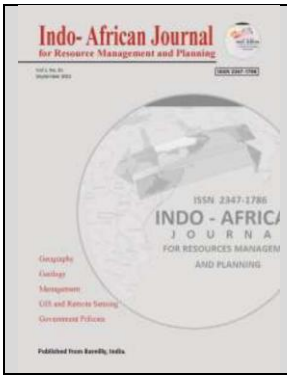

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TRANSFORMING SOLID WASTE OF MEKELLE CITY IN TO GREEN ECONOMY

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Abstract

Solid waste management is very crucial for healthy living and safe environment. However, most developing countries like Ethiopia, the issue of solid waste has given less attention and hence, cities and towns are easily exposed to unmanageable solid waste which ultimately resulted in environmental pollution and health problem. Hence, the overall objective of the study is to describe and analyze solid waste management in Mekelle city. Secondary data were collected from the municipality of Mekelle city. Data were classified and analyzed using thematic review. The review revealed that most solid waste was generated by the house were poorly managed by municipality. The awareness of the people towards managing solid waste was found very weak. In addition, there is a positive link between household's income and waste generation. Though all households have temporary storage in their home, they did not store wastes separately based on its nature. Disposed of solid wastes in unauthorized sites by the households is highly practiced in Ambo. The empirical analyses, using the logistic regression model, shows that, household head sex, household head educational level, household's location (distance of residents from the main road or center), household's willingness to pay, household's awareness on solid waste management and household's access to the private waste collectors' service are the major determinants of effective household solid waste management in the study area. Moreover, the qualitative analyses, using the interview and focus group discussion data, show that manpower, budget, and facilities such as container, adequate vehicles, waste gown, and gloves are the other major determining factors of effective solid waste management at household level in Ambo.

1. Introduction

Rapid population growth, fast urban expansion, economic growth and changes in the life style of the people are significantly shifting the patterns of production and consumption in cities and towns. As a result, managing solid waste is indispensable to prevent the ecology, human health and aesthetic value of the cities and towns. Municipal solid waste management has gone through a history of shifting problems, demands and strategies over the years. Therefore, this term paper attempts to discuss on transforming solid waste to green economy through applying DPSIR framework in Mekelle city. First, the paper describes the background of the Mekelle city. Second, it reviews the meanings and concepts of solid waste management. Third, the paper discusses on how to transform solid waste to green economy using DPSIR frame work. Finally, it will explain the strategies and action plan to transform solid waste to green economy in Mekelle city.

2. Review of Related Literature on Solid Waste.

2.1.Definitions and concepts of solid waste.

Waste is often found in liquid or solid form. Solid waste is any type of wastes which may include used plastic bags, broken bags, leftover food or foods remains and the likes. It is a by-product of human activities that tends to increase with the rate of urbanization, changing patterns of consumption and the improvement of living standards.[1] Solid waste is also defined as material which no longer has any value to its original owner and discarded as useless. These include organic waste, paper, glass, metals, plastics, ash, street sweepings and so on.[2]

2.2.Solid waste management

Solid waste management is a process that seeks to minimize the impacts of solid waste on health, environmental and aesthetics values of the people. Increasing the amount of solid waste has become a major challenge for the growing towns and cities, like Mekelle city. Hence, solid waste management is necessary to tackle the challenges emanated from solid waste. Municipal solid

[1] *ENPHO (2007) Solid waste management in Nepal. 110/25 Adarsa Marga-1, Thapagaon, New Baneshwor GPO Box: 4102, Kathmandu, Nepal. Available at www.enpho.org. (Accessed date: 25 January 2011).*

[2] *Rouse, J. (2008). Planning for sustainable municipal solid waste management: Practical Action; the Schumacher Centre for Technology and Development Bourton-on-Dunsmore Rugby, Warwickshire, CV23 9QZ. United Kingdom. http://www.practicalaction.org. (Accessed date: 23 January 2011)*

waste management involves the generation, storage, collection, transfer and transport, processing, treatment and disposal of solid waste with the best environmental and social considerations.[3]

2.3.Sources and types of solid waste

Table.1. Source and type of solid waste

Source	Typical waste generators	Types of waste
Household	Single and multifamily Dwellings	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g. bulky items, consumer electronics, white goods, batteries, oil, tires), and household hazardous wastes
Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants	Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes
Commercial	Stores, hotels, restaurants, markets, office buildings, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
Institutional	Schools, hospitals, prisons, government centers	Same as commercial
Construction and demolition	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt, etc.
Municipal Services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants	Street sweepings, landscape and tree trimmings, general wastes from parks, beaches, and other recreational area, sludge

Source: Adopted from CED, 2013.

