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# Developing 3Rs (Reduce, Reuse And Recycle) Strategy for Waste Management in the Urban Areas of Bangladesh: Socioeconomic and Climate Adoption Mitigation Option

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***Abstract:*** *Waste generation and its management are being widely debated across the globe and in recent years, it has become a niche spot. Both the developed and developing countries are trying to find out new ways for climate change mitigation and adoption options respectively. Global climate change is a burning issue and presently Bangladesh is facing grave situations. A large proportion of the waste is not properly managed and dumped in unplanned sites that are creating severe environmental hazards. Gradually, it can be replicated in each urban and rural centre and growth points of Bangladesh can play a vital role in climate change mitigation. Implementation of the 3Rs will have a profound socioeconomic impact, also modern 3Rs (Reduce, Reuse and Recycle) strategy acts as a sustainable and socioeconomic option for climate change mitigation by reducing green house gas (GHG) emission from the municipal solid waste.*

***Keywords:*** *Dhaka City Corporation, Green House Gas (GHG), Municipal Solid Waste (MSW), Waste management, 3Rs.*

## I. Introduction

Municipal solid waste (MSW) generation and its management are being widely debated across the globe at various events, from local forums to international conferences and summits. Solid waste management became a niche spot in recent years. The conspicuous intensity of building causes difficulty in waste collection from the city particularly from the Dhaka area. There are a number of studies available on waste generation and characterization of six City Corporations and some municipalities in Bangladesh [1, 2]. In Bangladesh context, all the landfill sites are unmanaged and open dumped. These sites can be the optimal candidates for Landfill gas emission. A significant amount of municipal waste is dumped in the dumping sites which produce significant amount of $CH_4$ for emission into the atmosphere. Rapid urbanization and population growth are largely responsible for very high increasing rate of Municipal Solid Waste generation in the urban areas like Bangladesh, which is densely, populated Least Developed Asian Countries (LDACs). These scenario posses a social, environmental and professional threat for city dwellers, urban planners, development authorities and other concerned stakeholders. In Bangladesh, a major portion of population does not have access to waste collection services and only an insignificant fraction of the generated wastes are actually collected by door-to-door collection system introduced by nongovernmental organizations (NGOs) and community based organizations (CBOs) in late 90's against tiny payment [1]. Also the collection pattern and average rate of recycling varies with the size of the city, e.g. in the city corporations it is around twice as much as in the Pourashavas and other urban areas. 4 to 15% of the total generated waste is being recycled by the informal sector. It is estimated that every year Tk 10,706 million can be saved through recycling and it can be increased by properly maintaining the 3Rs manners. In Dhaka alone, approximately 0.12 million urban poor are involved in the recycling chain. [3, 4 and 5]

The basic objectives of this article is to get an general idea regarding the waste management system and waste generation, green house gas effects, implementation of 3Rs strategy and its benefits, management of 3Rs and risk assessment. Additionally this paper will unveil the answers some of the questions like how 3Rs can be a significant tool for waste management in Bangladesh by reducing GHG emissions and also expose some guidelines for different organizations concerning how to implement 3Rs to extract maximum benefits from products and to generate minimum amount of waste.

## II. Overview of municipal waste management and 3Rs

Numerous studies discussed about the waste management system of Bangladesh and different models for sustainable waste management and marketing. Municipal solid waste (MSW) generation and its management are being widely debated across the globe at various events, from local forums to international conferences and summits. On a global scale, we currently are facing three major environmental crises: global warming, depletion of resources, and destruction of our ecosystem [6]. These crises are interrelated and connected to waste and waste management.

A rising quality of life and high rates resources consumption patterns have had a unintended and negative impact on the urban environment generation of waste far beyond the handling capacities urban government and agencies [7]. Dhaka city, with almost 15 million inhabitants is experience particularly serious difficulties in dealing with ever increasing waste disposition burden. There are more than 522 towns and cities in Bangladesh which accumulate 13,332 tons of waste per day or 4.86 million tons annually. It is projected that this amount will grow up to 47,000 tons/day and close to 17.2 million tons per year by 2025. The Dhaka City Corporation alone generates approximately 1.6 million tomes of municipal waste per year which emits approximately 1 million tons GHG annually.

