other health care establishments. The surgical instruments or residue from surgical procedures including synergies, instruments and laboratory waste is considered hazardous waste and require complete destruction. However, these establishments also produce non-hazardous waste which is similar to residential waste.

2.1.2. Composition of solid waste

The solid waste can be composed of following material (Adam, 1999)

- **Organic waste** which is biodegradable in nature and mostly entails spoiled food.
- Plastics, wood, paper, cardboards or other packaging material are **combustible wastes** and have low moisture content and high burning value.

- Metals, steel, tin cans or stones are **non-combustible wastes**.
- **Hazardous wastes** are those which can cause permanent damage on people, environment and ecosystems if not death with properly. Industrial byproduct, chemicals and medical residue are generally categorized as hazardous.
- **Ash, rocks and sand** are noncombustible and are a cause of reducing the burning value of combustible waste.
- **Dead animals** can also be found in municipal waste dumbs.
- Rubble, concrete or broken bricks from demolition site are **construction waste**. These can be used as input in the cement manufacturing process.

2.1.3. Physical characteristics

Physical characteristics of all types of waste decide whether the material can have value beyond its current state. Most important characters are moisture content, burning value and chemical composition (Hosetti, 2006).

2.1.3.1. Moisture content

Moisture content is defined as the portion of weight of moisture from the total weight of the material. Except plastics or other inorganic material most of the components of waste have inherent moisture. The moisture content typically varies between 20-40% with organic material having the most moisture content. However, the moisture level varies with the weather. Moisture content is imperative in determining the value of heat a material can generate. The relationship between two variables is inverse i.e. higher the moisture in a material less heat energy will it produce. The rationale behind this relationship dictates that when materials with high moisture are burned, the resulting heat generated is first consumed to evaporate the moisture; the resulting residue is devoid of any moisture. Once the moisture evaporates the remaining heat is then utilized for the purpose of deriving valuable fuel energy. Therefore, when waste is used as a fuel source, it will give the maximum value when the moisture content is low.

2.1.3.2. Heating value

The energy released when a material is burned is known as heating value. The measuring unit of heating value is kilo joules/ kilo gram (kj/kg). The heating value is important in determining the

value of material as a potential energy source. The heating value of conventional fuel like coal is around 8000 kj/kg. Keeping coal as benchmark, waste material is evaluated as potential fuel by determining its heating value through sample testing. A bomb calorimeter is used to burn a dry sample under controlled temperature to determine the heat value of the sample.

2.1.3.3. Chemical composition

The chemical composition decides whether the waste material is combustible or not. Municipal solid waste is typically composed of organic material made up of combustible elements like lipids, proteins, carbohydrates and natural fibers. Synthetic organic material like plastic which constitutes 10% of municipal waste is highly combustible making it ideal fuel supply. However, plastics are non-biodegradable making them a hazard if methods other than recycling or burning are utilized for its management.

2.2. Impact of waste mismanagement

Solid waste is a cause of disease transmission if not dealt with properly in timely fashion. The decomposing waste especially organic components breeds bacteria and pathogens which can find its way into food streams giving birth to diseases like gastroenteritis, diarrhea and cholera. The decomposing waste also attracts house flies which carry the germs to far flung areas thus increasing the span of disease spread.

The most concerning issue is the toxic material found in waste. Lead, mercury and zinc components can cause poisoning, dental impairments, hearing and vision abnormalities if they find their way into human blood. The waste if left untreated can be ingested when agricultural crops are affected by it through the spoiled soil. Humans can also end up getting high level of toxic material in their blood if they feed on livestock affected by these crops. Most toxic substances found in waste are Persistent organic pollutants (POPs) (Beyene & Banerjee, 2011) like aldrin, dieldrin, dichlorodiphenyl-trichloroethane (DDT) and endrin etc. POPs do not decompose and they stay in the ecosystem for lifetime except when destroyed through incineration. If POPs remain in the food chain they can find its way in all the crops, livestock and eventually in humans. Although there is a ban on material containing POPs but the world without these toxic material is still a dream.

The waste material containing pathogens and bacteria through rain can find its way into ground or surface water eventually contaminating the drinking water supply (USAID, 2009). In developing

countries waste is often dumped into rivers and fresh water streams which is carried into oceans. This adversely affects the aquatic life killing or intoxicating the fish that humans consume.

The decomposing waste is also a source of air pollutants. Other than toxic gases and bad odor, the decomposing waste releases methane that traps heat in the atmosphere causing greenhouse effect (Abul, 2010). Often in order to deal with overflowing waste dumps the authorities burn the waste in open air. Burning releases carbon monoxide, nitrogen oxide and other gases which are often responsible for causing respiratory abnormalities in people inhaling the polluted air.

Last but not the least, waste has unpleasant odor and can ruin the aesthetics of an area. This not only affects the morale of the people but affects the tourism. Furthermore, studies suggest that people living in poor conditions and near unclean areas are unhappy and more psychologically vulnerable.

2.3. Waste Management Hierarchy

In order to address the waste management issue the specialized authorities worldwide have established certain concepts. Upon these agreed concepts waste management policies are defined. One generally accepted concept is waste management hierarchy. This hierarchy indicates a series of steps to be followed in certain preferred sequence in order to address the waste management (UNEP, 2013).

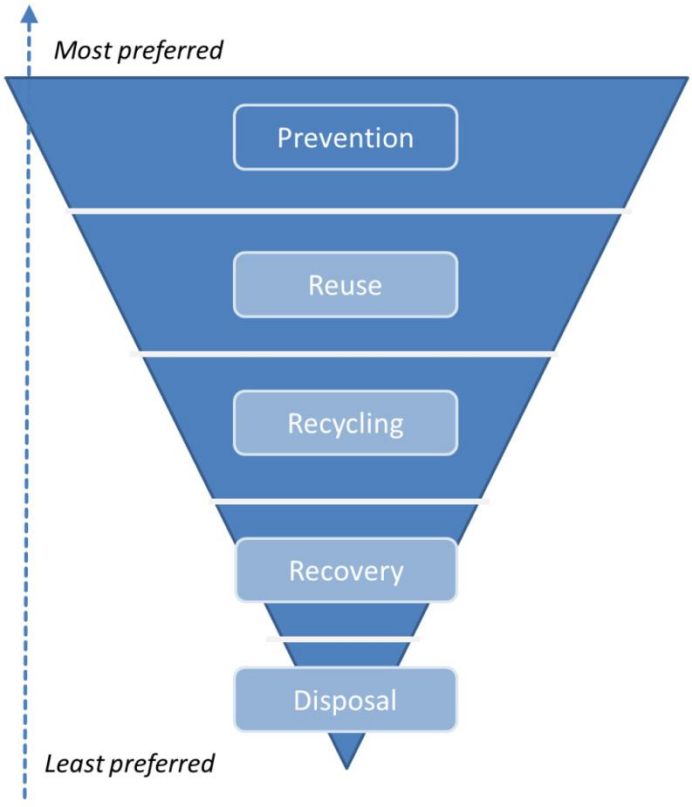


Figure 1: Waste Management Hierarchy

The steps are presented in inverted pyramid starting with most preferred solution to the least preferred. The most preferred action is prevention i.e. addressing the root cause of the problem and deriving action towards reduction of unnecessary wastage. Although some wastage from any process, may it be at

individual level or at industrial level, is unavoidable however steps can be taken to reduce the waste generation. Many industries utilize zero waste methods to reduce the by-product of their processes to bare minimum. At household levels, individuals can be trained to be mindful about things they consider waste and how some of the discarded material can be categorized as useful.

The next action is reuse of the waste already been produced. Here, there are numerous examples on how some of the by-products are being used as a resource e.g. waste as fuel, as fertilizer or as a raw material for another industry. Recycling waste like plastic in order to remake the finished product is another method that is perhaps the most effective waste management solution. Waste recovery or turning waste into an energy source is one of the most difficult yet effective actions. However, much research and technological advancement is required to fully utilize the potential of turning waste into energy. Most of the developed countries have established special thermal energy recovery units to produce electricity from burning waste.

