R4D PROJECT:

CHALLENGES OF MUNICIPAL WASTE MANAGEMENT: LEARNING FROM POST-CRISIS INITIATIVES IN SOUTH ASIA

PROJECT WORKING PAPER #8

VALORIZATION OF PLASTIC WASTE IN KERALA

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LIST OF ABBREVIATIONS

Abb.	Expansion
CE	Circular Economy
DSWM	Decentralized Solid Waste Management
DSS	Decision Support System
GIS	Geographic Information System
HDPE	High Density Poly Ethylene
HKS	Harithakarmasena
IEC	Information Education Communication
IE	Industrial Ecology
IS	Industrial Symbiosis
ISWM	Integrated Solid Waste Management
LDPE	Low Density Poly Ethylene
MRF	Material Recovery Facility
MCF	Material Collection Facility
MSWM	Municipal Solid Waste Management
PP	Poly Propylene
SWM	Solid Waste Management
TPD	Tonnes of Plastic Per Day
UN-SDGs	United Nations Sustainable Development Goals

CHAPTER 1
INTRODUCTION

1. BACKGROUND

The United Nations Conference on Environment and Development (Earth Summit) in 1992, identified the goal of sound management of wastes as one of the key goals in maintaining the quality of the Earth's environment. The World Summit on Sustainable Development in 2002 again highlighted the significance of scientific solid waste management. It focussed on the importance of prevention, minimization, recycling, and treatment of waste.

A substance regarded as waste to one individual, may be a resource to another.

A material can only be regarded as a waste when the owner labels it as such (Dijkema et al., 2000). There is no doubt that the global issue of waste increase presents a threat to eco-economic sustainability. To implement prevention strategies, the waste management process requires interdisciplinary research and collaboration, ground-breaking transformations and improvements. To ensure sustainable development, wastes should be prevented, minimized, recycled and processed (Guman and Kozlova, 2020).

By 2050, the world is expected to generate 3.40 billion tons of waste annually, increasing drastically from today's 2.01 billion tons (Kaza et al., 2018). Each year, 90 billion tonnes of primary materials are extracted and used globally, with only nine per cent recycled (UNEP, 2019). While this is unsustainable, and has significant detrimental impacts on human health, climate change and the environment (CSIRO, 2020). Circularity is a key to sustainability. A circular economy is impossible without circular waste management systems. This is achieved by using all materials to their fullest extent. When waste is managed in a circular manner, countries are able to neutralize the amount of waste that they produce. In this way, waste is no longer a problem that's polluting our Earth but rather a valuable resource that allows communities and countries to enjoy sustainable living while saving money, preserving resources, and creating new jobs and industries (tontoton.com, 2020-Plastic Responsibility).

Managing waste properly is essential for building sustainable and liveable cities, but it remains a challenge for many developing countries and cities. Effective waste management is expensive, often comprising 20%-50% of municipal budgets. Operating these essential municipal services requires integrated systems that are efficient, sustainable, and socially supported (The World Bank IBRD.IDA, 2022).

The present study aims to identify the circular economy pattern existing in several recycling sectors, to understand the flow of plastic waste materials and thereby to elucidate the value chain from the obtained data.

1.1. WASTES

Waste (or wastes) are unwanted or unusable materials. Waste is any substance which is discarded after primary use, or is worthless, defective and of no use. The amount of waste produced is influenced by economic activity, consumption, and population growth (USEPA, 2022). Two main waste categories can be established based on the distinct legislation and policy instruments usually in place: non-hazardous or solid waste; and hazardous waste. Hazardous waste is usually regulated at the national level, while non-hazardous wastes are regulated at the regional or local (municipal) level (https://sisu.ut.ee-Sisu@UT-Definition and classification of waste).

According to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal of 1989, Art. 2(1), "Wastes' are substance or objects, which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law "(Basel Convention, 1989).

1.2. SOLID WASTE

Solid waste can physically be a solid, liquid, semi-solid, or container of gaseous material. Solid waste can come from industrial, commercial, mining, or agricultural operations, and from household and community activities. Solid waste does not include wastes such as solid or dissolved materials in domestic sewage, or source, special nuclear, or by-product material. It is categorised according to its origin (domestic, industrial, commercial, construction or institutional); according to its contents (organic material, glass, metal, plastic, paper ,etc,); or according to its hazard potential (toxic, non-toxin, flammable, radioactive, infectious etc,) (Katiyar, 2016).

According to the World Bank's "*What a waste 2.0*" report, the world generates 2.01 billion tonnes of municipal solid waste annually, with at least 33% of that not managed in an environmentally safe manner. Population growth, coupled with enhanced life-styles, results in increased generation of solid waste in urban as well as rural areas. The solid wastes from rural areas are more of a biodegradable nature and the same from urban areas contains more non-biodegradable components like plastics and other packaging materials. The repugnant attitude towards solid waste and its management are, however, common in both areas. Universally 'putting garbage out of sight' is the commonly followed practice. Management of solid waste reduces or eliminates adverse impacts on the environment and

human health and supports economic development and improved quality of life (Agarwal et al., 2015).

1.3 INTERNATIONAL SCENARIO

(Source: m.timesofindia.com)

1.4 INDIAN SCENARIO

India is rapidly shifting from an agriculture-based nation to and industrial and service-oriented country. India has different geographic and climatic regions (tropical wet, tropical dry, subtropical humid climate, and mountain climate) and four seasons (winter, summer, rainy, autumn) and accordingly residents living in these zones have different consumption and waste generation pattern (Joshi, 2016).

Composition & characteristics of Indian Municipal Solid Waste

- Biodegradable Waste: Food and kitchen waste, green waste (vegetables, flowers, leaves, fruits) and paper
- Recyclable Material: paper, glass, bottles, cans, metals, certain plastics, etc.
- Inert Waste Matter: construction and demolition waste, dirt, debris
- Composite Waste: clothing, Tetra packs, waste plastics from toys, etc.
- Domestic Hazardous Waste (also called “household hazardous waste”) and toxic waste: Waste medicine, e-waste, paints, chemicals, light bulbs, fluorescent tubes, spray cans, fertilizer and pesticide containers, batteries, shoe polish, etc.

MSW in India has approximate 40-60% compostable waste, 30-50% inert waste and 10% to 30% recyclable waste (Joshi, 2016).

Increased industrialization in the wake of the green revolution coupled with population growth has paved its way to enormous solid waste generation. The per capita waste generation is escalating,

continuously challenging the global sustainability. Most of the waste produced in India is directly disposed of to landfills without any proper sorting and segregation. This generates greenhouse gases and, poses risks to human health and the environment. Moving toward "zero-waste production" and "waste prevention" aims at reduction of gaseous emissions, solid residues, and pollution, contributing to the protection of climate and environment (Mohanty et al., 2021).

The Circular Economy (CE) represents the most recent attempt to conceptualize the integration of economic activity and environmental wellbeing in a sustainable way. A better strategy to curb eco-damages is observed in the CE approach. To enable an effective 'industry-government-citizens' triad for sustainable development, the contention 'the poor cannot afford eco-friendly products' needs to be replaced with 'the poor can be enabled with circular economy policies and sustainability practices.' The transition from a linear to a circular economy in developing countries like India may prove to be challenging in the beginning but is a necessary challenge to overcome. Overall industry shift towards CE practices may be slow but need to be initiated today. Educating and increasing awareness levels of people of India for effective methods of waste management goes a long way towards accepting new sustainability policies and practices (Krishnamurthy et al., 2016).

1.5 KERALA SCENARIO

Kerala is a state considered to be having a developed modern society. Kerala was one of the first states in the country to deprive the practice of scavenging as a culmination of people's movement for basic human dignity. Further, Kerala is one of the three open defecation free States in the country (Economic Review, 2017).

The generation of all types of waste including solid, hazardous and biomedical waste generation in the state is higher compared to other states in the country. There is a series of actions initiated at State level to abate the problems arise due to the wastes, particularly the pollution problem. The responsibility of collection, treatment and safe disposal of all types of solid wastes rests with the generator (MoEFCC, 2022).

Nearly 25% of the municipal solid waste generated in Kerala is not being treated as per the provisions of the Solid Waste Management Rules, 2016. The total quantity of solid waste generated in Kerala was about 11,500 tonnes per day (2020), while the quantity of waste treated by the local bodies was 8,500 tonnes per day. The gap in treatment capacity was nearly 3000 tonnes per day. Of the total 11,500 tonnes a day, the generation in urban areas was 3,000tonnes while the corresponding figure in rural areas was 7,900 tonnes per day (THE HINDU dated 10th August, 2021).

In an effort to make the cities of Kerala free from solid waste, the Kerala government has initiated a comprehensive solid waste management project in all the 93 urban local bodies in the state (https://swachhindia.ndtv.com).

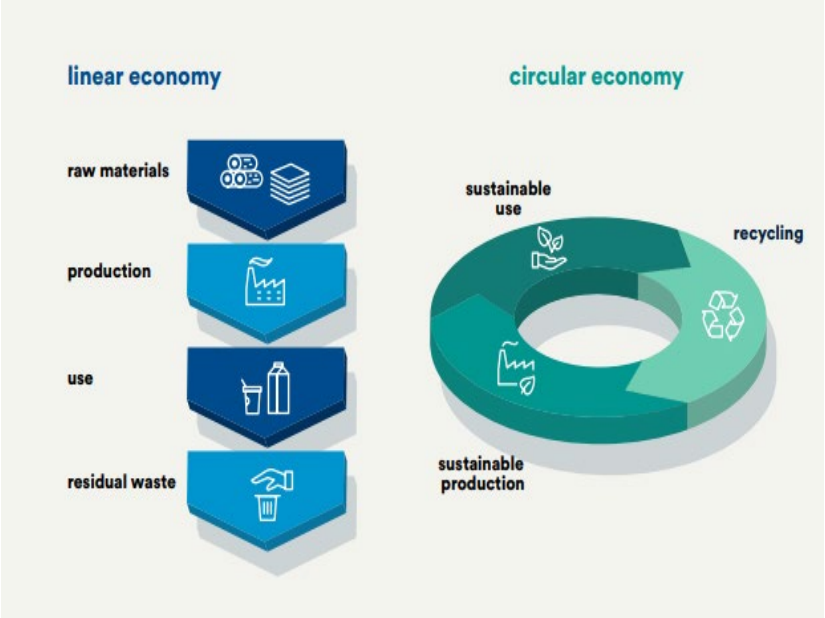
Decentralized Solid Waste Management (DSWM), as conceived in Kerala, is a system involving the segregation and processing of waste at source to the maximum extent possible and then at the community level. The decentralized system has been credited for not only being sustainable and financially viable but also for helping improve the quality of life and working conditions of the waste collectors. The Kerala administration gradually adopted DSWM, with an emphasis on building a circular economy. In regard to wastes, a circular economy follows the 3R-approach – Reduce, Reuse and Recycle. To achieve this, the Government of Kerala introduced the "Green Protocol" which focuses on reducing waste generation and the use of non-degradable wastes like plastics, and as well as finding alternatives for plastics. The Green Protocol also brings in rules and restrictions on the use of plastics and other such materials at public and private functions. This shift of the administration towards decentralization and a circular economy strategy has also implied a significant change in the approach of the administration –towards looking at 'waste' as a 'resource'. In order to turn waste into a valuable resource, the need for systematic ways to manage resources has been recognized and this management has to begin right at the household and the institutional waste generator level.

A major component of building a sustainable system for waste management has been the formation of the Haritha Karma Sena (HKS) in 2016. There are local governments, who are the most significant stakeholders and the lynchpins of the waste management system; the Kudumbashree Mission(State Poverty Alleviation Mission, Kerala) that empowers the Haritha Karma Sena to find sustainable livelihoods through waste management; the Clean Kerala Company which has been tasked with removing non-biodegradable waste and with converting it into resources wherever possible and technical support agencies such as Haritha Keralam Mission and the Suchitwa Mission who are responsible for providing support, handholding and Information-Education-Communication (IEC) to kindle behavioural changes pertaining to waste management. In sum, today, Kerala's waste management space has multiple stakeholders working in close coordination with each other, exchanging knowledge and resources to bring decentralized waste management and the circular economy idea to fruition (Waste Management in Kerala Report 2021).