Waste generation is closely linked to population, urbanization and affluence. Waste-generation rates can be correlated to gross domestic product (GDP) capita, energy consumption capita, and private final consumption capita [8, 9]. In developed countries seeking to reduce waste generation, a current goal is to decouple waste generation from economic driving forces such as GDP [10] found that total waste generated in the urban areas of Bangladesh per day is 13,332.89 tons. Based on the total estimated urban population of the year 2005, per capita waste generation rate is computed as 0.41 kg /capita/day. Per capita waste generation would obviously depend on a number of socio-economic parameters affecting consumption and other behavioral factors also.

In most developed and developing countries with increasing population, prosperity and urbanization, it remains a major challenge for municipalities to collect, recycle, treat and dispose of increasing quantities of solid waste and wastewater. It is important to emphasize that post-consumer waste is a significant renewable energy resource through thermal processes (incineration and industrial co-combustion), landfill gas utilization and the use of anaerobic digester biogas. Waste has an economic advantage in comparison with many biomass resources because it is regularly collected at public expense. The energy content of waste can be more efficiently exploited using thermal processes than with the production of biogas: during combustion, energy is directly derived both from biomass (paper products, wood, natural textiles, food) and fossil carbon sources (plastics, synthetic textiles). For the many countries that continue to rely on land filling, increased utilization of landfill $CH_4$ can provide a cost-effective mitigation strategy. The combination of gas utilization for energy with bio covers to increase $CH_4$ oxidation can largely mitigate site-specific $CH_4$ emissions [11]. These technologies are simple ('low technology') and can be readily deployed at any site. Moreover, R&D to improve gas-collection efficiency, design biogas engines and turbines with higher efficiency, and develop more cost-effective gas purification technologies are underway. These improvements will be largely incremental but will increase options, decrease costs, and remove existing barriers for expanded applications of these technologies.

Another study found that the composition of the entire waste stream was about 74.4% organic matter, 9.1% paper, 3.5% plastic, 1.9% textile and wood, 0.8% leather and rubber, 1.5% metal, 0.8% glass and 8% other waste in six major cities. [1] The per capita generation of municipal solid waste was ranged from 0.325 to 0.485 kg/cap/day while the average rate was 0.387 kg/cap/day. PREGA made a feasibility study report in Khulna and found major portion of solid waste consists of green vegetables and fruit residues [12].

One of the environmentally harmful consequences of unsanitary waste disposal is the emission of green house gases (methane, carbon dioxide etc.). Since the final disposal of urban solid waste in Bangladesh is yet to be sanitized, it has been coupled with the unutilized high organic content of waste, which contribute to increased GHG emission potential. In six cities of Bangladesh, pourashava and other urban center and found that about 2.19 million ton $CO_2e$ is emitted per year from the total generated urban waste. [10] This high GHG emission potential indicates the necessity of proper waste management and disposal system along with the prospect of trading the reduction of GHG emission with developed countries.

Recently, the importance of recycling activities in reducing waste volume, recovering resources and its economic benefits is being acknowledged. Many NGOs and CBOs are actively working on 3R related issues, often in a decentralized manner failing to fit in the bigger picture due to lack of communication, networking and other factors. As of today, a long-standing practice and a complex networking of informal source separation and recycling of materials exists. In most cases, they were compelled to focus more on reusing and recycling of waste than on source reduction. Prioritizing the 3Rs among themselves may not promise a drastic change within a short period, but will reap a significant reward in the long run. [12]

The 3Rs can be a vital and sustainable option for reducing waste at a minimum level. 3R Initiative" was officially launched at the 3R Ministerial Conference hosted by the Government of Japan in April 2005, with

an aim to promote global action on 3R. In March 2006, a Senior Officials Meeting on 3Rwas organized in Japan resulting in strong commitment of governments and other stakeholders to implement 3R at local, national, and regional level. [13]