The last step is disposal of waste. This method is least preferred because no value can be derived from the waste at this stage. Landfills or destruction from burning are few steps being used by some authorities. However, if waste is being disposed in a manner where it can be utilized as fuel source as in; biomass waste for cement industry fuel, then perhaps energy can be recovered from this step as well.

2.4. Global review of solid waste management

2.4.1. Waste generation in world regions

Waste generation varies according to the region of the world. Even within a certain region the waste generation depends upon income, affluence and population of the area (Hoornweg & BhaDa-Tata, 2012). In Africa region the waste generated per day is approximately 160 thousand tonnes which adds up to 62 million tonnes per year. The total population of this region is 260 million. The data from this region is not complete as not all countries in Africa have waste management policies.

The population estimate of Latin America and Caribbean region is 399 million and waste generation estimate per day is 437 tonnes and 160 million tonnes annually. For the region of East Asia Pacific, the population amounts to 777 million, with 73 thousand tonnes waste generation in a day and 270 million tonnes in a year. The major contributor of waste generation in this region is China.

Meanwhile in East and Central Asia the population estimate is 227 million, per day waste generation is 254 thousand tonnes and annual figure is approximately 93 million tonnes.

The urban population of Middle East and North Africa region is 162 million. The approximate annual waste generation is 63 million tonnes. Furthermore, the South Asia region with population of 426 million produces 70 million tonnes of waste annually.

Table 2: Waste Generation in World Regions

Region	Total Urban Population (millions)	Waste Generation (Tons/day)
Africa	260	169,119
Latin America and Caribbean	399	437,545
Eastern and Central Asia	227	254,389
East Asia Pacific	777	738,95
Middle East & North Africa	162	173,545
South Asia	426	192,410
OECD	729	1,566,286
Total	2,980	3,532,252

Source: (Hoornweg & BhaDa-Tata, 2012)

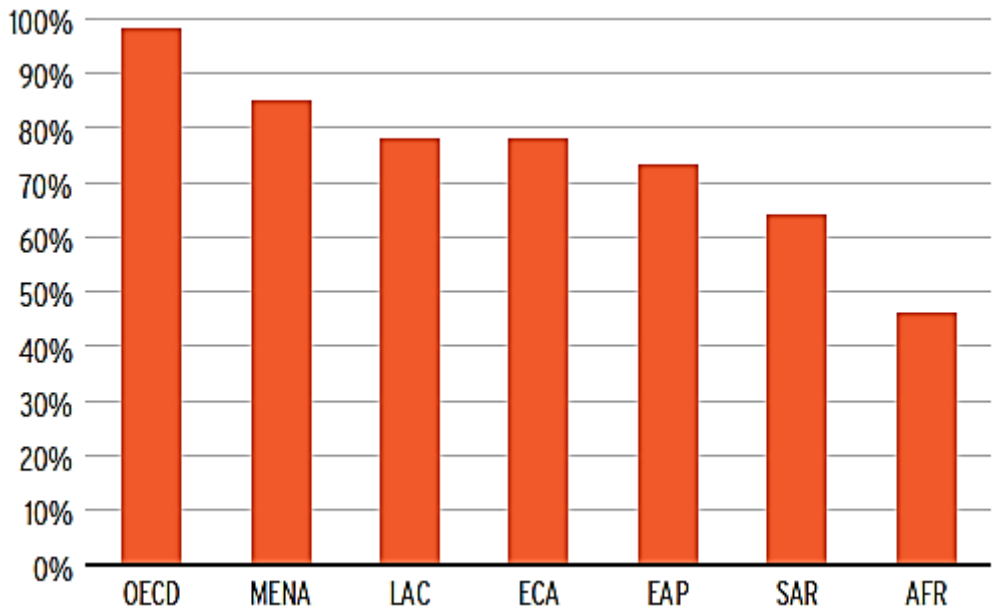
The population estimate of 34 countries in organization for economic co-operation and development (OECD) is 729 million. Major economies in OECD are European countries and USA, Canada, Australia and Japan. The waste generated in this region is 572 million tonnes per year, making it the largest waste producing region. The second largest waste producing region is East Asia Pacific.

2.4.2. Waste management in world regions

Waste collection in the above mentioned regions mainly correlates with the income level and development in the countries of the regions. Considering the countries within the organization for economic co-operation and development (OECD) are developed with high average income levels, it is of no surprise that the collection rate and appropriate management of waste in this region is 98%. Comparatively the region of South Asia and Africa are developing or under-developed with lower

average income levels. The collection and treatment rates in these regions are 65% and 46% respectively.

Figure 2: Waste Management in World Regions



Source: (Hoornweg & BhaDa-Tata, 2012)

2.5. Global Waste Management Practices

Waste management cycle starts from the waste generation at household, commercial, industrial or municipal level. This waste is then collected and transported by the authorities to a storage site. Next, waste is subject to different handling, management and disposal techniques. Following are the conventional waste management methods used worldwide.

2.5.1. Waste prevention

The reduction of waste at the source of generation not only saves cost but also reduces pressure on the authorities. Waste prevention awareness is in place in developed regions of the world where people are educated at individual level on importance of reducing waste. Furthermore, waste is recycled into useful products to increases it life span. Industries are implementing zero waste quality parameters to monitor the waste generated by its process and research at industrial level is underway

for reducing the waste generation. Unfortunately, in developing nations the focus on waste prevention is negligible.

2.5.2. Open dumping

In underdeveloped and developing countries where there is lack of waste management legislations, open dumping is a norm. Waste is usually collected from the households and transported to open dumping areas where it is left untreated. Scavengers pick up useful burning material like plastic, wood and rubber. The open dump not only releases harmful gases but are also a cause of diseases in the neighboring residential areas.

2.5.3. Recycling

Reusing a waste material, which is discarded as having no further value, for making something valuable out of it is known as recycling. Waste pickers or scavengers collect material that can be sold to recyclers from waste dumps and waste bins. There are many industrial plants worldwide which convert the recyclable material into raw form. This raw material is then sold to manufacturers for reuse. Following are the materials which can be recycled.

1. **Paper and cardboards** are common waste items in municipal waste. Paper recycling is one of the most profitable industries. The paper waste is readily accepted by the paper mills who reintroduce used paper as a raw material to make new paper products.
2. **Glass** is also commonly recycled. The glass waste items are collected and crushed into smaller pieces and sold to glass manufacturers. Glass waste is usually turned into green or brown colored glass bottles. Other markets for glass waste are windows and art glass products.
3. **Metals** like iron, steel, aluminum make up around 2% of the municipal waste (UNCHS, 1989). Metals are picked by scavengers and sold through vendors to the manufacturers of metal products like appliances, equipment etc.
4. **Plastic** constitutes 10% of the municipal waste and is one of the most popular discarded materials for recycling. Plastic is 100% recyclable where the item is crushed into small pieces and sold to plastic product manufacturers. Worldwide plastic recycling market is flourishing and is encouraged by all environmentalists. Plastic does not completely degrade in a landfill

and with incineration it releases toxic gases which are difficult to control, therefore plastic recycling is the most environmentally sound way of handling this waste.

2.5.4. Composting

Composting is another form of reusing waste material. Organic matter like biomass, leaves, agricultural waste, cow dung and food scraps are biologically decomposed in a controlled environment. The result is soil like material which is called compost or humus. Humus is used as a natural fertilizer and used by farmers to replace the chemical fertilizers. The composting process is an alternative to landfill and saves cost of waste disposal.

2.5.5. Incineration

Controlled burning or incineration is also a method of waste management used globally. In under developed regions open burning of waste is a common practice. However in more environmentally conscious countries, the waste that cannot be recycled is burned in incinerators for complete destruction. Many industries like cement plants are burning biomass waste which can provide certain heat value for their manufacturing processes. The burning of waste releases harmful emissions that require controlled monitoring continuously. Certain incinerators or plants have installed filters which capture the emission. These gaseous emissions can be utilized to generate electricity. Regions which are overwhelmed by waste generation usually deploy this method in order to reduce the cost and land dedication of landfills.

2.5.6. Landfill

Landfill is one of the most common disposal method used worldwide. In developing region of the world, landfills are semi-engineered where waste is simply buried underground. These semi-engineered landfills on the surface do seem to provide a solution but in reality they cause more damage in the long run. The organic matter decomposes to form liquid and gases. The liquid can seep through the soil and contaminate the water supply. The gases mainly methane when released cause greenhouse effect and even fire.