2.4. Approaches of solid waste to solid waste management

Conventional approach: In this approach, the waste generator households are responsible to transport solid wastes to the nearest dustbin or container which is provided by the city municipality and then the municipality is responsible to collected waste from the containers and transports it to its final disposal sites.[4]

[3] *ENPHO, 2008: pp.1.*

[4] *Rahman, M. Bahar, M. Uddin, N. Islam, A. and Harun, A.Y. (2005) People's Perception of the Existing Solid Waste Management of Khulna City Corporation (KCC) Area: A Case Study of Participatory Management. A paper presented in: National Workshop for REGA and CDM Awareness Building & Motivation under the ADB PREGA Project in the Western Inn. Ltd., Khulna Bangladesh on 03-04 July, 2005, organized by Bangladesh Centre for Advanced Studies*

Participation based approach*:* In this approach, the households are responsible to store their waste in plastic bags or other available materials by sorting in terms of their nature and hand over to the door to door collectors and they are accountable to appropriately collecting solid wastes from the households and dispose in secondary collection, then to the final disposal sites.[5]

2.5.Challenges of solid waste management

The production of waste is inevitable so long as human activities exist. Hence, regular waste collection and disposal services are necessary to secure clean, reliable and healthy living conditions in cities and towns. Moreover, the dramatic increase in the quantities and compositions of solid wastes coupled with the rapid urbanization and population growth need an effective and efficient solid waste management system.[6] However, due to the rapidly expanding of cities and towns, the activities of collection and disposal of solid waste are increasingly beyond the financial and administrative capacity of cities and towns. Generally, the challenges of solid waste management include: inadequate service coverage, operational inefficiencies of services, limited utilization of recycling activities inadequate management of non-industrial hazardous waste, inadequate landfill disposal and so on.[7]

3. Transforming Solid Waste in to Green Economy in Mekelle city

3.1. Background of the city

Mekelle city is one of the largest cities of the Federal Democratic Republic of Ethiopian. It is located at the northern part of the country. Mekelle city is the capital of Tigray National Regional State. According to 2014 report of the municipality, the total area of Mekelle city is about 19,200 hectare. Astronomically, the city is located at 13^0 32' N latitude and 39^0 33' E longitudes. It is about 780 km north of Addis Ababa, the capital city of Ethiopia. The city is situated at East-West bottom from the Endayeus to Messebo uplands.[8] The average elevation of Mekelle is 2200 meter above sea level and has a Woinadega type of climate. The mean annual temperature of the city is 24.4^0c.

[5] *Ibid.pp.72.*

[6] *Solomon, A. (2006) Solid Waste Management: A Case Study of Household Solid Waste Management in Arada Sub-City, Addis Ababa. A Master"s Thesis presented to the school of graduate studies of Addis Ababa University. Addis Ababa, Ethiopia.*

[7] *Ali, S. M. (2001) Assessment of Solid Waste Management Practices of Households: A Case Study of Two Selected Coastal Barangays of Catanauan Municipality, Quezon Province, Philippines. Available at: www.upd.edu.ph/~surp/about_surp/2001-ali.pdf. (Accessed date: 15 December 2010)*

[8] *Wikpidia free encyclopodia*

The mean annual rainfall is 579 mm where the highest occurs in August and the lowest in December.[9]

Historically, the city of Mekelle was founded by Emperor Yohannes IV in 1873 when the Emperor shifted his capital from Adwa to Mekelle. As the Emperor died at the battle of Mettema in 1889, the capital was moved to Addis Ababa and since then Mekelle has remained the capital of the Tigray Region.[10] Some studies revealed that since its establishment as a capital, Mekelle city has been showing tremendous changes in terms of political, socio-economy and rapid Population growth. Administratively, the city has been Special Zone consists of two Woredas: Northern and Southern. Theses woredas have been further subdivided into 19 kebelles. Moreover, recently, the city has incorporated two small towns, namely, Quiha and Aynalem.[11]

According to the Central Statistical Authority (CSA) in 2007, the city has a total population of 215,914, of whom 104,925 are men and 110,989 women. The population has increased on the average by 3.62% annually. Tigrigna is widely spoken language by 95.55%, and Amharic by 3.18%; the remaining 1.27% is spoken by others. About 92.68% of the population was Orthodox Christians, 6.03% was Muslim and 1.29% was other religious believers.[12] Population growth and rate of urbanization is very high which is similar to other cities of the country. In 2010, the number of households was about 44,906 with average family size of household was 3.8.[13] The population distribution varies from kebelle to kebelle. Hence, kebelle *Adi-Haki* has highest number of residents that accounts for about 9.9 % of the city's population whereas kebelle *Hayet* has the lowest number of residents that is only about 2.2 %.[14]