For most of the developing countries of Asia, MSW management has become a difficult task. The existing system is to collect and dump to the land fill. For promoting 3Rs in developing countries the participants of 3R South Asia Expert Workshop identified some priority issues which are: a) establishing 3Rs related policies along with environmentally sound recycling industries b) supporting improving informal waste recycling and c) utilizing financial incentives and market forces. The popular and well known concept of "3Rs" refers to reduce, reuse and recycle particularly in the context of production and consumption. [14] It calls for an increase in the ratio of recyclable materials further reusing of raw materials and manufacturing wastes and overall reduction in resources and energy used. The ideas are applied to the entire lifecycles of products and services, this theory can be applicable in the agricultural sector also.

The Global 3Rs initiative aims to promote the 3Rs (reduce, reuse and recycle) globally so as to build a sound material cycle society through effective use of resources and materials. Waste Concern - an NGO working with waste management proposed a decentralized waste collection and composting scheme to manage the MSW in a sustainable manner. But under the present conditions this would not be feasible, as the availability and price of land in and around Dhaka city for composting would not be financially viable [15].

## III. Solid waste management

Solid Waste means any garbage, refuge, sludge, or other discarded material, including solid, liquid, semisolid or contained gaseous material resulting from industrial, commercial mining or agriculture operations of from community activities. One study found that in some countries the solid waste management system also handles human wastes such as night soil ashes from incinerators, septic tank sludge and sludge from sewerage treatment plants. If these wastes manifest hazardous characteristics they should be treated as hazardous wastes. [16] Waste management means collection of resources from different sources including recycling and re-use of materials.

### 3.1 Characteristics of solid waste

In Bangladesh solid waste are mostly generated from residential, industrial and commercial sources. These includes dust, ash, vegetable and animal bones, paper and packing of all kinds, rags and other torn fabrics, garment materials (wastes) glass and many other non-combustible trash. Approximate composition of Solid Waste **(% by weight)** in Bangladesh compared with India and Europe are laid down below:

| Waste Components | Bangladesh | India | Europe |
|---|---|---|---|
| **Food and vegetables** | 70 | 75 | 30 |
| **Paper products** | 4 | 2 | 27 |
| **Plastics** | 5 | 1 | 3 |
| **Rags** | - | 3 | 3 |
| **Metals** | 0.13 | 0.1 | 7 |
| **Glass and Ceramics** | 0.25 | 0.2 | 11 |
| **Wood** | 0.16 | - | - |
| **Garden waste** | 11 | - | 4-5 |
| **Others (Stones, dirt etc)** | 5 | 7 | 3 |
| **Medicine and Chemical** | - | - | - |
| **Moisture content** | 65 | 22-32 | 15-35 |

Table: 01: Composition of solid waste [2]

The composition of solid waste in Bangladesh although vary with the location and season of the year includes organic food waste, paper and paper products, wood, metal, glass, plastics including hospital waste, construction waste, industrial; waste, dust, firewood and others.

### 3.2 Solid waste generation

It is very important to estimate the waste generation in Bangladesh in the planning for proper solid waste management.. The waste stream is more than 80% organic matter and contains a wide variety of substances such as waste, paper, cloth, agricultural waste, etc. In Dhaka city, the waste generation rate is approximately 1.65 million metric tons of solid waste annually per capital waste generation estimates between 0.29 and 0.60 kilograms per person per day depending on the individual level of income (higher income individuals tend to generate more waste).

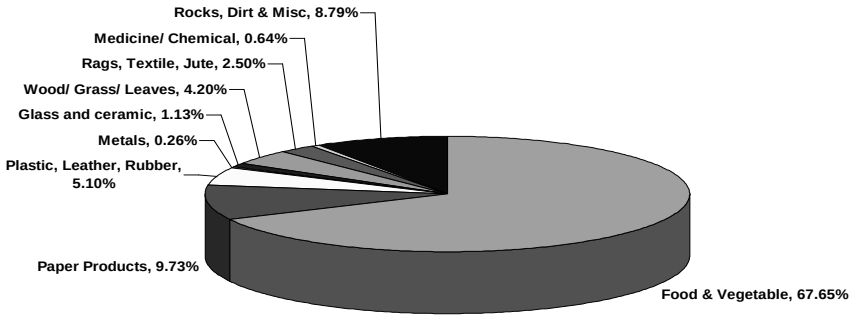


Fig 01: Average Composition of the waste generation in Bangladesh (compiled from different sources)