1.6 CIRCULAR ECONOMY AND VALUE CHAIN

Waste is a part of the economy- it is a by-product of economic activity by businesses, governments, and households. Waste also provide inputs for economic activity, whether through material or energy recovery (www.defra.gov.uk.2011-_The Economics of waste and waste policy). In our current

economy, we take materials from the Earth, make products from them, and eventually throw them away as waste – the process is linear (ellenmacarthurfoundation.org, 2022). The linear economy is a traditional model based on the 'take-make-consume-waste' approach to using resources. The raw material is transformed into a product and after it ends its life cycle is thrown to waste. The world population is booming and at the same time it is draining the Earth's natural resources at an alarming rate. The growing human need for food, water, housing, clothing, and recreation takes a heavy toll on the environment. These are the reasons why many countries try to switch from linear to circular economy. The transition from linear to circular economy goes through the reuse economy approach. The model adds a new link to the linear economy approach. The raw materials are transformed into a product that is recycled when it ends its life cycle into a new product (entrepreneurship-campus.org).



(Source: newsroom.tomra.com)

According to the Ellen MacArthur Foundation, the circular economy development path in India could create an annual value of 14 lakh crore (US $218 billion) in 2030 and 40 lakh crore (US $624 billion) in 2050 in comparison to the current development scenario. It could reduce greenhouse gas emissions by 44% along with significant reduction in air pollution, thus contributing to health and economic benefits for society (UNDP, 2021).

A circular economy aims to maintain the value of products, materials, and resources for as long as possible (Joe Whitworth, 2022). The circular economy intends that products, components and resources in general maintain their usability and value at all time, which is basically eliminating the word "waste". All the biodegradable material should be brought back to the nature, and for the non-biodegradable ones, a new use must be found, in order to reintroduce it to the system. The importance of changing our behaviour towards a circular economy should not be only regarding the economic

benefits that may achieve in the process, but also because of the necessity to reduce the environmental impact and to increase the social impact with our actions (ekiona.com/en/circular economy.2020).

The adoption of circular practices within environmental management is gaining worldwide recognition owing to rapid resource depletion and detrimental effects of climate change. Though India is extremely dedicated towards attainment of the sustainable development goals, penetration of CE principles within administration requires considerable efforts especially since waste management regulations for municipal, plastic and e-waste lack alignment with CE principles. Integration of waste management and renewable energy policies under an umbrella CE policy would provide further impetus to the attainment of circularity and sustainable development within the Indian economy (Priyadarshini et al., 2020).

Source: (istockphoto.com)

Value chain is a concept that has circulated since the seminal work of Porter in 1980 (Porter, 1980). This concept is introduced to describe the full range of activities, that are required to bring a product or service from conception, through the different phases of production, distribution to consumers, and final disposal after use. As the product moves from one player in the chain to another, it is assumed to gain value (Zamora, 2016). Value chains are an integral part of strategic planning for many businesses today. A value chain refers to the full lifecycle of a product or process, including material sourcing, production, consumption and disposal/recycling processes (WBCSD, 2011).

Value chains in most cases relate to the production of products or services. Value chains in product or services will characterise as value added stream, where each activity will subsequently be adding value. Value chains for products usually begin at producer value (Factory) that flows to consumer value (Household). For waste the value chain is from the Household (Producer of Waste) that flows to the factory (Consumer of Waste). The concept of value chain provides strategic management ability to pinpoint strategic development to achieve sustainable competitive advantage (Hakim et al., 2017).

1.7 OBJECTIVES

The basic objective of the present study is to understand the circular economy options in the plastic waste life cycle and also to identify the potential of circular economy solutions in the management of plastic wastes

CHAPTER 2

2.0 REVIEW OF LITERATURE

An integrated waste management system entails a careful analysis of what is in the waste stream and offers ideas on practices to recover the various materials at the point of highest value. The theoretical and practical issues of waste management based on Circular Economy (CE) principles from perspective of cross-disciplinary eco-economic collaboration and the application of tools and principles of CE is more frequently considered as key driver to reach sustainable development goals (Guman et al., 2020. Waste Management based on circular economy principles). The United States Environmental Protection Agency report (2020) clearly reviews the key benefits of effective solid waste management systems, and common challenges that prevent cities from establishing and effectively implementing those systems. It was identified that many health, environmental and other concerns associated with inadequate solid waste management. The common challenges identified includes- limited financial resources and capacity, limited access to and technical knowledge of equipment, limited technical expertise and awareness of best practices, limited staff capacity, lack of planning and evaluation, and limited or lack of communications with relevant stakeholders (USEPA, 2020. Best Practices for Solid Waste Management).

The 2020 Asian Development Bank Institute (ABDI) report reveals about the current situation of waste management in Developing Asia due to population growth and urbanisation. The paper also explains the need to have a transition from a linear system of production, consumption, and waste to a Circular Economy (CE). Also, the current study focusses on the point that a transition to more sustainable production and consumption practices will be imperative for Asia to achieve the 2030 Agenda for sustainable development (ADBI, 2020. Solid Waste Management in Developing Asia). To achieve the CE, there is need to establish processes wherein waste generated at all stages of production and consumption value chains, either in the form of natural resource or man-made materials, components, products, are recovered and maintained in the system. This refers to resource recovery from waste. It is not a straightforward process. It depends on the varying composition of solid waste and the diverse collection and management regimes that are implemented around the globe. The sustainable management of municipal solid waste is a prerequisite for achieving the CE, as it can promote environmental and human health protection, while it can boost the economic productivity of a region through resource recovery from waste; hence, creating an effective supply and demand market (Cana et al., 2022. Journal of Cleaner Production).

The concept of CE is relatively new, the theory of CE is closely associated with various other economic sustainability approaches such as industrial ecology (IE) and industrial symbiosis (IS),

essentially targets the circularization of linear value chains (Morseletto, 2020. Targets for a Circular Economy). Morseletto (2020), further refined the concept of CE as an "economic model aimed at the efficient use of resources through waste minimization, long-term value retention, reduction of primary resources, and closed loop of products, product parts, and materials within the boundaries of environmental protection and socioeconomic benefits".

Another closely associated concept with CE is that of sustainable development. The United Nations Sustainable Development Goals (UN-SDGs) provides a pathway to world economies for harmonious co-existence with nature and it contains a number of goals and targets associated directly or indirectly with CE principles. Target 8.4 of goal 8 of SDGs (Decent work and Economic Growth) stresses on the need to achieve economic growth which is a key principle of CE (Priyadarshini et al., 2020. Circular economy principles within energy and waste management sectors of India). Therefore, it is clear that policy makers regard CE as an important approach in attaining sustainability. The different practices of SWM employed in selected Middle East and North Africa (MENA) region countries and their approaches to embracing the CE examines the extent to which policies and technologies applied play any role in this context. The study revealed that most waste management issues in the countries analysed appear to be due to lack of planning, lack of proper disposal, insufficient collection services, inadequate financing, and use of inappropriate technology (Hemidat et al., 2022. Solid Waste Management in the context of a Circular Economy in the Mena Region). Khatiwada et al., (2021) in their study proposes an integrated resource management systems that aims to increase the efficiency of natural resources utilization and reduce emissions and waste generation. The paper suggests that the definition of systems boundaries, materials/resource flows analysis, environmental accounting, together with innovative industrial symbiosis and CE is required to optimize the socio-economic solution to improve the quality of the nexus in cities (Khatiwada et al., 2021. Circularity in the Management of Municipal Solid Waste – A Systematic Review).

CHAPTER 3

3.0 METHODOLOGY

The following methodology was adopted in this study

- Preparation of Survey Questionnaire
- Collection of primary data on plastic waste materials with respect to its segregation, collection, storage, recycling, and the financial aspects
- Identification and mapping of all the plastic waste scrap dealers and plastic recycling units using field study and GIS mapping and understanding the waste flow
- Identifying the value chain and the potential for circular economy of different recycled products from the plastic wastes

3.1 STUDY AREA

The study area selected was Ernakulam district of Kerala, located between 76°9′ 57.481″ E to 76° 49′ 18.407″ E and 10° 17′ 39.328″ N to 9° 47′ 33.305″ N. The district is situated almost in the middle of Kerala State and on the coast of the Arabian Sea. Ernakulam District is the Commercial capital of Kerala as it is the major business hub of Kerala State and the highest revenue yielding district in the state. It is the third most populous district in Kerala, after Malappuram and Thiruvananthapuram. It is surrounded by Thrissur District, Idukki District, Alappuzha and Kottayam districts and also by Arabian sea to west. Ernakulam district also hosts the highest number of international and domestic tourists in Kerala state. The district was formed in 1958 by carving out regions from Thrissur and Kottayam district. The district is bounded by a 46.2km. coastline of the Arabian Sea on the west (https://www.justkerala.in.2017). The study area selected is located in two taluks in Ernakulam district that is Aluva and Kunnathunad.

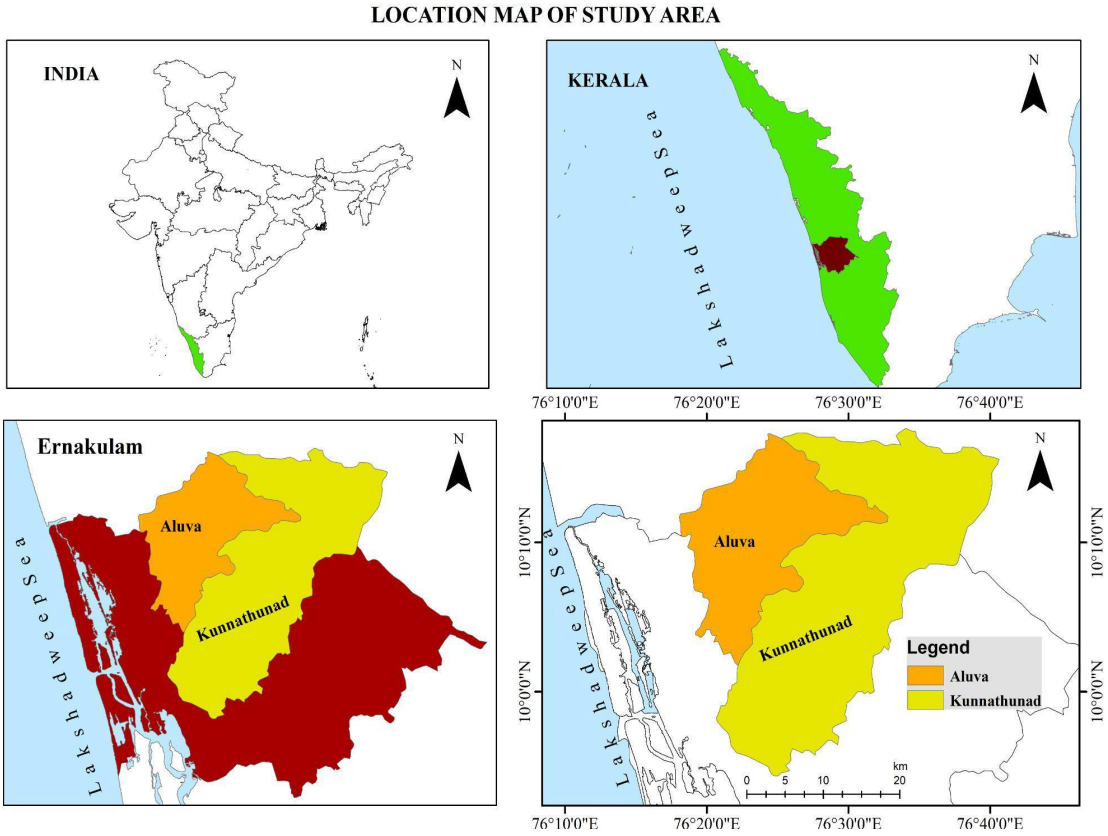


Fig. 3.1 Location map

LANDSCAPE MAPS:

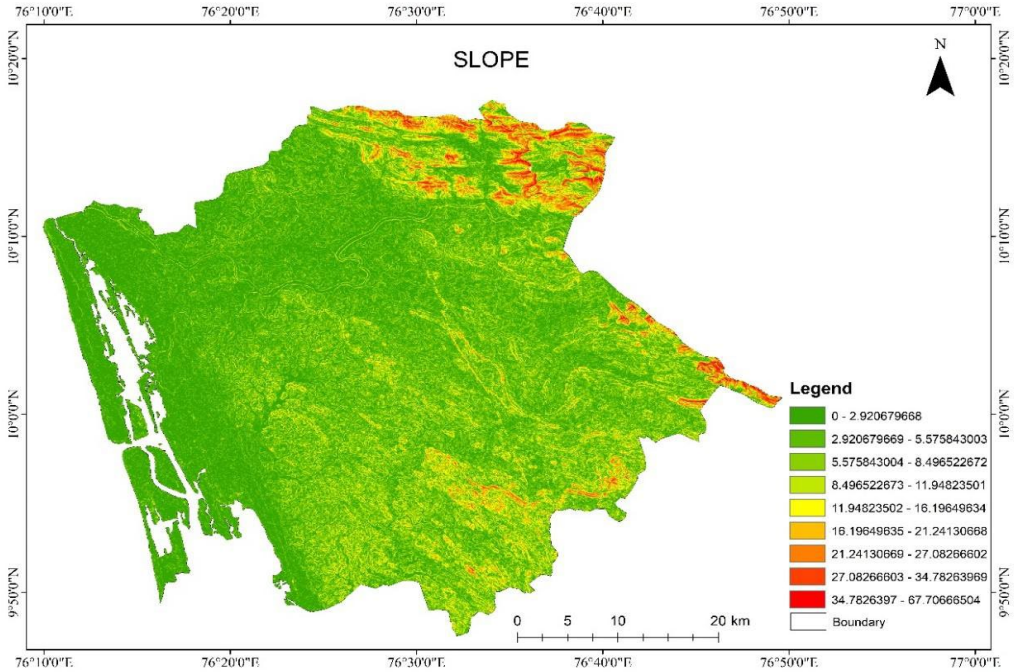


Fig. 3.2 Slope Map

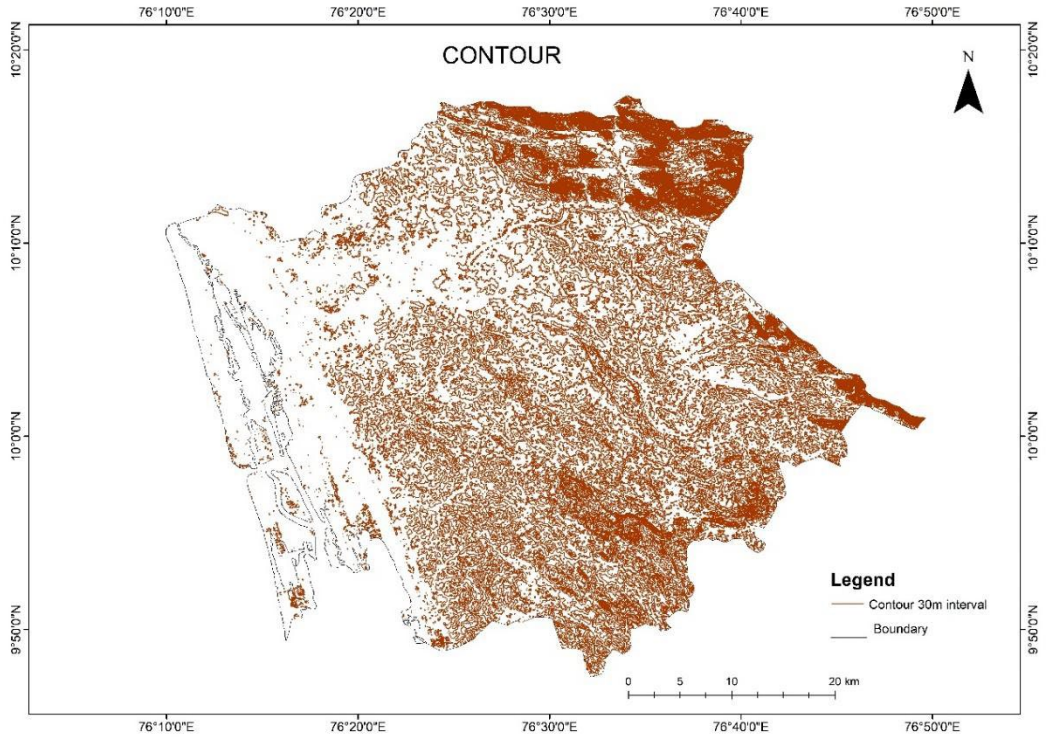


Fig. 3.3 Contour Map

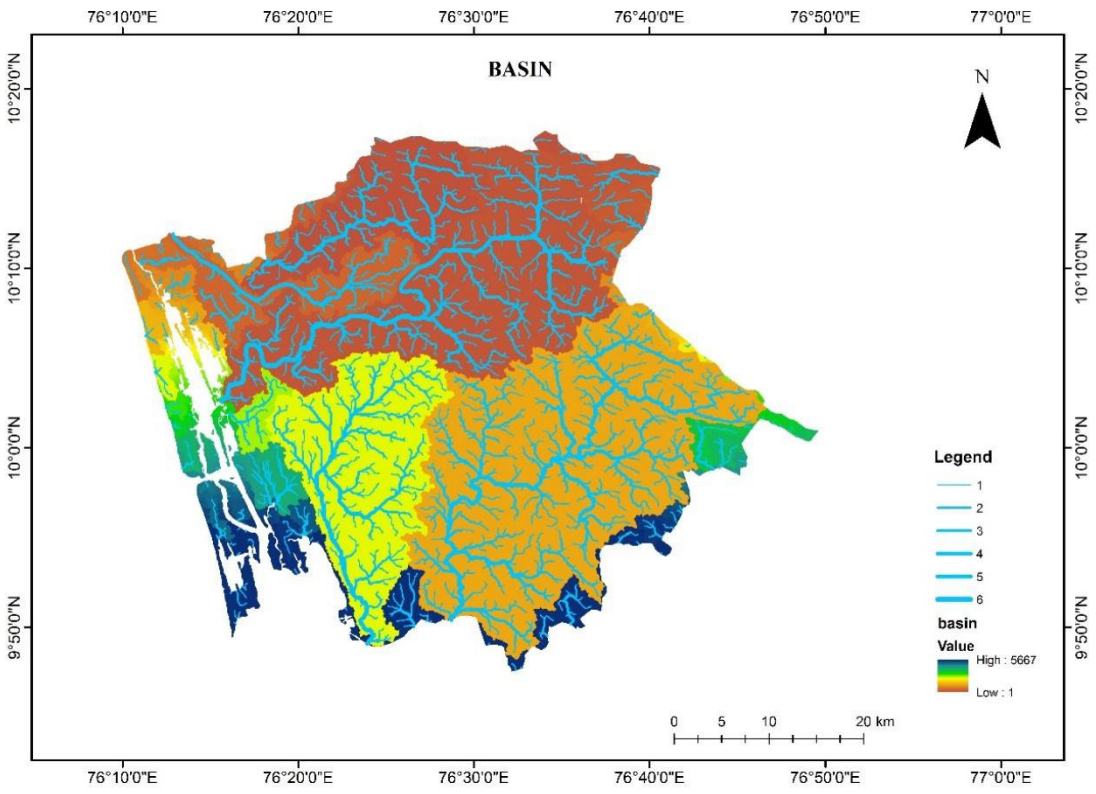


Fig. 3.4 Basin Map

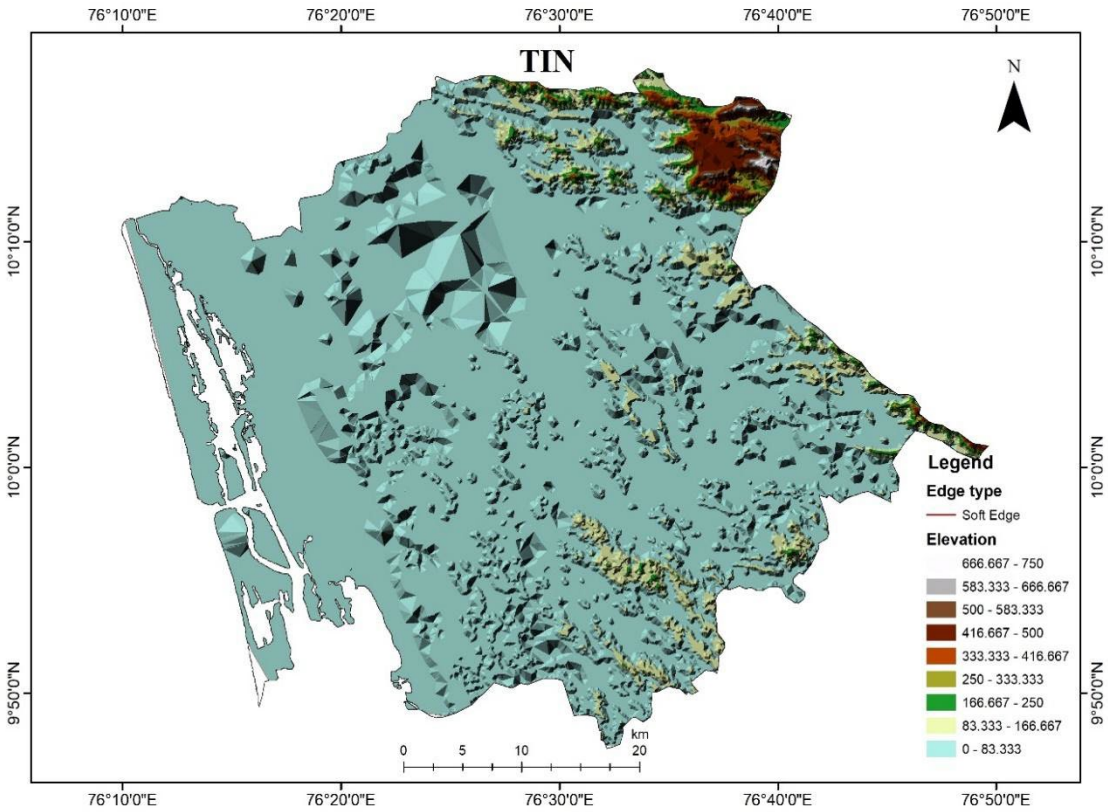


Fig. 3.5 TIN Map

3.2 GEOGRAPHY AND CLIMATE

Ernakulam district covers an area of 3068 Sq.km located on the Western Coastal Plains of India. The Periyar River, Kerala's longest river, flows through all the taluks except Muvattupuzha. The district has a moderate climate, and mostly falls within the Malabar Coast moist forests ecoregion, while the highlands are part of the South Western Ghats moist deciduous forests ecoregion. Many types of sands, soil and also rocks which has geological importance is abundant here. Ernakulam has a tropical climate; therefore, the weather is pleasant here. The average maximum temperature can go up to 36.0°C in summer months and to a minimum of 18.0°C in winter. Monsoon comes to Ernakulam normally in the month of May (https://www.justkerala.in.2017).

3.3 DRAINAGE

The district is drained by the Periyar and its tributaries in the north and Muvattupuzha River in the south (Anitha, 2013).

3.4 PEDOLOGY

On the basis of morphological features and physico-chemical properties, the soils of the district are classified as Lateritic, Hydromorphic saline, Brown hydromorphic, Riverine alluvium and Coastal alluvium (Anitha, 2013).