[9] *NUPI (1993). Mekelle Development Plan. Final Report (Executive Summery). Addis Ababa.*
[10] *Gebretsadikan Gberekidan(2002). Solid Waste Manament in Meklle City.*
[11] *Mekelle municipality administration.2014.*
[12] *Census 2007 Tables: Tigray Region,*
[13] *Health Office, Polio-Eradication Campaign. 2010.*
[14] *G/ TSADKAN, G. (2002) Domestic Solid Waste Management in Mekelle City: Tigray Region. A Master"s Thesis presented to the school of graduate studies of Addis Ababa University. Addis Ababa, Ethiopia.*

Map of Mekelle city

3.2. Defining green cities and green economy

Green cities are defined as those that are environmentally friendly. Indicators measuring environmental performance can include: levels of pollution and carbon emission, energy and water consumption, water quality, waste volumes and recycling rates, green-space ratios, and the like. [15] According to United Nations General Assembly (UNGA), green economy has defined as a concept that focuses on the intersection between environment and economy and on the opportunities to advance economic and environmental goals simultaneously.[16] Less than 2% of the earth's surface is occupied by urban areas, but these areas accommodate more than half the world population and accounts for 70% of the GDP. The green economy requires cities to play a leading role in shaping urban areas to be more prosperous, equitable and greener. For instance, energy efficient buildings, renewable energy, efficient distribution of clean water and proper disposal of solid waste, green transport schemes, and clean air zones.[17] However, this paper is going to discuss on transforming solid waste in to green economy in Mekelle city.

3.3. Integrated environmental assessment using DPSIR framework.

3.3.1. What is DPSIR framework?

DPSIR framework is seen as giving a structure within which to present the indicators needed to enable feedback to policy makers on environmental quality and the resulting impact of the political choices made, or to be made in the future. The application of the DPSIR framework involves a great deal of information gathering to formulate indicators that can reflect the causal relationships

[15] *The greening of cities requires some, or preferably all, of the following: (1) controlling diseases and their health burden; (2) reducing chemical and Physical hazards; (3) developing high quality urban environments for all; (4) minimising transfers of environmental costs to areas outside the city; and (5) ensuring progress towards sustainable consumption (Satterthwaite 1997). This chapter cuts across all five areas, but the issue of cities in relation to climate change – given its primacy in international environmental policy – is given added weight.*

[16] *UN General Assembly, 2010.*

[17] *Uinted Nations Framework Convention for Climate Change(UNFCCC).1992*

between human activities, environmental consequences and responses to environmental changes. In DPSIR framework, there is a chain of causal links starting with driving forces through pressures to states and impacts on ecosystems, human health and eventually leading to political responses. Describing the causal chain from driving forces to impacts and responses is a complex task, and tends to be broken down into sub-tasks.[18]

Table2. DPSIR framework diagram

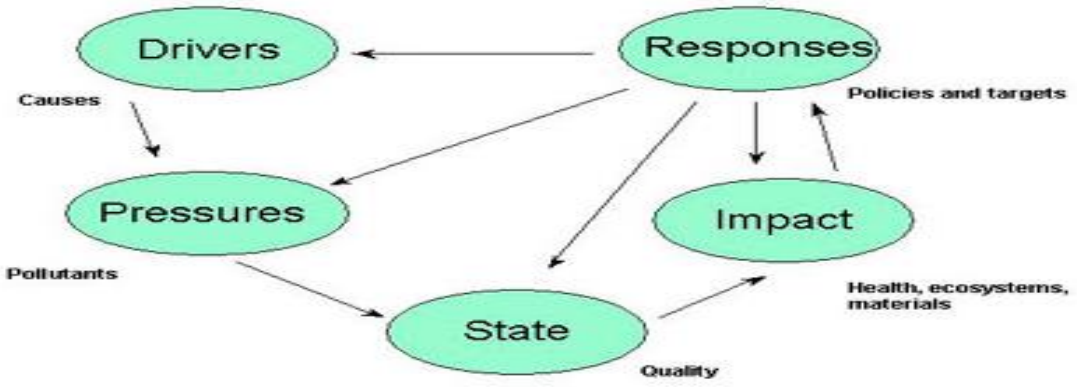


Figure 1. The DPSIR assessment framework

Source: Taken from Peter Kristensen (2004)

The Millennium Ecosystem Assessment (MEA) determined that both anthropogenic and natural factors can be drivers that directly or indirectly cause a change in an ecosystem. It employed the DPSIR framework to illustrate the cyclic consequences among human impact, ecosystem degradation, ecosystem service change, human wellbeing and responses to changes.[19] Similarly, in this term paper, DPSIR framework is applied how to assess solid waste and transform to green economy in Mekelle city. The major components of the DPSIR framework are defined in the following.