The above figure-01, shows the average composition of the waste generated in Bangladesh, where 68% is biodegradable waste or food & vegetable waste, 8% is paper, 6.1% plastic, leather and rubber, while 2% is metal and glass waste.

Ultimate disposal of all types of waste is done crudely in open dumps, lowlands or water bodies in an unsanitary manner. As a result, the surroundings of the dumpsites are barely hygienic. The increasing demand for landfill is also a big problem for the authorities to find suitable lands for dumping wastes. At current waste generation rate the total land required for municipal solid waste per year with the existing collection efficiency and 100% collection efficiency will be 141 acres and 273 acres respectively having a depth of 4 meters [5, 19].

Managing MSW cannot be single-handedly managed by the smallest administrative unit of a town or even by the federal government. It has to be a concerted effort of all stakeholders; from waste generator, municipal administrator to community based waste management committee, informal sector involved in waste management and technology providers.

The following table shows the urban areas of Bangladesh:

| City/Town | *WGR(kg/cap/day) | No of City/Town | Population | Average **TWG (ton/day) |
|---|---|---|---|---|
| **Dhaka** | 0.56 | 1 | 6,728,404 | 4,634.52 |
| **Chittagong** | 0.48 | 1 | 2,622,098 | 1,548.09 |
| **Rajshahi** | 0.30 | 1 | 468,378 | 172.83 |
| **Khulna** | 0.27 | 1 | 967,365 | 321.46 |
| **Barisal** | 0.25 | 1 | 437,009 | 134.38 |
| **Sylhet** | 0.30 | 1 | 386,896 | 142.76 |
| **Pouroshovas** | 0.25 | 298 | 15,215,306 | 4,678.40 |
| **Other urban areas** | 0.15 | 218 | 9,217,612 | 1,700.65 |
| **Total** | | **522** | **36,042,067** | **13,332.89** |

Table 02: *WGR= Waste Generation Rate, **TWG= Total Waste Generation

## 3.3 Waste collection in Dhaka city

For administrative purposes, Dhaka is divided into two distinct units – Dhaka North City Corporation (DNCC) and Dhaka South City Corporation (DSCC). These units are responsible for solid waste collection and disposal in their respective areas. In the DNCC, it is estimated that only 40–60% of waste is collected; a 2007 study estimated that approximately 42% of the entire city's (DNCC and DSCC) waste is collected. Uncollected waste is deposited in open spaces, where its accumulation contributes to foul odors, rodents, and clogged storm water and sewer drains. It is often burned deliberately to reduce its volume and by accident, which contributes to a range of health and environmental impacts. Waste collection is particularly insufficient in the slum areas, which are home to approximately half of the city's poor and where government services are minimal. Dhaka is making improvements under its 2005 Solid Waste Master Plan, which led to a new system for regularly collecting household waste from a network of collection bins throughout the city. However, that plan is due to expire in 2015, and it is not certain that a new plan will replace it. Volume and by accident, which contributes to a range of health and environmental impacts.

Most of the cities in Bangladesh, waste collection consists of two parts, namely primary collection and secondary collection. City authorities are responsible for secondary waste collection to remove the waste from the dustbins/containers and transport the waste to final disposal sites. Residents are responsible to bring their waste collection points where dustbins/containers are located. Rickshaw cans are used to collect the waste from each house. For this, residents have to pay specific fees at the end of each month. This covers the salary of the van drivers, waste collectors and maintenance costs.