3.5 LAND USE, IRRIGATION AND CROPPING PATTERN

About 83% of the total area of the district is cultivable land, 10% is under forest cover including reserve forest and plantations; water bodies constitute 5.3% and built-up area constitutes nearly 2% of the total area. An area of 26,825 hectares is under irrigation (net area) in the district. Periyar valley irrigation project with a barrage at Bhoothathankettu which uses the tail race water of Sengulam, Panniyur, and Pallivasal Hydro-electric projects and Chalakudy diversion project are source for canal irrigation in the district. The major crops under irrigation in the district is paddy, coconut, rubber, banana and arecanut. Paddy is cultivated in more than one season. Rubber is the major crop in the district followed by Coconut, Paddy and Banana. Spices, Areca nut, oil seeds and vegetables are also cultivated in the district (Anitha, 2013).

3.6. GEOGRAPHIC INFORMATION SYSTEM (GIS)

3.6.1. Application of GIS in Solid Waste Management:

The application of GIS to SWM has been widely adopted in many cities around the world. Planning a sustainable waste management approach is complex, tedious, and time-consuming, and decision-makers are frequently subjected to conflicting factors. GIS has a crucial role in simplifying and facilitating the implementation of sustainable SWM. It is a powerful tool that can assist in minimizing value conflicts among preference and interest parties by providing better information. The important application of GIS in SWM includes site selection of waste management system, effective route tracking, establishing the drive time bands. The present study also uses GIS application for identifying and mapping all the plastic waste scrap dealers and plastic waste recycling units and for understanding the waste flow.

A field survey was conducted using structured survey questionnaire for collecting data from households, scrap shops, mobile scrap dealers and recycling units.

3.7 WASTE VALUE CHAIN OF INDUSTRIES

The study focused on the need for a transition from a linear to a circular economy and about the value chain of different recycled products from the waste. The study team was able to locate and visit many plastics scrap shops, recycling, and manufacturing units in the area. The recycling units visited are:

- **Cheerakattil Polymers**

A plastic recycling unit in Perumbavoor. The waste plastic materials are collected from scrap dealers. The first step involves separation and sorting of waste plastics into different categories. The materials are made to pass through grinding machine to form chips and are sold to manufacturing industries to make granules followed by injection moulding.

- **Creative Plastics**

A plastic recycling unit in Vallom. The used plastic chairs are being processed in this industry. The first step involves separation and sorting of chairs based on its colours. Mainly separated into 10 colours- coffee, sandal, white, red, blue, black, pink, silver, green, and orange. The materials are then made to pass through the grinding machine to form chips and are sold to manufacturing industries for the production of chairs and plastic pots.

- **Evershine Plastics**

A plastic recycling unit in Perumbavoor near Mudickal. Here, the waste plastic materials are collected from various sources. The first step involves separation and sorting of waste plastics into different categories. The large items are made smaller by using a cutter. The materials are made to pass through grinding machine to form chips. The chips are then washed and dried and are used for making new products through injection moulding.

- **Ideal Plastics**

A recycling industry in South Aduvassery. Mainly paper items are recycled here. The plastic sheet materials are made into smaller pieces. Water along with the sheet pieces are made to pass through plastic blow moulding machine and the grinding process takes place. Then it is made into the form of granules and are sold.

- **Mullappilly Traders**

A plastic recycling unit in Perumbavoor. Here, the waste materials mainly plastic boxes, cans, etc are separated and grinded in the machine. The formed chips are washed and then dried in the drier. The wax coated material formed is made to pass through the plastic granulator to form granules and are sold to the manufacturing industries.

- **Algo Trading Company**

A plastic recycling unit in Perumbavoor near Rayonpuram. Here, the waste materials are collected from various sources. The first step involves separation and sorting of waste plastics into different categories. The large items are made smaller by using a cutter. The materials are made to pass through

grinding machine to form chips and are sold to manufacturing industries to make granules followed by injection moulding.

- **Hamara Polymers, Koovappady**

A recycling unit in Kodanad. Mainly plastic materials are processed. The plastic waste materials after segregation and sorting are grinded to form chips and are then processed into granules. These granules are then moulded to form flower-pots and are sold to the customers through wholesale and retail shops. The primary data procured from the above industries was useful in the creation of the waste chain of certain industries. Schematic Structure of Waste Chain shown in fig. 3.6.

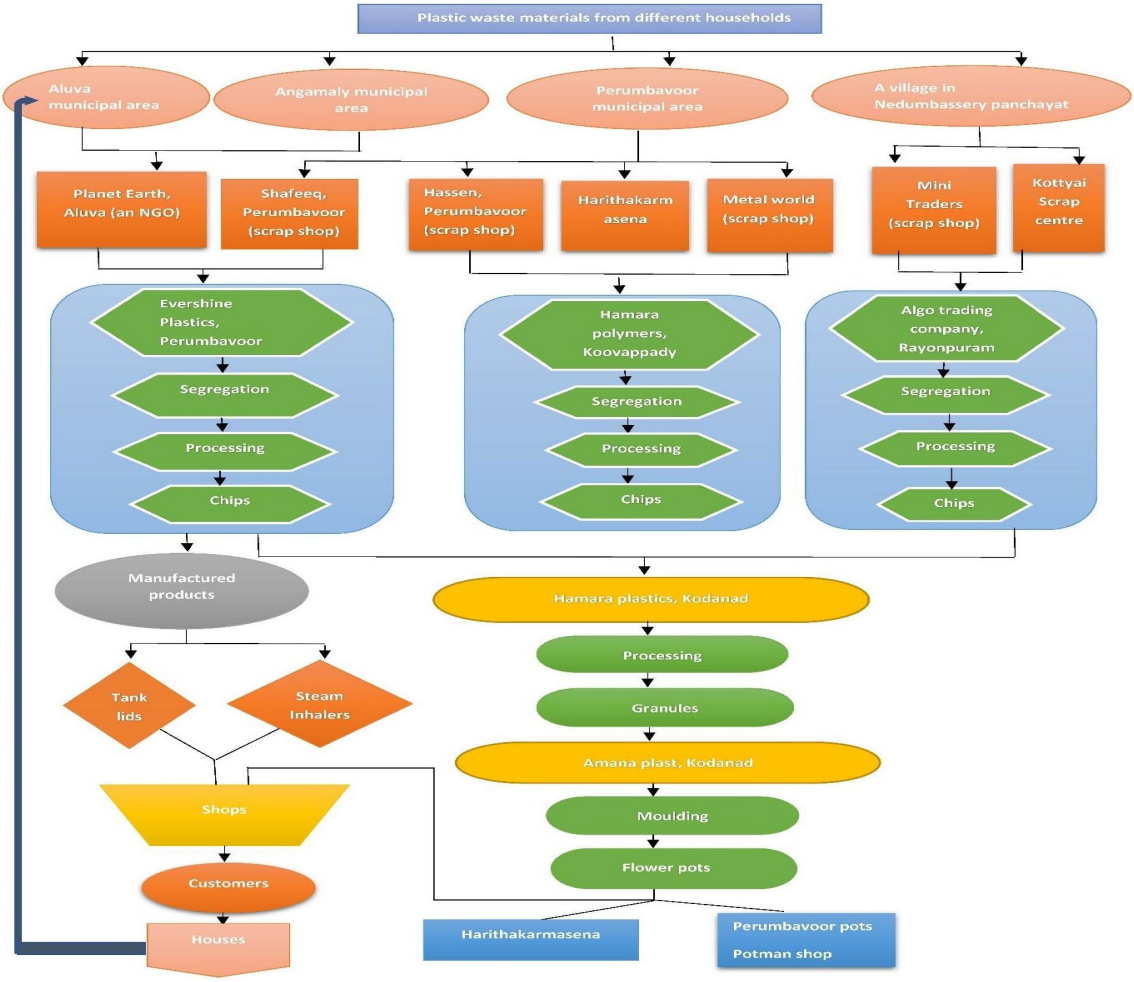


Fig. 3.6 Schematic Structure of Waste Chain

The present study mainly concentrates on plastic waste materials that are generated from different households of Aluva, Angamaly and Perumbavoor municipal areas and also from a village in Nedumbassery panchayat (Athani). The waste materials are collected from different households by the scrap dealers and find its way to the scrap shops as depicted in the picture. From the scrap shops these materials are collected by various recycling units like Evershine Plastics (Perumbavoor), Hamara Polymers (Koovappady) and Algo Trading Company (Rayonpuram) for further processing.

It is stated that recycling is a system and process for renewing the life of a used material. It supports a more "circular economy". In any recycling process, there are five key elements: Consumers, Haulers, Sorters, Reprocessors, and End Markets (Susan, 2020). The various processes taking place in the above recycling units include segregation and sorting, plastic grinding, and formation of chips. The chips are then further transported to various other units for the production of granules and are manufactured to produce recycled products like flowerpots, steam inhalers and tank lids. Thus, in the above waste flow chain a circular pattern is observed as the waste materials are returned back as a new recycled product and it finally reaches to the place where it is initially considered as a waste.

From the above waste flow chart, the objective of the study, the value chain analysis of two main industries located in Perumbavoor and Koovappady was obtained and also inferred on the circular economy pattern and the plastic waste flow. They are listed below.

3.7.1 Evershine Plastics, Perumbavoor

A plastic recycling unit in Perumbavoor near Mudickal. Here, the waste plastic materials are collected from various sources. The first step involves separation and sorting of waste plastics into different categories. The large items are made smaller by using a cutter. The materials are made to pass through grinding machine to form chips. The chips are then washed and dried and are used for making new products through injection moulding.

The different steps involved in the processing are as follows:

Fig. 3.7 (a) Collected waste plastic materials (b) Segregation &Sorting

(c) Cutting large materials (d) Plastic grinding & chips formation

The formed plastic chips are sold to various manufacturing units for further processing. On the other hand, Evershine also owns a manufacturing unit where, it uses the formed chips to manufacture steam inhalers and tank lids.

Steam Inhalers

White Lids

Blue Lids

Black Lids

The manufactured products are then sold to the wholesale shops and finally it reaches to the shops.

3.7.2 Hamara Polymers, Koovappady

A plastic recycling unit in Koovappady. Mainly, plastic materials are being processed here. It involves the segregation and sorting of materials and are grinded to form chips. The formed chips are then washed and dried. This industry consists of two other units namely – Hamara Plastics, Kodanad and Amana Plast, Kodanad. In the second unit i.e., in Hamara Plastics, the above formed chips are converted to granules and are then transported to their third unit. The third unit Amana Plast is a manufacturing unit where the formed granules are moulded to form flower pots and through the wholesale and retail shops it reaches to the customers. The waste flow to Hamara is mainly through the households of Perumbavoor municipality and the waste undergoes different processes to form the final product.

The different steps involved in the processing are as follows:

Fig. 3.8 (a) Collected waste materials (b) Plastic Grinding

(c) Washing and drying chips (d) Granules production

(e) Stored Granules (f) Manufacturing pots from granules

CHAPTER 4

4.0 RESULTS AND DISCUSSIONS

As part of the study, the Team prepared Route Maps depicting the shortest routes to collect and transport the plastic wastes from different sources such as plastic waste collectors, MCF, scrap dealers and finally to recyclers and retailers. The following maps were prepared at GIS Lab at CED, Thiruvananthapuram using Arc GIS 10.2 software. The municipality boundary map was collected from the Perumbavoor Municipality and verified with other published maps.

All the thematic maps were prepared based on the boundary maps.