- ***Driving Forces: -****A driving force is simply defined as a need. Driving forces help decision-makers to design a plan action to avoid the present and future pressures. For instance, for a given business enterprise, the driving force could be the need to be profitable and to produce at low costs.*[20]

[18] *Peter Kristensen(2004):The DPSIR Framework.*

[19] *Millennium Ecosystem Assessment (MEA), 2003. Millennium Ecosystem Assessment: ecosystems and human well-being- a framework for assessment. World Resources Institute, <http://www.millenniumassessment.org/en/index.html.>(reffered02.07.20 10)*

[20] *Peter Kristensen(2004):The DPSIR Framework.pp2.*

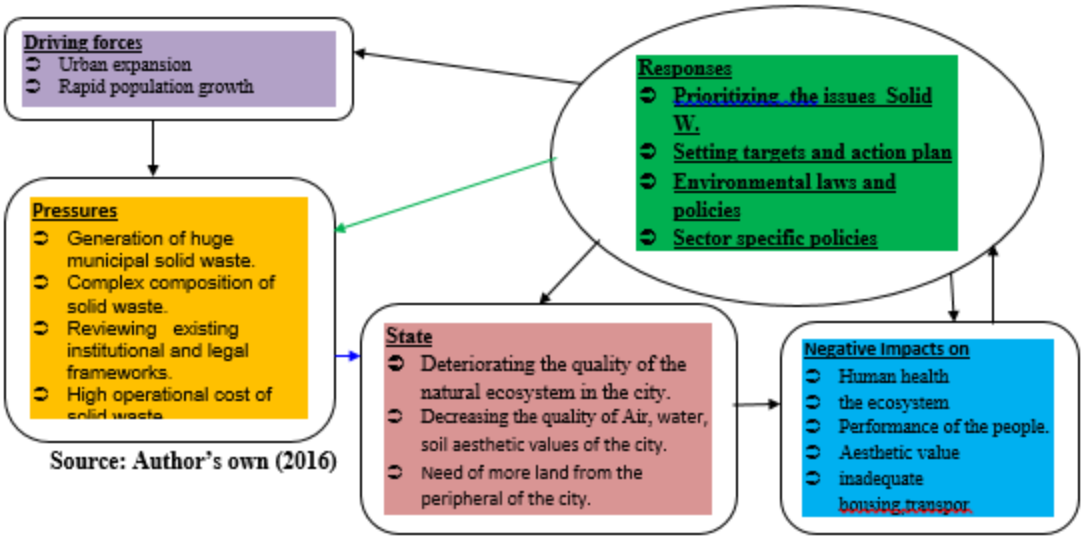
- ***Pressures: -*** *Are induced by driving forces in which human beings are trying to fulfill their needs through exerting pressures on the environment. These may include excessive use of environmental resources.*[21]
- ***State: -****Is a described as the changes in the quality of the natural system due to the existence of pressure. As a result of the pressures, the state or the quality of various environmental compartments such as air, water, soil, etc can be affected to great extent.*
- ***Impacts: -****The changes in the physical, chemical or biological state of the environment determine the quality of ecosystems and the welfare of human beings. In other words, changes in the state may have an impact on the functioning of the ecosystems, their life supporting abilities, human health, economic and social performance of society.*
- ***Responses: -*** *A response by society or policy makers is the result of an undesired impact and can affect any part of the chain between driving forces and impacts. It is a voluntary or enforced action to mitigate impact through adjusting or removing the driving forces, pressure, state and impact. Response includes a variety of concrete procedures in policy, strategy and practice such as emission regulation, environmental tax, technology development, resident relocation, investment, insurance, compensation and so on.*[22]

Therefore, in using integrated environmental management, DPSIR framework is preferable to assess the cause-and-effect relationship and finally come up with policy responses to resolve the problems. As a result, this sub-topic discusses on transforming solid waste to green economy using DPSIR framework in Mekelle city through identifying the major driving forces (urban expansion, population growth and operation costs of solid waste), pressures (generation of municipal solid waste), state (declining the quality of air, soil, water), impacts (human health, plants and animals) and response-treatment technology and involvement of management agencies in the municipal solid waste management.

[21] European Environment Agency EEA:http://www.eea.eu.int/

[22] *European Environmental Agency (EEA), 1999. Environmental indicators: typology and overview. European Environmental Agency, Copenhagen, pp. 1-25.*

Diagram1. Municipal solid waste management using DPSIR framework.



Source: Author's own (2016)

3.4. Greening Solid Waste in Mekelle city using DPSIR Framework

3.4.1. The major drivers of solid waste in Mekelle city

The EEA[23] describes driving forces as *"the social, demographic and economic developments in societies and the corresponding changes in lifestyles, overall levels of consumption and production patterns"*. The intensive industrialization, especially during the early stage of development in the urban areas is the common driving forces that exert pressure on the environment, which cause changes in the municipal solid waste management. Growth in the population size and density, economy has increased the generation of municipal solid waste. The major drivers of solid waste in Mekelle city include the following.