### 3.4 Waste disposal

Collected waste is first transported on hand trolleys (often by private micro-enterprises) from dense neighborhoods to consolidation locations, where it is loaded onto city owned trucks. Before 2007, these trucks transported the waste to two open dumps outside the city. In 2007, one of the dumps was converted to a controlled landfill (in DSCC), but access is limited by traffic congestion and a large portion of the waste generated in the DSCC is consequently transported to the DNCC.

The DNCC is planning upgrades to its dump, including adding a leach ate management system and a waste to energy facility.

### 3.5 Organic diversion

Only a small portion of Dhaka's organic waste is diverted before being transported to the city's landfills or deposited in open spaces. However, one small-scale, private composting company is currently collecting (for a fee) and processing approximately 100 metric tons of organic waste per day, and selling the compost to local farmers. Dhaka has preliminary plans to develop a larger Integrated Resource Recovery Center at one of the city's landfills to process waste into compost and to generate electricity using landfill gas.

### 3.6 Recycling

Dhaka has historically relied on the informal recycling sector (e.g., waste pickers, of whom there are an estimated 120,000) for the recovery of non-organic materials. In an effort to recover more recyclable materials, the city launched a source separation pilot program in 2012.

## IV. Existing system of waste collection in Dhaka city corporation

In most cities in Bangladesh, waste collection consists of two parts, primary and secondary collection (see Figure 2). City authorities are responsible for secondary waste collection to remove waste from the dustbins/containers, and transport the waste to final disposal sites. Residents are responsible to bring their waste to the waste collection points where dustbins/containers are located. NGOs/CBOs/private sector provide primary collection services to collect waste from door-to-door and transport the waste to dustbins/containers, or sometimes to vacant lands, by rickshaw vans. At present, NGOs/CBOs/private initiative primary collection services are prevalent in most cities. [17]

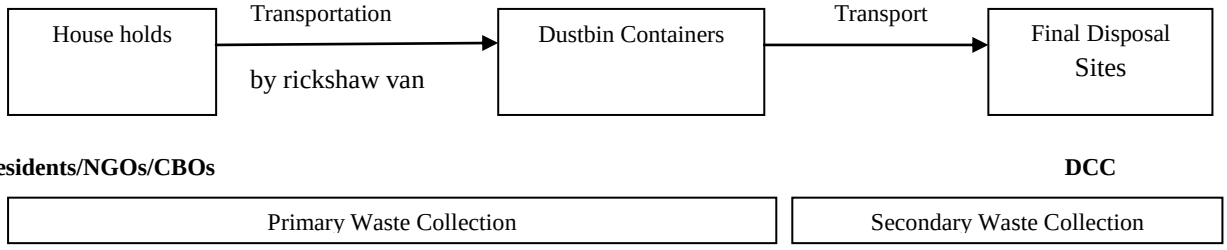


Fig 02: Existing waste collection system in Bangladesh

### 4.1 Problems of existing systems

Solid waste management is growing environmental and financial problem in developing countries. The majority of municipalities in the developing countries cannot manage the growing volume of waste gradually. The inability for waste management is poor institutional structure, lack of sanitation, inadequate financing, lack of manpower, inadequate waste collection, and lack of awareness among citizens, shortage of land for waste disposal. Also the green house gas emission is increasing day by day. Meanwhile, in many cities in developing countries, collection rates remain low and the quality of collection services are poor. Waste collection services are generally non-existent in poorer neighborhoods such as slums. While there are some successful examples where the private sector and communities are involved in waste management services, in many cities of developing countries, involvement of these segments of society is still very limited. The wastes collected typically end up in open dumps, where they may be burnt, and in some cases are deposited in illegal dumping sites.

## V. Methodology and implementation of 3Rs

The implementation of 3Rs can begin from our homes. Internationally recognized waste management hierarchy prescribes that the first priority should be given to waste minimization. Recycling, reusing, recovering, treatment and disposal in these orders may follow the minimization of all kind of waste. The 3Rs are

meant to be a hierarchy, in order of importance. The waste hierarchy has taken many forms over the past decade, but the basic concept has remained the cornerstone of most waste minimization strategies [18, 19 & 20].