However, developed regions deploy advanced landfill solution known as sanitary landfills (USEPA, 2002). These landfills are lined with a synthetic liner which prevents the liquid from decomposed matter to seep through the soil. Furthermore, new technological advancement has enabled the

collection of gaseous emissions from the landfills. The recovered methane from the landfills is in turn used to generate electricity. It is to be noted that even though properly designed landfills are one of the most efficient waste disposal methods but the cost of establishing these landfills is humungous.

2.6. Challenges and Opportunities

The waste management poses immense challenges worldwide. The sector is much neglected in majority of the world regions however focus has been shifting towards managing the issue before it takes a toll on the environment and economy. Some of the challenges being faced currently at global level are as follows.

2.6.1. Challenges

The waste collection and management is generally considered a sole responsibility of municipal authorities. Regardless of lack of resource dedication: may it be financial, technological or human, the municipal authorities are held accountable of poor management of waste. It cannot be overlooked that in developing countries municipal authorities are inept and rather ignorant to the need of waste management requirements. However, the responsibility does not lie with the authorities only. Considering the magnitude of waste being generated coupled with increasing population there are limitation on what municipalities can achieve with their current resource structure. Therefore, another crucial challenge in the waste sector is lack of community participation (Asnani, 2006). From individual level to the household and community level, no one is aware of the consequences of their actions. Waste is treated with much less respect than it deserves. Instead of reducing waste at the source, individuals are contributing to resource wastage and creation of garbage which combines to pose challenge authorities cannot handle. Although, it is true that government is required to educate people at the grassroots level about the importance of waste reduction and waste management, it is yet more important that each individual contribute towards resolving this issue on his own accord.

The world population is increasing at an immense rate; consequently the volume of waste generated is also increasing. The volume itself causes fewer problems as compared to the complexity of composition of waste. Waste composition depends upon the development in a certain region and its income level. The lower income region generates waste which is more organic and biodegradable in

nature, hence the management techniques require less resources and efforts. Compared to this the developed countries produce more industrial, construction and commercial waste (Bleischwitz 2009).This waste is hazardous in nature thus it requires more financial expenditure for handling and management.

The increasing volume of hazardous and non-hazardous waste in turn poses risk to human health and ecosystems. The situation is worse in developing countries where authorities are less equipped to manage the waste being generated. Last but not the least untreated waste is a major contributor towards climate change. The untreated organic waste releases gaseous emissions during degradation known as GHG emissions which contribute to global warming and change in climate. The discarded electronic appliances also release emissions which are directly linked with ozone depletion.

2.6.2. Opportunities

Despite the challenges of growing volumes of waste being generated, this sector also offers multitude of opportunities. The increase in waste generation is also coupled with increasing awareness regarding the greening of the environment at global level. This has given rise to development of new technologies for managing waste. This sector is gradually becoming lucrative for investors and business owners as a new opportunity in terms of growth and profits. Keeping in view the increasing resource scarcity and energy crises in developing countries, waste sector presents an opportunity of exploiting the waste products as a source of energy in industrial sector.

3. Solid Waste Management Practices in Pakistan

Pakistan is the 6th largest country in the world with population exceeding 180 million. Approximately 35% of the population lives in urban developments. The average daily waste generation is estimated to be 55,000 tonnes and only 60% of this waste is collected by the municipal authorities (Ministry of Environment, 2005). With poor legislations, financial support and technical and human capabilities, it is not a surprise that the country is facing a major challenge in waste management. Although, the subject has garnered interest and some action from the officials however, it is about time that the matter is dealt with strategic vision and long term sustainable solutions. By 2050 the population of the country is expected to reach staggering 350 million (Nizami, 2010). Considering the current

inadequate waste management practices the population increase indicates imminent crises with disastrous consequences.

In order to shed light on amount of waste generated per major city of the country following are the estimates based on the population growth till 2004.

Table 3: Waste generation estimates of cities of Pakistan based on population for 2004

Cities	Population (million) 2004	Solid waste generation rate Tonne/day	Waste generated Tonne/year
Karachi	**10.818**	**6,632**	**2,420,680**
Faisalabad	**2.307**	**902**	**329,230**
Hyderabad	**1.343**	**756**	**275,940**
Gujranwala	**1.312**	**615**	**224,475**
Peshawar	**1.153**	**564**	**205,860**
Quetta	**0.654**	**247**	**90,155**
Banu	**0.054**	**24**	**8,760**
Sibi	**0.095**	**27**	**9,855**
Other Urban areas	**31.818**	**14,414**	**5,261,110**
Rural Areas	**102.853**	**29,108**	**10,624,420**
Hazardous waste	**3% from industries**	**1,599**	**583,635**
Total	**152.409**	**54,888**	**20,034,120**

Source: (PEPA, 2005)

It is estimated that efficiency of waste collection ranges from as low as 0% in rural areas to 90% in urban areas however these figures do not represent the percentage of total waste being collected. (Mahari, Malik, Qadri, Ahmed, Khan & Khan 2007).

3.1. Common waste management practices in Pakistan

The most common practice of waste collection is through waste collectors. Open body waste trollies or donkey carts are used to collect waste from households without any regard to the health and safety of the waste collector. The waste collected is then transported directly to a dump site. Little effort is put to segregate the waste and that too is done by the collector rather than the waste generator. Other than the meager waste treatment i.e. separation of plastics and paper from the waste, little or no effort is made by the municipal authorities. Landfill or specialized waste treatment plants are still a relatively new concept in Pakistan with small number of private organizations dedicated to this area (Veenstra, 2007).

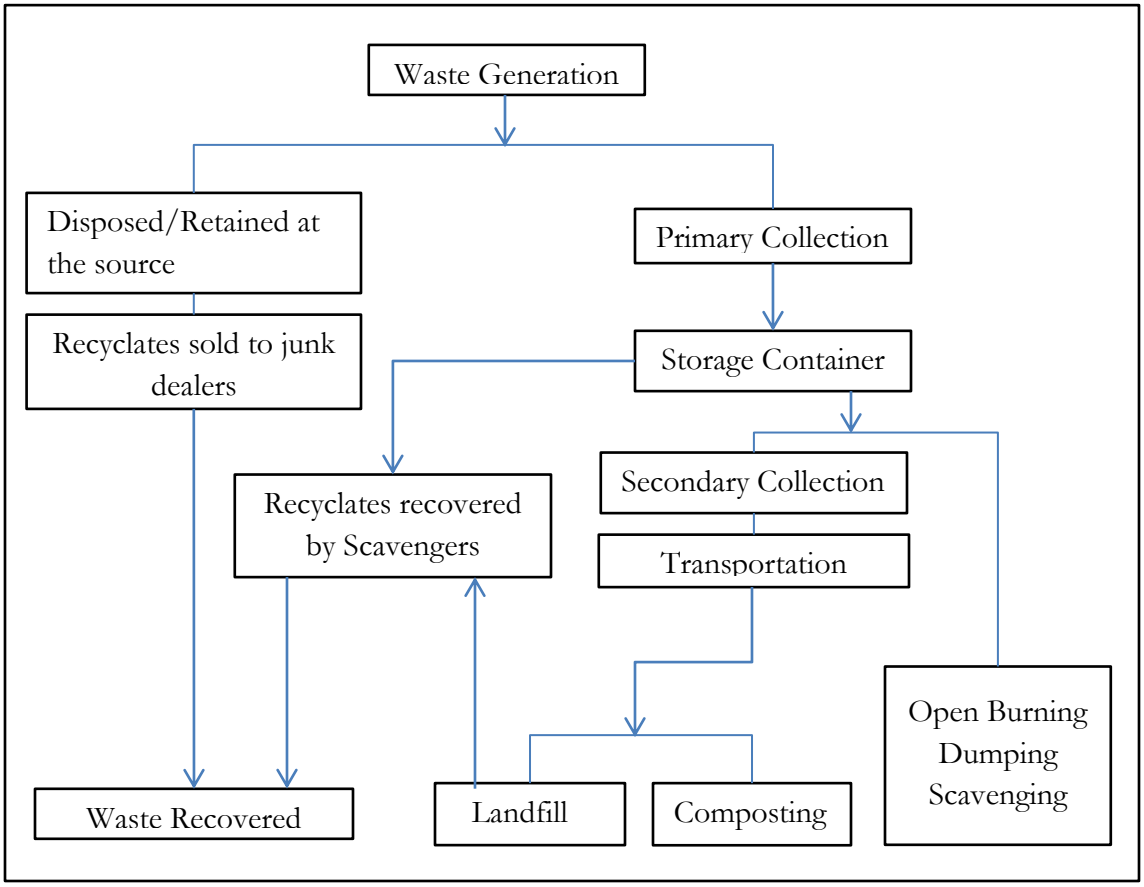
The poorly organized landfills and little thought to the utilization of new landfill technology have resulted in overflow of waste dumps. The cities lack dedicated waste storage areas and waste collectors mainly unload the waste on any available open space. The waste being dumped largely remains untreated and takes up a lot of space. In order to reduce the quantity the waste is burned in open air which releases toxic gases causing even more pollution (Rehan, Kaukab & Schertenleib 1998).