Driver 1: High rate of urban expansion in Mekelle city

By the year 2007, 50% of the global population lived in urban areas but it is now predicted to reach 69 % by 2050.[24] Globally, more than 50% of urban population occupies 2% of the earth's surface, 80% of GDP, 60 -80% of energy consumption, and about 75 % of CO_2 emissions.[25] Environmental threats such as ecological degradation, lack of fresh water; poor sewage systems and poor health services, etc. are some of the challenges of the growing cities and towns of developing countries. As cities and towns are expanded, the patterns of consumption and production become complex

[23] *EEA, 1999.pp.1-25.*

24 UN Population Division (2010). World urbanisation prospects: The 2009 revision. UN, Department of Economic and Social Affairs, New York.

[25] *Kamal-Chaoui, L. and Robert, A. (2009). Competitive cities and climate change. OECD Regional Development Working Papers 2009/2. OECD, Public Governance and Territorial Development Directorate.*

and this further resulted in high rate of solid waste generation through time and hence, environmental impacts become inevitable.[26]

Mekelle city has shown very fast urban expansion process, particularly, in the last two decades. The city is expanding to all directions, i.e., to South, South West, South East, West, East and North directions of the city. However, the rate of expansion may vary from place to place. The annual rate of urban expansion of Mekelle city is 5-8 % and such expansion process has been triggered by rapid population growth.[27] Therefore, the amount of solid waste in the city is increasing tremendously due to urban expansion, population growth, and the changes in the life styles of the people. Hence, urban expansion has created increasing volume and complexity of solid waste in Mekelle city and this situation further poses a serious risk to the ecosystems of the city and public health problems unless controlled properly.

Driver 2: Rapid population growth in Mekelle city

Population is vital source of development, yet it is a major source of environmental degradation when it exceeds the threshold limits of the support systems. Population may have negative impact on excessive use of natural resources and production of waste which could finally result in environmental stresses like loss of biodiversity, air and water pollution and increased pressure on other resources.[28] In 1994, the total number of population was 96,938 and according to population census in 2007, this figure was increased to 215,914 and in 2012, it was estimated 270,000 with the average growth rate of 4.376 % especially since 1994.[29] Therefore, rapid population growth definitely increases the complexity and the amount of solid waste in Mekelle city. In 994, the total annual solid waste generated in the city was 42,244m^3. Out of this figure, 27458.60 (65%) of the total solid waste was collected and disposed. However, due to population growth, currently, in 2014/15, the amount of solid waste generation has been increased to 103,674.8m^3. Out of this amount 90,125(85%) of the total solid waste. Therefore, any can observe that in the last 20 years, the total amount of solid waste generation increases from 42.244m3 to 103674.8m^3.

[26] *UN Population Division (2006). World Urbanisation Prospects: The 2005 Revision. Executive Summary, Fact Sheets, Data Tables. UN, Department of Economic and Social Affairs, New York.*

[27] *Mekelle City Administration report in 2014.*

[28] *United Nations Population Division, 2008. World Population Prospects: The 2008 Revision Population Database.*

[29] *Ethiopian CSA, 1994 and 2007.*

TABLE 2. Total solid waste collected and disposed

Year	Total solid waste Collected and disposed				
	Household	Construction and demolished	Service rendering institutions	Street sweeping	Total
2014/15	65%	15%	11%	9%	100%
	Composition of the solid waste				
	Organic	Recyclable	Inorganic substance	Other types	
	45%	27%	18%	10%	100%
	Total amount of solid waste disposed in the given year in m^3				
	Semen woreda	Debub woreda	Quiha	Aynalem	
	36,750 m^3	29,225m^3	18,045 m^3	6,132 m^3	90,125 m^3

Source: Mekelle Municipality report, 2014/15.

According to the table depicted above, 65% of the solid waste in 2013/14 was gathered from households, 15% of it was collected from industries (small, medium and large),11% from service rendering institutions such as hotels, restaurants, recreational, area, market areas and the like, and 9% of the waste was collected from street sweeping. With regard to physical composition of the solid waste in the city, 45% of the solid waste organic, 17% of it was recyclable and 28 % of the waste was inorganic and other types solid waste.[30] The total solid waste collected and disposed in the year 2014/15 was 90,125 m^3. The municipality planned to collect 103,674.8 m^3 and according to municipality report, 85% its plan was accomplished.