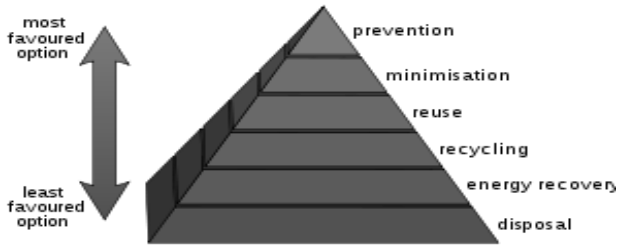


Fig 03: Waste Hierarchy

The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste. The impression of minimizing waste impacts in terms of extent or environmental effects, by reducing quantity of wastes, reusing the waste products with a simple treatments and recycling the wastes by using it as resources to produce products is usually referred to as "3Rs".

Implementation of 3Rs involves a number of steps:

- ***Demarcation of the project area:***

First step is the design of facility management, which will also include Planning and management for field survey, the second will be the identification or demarcation of project area. Using GIS is the modern and best possible method.

- ***Stakeholder Analysis:***

The project will conduct a vigorous stakeholder analysis to identify and assess the importance of key people, groups of people, or institutions that may significantly influence the success of the project to develop strategies, get maximum possible for the project and reduce any obstacles to successful implementation

- ***Stakeholder Consultations:***

Stakeholder consultation is a multi-step process. Initial consultations will need to be formal or informal one-to-one meetings with representatives of individual stakeholder groups and in groups. This is required to introduce stakeholders to the project objectives.

- ***Baseline Survey:***

A baseline study for 3Rs plan will be used to assess achievement of the outcomes and impact expressed in the program's logical framework. When compared with the condition of the same indicators at some point during implementation (mid-term evaluation) and post-operation implementation (final evaluation). The baseline study forms the basis for before and after assessment or a change over time. Below figure-4, is the explanation of how to do the baseline survey and last point the *Impact assessment* explain the exiting waste management practices on natural environment, occupational and public health:

- ***Emission calculation****:* 3Rs approach can reduce the emission from municipal solid waste up to 90%. So we can calculate the emission with and without project scenario. This calculation will also help us to predict whether this 3Rs project is feasible for CDM (Clean Development Mechanism) claim or not.
- ***Impact on occupational and environmental health:*** Inadequate collection and disposal of waste poses a serious health risk to the population. This causes environmental degradation in most cities of the developing countries like Bangladesh. The informal labours, which are working in collection, transportation and processing sectors never use any protective measure and are very vulnerable to infectious diseases.

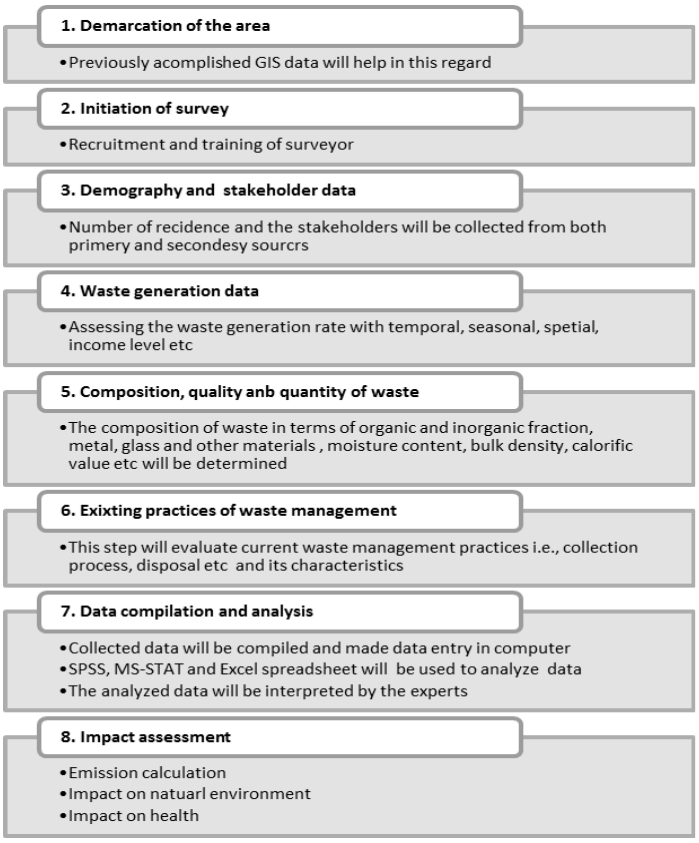


Fig 04: Development of baseline survey

### 5.1 Benefits of 3Rs

The benefits of 3Rs are many for the society and environment:

- Green House Gas (GHG) reduction through energy efficiency and resource efficiency and can reduce the Carbon Dioxide ($CO_2$) emission.
- Techniques adaptation, employment and job creation.
- Production of organic gas from bio-degradable wastes.
- Attracting foreign direct investment through emission reduction credits and pollution reduction and other environmental benefits
- Prevent pollution and enriches soil condition and can provide a healthy environment to the people of the cities
- Would be economically profitable as it will generate reusable power and energy.

### 5.2 Action plan of 3Rs

Under the action plan of 3Rs, the solid waste management (SWM) system will provide a reliable, sustainable waste separation system at source i.e. a house-to-house solid waste collection service. It can ensure that all residual waste is transported and the remaining fraction disposed of in socially responsible manner in a safe environment. It can achieve a recycling efficiency of at least 90 percent. In conjunction with other implementing stakeholders, 3Rs can make progress in initiating and improving the projects areas it approaches.

**The Action Plan of this 3Rs project has four components:**

- **Separation at source**
- **Reduction**
- **Reusing**
- **Recycling**

The action plan will be structured under the principles of efficient, accountable and transparent infrastructure service provision.

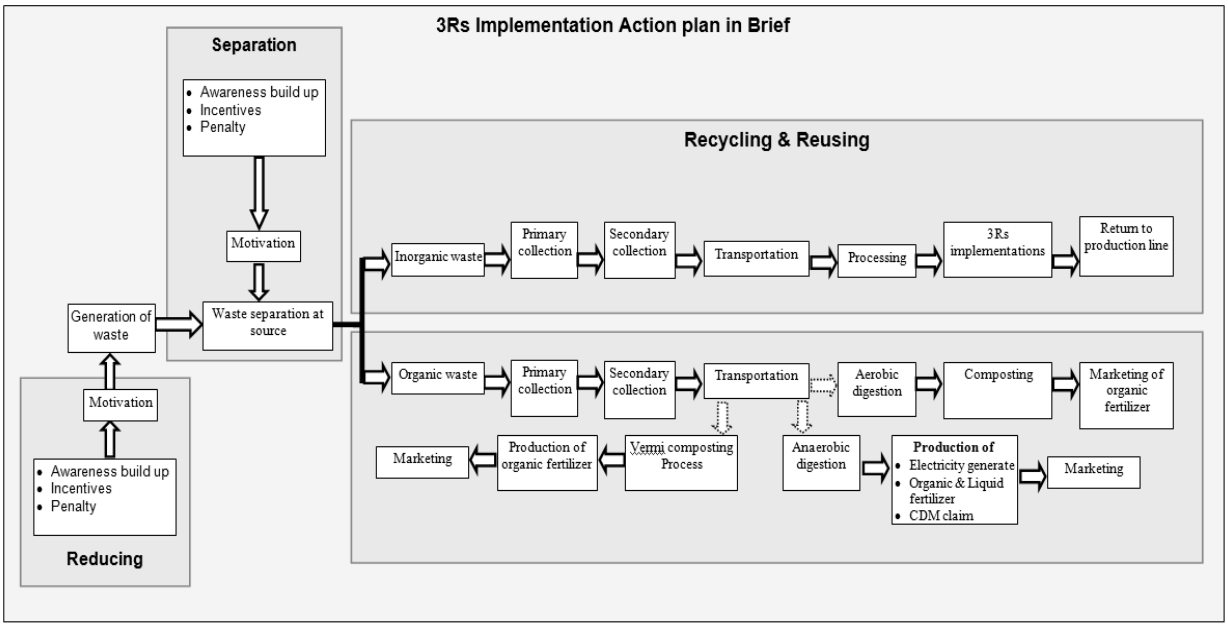


Fig 05: 3Rs Implementation action plan in brief way

### 5.3 Risk assessment and management of 3Rs

3Rs approach for sustainable solid waste management is relatively new to Bangladesh; therefore, obviously there would be some risk with this plan. Risk assessment and risk management are part of the broad landscape of conceptual approaches; action planning and tools that strengthen the sustainable management for this 3Rs project would address the risk factors related to the plan.