The waste pickers or scavengers collect items of their interest which normally includes plastics, wood, paper or cardboards. On minor sum they sell the collected waste to recycling plants. These recycling business units convert the PET bottles and other plastic into tiny plastic flakes which can be sold or exported to manufacturers of plastic products.

Another specialized form of waste recovery technique is composting. It is a natural process which turns organic components into dark rich matter called humus. Humus is used as a conditioner for soil to make it fertilize. In Pakistan there are some composting plants which receive or collect municipal wastes, segregate the organic material and shred it to small pieces. The segregated material is then mixed with leaves and soil and left in the form of large pile with controlled moisture. Over the period of 2-3 weeks the organic material will decompose and form a dark brown matter which is called humus or compost (Cooperband, 2002). Composting saves the cost of landfill and incineration and is one of the effective methods of waste management.

For the final and complete destruction of the waste it had to be burned to an extreme temperature exceeding 1000 degree centigrade. Special thermal burning units or incinerators are set up for this purpose. In developed countries these thermal energy recovery plants are established to generate electricity by burning the waste material, however in Pakistan there are a few incinerators and even less thermal energy plants.

Figure 3: Current Flow of Waste material from source to disposal



Source: (Masood & Barlow, 2012)

3.2. Legislative Framework

Lack of legislative framework has added to the problem. The scenario is worse in rural areas where open dumping of municipal waste on roads, streets and yards has become a common practice. Open dumps leads to dispersion of waste to the surrounding areas causing blockage of rain and sewerage drains (Ejaz & Janjua, 2012).

In 1997, Government of Pakistan enacted Pakistan Environmental Protection Act (PEPA). PEPA is primarily responsible for forming strategic implementation framework for provincial Environmental protection agenesis (EPA). National guidelines on landfill practices are available through National Environment Action Plan Support Program (NEAPSP) but authorities have so far failed to monitor

and evaluate the prevailing practices. Guidelines on safe disposal of hazardous hospital and medical waste are also available through Ministry of Health, however these are not being currently implemented neither are the authorities taking steps towards its enforcement. As a result this waste is being mixed with municipal waste.

EPA does have a legislation regarding emissions and it regularly monitors and controls the manufacturing plants on their emission of gases and residue. Unfortunately, EPA does not have any such law regarding the solid waste or residual waste generated after the manufacturing process.

The current legislation is inadequate and it does not identify the agents to be held accountable from the waste generation to its disposal. There are no industry specific guidelines on how to limit waste generation and how to dispose it in environmentally sound manner. Furthermore, penalties are not set and implemented in case of violation of environmental protection laws.

3.3. Prevailing challenges

The municipal authorities with limited funding and trained human resource have less than adequate capacity to handle the needs of waste management. Currently the municipalities are overwhelmed with the pressure of keeping the cities clean and handling the waste being collected. They resort to short term solutions of landfill and burning. Furthermore, they also fail to collect 100% of the wastage on daily basis.

Another major issue being faced by the country is lack of public awareness. People are not aware or conscious of hazardous effect that waste material can cause. They are not mindful of waste practices that can limit the volume of waste generation at individual level. If the public is educated about the benefits of waste segregation at household level then a major chunk of effort and cost can be saved. Furthermore, there are not enough initiatives to mobilize the community to actively address the issue and collaborate with each other to raise awareness (Bhatti & Mohmand, 2014)

Moreover, the database on waste generated per city per day is not being updated on regular basis. The current information is either inadequate or too old to be of any value. Special dedicated institutions and resources are required to maintain a database on the type of waste being generated and collected per city, on the composition of the waste, labor force working etc. With only accurate data can a clear picture of the issue be seen and only then effective waste management solution can be devised and implemented.

3.4. Opportunities in Pakistan

An energy crisis is prevalent in Pakistan with much focus on efficient alternative avenues of energy generation. Through incineration, thermal treatment or gasification the municipal solid waste is already being used to produce electrical energy. For Pakistan this is an opportunity if immense proportions considering the large volume of waste being generated. Nearly 90 of the municipal waste can be reduced through waste recovery and in turn can result in electric power generation.

The informal service sector including waste picker, scavengers and the waste collectors are a large sector of labor that is overlooked. Their contribution is significant and can be harnessed in even better way if their work is organized better than current status. If these scavengers are given incentives coupled with measures for their health and safety a large volume of waste can be segregated and collected at collection points and put to better use.

Another untapped opportunity is private sector. However, there are a few private businesses who have ventured into waste management business but this sector of the economy largely remains in isolation. Waste management market is not deemed profitable by the private businesses. Waste recovery, sorting and recycling requires heavy investment in equipment, machinery and labor. If government is to incentivize this sector and give special concessions to private organizations then a major load of waste management can be transferred and can perhaps be managed in a better way

4. Lafarge Pakistan Investment in Waste Processing Joint Venture Company

In 2010, Lafarge Pakistan embarked on the mission of fuel substitution and established the department of Industrial Ecology. By supplier building and sourcing of biomass fuel the result in the first year was 3% substitution. Steadily gaining acceleration and increasing supply of available alternative fuels and exploring new venues of potential supply streams, the substitution reached 28% in 2012. Lafarge largely depended on poultry shed waste with calorific value of 3000 kj/kg and carbon black (waste of tyre manufacturing) with calorific value of 6800 kj/kg as compared to coal which has calorific value of around 8000 kj/kg. However, the cost of procuring alternative fuel is far

less than that of coal e.g. 2800 PKR/- per tonne of poultry shed waste and 10,000 PKR/- per tonne of carbon black as compared to 15,000 PKR/- of coal.

However, by then the competition had also realized the cost saving potential of investing in alternative fuels instead of expensive coal. This resulted in demand surge in market, with more suppliers entering in the business. Through increasing competition between suppliers and consistent demand by the cement manufacturers, Lafarge faced the dilemma of diminishing supply, poor quality material with more moisture and less burning value and increase in prices of this substandard material. This made the substitution target of 50% not only difficult but even made it difficult to sustain the current substitution rate.

Realizing the need of augmenting the current alternative fuel supply with a steady long term supply chain, Lafarge decided to explore the potential of deriving fuel from municipal solid waste. There was no commercial operation specializing in making municipal waste a possible fuel in Pakistan. The vision was to get a direct access to the source and control of cost and quality of supply. This required collaboration with a company already involved in processing municipal solid waste.

4.1. Saif Holding Limited

Saif Holding Ltd (SHL) is a business development and Investment Company which provides consultancy and financial services to its associated companies. Saif group provides these services to one of its subsidiary Lahore Compost Ltd (LCL). Lahore Compost was established to convert municipal waste to compost or humus which is then sold to agriculture farms as a fertilizer. Composting is done through aerobic process and takes around 60 days to complete. Saif group, through Lahore compost has established first public private municipal waste management project under agreement with City District Government Lahore.