3.4.2. The pressures of solid waste in Mekelle City.

In most cases, pressures are described as undesirable ecological changes which deteriorate the quality of the natural environment. Pressures resulted in excessive use of resources, increasing the quantity and complexity of solid and increasing emissions of the pollutants to air, water and soil.[31] Moreover, rising incomes and purchasing power people and per capita consumption has also been doubled and tripled considerably. As the city has been expanded, the compositions of the solid

[30] *Official report of Mekelle city municipal report in 2014.*

[31] *European Environmental Agency (EEA), 1999.*

waste become more complex .The driving forces created several pressures in the city such as dumping of solid waste on open areas of the city. Dumping in open places is an illegal except in the permitted landfill since it poses a threat to human health and the environment. However, in Mekelle city, there are activities duping solid waste on unauthorized places such as roadways and on vacant land especially during the night time.[32]

3.4.3. The state in Mekelle City.

State is the quantity and quality of physical, biological and chemical phenomena which are found in a natural environment. As a result of the pressure, state of the environment can be degraded and affected to a great extent. Currently, most of the municipal solid waste is dumped in poorly regulated landfills sites. Solid waste can also be a source of environmental pollution through the process of leaching.[33]

3.4.4. Impacts of solid waste in the city

Impacts in this context are adverse effects of the growing solid waste which can be resulted from deteriorating the quantity and quality the environment. There are several adverse effects on human health and natural environment. The impact of poor solid waste management on human health can be seen in different ways. These can be emanated from poor solid waste management due to various reasons such as poor financial, institutions and backward technology.

Impacts of solid waste on human health: The concerns of public health are related primarily to the infestation of areas used for the storage of solid wastes whereby insects that often serve as potential reservoirs of disease. The practice of throwing wastes into unpaved streets, road ways and vacant land led to the breeding of rats, with their attendant fleas carrying the germs of disease that result in disease outbreak. For instance, children who are living in households where garbage is dumped or burned are suffering from sickness infection, high diarrhea rates, acute respiratory infections and the like. Besides, uncollected solid waste causes flooding and subsequent spread of water-borne diseases.

[32] *Official report of Mekelle city municipal report in 2014.*

[33] *In the city, there is a river which passes through the city and people dump solid waste to the rivers. As water percolates through municipal solid waste, it makes a leachate substances that consists of decomposing organic matter combined with inorganic matters.*

Impacts on the aesthetic values of the city: Aesthetic considerations are related to the production of bad odors and the unattractive conditions that can develop when adequate attention is not given to the maintenance of sanitary conditions.

Impacts on the ecological conditions of the city: Ecological impacts, such as water and air pollutions, also have been attributed to improper management of solid wastes. For instance, leachate from dumps and poorly engineered landfills contaminate surface waters and ground waters as it may contain toxic elements.

Generally, the major impacts of solid waste in Mekelle city include: (i) blockage of the drainage system that usually causes flooding on streets during the rainy seasons,(ii) dumping solid waste on open places, streets and market places causing bad odor, unattractive and boring, (iii) dangerous substances which are risky especially for children and people who are engaged in searching in solid waste, (vii) sometimes incineration of solid waste is taken place on disposal sites and this can cause major air pollution since toxic substance in the form of smoke is emitted to the atmosphere and this situation makes the disposal sites dangerous. [34]

3.4.5. Responses/measures to be taken by the municipality of Mekelle the city

Indeed, responses or measures to address the problem are not only emanated from the government; instead, responses are also expected from groups, individuals, NGOs and other actors or environmental activists. Particularly, governments attempt to prevent, compensate, adapt to changes in the state of the environment. The municipality of Mekelle city has taken various response or measures to correct the challenges of solid waste in the city. These include: involving different government agencies, local and national NGO, and Micro and Small Enterprises (MSE) which are involving in managing solid waste of the city. Among the local and national private enterprises which are currently involving in managing the solid waste of the city include BGI Ethiopia, Abenet promotion, Yohannes Greenery and so on. Small and Micro Enterprises are also effectively engaging in door to door collecting of solid waste twice per week. Other types of responses that can be considered in alleviating the impact of solid waste include: the purification

[34] *Challenges of solid waste management in Mekelle city. A paper presented in annual discussion on solid waste management in municipality of Mekelle city. June 24, 2015.*

of polluted water, changing disposal rules and treatment method, and controlling urban population are some of the responses to the driving force.

3.4.5.1.Appling various solid waste disposal technologies

Generation and disposal of solid waste is an inevitable phenomenon in cities and towns due to urban expansion and rapid population growth. Hence, seeking appropriate treatment technology for different solid waste compositions is important. Accordingly, there are various disposal methods have been adopted to manage solid waste.

Composting: is the process of decomposition and stabilization of organic matter under controlled condition. Composting is the most preferred method of municipal solid waste, mainly due to the high percentage of organic material in the waste composition. However, it also produces methane gas which is a useful source of bio-energy but if properly used.[35] In Mekelle city, compost should be used to improve the physical, chemical and biological properties of cultivation soil. Hence, the municipal management has to introduce the composting method controlling solid waste in the city.