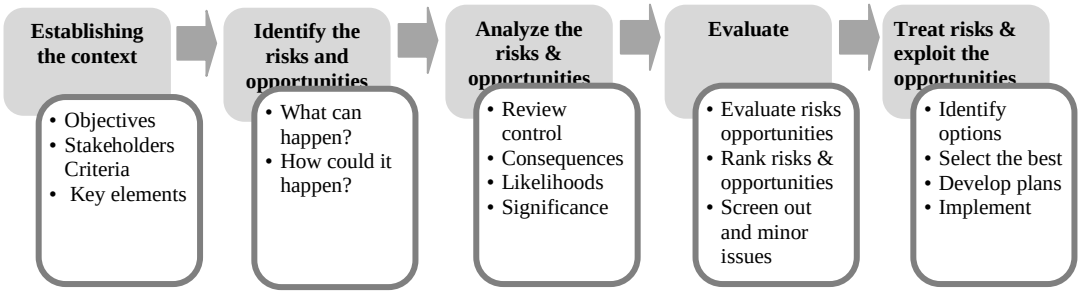


Fig 06: Process of risk management

Predicted risks and their mitigation plan could arise from the following points which need to be mitigated:

a. Non cooperation of the stakeholders (household, waste collector etc)
b. Political disturbance
c. Protection from the waste pickers
d. Non-compliance in source separation
e. Non-compliance in source separation
f. Digesters events
g. Health risk of waste collector

## VI. Conclusion and expected outcome from 3Rs

In a nutshell, waste management must be put in place from micro level of household to macro levels of city, state and nation. Towards sustainable waste management, 3Rs can play a vital role to protect environment from green house gas emission and convert waste into invaluable resources.

❖ *Capacity Building of City Corporation and Community Based Organizations*

With the implementation of the project simultaneously capacity building of city corporations and community bases organizations (CBO) will take place.

❖ *Socioeconomic and environmental benefits of the 3Rs Plan*

The long-term objective is therefore to reduce the environmental degradation caused by solid waste. By using anaerobic methods to manage the biodegradable waste, we are able to:

- Minimize waste that needs to be disposed in centralized landfills, thus extending existing landfill capacity and reduce the environmental impact of disposal sites.
- Benefit the soil by using organic compost instead of chemical fertilizers and ensures sustainability of the project at the local level; Reduced GHG emission and less air, water and soil pollution because of MSW

❖ *Empowerment of Women*

The scheme aims at empowering women, and in particular women from socially and economically disadvantaged groups and living with disabilities, by offering them continuous employment and a guaranteed salary.

❖ *Poverty Alleviation and Improved Occupational Health*

There will also be opportunities for the start-up of micro-enterprises in recycling, e.g. recycling of paper, Cartons and Pet bottles. Good working conditions, continuous training and the adoption of scientific and professional methods of handling waste will minimize health risks and other occupational hazards that are common in informal settings.

❖ *Making the waste into resource by composting*

Waste always has been treated as a burden to the community and the city corporation. But the scenario has changed now; there are various techniques and processes through which the municipal solid waste can be converted into valuable resources. If the waste generation is low then it can be compost or if the biodegradable waste generation is high, then it can generate electricity by using anaerobic digestion depending upon the feasibility. Comparatively the anaerobic digestion (produce electricity, solid and liquid fertilizer, 90- 95% CDM claim) process is more desirable in terms of economic returns.

Thus if implemented successfully this 3Rs scheme will be a win-win situation for all stakeholders.

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