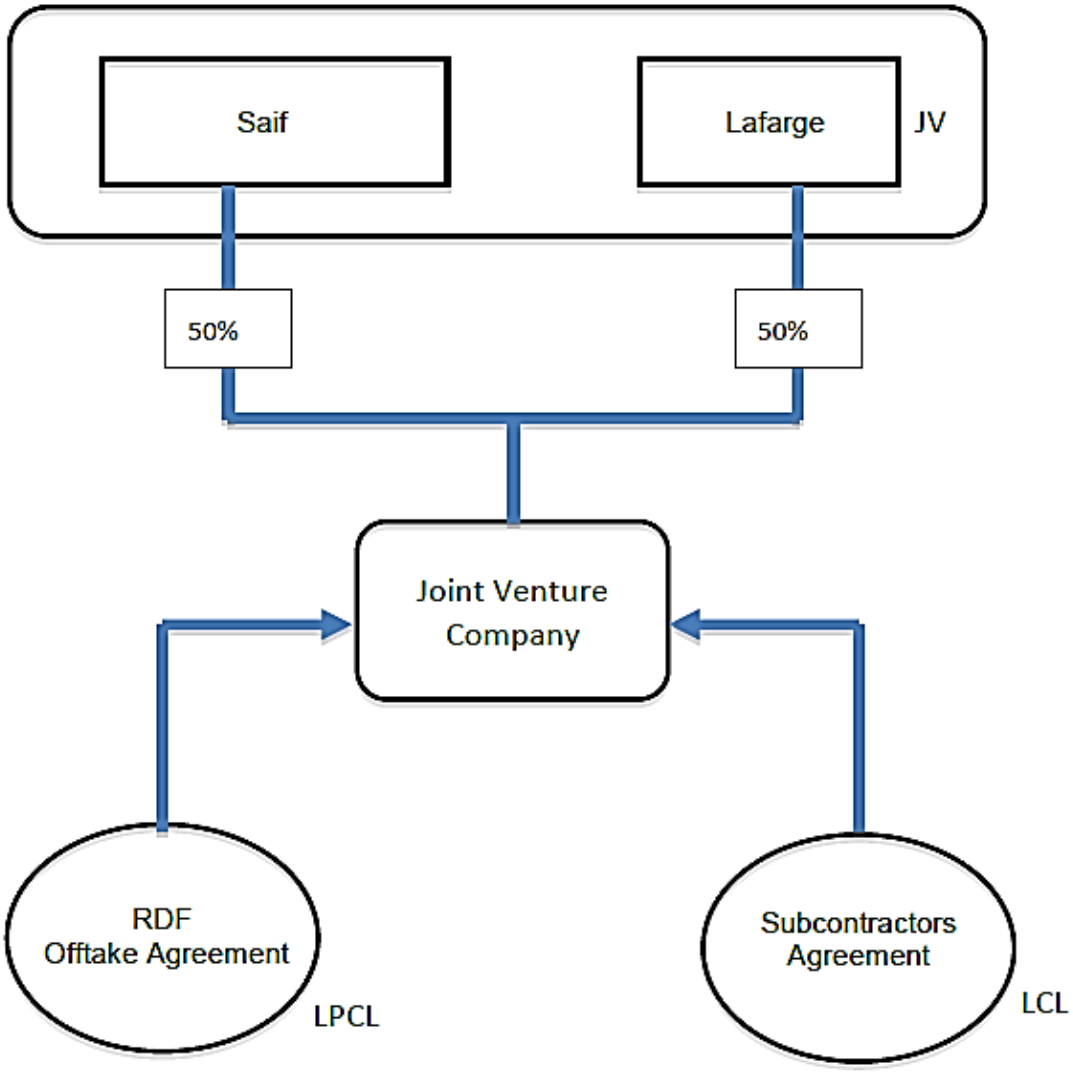
Considering that Lahore compost already had a unit established for municipal solid waste, it was best suited for Lafarge to invest in it. Through sorting the organic component of the waste was used for the compost but rest 25% combustible material was thrown in a landfill. The potential calorific value of this combustible waste was around 4500 kj/kg, which made it a feasible alternative fuel source. Therefore, Lafarge chose to invest in a processing plant whereby, the useful waste like plastic paper and wood was segregated from the rest. This segregated waste is called Refused derived fuel (RDF). With the installment of sorting unit, the plant has the capacity to process 1000 MT of solid

waste resulting in 100-150 MT of RDF. Lahore Compost with its experience of handling municipal waste and already built relationships with municipal authorities managed to provide a secure long term supply to Lafarge.

4.2. Investment by Lafarge

With investment in waste sorting unit at Lahore Compost site, Lafarge then proceeded to invest in RDF shredder for slicing the sorted material into small pieces which were easy to feed into the fuel feeding system. The shredder was set up at Lafarge plant in Chakwal. The idea was to shred the sorted RDF being transported from Lahore Compost on need basis.

Figure 4: Joint Venture between Lafarge and Saif Group of Holdings



The joint venture company had 50% financial contribution from each party. While Saif Holdings looked at the managerial and operational aspects of the project, Lafarge provided technical expertise including global research and development. Lafarge also helped procure the equipment required to set up the waste processing unit at Lahore plant.

4.3. Objectives of the project

Although the main objective of the project was to secure supply stream which is not subject to market fluctuation, however by this joint venture Lafarge has also managed to achieve following long term objectives.

1. The waste management infrastructure is almost non-existent in Pakistan. Through this joint venture Lafarge has contributed by forming one of a kind waste management business model.
2. This venture provides another available option of waste management. This profitable avenue has a potential of attracting businesses and can also encourage government authorities to seek out partnerships with private sector.
3. In longer term waste management units like these help reduce the CO2 emissions and in turn reduce the pollution.
4. It can also highlight the much neglected waste sector by shedding light on how waste life span can be increased and utilized for the benefit of the country.
5. More investment in these business units can help increase job, safety and environmental protection.
6. Last but not the least Lafarge through its joint venture has become a catalyst for alternate energy initiatives and energy efficiency in the country

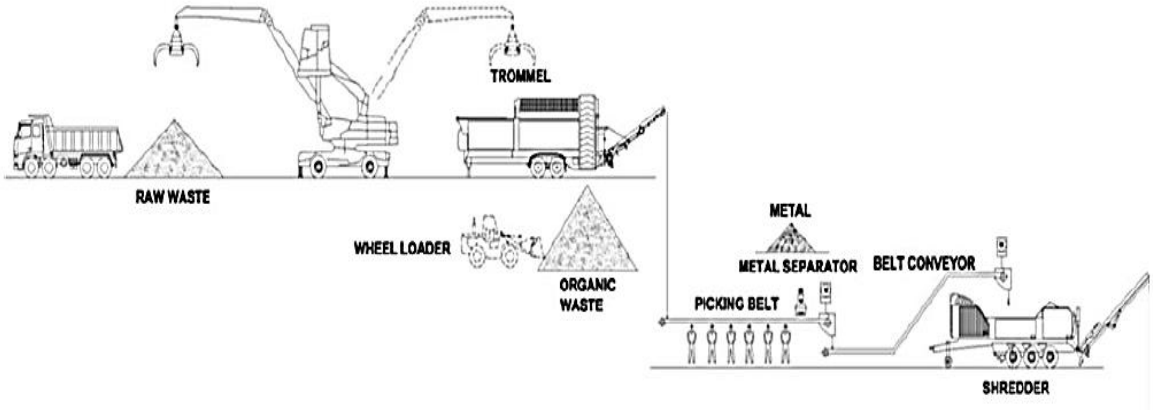
4.4. Process description

The preparation process of RDF from municipal solid waste consists of following steps (Lafarge, 2012)

1. The sorters (labour) will manually sort the waste and pick out unusable items like dead animals, large steel pieces etc.

2. A mobile loader will then load this loosely sorted waste from the heap to the receiving end of the waste screening machine called Trommel.
3. The Trommel machine is equipped to extract fine biodegradable material through the screen attached. The screen would only let a pre-set size of material to pass through. This material is usually the organic waste which is used to make the compost. The rest of the material is potential RDF. The machine has two outgoing movable conveyer belts one for the organic material and another for RDF. A magnetic separator is also installed above the screen of Trommel machine which pick all metallic and magnetic items from the waste. This waste is then sold to scrap metal market earning a profit for Lahore Compost. The organic material is then transported to the field for making composting piles.
4. The RDF waste is then transferred to a manual picking belt which is the third separation stage of the process. Here 6 sorters with each on the sides of belt will manually pick out any unusable waste left in previous process. Only the waste which has burning value like plastic (bottles, bags etc.) wood bars or chips etc. will be left.