Landfill: is another preferable method for the final disposal of municipal solid waste in many cities. As per the information obtained from the municipality, Mekelle city has only one landfill site and four temporary transferable solid wastes. Hence, municipal management should increase the number of the landfill and temporary transferable dustbin depending on the pressure of the solid waste of the city.

Incineration: is one of the waste treatment methods that involve the burning of organic materials and other substances. It is a process of converting the waste into bottom ash. However, it must be done carefully since this process can cause pollution and has impact on the local people.

3.4.5.2. Integrated strategies for greening Mekelle city.

The municipality of Mekelle city has designed six integrated strategies towards realizing a healthy, prosperous, resilient and green city. Like other cities in the world, Mekelle city faces challenges that call for decisive actions and every resident and business enterprise will play a crucial role in supporting the integrated strategies for greening the city. Driving forces such as urban expansion, growing population, climate uncertainty, growing the amount and complexity of solid waste and

[35] *Renbi, B. and Sutanto, M., 2002. The practice and challenges of solid waste management in Singapore. Waste Management.*

shifting economic opportunities of the people are just some of the driving forces that need hard working to transfer solid waste to green economy in Mekelle city. However, this paper focuses on the first two driving forces (urban expansion, growing population) which demand integrated strategies for addressing the drivers.

Fortunately, there are many ways of managing solid waste, climate change and other environmental challenges through creating green jobs, strengthening local community and improving the well-being of the residents. Greening the solid waste in particular and natural ecosystem in general has been given attention in the national and international levels. Accordingly, the municipality of Mekelle city has designed the following integrated strategies how to make the city green in 2016-2020.

Strategy I: Creating awareness on solid waste in Mekelle city.

Solid waste has become so common phenomenon and it is inevitable in the life of humans and hence, it must be critically managed. In 2016-2020, the following are the top priority strategies of the city to manage solid waste: (i) developing education and enforcement programs to sort the recyclables from non-recyclable, (ii) creating awareness through mass media on the culture handling solid waste. This strategy aims at changing attitude of residents and actions to promote such awareness include developing education programs, enforcing disposal bans at the household and business level; supporting community assets and infrastructure like recycling, drop-off locations, and composters.

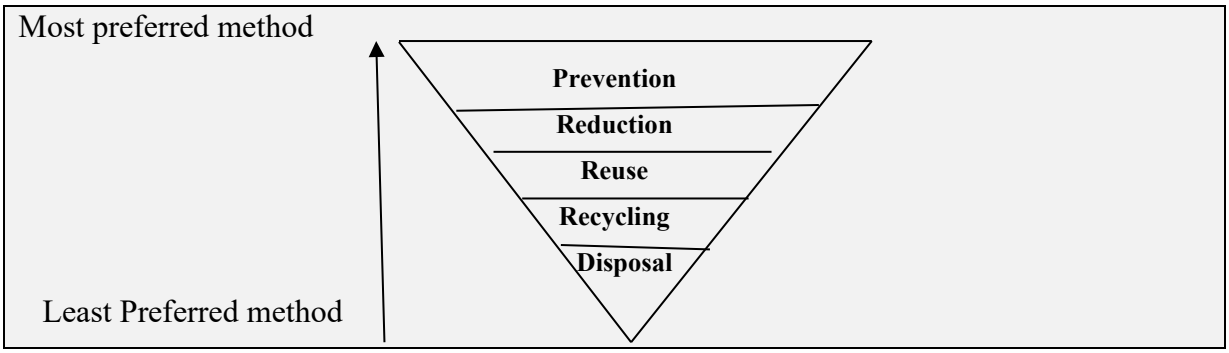
Strategy II: Employing 3rs (reduce-reuse-recycle)

Above all, prevention of can be considered as the most preferable method managing solid waste whereas disposal is the least preferred one. The concepts of 3Rs are described as waste reduction, reusing and recycling in the context of production and consumption life cycle. Reducing refers to minimizing the amount of waste by increasing the efficiency of resources. Reusing implies using recyclable resources from used items again. Recycling indicates using recyclable resources as raw materials to make new products. There must be a policy that promotes recycling or resource conservation, and the municipalities should have the expertise to launch the recycling activities. Recycling technology has its own procedures: High level of separating the solid waste even using

the identifying device, refinery to extract valuable materials from waste, composting of biodegradable waste, methane recovery that catches and utilizes biogas generated from landfills, thermal and energy recovery.

