

Institutional Adaptation of a Few Selected Public Sector Institutions in Kerala in the Context of Climate Change

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Abstract

The paper investigates the adaptation strategies of public sector institutions in Kerala in response to climate change, highlighting their eco-friendly initiatives. The study underlines the critical role of institutional frameworks in facilitating effective adaptation measures that align with sustainable development goals. For realisation of the objective this study used a case study approach on adaptation strategies of selected public sector institutions in Kerala. The work focuses on three public institutions MG University, Kochi Metro Rail Limited & Kochi Water Metro Limited, and Cochin International Airport Limited (CIAL), which serve as models for implementing eco-friendly projects. By utilizing both primary and secondary data, the study analyses the economic valuation of their eco-friendly initiatives and their effectiveness in addressing climate vulnerabilities. The findings underscore the necessity for tailored solutions that address local vulnerabilities while promoting resilience against climate impacts. This work contributes to the broader discourse on climate adaptation by providing insights into how public institutions can lead in implementing sustainable practices that mitigate environmental challenges.

Keywords: *Climate Change Adaptation, Institutional Frameworks, Sustainable Development, Resource Conservation, Residue Disposal and Management.*

1. Introduction

The increasing climate vulnerabilities has prompted the world towards the need for effective adaptation strategies. This paper delves into the intricate relationship between institutional-level eco-friendly projects, climate change adaptation, and sustainable development while analysing some of the cost-benefit dimensions of such initiatives. The institutions selected for the analysis are Mahatma Gandhi University (MGU), Kochi Metro Rail Limited (KMRL), Kochi Water Metro Limited (KWML) and Cochin International Airport Limited (CIAL). These are pivotal public sector institutions in Kerala, which contributing significantly to the region's socio-economic landscape along with attracting international appreciation for its performance in different areas. MGU, established in 1983, is a prominent state university known for its emphasis on research and sustainable development. KMRL plays a crucial role in enhancing urban mobility through the implementation of eco-friendly metro services and along with this Kochi Water Metro Limited (KWML) aimed at enhances urban transportation in Kochi, by integrating water-based transit systems with existing public transport networks. While CIAL stands out as the world's first fully solar-powered airport, showcasing innovative approaches to sustainability and environmental stewardship. Together, these institutions exemplify the integration of eco-friendly practices within public infrastructure, addressing climate change challenges while promoting sustainable development.

Apart from the introduction this section contains the review of literature. The second section deals with method of study and conceptual framework. While the ensuing section delves with the data analysis of the selected public sector institutions. Then concluding remarks are given in the last section.

1.1 Climate change

According to the United Nations Framework Convention on Climate Change (UNFCCC), “Climate change means a change in the climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere, and which is addition to the natural climate variability observed over comparable time periods” (UNFCCC’s Article-1 Definitions). The United Nations defines climate change as the long-term shift in the temperature and the weather patterns. Before 1800 the shifts had been natural because of volcano eruptions etc. but since 1800 the human activities have been playing a major role in these shifts through the burning of the fossil fuels, deforestation etc. (IPCC Sixth Assessment Report, 2023). Early observation of the climate change, in terms of increase in the

temperature, was first tracked by the French Mathematician and Physicist Fourier in 1824, and he wrote that different gases in the atmosphere trap the heat and make the planet warmer. After him there were a series of publications presented by various scholars and researchers like Newton Foote, John Tyndall and Guy Callender revealed the increase of gases like the carbon in the atmosphere that leads to varying the climate. In 1953 Canadian Physicist Gilbert Plass (1953) warned that the anthropogenic carbon dioxide emissions give rise to an increase in the surface temperature at a rate of 1.5 degrees per century. Followed by him an array of publications entered the mainstream mainly by researchers like Syukuro Manabe, Richard Wethrald and many other palaeoclimatologists (Gomystym, 2024). The study related to the weather and the climate change became easy for the scientists with the adoption of the sophisticated modern technologies, which enabled them to launch the satellite programs for studying the Earth's weather and atmosphere. The first satellite was launched in the 1960s to study the earth's climate by NASA, for example, Nimbus, TIROS-1 etc. Recent initiatives include the PREFIRE (Polar Radiant Energy in the Far-InfraRed Experiment) mission, PACE (National Aeronautics and Space Administration, 2024), Earth CARE (European Space Agency, 2024) etc.