Figure 5: Process Flow Diagram of Joint Venture RDF Project



5. The sorted waste is then baled up to 650 kg of bundles each and loaded into trucks for transfer to Lafarge plant at Chakwal.
6. The shredder is installed at Chakwal plant where the material is shredded to reduce the size to less than 50 mm of pieces.
7. The shredded waste is then transferred through the loader into a conveyer belt which will feed it to the intake fuel hopper at the cement plant.

4.5. Evaluation of the Project

The total investment in the joint venture was of 825,000 Euros and the company succeeded to manufacture good quality RDF with initial production capacity 120 tonnes per day. The production capacity increased to 200 tonnes by the end of 2015. The average waste being processed has reached 1000 tonnes on daily basis and has reduced the processing load from the local municipalities.

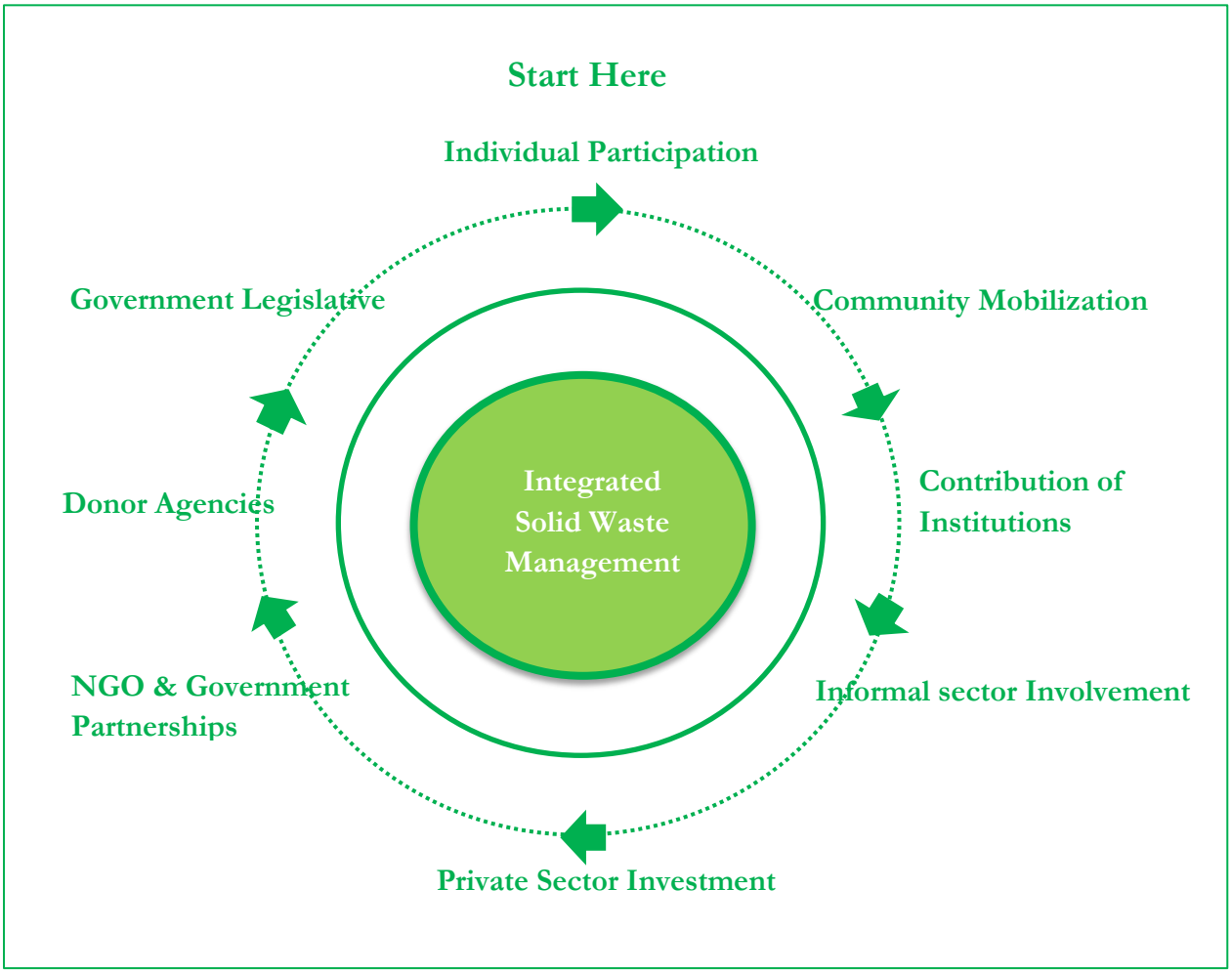
The project implementation took 6 months with payback period of 2.3 years. The cost saving from the project reached 30% by the end of 2015. By the end of 2015, Lafarge through this project managed to get 10% increase in its alternative fuel supply. This venture is one example how completely unused waste market can be turned into a profitable business.

5. Integrated Solid Waste Management Approach

It is a common belief that by holding the authorities responsible and by fixing their actions the waste problem will be resolved. However, in truth all the actors of the economy from the waste generation, its handling and ultimate disposal are responsible for creating the mismanagement and therefore must play their part in effective resolution. The management always starts at the smallest scale i.e. individual and household level. By educating the masses on how to manage their waste production and minimizing the situation at the source, we can expand the idea to a broader scope. Once individuals are being sensitized, community engagement comes into play, here community as a whole can help educate, spread awareness of waste management and ultimately collection of waste. Next step is collection of waste from the institutions and transportation to the collections sites. One of the most important yet often overlooked sectors is informal waste collector i.e. waste pickers or scavengers. This sector is responsible for segregating waste and then selling the good quality waste to recyclers. Informal sector can play a vital role in the management of waste if given proper incentives and importance.

Once the collection is completed and waste is transported to designated collection points in a safe manner, the disposal phase of management starts. Here, private sector can be encouraged to invest in disposal, recycling and other business ventures. NGOs and donor agencies can also be invited to play their part in awareness projects or investing in business ventures.

Figure 6: Integrated Solid Waste Management



Last but not the least, government sector and municipal authorities have to play their much needed and important role. Not only a change in legislation is required but more importantly the implementation of current regulations is much needed. Furthermore, government has to look at waste management as a potential contributor towards the economy and have to explore options for making it a lucrative sector for private sector and foreign donor agencies.

It is to be noted that not one of the above-mentioned options would prove fruitful if used in isolation. The holistic approach would be collaboration among each actor and expansion of waste management activities across each sector to effectively manage the waste problem which is crippling the economy of Pakistan.

5.1. Waste Collection

The first step to a waste management program is its collection. Currently the municipal authorities collect waste from households and institutions through waste collectors. These waste collectors have open wooden carts which are unhygienic. After collection the waste is either burned in an open ground or dumped in a collection site. In order to streamline a proper waste management process the collection requires much more awareness and sophisticated method.

5.1.1. Individual Participation

One of the most critical aspects in effective waste management is its segregation. There is only little municipalities can do with the mixed waste which has lost most of its useful purpose. In order to keep the valuable waste intact its segregation must be done. The most effective method of segregation is at its source. Majority of the municipal waste is collected from households who are not aware of segregating waste according to its value. Even if individuals are aware, they do not practice the concept as eventually the waste will be combined by the collectors anyway.

Here, Pakistan needs to adopt the collection practice implemented by the developed countries. Following are the steps that individuals can take in order to segregate the waste being generated in their households.

i. The first step is to raise awareness towards segregating the waste in three separate bins or colored plastic bags instead of a single waste bin. The waste which can be recycled like plastic, wood, cans and papers should be placed in a separate bin. Another waste bin should be for non-recyclables like soil, diapers, human waste etc. If separated from the rest of the waste material, this unhygienic waste would be dealt with in a safe manner. The third bin should be dedicated for kitchen and food waste which can be used as compost.
ii. In order to inculcate segregation habits at individual level specialized education, training programs and awareness campaigns are required nationwide. Here, government, communities and civil society have to actively cooperate and play their part.
iii. Initiatives for capacity building at household levels are required. In order to properly segregate the waste rubbish bins or garbage wrappers are required at a large scale.