Therefore, from 2016-2020, the municipality of Mekelle city set a strategy to employ Prevention, reduction, reuse, recycling and disposal methods. Accordingly, in coming 5 years prevention solid waste will account 10%, reduction 15%, reusing 5%, recycling 20% and disposal will account 50% of the total amount solid waste of the city.

Figure1. Prevention, Reduction, Reuse, Recycling and Disposal



Source: The author's creation, Jan, 2016.

Strategy III: Green job creations in Mekelle city

Green jobs are described as those that contribute substantially to preserving or restoring environmental quality, minimizing/avoiding of generating of all forms of waste and pollutions. Some of the green jobs which can create green job opportunity include: waste reduction, recycling facility operators, solid waste technicians, waste collectors, compost collectors and so on. Moreover, the number of national, regional and local organizations should be increased and actively engaged in greening Mekelle city through developing programs to support green jobs, establishing green enterprises, delivering business engagement programs and so on.

Until the end of 2015, there total number of Micro and Small Enterprises(MSE) which have been engaged green jobs in city were 85 and the total members of the MSE was 1257. However, by the 2020, the number of green jobs will be doubled. This number could contribute for achieving the standards of green cities and Mekelle city will be competent city nationally and internationally.

Strategy IV: Reducing GHG emissions

The municipality of Mekelle city has incorporated strategies for protecting the ecology of the city, greening the city to enjoy clean air, green space, healthy citizens, and create new job opportunities. It is true that most cities usually produce greenhouse gases (GHGs) from different sources. Particularly, landfills are common disposal sites in many cities and they are major sources of methane and carbon dioxide. Hence, landfill sites should be properly managed and incorporated in the strategy of the city to reduce GHG emission. In this case, production of methane should be controlled using certain technology and converted to heat or electricity. Therefore, the city has planned intensify renewable energy sources such as electric power, solar energy, biogas technology, wind energy (especially, the Mekelle city can use energy from Ashogoda wind energy 25km way from the city). Hence, by 2020, it will reduce GHGs and other pollutants by half of the level of 2015.

Strategy V: Constructing green buildings

Urban expansion is characterized by intensive construction of buildings. However, the construction of building should be designed in a way to reduce greenhouse gas emissions, especially, the mirrors used for windows and doors are contributing for emission of GHGs. Nowadays, buildings are parts and parcels of human beings in the contemporary world and many activities are taken place. Therefore, building should be designed to reduce greenhouse gas emissions. Financing tools and incentives to green the existing buildings provide ways to address concerns of affordability and fairness, and increase the pace of change towards green developments. Capacity building is also necessary factor to bring together different groups and build partnerships that ensure there are enough skilled workers to meet the needs of a rapidly growing green building sector. There are some guiding principles how to construct green building. Modifying the existing laws and regulations to make the buildings which are energy efficient and reduce greenhouse gas emissions in both new and existing buildings. Moreover, developing and promoting financing sources that enable energy efficiency and greenhouse gas reductions buildings. Therefore, the municipality has planned to control the overall construction of buildings to follow the criteria of green building and this could contribute to effort of greening the city. Hence, from 2016-2020, every building must be constructed in accordance the criteria of green building.

Strategy VI: Developing green transportation

Green transportation is a transit which includes pediatrician walking, vehicles and others. Green transportation can be achieved where there should be fast, frequent, reliable, accessible, and comfortable transit. Encouraging green transportation makes sense for many reasons such as healthy, resilient, affordable, community, economy and environment. In the year 2016–2020, Mekelle city has set the top priority actions: the city has prepared transportation master plan and updated the old one with direction from the strategies in greening the city, it has developed, improved and incorporated pedestrian safety in the greening strategy, and the city will also work with trans-link and the regions for fast, frequent and reliable transit.

3.4.6. Conclusion

This term paper has applied DPSIR framework to analyze the challenge of solid waste and designed various strategies how to make the Mekelle city green and comfortable. Based on the analysis, the driving forces for solid waste in the city are many. However, the author focused on two major drivers, namely, urban expansion and rapid urbanization which caused to increase the solid waste generation in the city. According to the analysis, Solid waste is still collected without sorting, poor quality of treatment facilities and still solid waste is dumped on open areas. The future trends of rapid population growth and urban expansion will cause high rate of solid waste generation and needs area for landfill in addition to the existing one. The analysis has shown that solid waste disposal needs immediate attention and strict monitoring. As per the assessment, urban expansion and rapid population growth are the key driving forces contributing to the increasing amount of municipal solid waste generation. The linkage between driving force, pressure, state, impacts as well as possible responses to the factors in the DPSIR framework were investigated. Finally, six major strategies are described to green and improve solid waste in Mekelle city. Note that, greening solid waste can viable when other factors which I mentioned in the strategies are very crucial. That is, greening a city requires not only managing the solid waste but also fulfilling other component which can realize the greenest city.

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