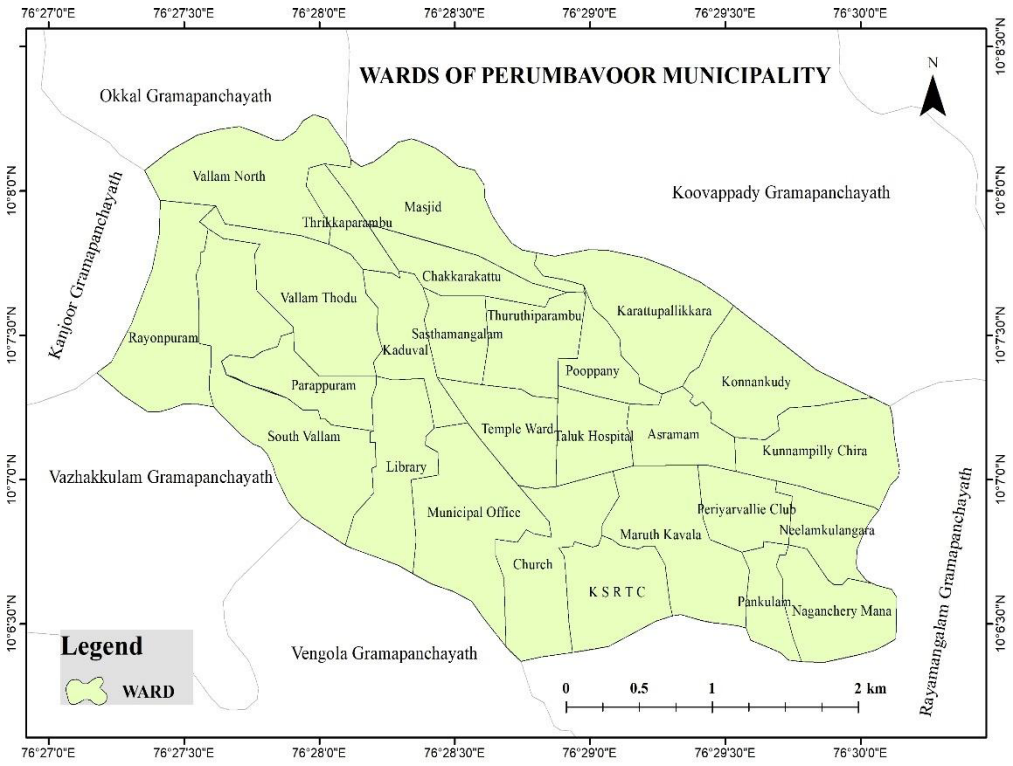


Fig: 4.0 Wards of Perumbavoor Municipality

The map showing all the waste collecting wards of Harithakarmasena in Perumbavoor municipality

4.1 ROUTE MAPS

Fig: 4.1 illustrate the shortest enroute map of Evershine Plastics from the scrap shops to the retail shops. The route begins from the scrap shop units from where the waste materials are collected and taken to the recycling unit namely Evershine Plastics. The recycling unit includes the processing of

the collected waste materials and after processing it is sold to the wholesale shops and thereby to the retail shops.

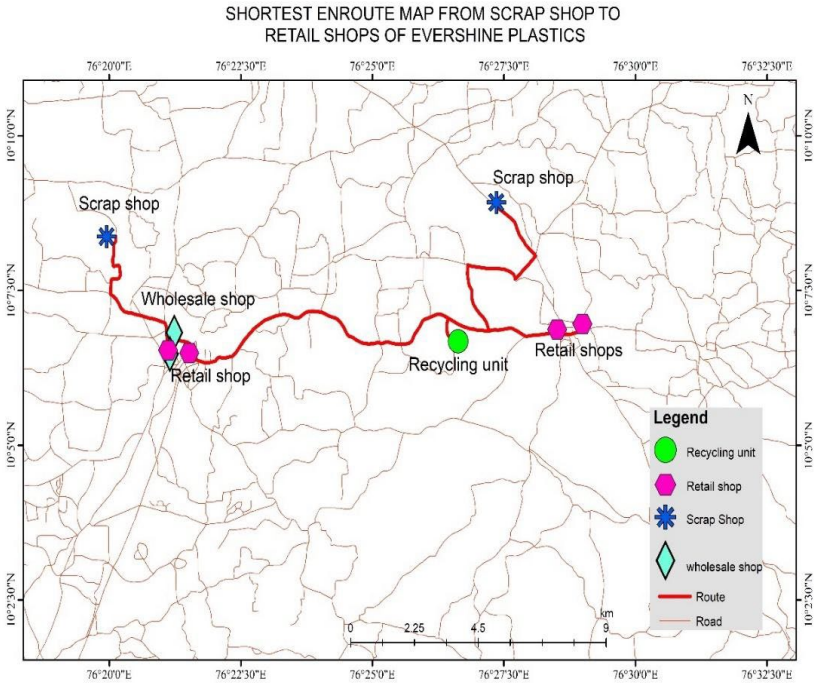


Fig. 4.1 Route map of Evershine

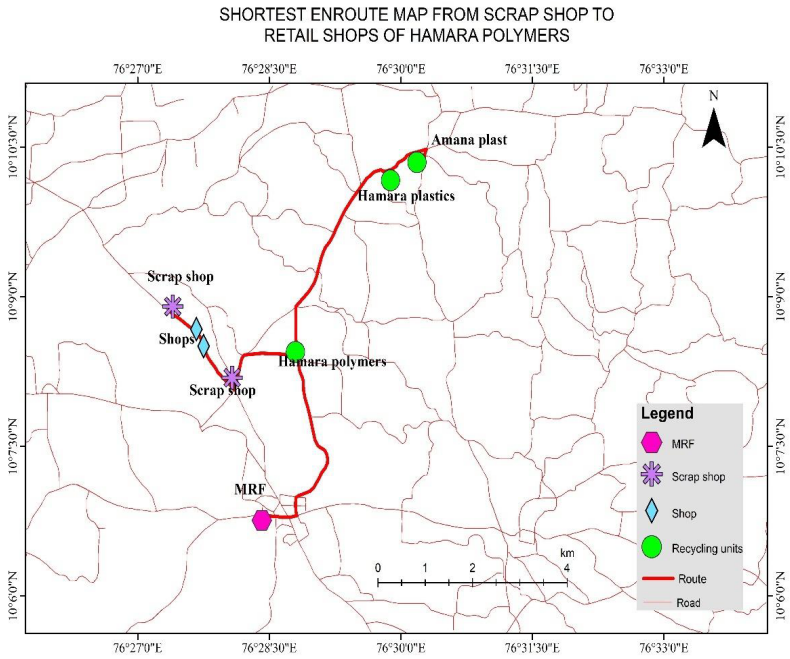


Fig: 4.2 Route map of Hamara Polymers

Fig: 4.2 illustrate the shortest enroute map of Hamara polymers from the scrap shops to the retail shops. The route begins from scrap shops and MRF centres, from where the waste materials are collected, and it is transported to the recycling unit namely Hamara polymers. After the first stage of

processing, it is carried to the second unit namely Hamara plastics. This unit processes the materials into its granule form and is taken to the manufacturing unit called Amana plast. The products formed in this unit is sold to the shops.

The figures below show all the identified scrap shops, plastic reprocessing units, and plastic manufacturing units.