Furthermore, municipalities have to take the responsibility of collection according to the segregated waste.

5.1.2. Community Mobilization

Considering the overwhelming pressure on municipal authorities of Pakistan and lack of resources, there is a dire need for mobilizing communities to take up steps for resolving waste management issues. In areas where there is negligible waste management from authorities following steps can be taken by the communities.

i. Each community can make an internal planning committee which would analyze the current waste management status in the area. Based on the analysis they can plan for effective waste collection and transportation to the collection points.
ii. The committee can make an implementation team which will insure the waste segregation, can monitor the collection and transportation process and can keep the neighborhood clean from unregulated dumps.
iii. Separate bins can be introduced around communities which would then be moved to waste processing collection points.

The community model will insure the implementation of waste management practices at grassroots level and can be more effective than municipalities. The segregated waste will be of better quality and through transportation to the collection points the community can ensure that waste does not find its way to open dumps. The communities can even sell their own recyclable wastes to the recyclers and waste processes. This could become a revenue generating opportunity for each community or a housing society.

5.1.3. Institution based Solid Waste Management

Commercial, Institutions and industrial sectors can play an active role in waste collection, transportation and management.

i. Commercial sector like restaurants, food courts etc. can encourage the culture of waste reduction and segregation. The can establish separate bins in their establishments. The publicity campaigns can also be focused on promoting the culture of waste management.

ii. Institutions like schools, universities and business establishments can play a vital role in introducing the culture of waste management. If done properly the practices of waste management learned by the individuals will also reflect in their households.

iii. Industrial sector can implement waste reduction processes and can plan for environmentally safe disposal of chemical and hazardous wastes. The proper disposal protocols are followed by the MNCs, however this practice is negligible in local industries.

5.1.4. Informal Sector Involvement

One of the key contributors to the waste handling in developing countries is the informal sector. The contribution of these self-employed and informally organized groups of waste collectors, pickers, segregates and scavengers is often overlooked. Along with the lack of recognition and due respect for their part, this unstable and poor sector of the economy is indirectly serving the waste sector in poor working conditions. They collect the waste in unhygienic environment without proper safety equipment and are exposed to diseases. Furthermore, the waste they scavenge is sold for a very minimal price to recyclers. Most of the developing countries including Pakistan have failed to integrate this sector in its waste management programs. Following are the ways in which this sector can become a formal contributor to the combined program

i. First, there is a need of changing perception of social status of waste collectors. Second, this sector requires economic and social support for improving their living conditions. Instead of being treated as competition, the informal sector can actually integrate with the municipalities and share their burden. Municipalities can also enhance the effectiveness of waste management by using this already established work force for fixed sectors or areas.

ii. Legislative changes must be done in order to recognize the working status of waste collectors. Instead of collecting waste from the dumps, informal workers can be given opportunity of collecting waste from the source. This will not only provide job stability for the workers but also give them access to a larger quantity of segregated wastes. They can be given the opportunity of collecting their share of recyclables.

iii. If informal work force is utilized to collect the already segregated waste from each household, the municipalities will save humongous amount of collection and

transportation costs. Furthermore, by establishing and mobilizing a formal organization of waste collectors, the municipalities will forgo the need of establishing their own formal waste collection processes.

5.2. Waste Transportation & Storage

Even if the collection system is well organized the whole value chain will become ineffective if the transport and storage processes are not established. Following are the steps to be taken in order to ensure an effective waste transportation process and storage units.

i. For primary collection purposes from each household, closed containerized handcarts should be used. The segregated waste would go into a separate container; this will keep the waste from being mixed up. The closed container pushcarts will also ensure the safety of waste collectors. Another option, wherever applicable, is collection by the trucks or containerized vehicles. Considering the increased cost of vehicle collection method and inconvenience in small towns and areas, handcart collection can be more appropriate method.

ii. The collectors will then take the waste to a collection point designated for each area. The collection points would be covered areas where hand collected or truck collected segregated waste will be temporarily placed.

iii. The movement of waste from the truck to the collection depots will be done with transfer machinery which will pick and place the waste in a particular slot. The machinery method will minimize the contact with people. However, in case of lack of funds the dumpsters can manually be placed as well.

iv. The number and size of the collection points or transfer units will depend upon the volume of waste being collected. Therefore the distribution of these units will vary with the local area and the collection method being implemented in that area. The cost analysis should be conducted to decide optimal number of units, the distance from the settlement and transportation expenditure.

v. From here onwards, the waste will either move directly to the processing facility or move to a temporary storage unit outside the city premises. The storage of waste will not be in a form of open dumping rather in closed containers. From the storage units, the recyclable waste will be moved to the recyclers, the organic waste to composting units,

the hazardous waste to incinerators and the leftovers will be moved to sanitary landfill sites. The location of the storage units will also depend upon the location of the processing and disposal sites and an optimal site should be decided depending upon the transportation distance and relative costs.

5.3. Waste Processing

After effective, collection, transportation and storage of waste the next crucial step is its processing. There are multiple steps that Pakistani municipalities and local governments can implement i.e. composting, landfilling, incineration plants, recyclers etc. However, these projects require huge investments and that can only be achieved with the active participation of following actors of the economy.

5.3.1. Private Sector Investment

Private sector is one of the most untapped avenues in waste management program in Pakistan. The sole responsibility of managing the waste is levied on local governments and municipalities. The meager private investment present in this sector is either ill organized or not expanded fully to support the municipal authorities. With effective planning and promotion from the government private sector can be involved to become a contributing factor in the economy of waste sector. Following are the partnerships models that can encourage the private sector participation.

i. Private-private partnership

By commercializing a part of waste sector a major chunk of waste management cost can be transferred to the private businesses. The private sector will be more invested in providing a better quality service as compared to the public sector as the return in terms of revenues will be much higher. By delegating certain areas to private establishments for waste collection and processing, not only the recyclers or processors will get access to useful waste but will also be able to generate money by levying collection fee to the households. Private establishments depending upon their expertise in wide range of waste management activities i.e. collection, transfer, storage, processing and disposal, can form partnerships to effectively manage and form a mutually beneficial relationship. One example of this model is the partnership between Lafarge and Saif group of

Holdings. However, for success of this model, regulation and management is required by the local governments and municipalities.

ii. Private-NGO partnership

NGO's can form partnerships with private businesses to cooperate for the organization of awareness campaigns, to establish collection and storage units in cities and in training the waste management staff. NGOs have experience and knowledge of effective and organized waste management techniques. Private sector can utilize the expertise offered by NGOs in formulating innovative ways to utilize waste product into developing useful material. One such example is Gul Bahao NGO in Karachi which has developed an innovative way of making blocks and panels from rubbish and using these panels for construction of houses. By forming partnerships with NGOs like Gul Bahao, private businesses can explore new business opportunities.

iii. Private-government partnership

In low income areas where there is less incentive for private businesses, the municipalities can commercialize a part of waste management process and take responsibility of the rest. The municipalities can form exclusive contracts with waste processors and recycler, where these establishments will get access to segregated and recyclable waste for a fixed price. In this way municipalities will save the cost of waste processing.

5.3.2. NGO and Government Partnership Model

Climate change is a pressing challenge being faced at global level and as a part of millennium development goals; this has become a forefront matter for United Nations. UNDP and specialized environmental NGOs have renewed their efforts for environmental protection policy programs. One such NGO working in Pakistan is International Union for Conservation of Nature (IUCN). Waste management is a key contributor towards environment and ecosystem protection. NGOs can contribute towards the waste management efforts in the following ways:

i. NGOs can help municipalities in organizing awareness campaigns
ii. They can provide technical guidance on how to effectively establish a collection and storage program
iii. They can develop linkages between government, public and private sector

iv. They can help increase the capacity of government, municipalities, communities and informal sector.

5.3.3. Donor Agencies

In order to increase the financial capacity of the country donor agencies can provide the aid. External agencies like UNHABITAT can first provide technical guidance on waste management in urban settlements. Second, they can contribute funds for effective capacity building and waste management initiatives. There are multiple external donor agencies working in the field of improving the waste management conditions in developing countries. Therefore, cooperation and linkages are required to be developed with these agencies to gain their support and expert knowledge.