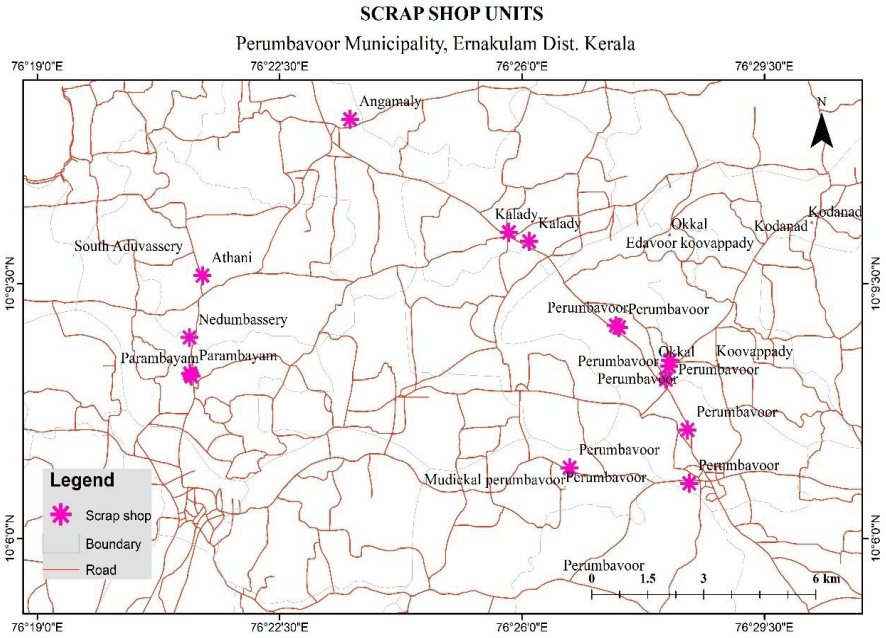


Fig. 4.3 Scrap Shops

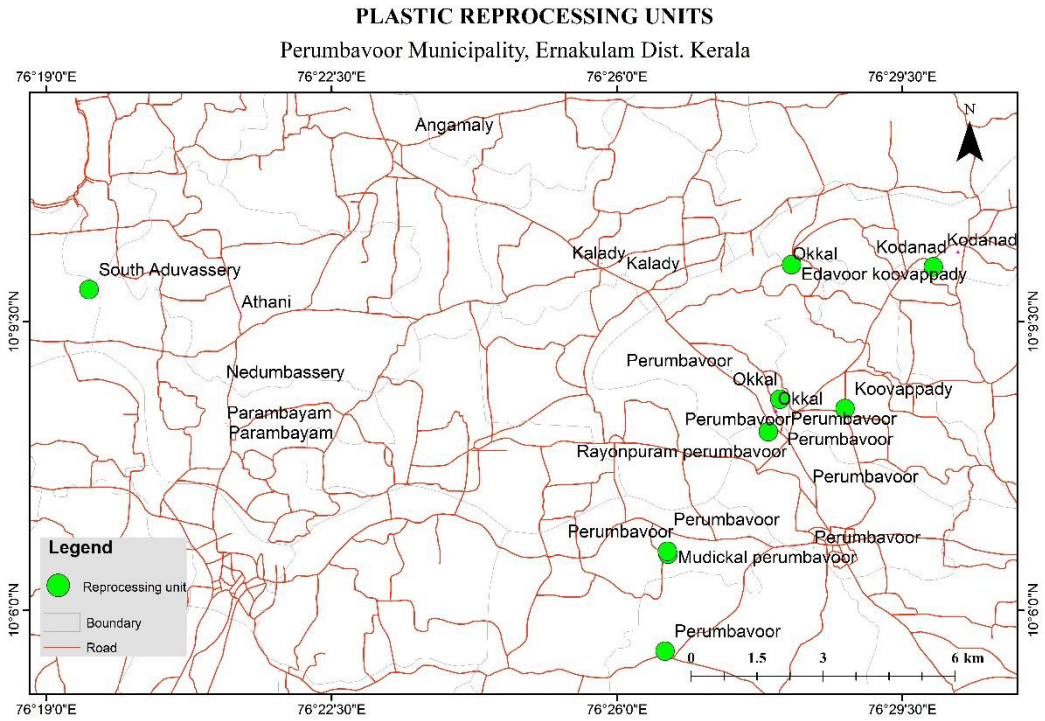


Fig.4.4 Plastic Reprocessing Units

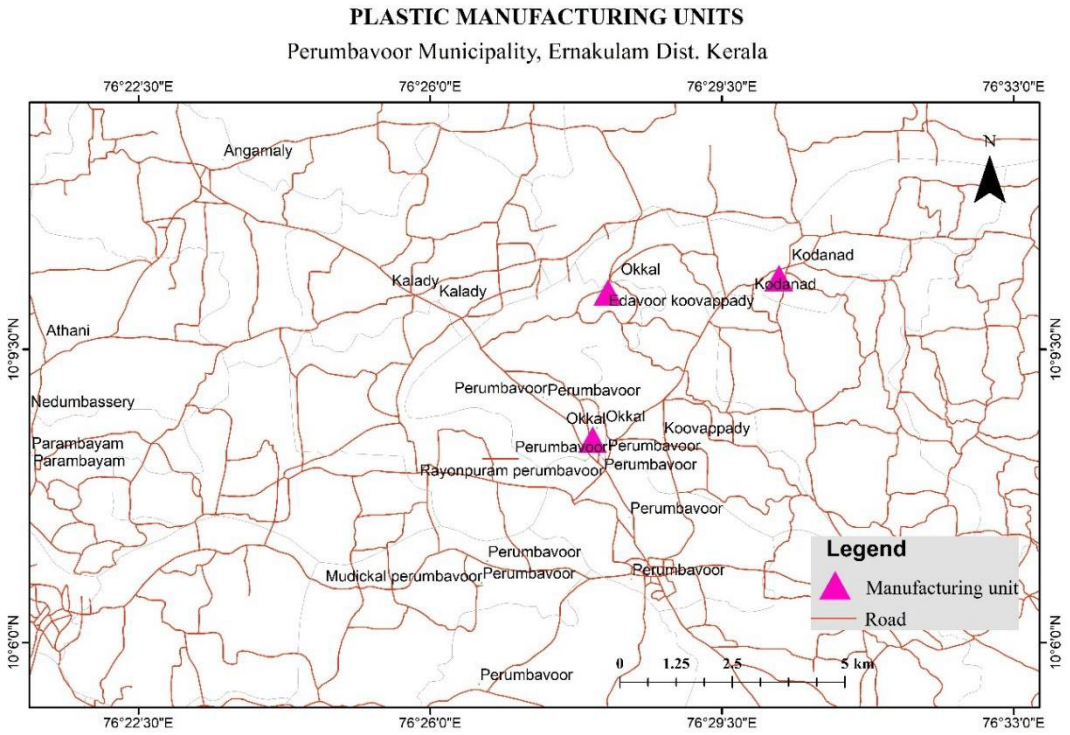


Fig. 4.5 Plastic Manufacturing Units

4.2 PLASTIC WASTE VALUE CHAIN AT PERUMBAVOOR, KOOVAPPADY AND SOUTH ADUVASSERY

The primary data obtained from each factory shows that the value of the plastic material that is considered as a waste is increasing at each of its processing stage and the value attains a stable hike. This is most evident from the value chain chart of each industries shown below.

Evershine Plastics:

Table: 4.1 Value Chain Chart of Evershine Plastics

Sl. No	Location	Materials	Price in Rs/kg	Steps	Final products	Price in Rs/kg	Manufactured products	Price in Rs/kg
1	Evershine plastics	Plastics: Mix plastics Broken plastic pieces (low grade)	25 8	Sorting Cutting Grinding	Chips: PP Coloured PP white HD LDPE	35 45 55 50	Tank lids Steam Inhaler	70 140

PP – Poly Propylene

HD- High Density Poly Ethylene

LDPE- Low Density Poly Ethylene

It is to be mentioned that the expenditure for converting the scrap plastic in to the value added product has to be taken in to consideration, during the calculation of final financial benefits.

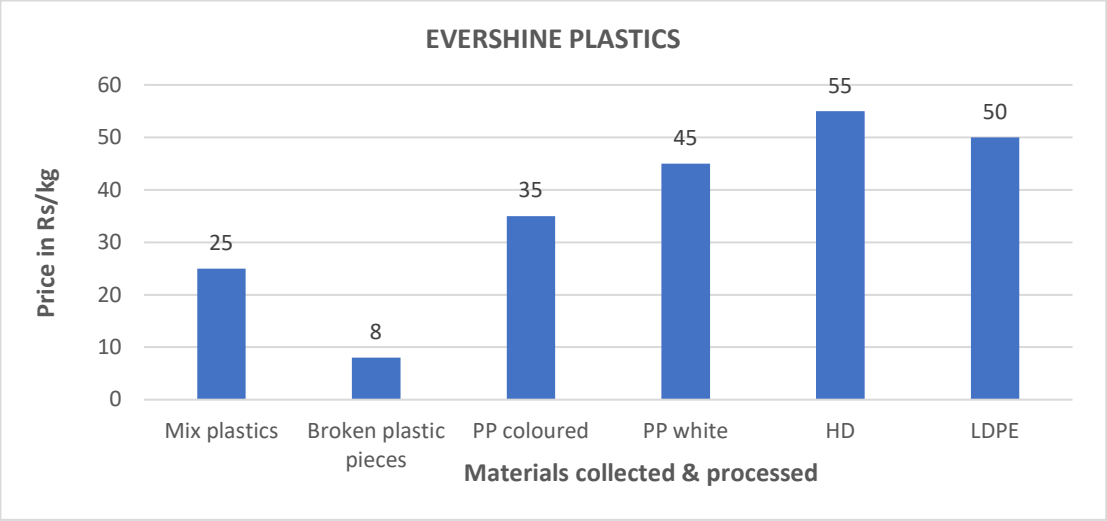


Fig 4.6. Value chain of Evershine Plastics

Table:4.1 provides a summary of the waste value chain chart of Evershine Plastics. Evershine is a plastic recycling unit in Perumbavoor. The recycling unit mainly collects the plastic waste materials that includes mix plastics and low grade broken plastic pieces and are collected from various scrap shops for Rs 25/- and 8/- respectively. After sorting, cutting and grinding processes the materials are finally converted to chips of various colours and are sold to various manufacturing units at a reasonable rate as shown in the table. Evershine also owns a manufacturing unit where by it produces tank lids and steam inhalers through injection moulding. Later, the products are sold to wholesale shops at the wholesale rate. It was identified that the recycling unit follows a circular economy path and the value chain chart is also found to be increasing from its collection stage to manufacturing stage.

Hamara Polymers:

Table: 4.2 Value Chain Chart of Hamara Polymers

Serial No	Location	Materials	Price in Rs	Final products	Price in Rs	Manufactured products	Price in Rs
1	Hamara polymers	Hard plastic items Soft plastic Items	10 to 25/- 4 to 40/-	Granules: Transparent Black colour Filler black Pink colour	97/- 50/- 45/- 35/-	Flower Pots	Price ranging from Rs 16/- to 100/- based on its inch

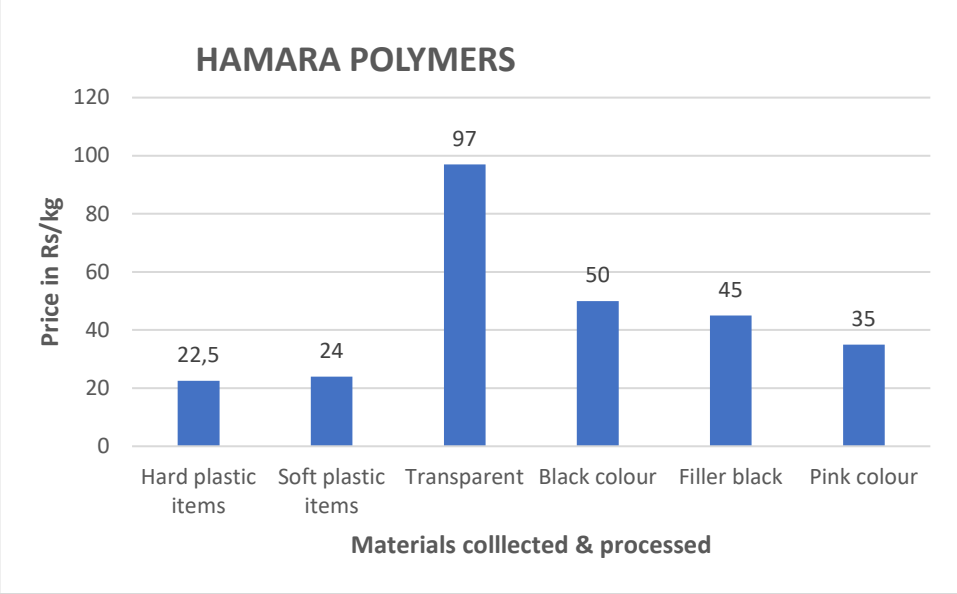


Fig 4.7. Value chain of Hamara Polymers

Table:4.2 provides a summary of the waste value chain chart of Hamara Polymers. Hamara Polymers is a recycling unit in Kodanad. It mainly processes plastic waste materials. The materials collected includes hard plastic items ranging from Rs.10 to 25/- and soft plastic items ranging from 4 to 40/-. The collected materials after segregation and sorting are grinded to form chips and are then processed into granules. The granules produced are of different colours that includes transparent, black, pink, etc. The data collected from the recycling unit reveals that the granules are sold to various other manufacturing units. Also, this industry possesses a manufacturing unit where it moulds the granules into flower pots and are sold to various wholesale and retail shops at the price ranging from Rs. 16/- to 100/- based on its size. It was identified by the study that the value of the waste product is increasing at each of its processing stage as shown in the table.

Cheerakattil Polymers:

Table: 4.3 Value Chain Chart of Cheerakattil Polymers

Serial No	Location	Materials	Price in Rs/kg	Steps	Final products	Price in Rs/kg
1	Cheerakattil Polymers	Plastic Items Bottles	19 28	Separation & sorting Plastic grinding	Chips: PP HD	30 35

PP – Poly Propylene

HD- High Density Poly Ethylene

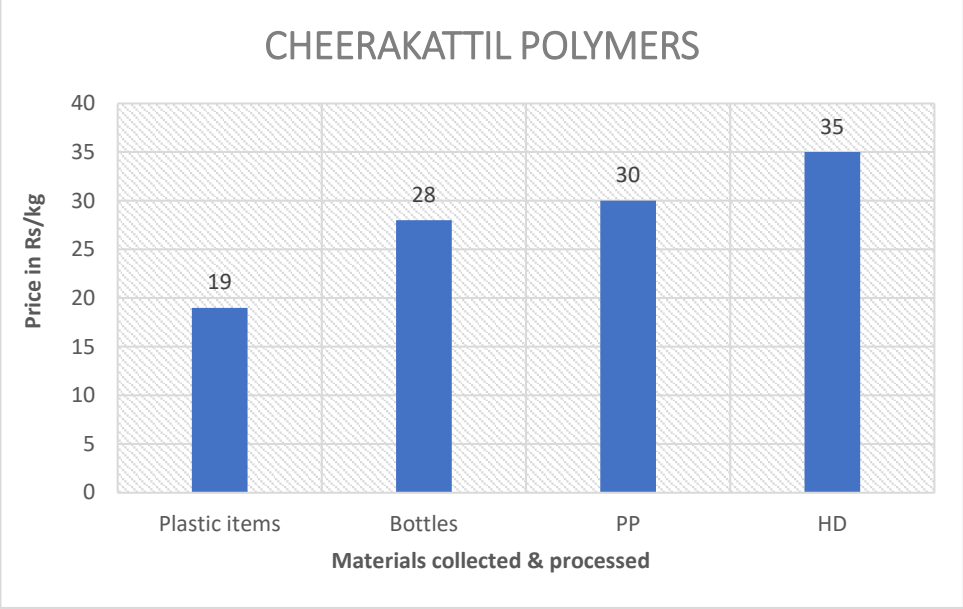


Fig 4.8. Value chain of Cheerakattil Polymers

Table 4.3 provides a summary of the waste value chain chart of Cheerakattil Polymers. Cheerakattil Polymers is a plastic recycling unit in Perumbavoor. The collected materials include various plastic items for Rs 19/Kg- and plastic bottles for Rs 28/Kg-. The plastic grinding of the materials results in the formation of chips and are sold to various manufacturing units at a reasonable price that varies for different grades of chips. It was found that in the case of this recycling unit the value chain chart is found to be increasing.

Creative Plastics:

Table: 4.4 Value Chain Chart of Creative Plastics

Serial No	Location	Materials	Price in Rs/kg	Steps	Final products	Price in Rs/kg
1	Creative Plastics	Plastic chairs	15	Separation &Sorting Plastic grinding	Chips	20

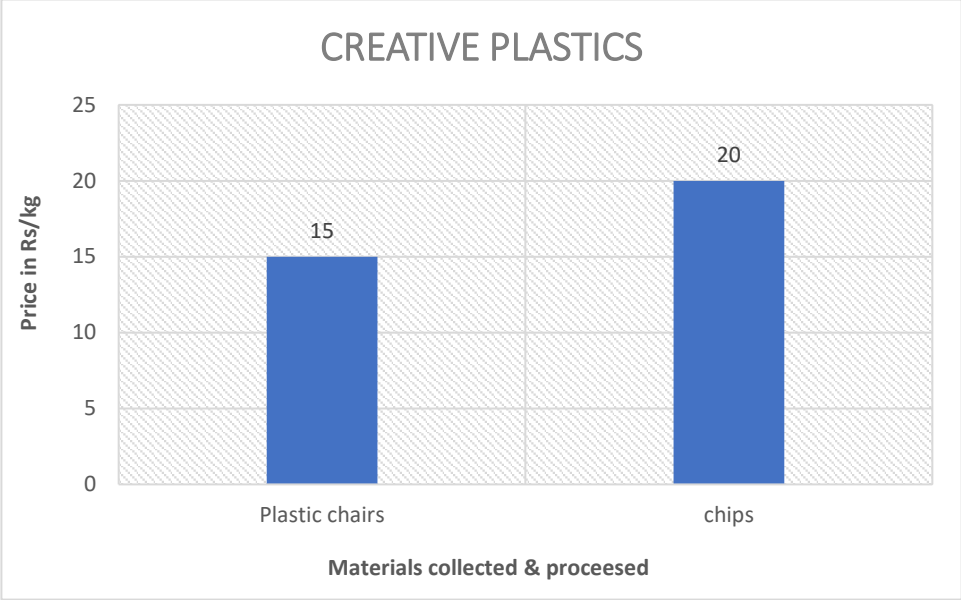


Fig 4.9. Value chain of Creative Plastics

Table: 4.4 provides a summary of the value chain chart of Creative Plastics. Creative Plastics is a plastic recycling unit in Vallom, Perumbavoor. The used plastic chairs are mainly processed in this industry. The waste plastic chairs are mainly collected from the scrap shops for Rs 15/-. After separation and sorting, the materials are grinded to form chips and are sold to other manufacturing units for Rs 20/Kg. The data obtained from this industry also shows that the value is increasing after each of its processing as shown in the value chain table.

Mullappilly Traders:

Table: 4.5 Value Chain Chart of Mullappilly Traders

Serial No	Location	Materials	Price in Rs	Manufactured products	Price in Rs
1	Mullappilly Traders	Plastic Materials	15/-	Granules: Natural PP White PP Black PP	 95/- 70/- 60/-

PP – Poly Propylene

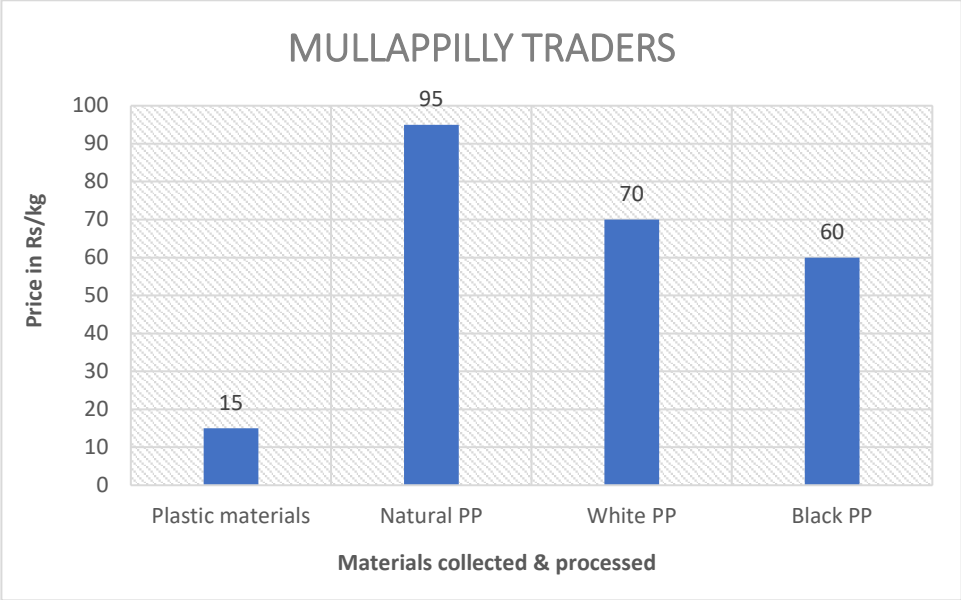


Fig 4.10. Value chain of Mullappilly Traders

Table: 4.5 provides a summary of the waste value chain chart of Mullappilly Traders. Mullappilly Traders is a plastic recycling unit located in Perumbavoor. Here the plastic waste materials are collected at the rate of Rs 15/Kg. After processing it is converted into the form of chips and it is made to pass through the plastic granulator to form granules of different colours as explained in the table and are sold to manufacturing units at the rate ranging from Rs 60/- to Rs 95/Kg The study reveals that value is seen to be increasing after each processing.

Algo Trading Company:

Table: 4.6 Value Chain Chart of Algo Trading Company

Serial No	Location	Materials	Price in Rs/kg	Steps	Final products	Price in Rs/kg
1	Algo Trading company	Plastic items: Bottles Bucket PVC Chairs Fish box White can Blue can Black can	 15/- 25/- 50/- 30/- 50/- 45/- 40/- 40/-	Separation &Sorting Cutting Plastic grinding	Chips: PP (colour separate) PP (colour mix) HD blow mix HD blow colour(blue) HD blow white HD injection colour	 45/- 45/- 50/- 70/- 70/- 50/-

PP – Poly Propylene

HD- High Density Poly Ethylene

Fig 4.11. Value chain of Algo Trading Company

Table: 4.6 provides a summary of the waste value chain chart of Algo Trading Company. Algo Trading Company is a plastic recycling unit located at Perumbavoor. The plastic waste materials like bottles, buckets, cans, etc are collected from various scrap shops at the rates given in the table. After processing it is converted into the form of chips of varying colours and are sold to other manufacturing

units for further processing at a rate ranging from Rs. 45/- to 70/-per kilogram. The value is found to be increasing in each of its processing stage.

Ideal Plastics:

Table: 4.7 Value Chain Chart of Ideal Plastics

Serial No	Location	Materials	Price in Rs/Kg	Manufactured products	Price in Rs/Kg
1	Ideal plastics	Waste Plastic sheets	50/-	Paper Granules: LD granule blue LD granule white LD granule dim white	 78/- 95/- 85/-

LDPE- Low Density Poly Ethylene

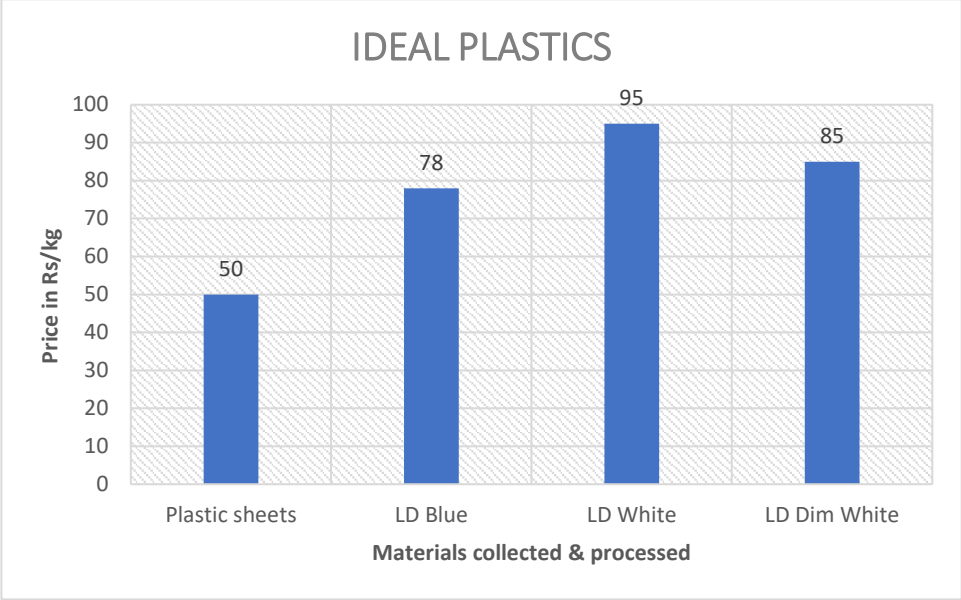


Fig 4.12. Value chain of Ideal Plastics

Table 4.7 provides a summary of the waste value chain chart of Ideal Plastics. Ideal plastics is a recycling industry located at South Aduvassery. The plastic sheets from various sources are recycled here. The sheets are mainly collected at the rate of Rs 50/Kg. After processing it is converted into the

form of granules of various colours like blue, white, etc. and are sold to other manufacturing units at a rate ranging from Rs 78/- to 95/-. In the case of Ideal plastics also the value is seen to be increasing. The tabular column of above given industries infers clearly that the value chain is increasing in every step favouring a way to circular economy and aiming towards sustainability.

4.3. PICTORIAL REPRESENTATION OF WASTE VALUE CHAIN OF EVERSHINE PLASTICS AND HAMARA POLYMER

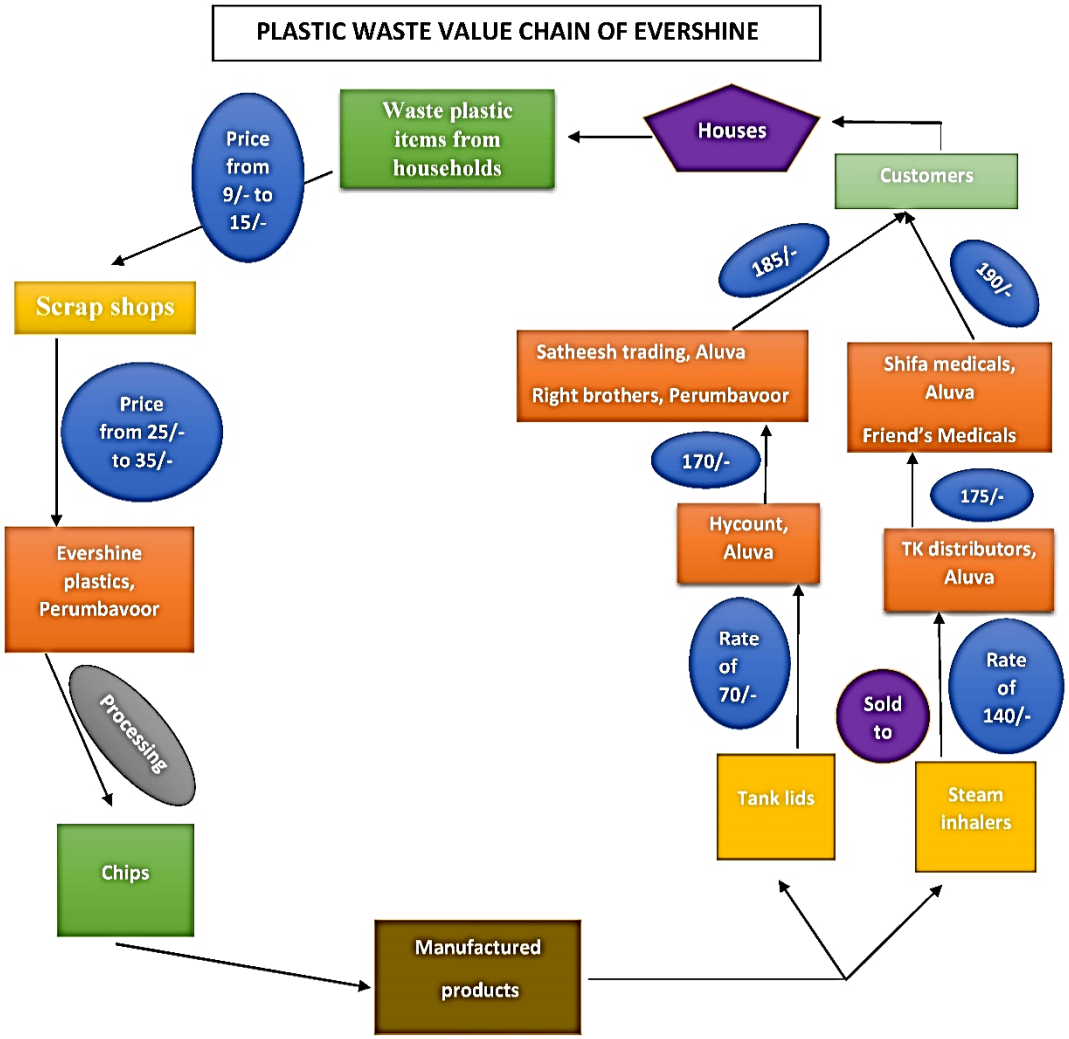


Fig. 4.13. Flow chart of Evershine

The flow chart 4.13 is a diagrammatic representation depicting the value chain of plastic wastes of Evershine. The plastic waste materials are initially collected by the scrap dealers from various households at the rate of Rs 9/- to 15/Kg- to the scrap shops. Then the materials are sold to various recycling industries for further processing and one of it is the Evershine plastics, located in