5.3.4. Government Legislative Initiative

There is a need of revision and amendments in the current legislation regarding environmental protection in Pakistan. Foremostly, EPA has to consolidate disperse and often contradictory rules of emissions and waste management. For that purpose EPA should bring together all the decision making and implementation bodies and devise a consolidated plan for effective waste management at local and national level. A central controlling body should be established with the responsibility of enacting all the regulations. The central body should have the right to grant the waste management contracts to private sector. The central authorized body will seek guidance, support and financial backing from the national and local governments.

Along with the central controlling body, the local municipalities should also be given certain authority to execute the waste management initiatives in their areas. However, these municipalities will depend upon the national government for capacity building and technical support. Furthermore, in order to achieve the holistic solid waste management across all the cities, the local municipalities will have to cooperate with each other as well. The budget for each municipal area will vary according to the waste being generated and the collection capacity of the municipality. The central body will decide the allocation of budget however the authority of expenditure will lie with the municipal authorities and the local governments.

Moreover, national government body should initiate the environment protection program country wide with comprehensive budget allocation to this cause. Other than the budget allocation, the government can seek financial aid and grants from the NGOs and the external donor agencies. Self-

financing is another model that local government bodies can explore. By levying user charges for door to door collection on households and also the waste management taxes, a significant amount of funds can be generated. These funds can be used to develop waste management infrastructure and more importantly, waste processing facilities like composting units or landfills, which could in turn become a source of revenue for the local bodies. One other sector which is increasingly becoming a popular one for the government is the private sector investment. While providing business opportunity to the private businesses, the government can decrease the load form the local bodies and will decrease the need of more financial investment.

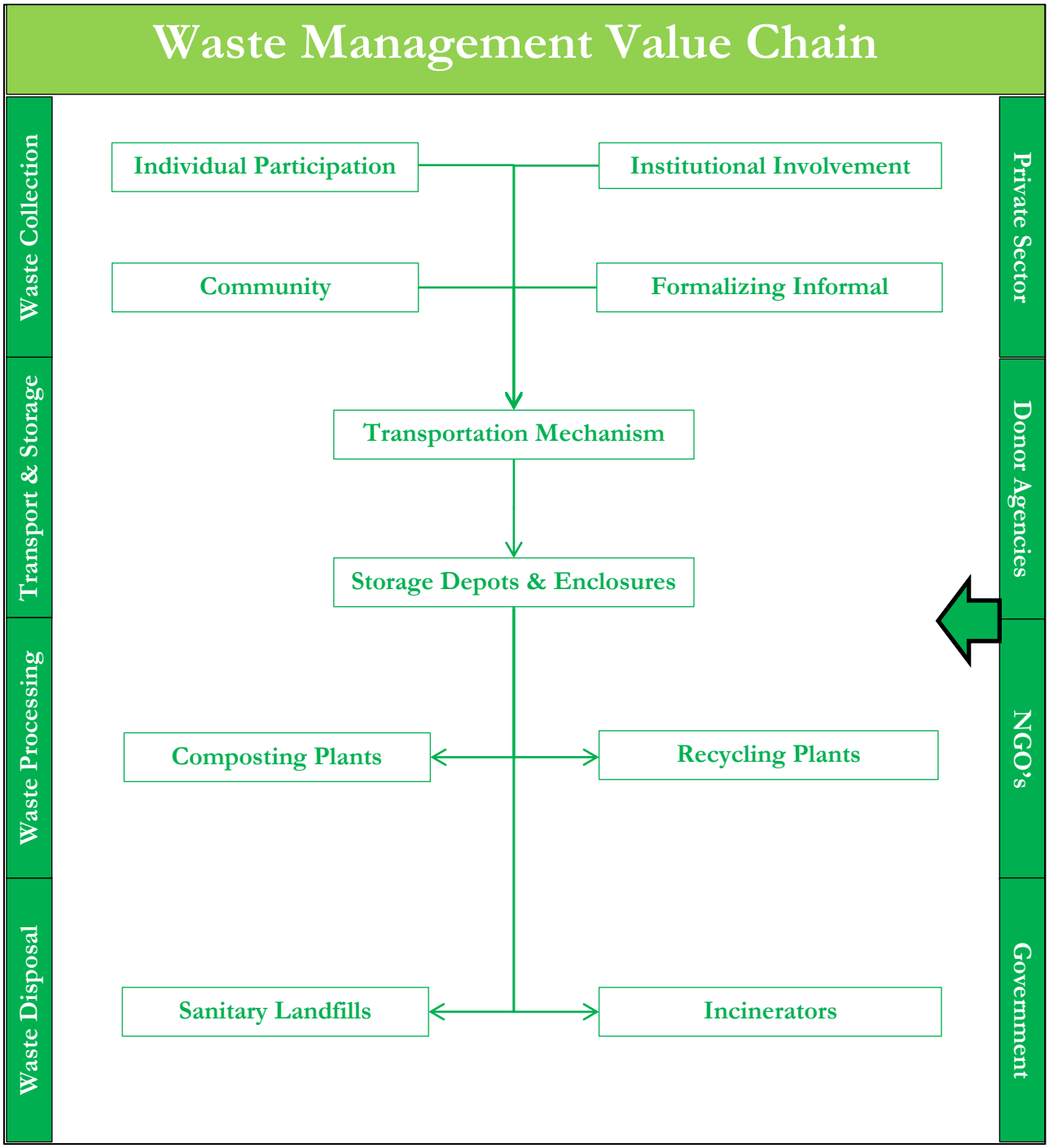
As mentioned previously, the data regarding each municipal area is inadequate. Data collection units should be established in each municipality with dedicated resources responsible for maintaining waste collection, transportation and disposal data. These data reports would indicate the performance of each area and will identify the trends wherever there is inadequacy in performance.

5.4. Waste Disposal

The waste disposal option will vary considering the success of the previous steps and also the participation of all the actors of the economy. Furthermore, it will also depend upon the resource allocation for the different disposal methods by the government. Some of the options can be as follows.

i. Composting units can be set up for production of compost. These could either be private or governmental establishments or could also follow private-private or public-private partnerships model.
ii. Recycling plants; both private and government, should be set up for the specialized recycling of plastics, metals and glass products.
iii. Latest sanitary landfills could be set up, for non-biodegradable wastes only, near the collection sites with methane collecting thermal plants for the production of electric energy.
iv. Lastly, for the hazardous waste and where landfill is not the only option, incineration and thermal destruction plants can be established by the government and the private sector

Figure 7: Flow of Waste Management Activities



6. The Way Ahead

The above mentioned steps present a possible solution for the problem Pakistan is current facing. However the list is not exclusive and much more initiatives are required to fully address it. Even with the active participation of all the actors in the economy there are still certain gaps which need to be addressed. One major concern for the municipal authorities and local government is the lack of waste generation and collection data. There are no dedicated institutions and human resource that collect, update and disseminate this information. With the help of donor agencies and government cooperation a special data collection unit can be established which can maintain and update waste management information regarding each town and city. This accurate information can help the authorities in pinpointing the inefficiencies in a particular region and in addressing the effective resource allocation.

Building upon the information gathered investment in technology and research facilities is essential to formulate long term and sustainable waste management solutions. The research areas can include new technological advancement for turning current landfills into energy generation units. Furthermore, guidance from international waste management research cooperation can also prove fruitful. Legislative changes and providing incentives to private sectors for investment in waste management solutions is one way to increase interest in this sector. However, the winning solution is engaging the community at the grassroots level, building upon the current infrastructure and involving all the stakeholders to sensitize the masses towards the waste management.

This study only gives a glimpse of current waste management situation in Pakistan with a suggestion of a participative solution where different actors of the economy would need to play their vital role. However, much more studies in this sector are required to shed light on the enormity of the waste situation in the country. As mentioned previously the lack of waste generation and management data is the first and perhaps one the most important gaps that requires attention. And the attention towards finding solution to this problem can only be achieved if enough importance is given to the subject. We can expect to see positive advancement in this sector when we start giving waste the importance it deserves, start realizing the harmful impact it has on our ecosystems and start treating it as a potential contributor towards economic progress.

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