Perumbavoor. This industry collects the waste materials at the rate of Rs 25/- to 35/-Kg. Further processing of the waste materials makes it in to the form of chips. This industry itself owns a manufacturing unit whereby it processes the chips to form the products like tank lids and steam inhalers. These products then find its way into the wholesale and retail shops and finally to the hands of customers. In the case of tank lids, the industry sells its product to the wholesale shop named Hycount (Aluva) at the rate of Rs 70/-. From the wholesale shop it is again sold to the retail shops like Satheesh Trading (Aluva) and Right Brothers (Perumbavoor) at an average price of about Rs 170/ per unit. Then it reaches to the hands of customers at an average rate of Rs 185/unit. Also, in the case of steam inhalers, the product is first sold to a wholesale shop named TK Distributors (Aluva) by the industry at the rate of Rs 140/unit. From the wholesale shop, it finds its way into the retail shops like Shifa Medicals (Aluva) and Friend's Medicals (Perumbavoor) at the rate of Rs 175/unit. Then, finally it reaches to households through customers at an average rate of Rs 190/unit. It is seen that the value of the waste product is increasing from its initial level to final level of processing. Thus, making it a valuable resource that is to be considered with utmost priority for protecting the environment and its resources through the sustainable use.

The flowchart 4.14 is a diagrammatic representation explaining about the waste value chain of Hamara polymers. Initially, the waste plastic materials are collected from the households by the scrap dealers at the rate of Rs 9/- to 15/kg and are directly sold to the scrap shops. From the scrap shops, this recycling unit buy various plastic items for amount varying from 10/- to 40/Kg. They also collect various waste materials from Harithakarmasena. After collection, initially the waste materials are segregated and sorted and are grinded to form chips which are again processed to form granules. These granules are then moulded to flower pots. The flower pots are sold to various pottery shops at an average rate ranging from Rs 16/- to 100/Unit. The rate variations are based on its size. It is estimated that from the shops, the pots are sold directly to the customers at the rate ranging from Rs 20/- to 150/-. Also, the Harithakarmasena members collect the pots directly from the industry for Rs 23/- and they sell it for Rs 25/-. Thus, it is to be noted that a considerable increase in the value of waste flow is seen from its collection to its distribution stage and thus favouring circular economy

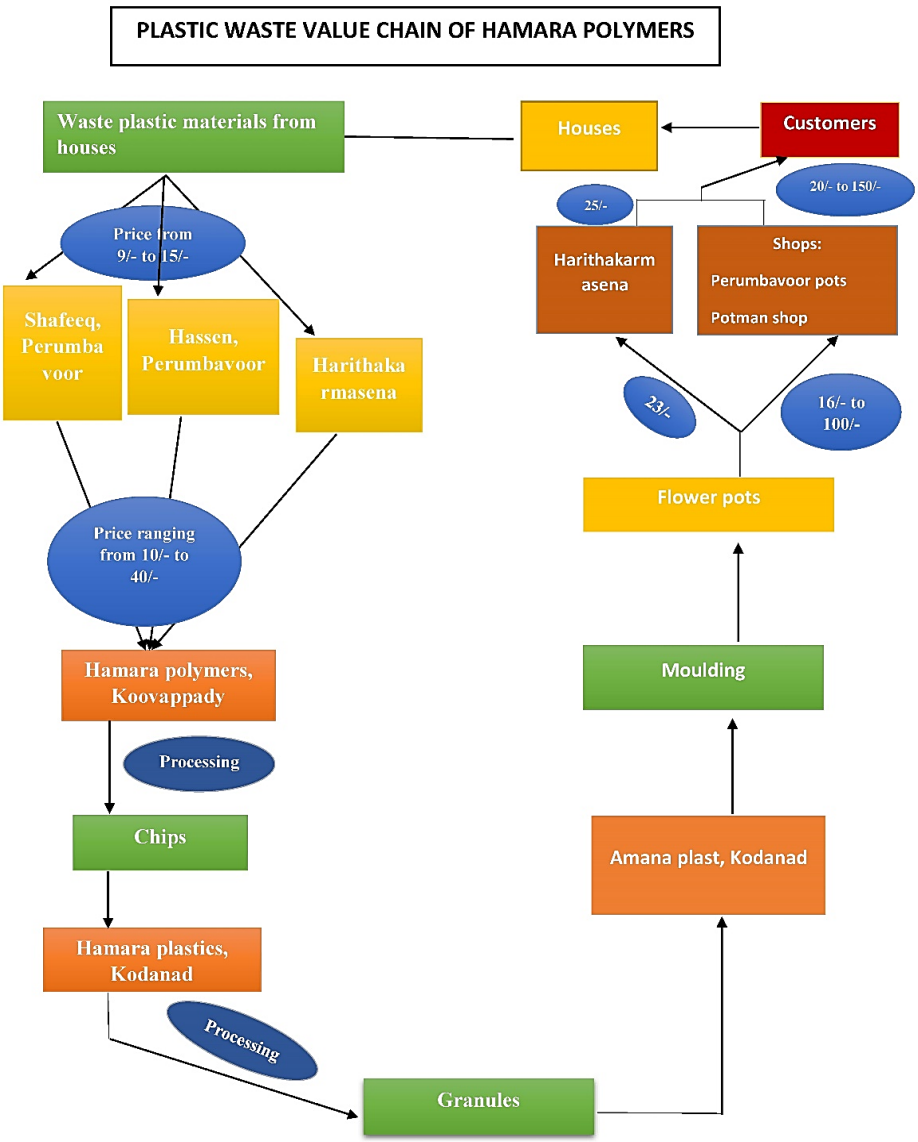


Fig. 4.14. Flow chart of Hamara Polymers

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4.4. DISCUSSION

The study results shows the significance of need of value chain and its increase in probability leading to circular economy. Our existing plastic waste management system and infrastructure are restricted by inadequacies and inefficiencies to deal with the fluxes of waste generation. There is a need for innovations in existing products and technologies which would inspire economic and environmental efficiency which leads to zero waste situation. Moreover, the integration of new sustainable technologies into the current waste management system would envisage a future in which all plastics are either reused or recycled. Results of the key findings make it apparent that fragmented research

is being dedicated towards the necessity of adopting sustainability and circularity practices within economies for the continued sustenance of environment and development.

The principles and practices surrounding the concept of circular economy have gained widespread recognition within scientific community in recent years which was evident from the results of the survey and primary data collection as the search hit 'circular economy yielded the maximum number of results. Sorting of articles based on the relevance in each category revealed that several articles approached CE through waste management as well as through improvement in product/ process efficiency. Furthermore, the developed and fast emerging economies from United States, Europe and South Asia were combined with the keyword CE to comprehend research efforts dedicated to this concept at national scales. Search results yielded maximum results for Evershine Plastics, Perumbavoor followed by Hamara Polymers, Koovappady. This is also visible in their practice during this research study.

4.5. KEY FINDINGS:

- Collection and elucidation of data and preparation of Perumbavoor ward boundary map and submission of the same to the municipality which can be utilised for their future work.
- Prepared the shortest enroute maps for the transport of plastic wastes
- The value chain increases and is directly proportional with increase in the quantity of the plastic waste
- Considerable achievements in circular economy through efficient management of plastic waste through enforcement of management policies related to 'zero waste'

CHAPTER 5

5.0 CONCLUSION

The circular economy relates to the concept of value chain. Important factors of a circular plastics economy are product functionality, recyclability and/or biodegradability. The negative repercussions of linear value chains are promoting transitions towards circularity. CE essentially targets increasing availability per unit of resource extracted through reutilization, waste minimization and value-added production. The present analysis focused on assessing the role of research in CE in context of the plastic waste management sectors of India. Restructuring our policies around psychological and behavioural aspects of social awareness, incentivizing sustainable products and processes through tax cuts, discouraging low recyclable plastic products, encouraging public-private investments in research and infrastructure would help in achieving inclusive and sustainable plastic waste management. Our strategies and action should reflect our readiness for any future crises so that we should not have to choose one crisis over another.

The present study is based on the value chain analysis of plastic waste materials. Our history makes it evident that Indian plastic industry made a vigorous beginning in 1957. Extrapolation of plastic waste generation data from 60 major cities showed that around 25,940 tonnes of plastic waste per day (TPD) is generated in India (Rashmi Shrivastav, 2019). The simplest way to reduce plastic waste is to avoid unnecessary and single-use plastics, support businesses who are reducing plastic waste and re-use existing plastic (DCCEEW, 2021). With advanced recycling, the used plastics can be converted into new products, which helps keep them out of the waste stream. Advanced recycling will help create a circular economy for plastic, in which plastic is reused instead of discarded (https://www.businessinsider.com, 2022).

A detailed physical visit to all the plastic recycling units in the selected study area was made and was able to uptake the waste flow and thereby elucidate the plastic waste value chain and aiming towards a sustainable future.

5.1 The way forward

Valorisation of waste materials is an emerging topic in the concept of solid waste management. This paper can be used as a reference to identify the value chain of other solid waste materials and circular economy pattern in the study area. The Perumbavoor ward boundary has been reproduced and is submitted to the municipality and which can be utilised by them for further use. Though this paper

only concentrates on plastic waste materials, this study can further be used to identify the value chain of other solid waste materials that can be recycled and regenerated as new products and also to know about the economy pattern that exists in case of several waste materials as a part of the research study.

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ANNEXURE 1

HOUSEHOLDS

Household survey form

1.	Name of owner
2.	Location of House
3.	Types of waste generated
4.	How the waste materials are stored before collection
5.	How the materials are sold to shops – either directly /through scrap workers
6.	Price to which the materials are sold
7.	How often the workers came to collect the waste materials
8.	Do you segregate waste into wet and dry
9.	How do you manage your food waste
10.	What are the kinds of plastic waste generated
11.	How much you pay as service charger/user fee for waste management monthly
12.	Is the SWM in the municipality is effective
13.	If a more effective solid waste service is provided by the Municipal corporation, are you ready to pay for it in the form of user fee

ANNEXURE 11

SCRAP DEALERS

Scrap dealers survey form

1.	Name of the shop
2.	Type of Business
3.	Name of owner
4.	Location of the shop
5.	Total number of employees
6.	Source of waste collection
7.	Types of waste and price of their collection
8.	Details of the industries to which the waste materials are sold
9.	The approximate price received for each type of waste sold

ANNEXURE 111

RECYCLERS

Recyclers survey form

1.	Name of the industry
2.	Name of owner
3.	Location of the industry
4.	The types of waste materials collected
5.	Total number of employees
6.	The areas/sectors from which the waste materials are collected
7.	The approximate price for which the waste materials are collected
8.	About MRF/MCF
9.	Amount and type of waste that can be recovered/recycled
10.	About the segregation and recycling processes and its methodology
11.	Peculiarity of each waste collected and to which extent its recovery is possible
12.	About the different processes taking place in this industry
13.	The amount of waste materials recovered
14.	Type of materials gone as waste itself
15.	Demand for raw material in the market
16.	How the value of a waste material changes after each process
17.	To which all manufacturing industries the raw materials are sold
18.	Which material is in great demand
19.	Price to which the materials are sold

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