1.2 Impact of climate change

The sudden changes in climate have a significant impact on the survival of life forms on the earth. It has a far-reaching effect on the earth and on its living creatures. The impact of the climate change is diverse and many, it can be analysed from different dimensions, and the effect of the climate change is considered detrimental or beneficial according to the negative and positive aspects evolved from that action (Review of Environmental Economics and Policy 2018). The possible impacts of the climate change are the varying temperature patterns, seasonal variation, ocean dynamics which include the sea level rise and marine currents, increasing the concentration of the CO₂, which in turn lead to the variation in the pH of the ocean, in addition, the increased or reduced amount of precipitation will lead to the floods, otherwise extreme drought, both in turn pose threat to both biotic and abiotic organisms. All these impacts affect the species, biodiversity, population, ecosystem and the biome scale (Céline Bellard et.al, 2012).

Human actions from the ancient times also affected the environmental system in the form of deforestation, with the advent of agriculture and the increased population, even so the pressure exerted by human activities was at a tolerable level and the earth had the capacity to

regenerate. But innovations like the steam engine, which paved the way for the industrial revolution resulted in the increased burning of fossil fuels and ultimately the major cause for the temperature variations. The initial evidence of the climate change is observed through the reduction in the glaciers and the decreasing amount of the snow cover in the mountain ranges and the reduction in the extent of the arctic ice, in addition to these the other facts about the climate change is noticed through the research conducted on the tree rings and the desertification happened in the Sahelian countries of the Sub-Saharan Africa (Markham, 1996). Recent evidence such as, reduction in the thickness of the arctic ice sheets (it was typically 2 to 3 meters and in some regions it was 5 meters and now it reduced to 1 to 3 meters) indicates the arctic sea is warming highly (National Snow and Ice Data Center,2024), compound weather events leads to the simultaneous flood in Portugal and the Saharan dust outbreak (Pons, F. et.al., 2024), landslide in the Wayanad district of Kerala, the increasing vegetation cover and the changes in the soil chemistry of Antarctica (Nature Geoscience, Cannone, N.et.al., 2021) etc.

Human induced issues related to the climate change is viewed at a global scale, but the effects are highly detrimental for the local communities residing over the areas that are very vulnerable to climate change. The hurricane Ida did not create a landslide but caused rain effects which led to flooding in New Jersey (New York State Department of Environmental Conservation ,2021), decreasing the lobster population in New England due to the rising of the ocean temperature which affected the economic base of the communities that rely on the lobster fisheries.

1.3 Economics of climate change adaptation

Climate change adaptation is all about adjustment mechanism which tries to deal with the effects of increasing environmental issues. The Economics of Climate Change Adaptations (ECA) studies how to keep down the negative impact of climate change on the economy while amalgamating adaptation into economic development. The ECA methodology is a tool that helps decision makers understand the impact of climate change and identify cost-effective adaptation measures. In 2007 Intergovernmental Panel on Climate Change (IPCC) defined adaptation to climate change as “adjustments in natural and human systems in response to actual or expected climate stimuli or their effects, which moderate harm or exploit beneficial opportunities” (IPCC, 2007). The Adaptation activities can take on different forms, there is no ‘one-size-fits-all-solution’, depending on the context of a

community, business, organization, country or region it will differ. Such initiatives can range from building flood defences, setting up early warning systems for cyclones, switching to drought-resistant crops, to redesigning communication systems, business operations and government policies. Many nations and communities are already taking steps to build resilient societies and economies. However, this needs cost-effective inventions and innovations (UNFCCC, 2024).

1.4 Institutional level adaptation to climate change

Institutional adaptation means the actions taken to adjust the governance to the new (experienced or expected) climate conditions to moderate the impacts of the climate change on the individuals, infrastructure and ecosystems (Patterson, 2021). Here the institutions refer as the rights, rules and the decision-making procedures. This can be formal or informal. The formal aspects include the laws, procedures and policies and the informal aspects refers to the routines, beliefs and norms. Among the different dimensions of the climate adaptation, the institutional level adaptation primarily focuses on the planning (Patterson, 2021). These institutions such as the norms, rules etc. will affect the collective action and govern the social behaviour (Helm, et.al, 2024). According to the UNFCC Adaptation Committee the institutional adaptation does not have a single definition, and the term can be used in many different forms and contexts. They state that the institutional arrangements for the adaptation are those structures, approaches, practices or rules set for the stakeholders to steer adaptation at all levels for: assessing impacts, vulnerability and risks; planning for adaptation; implementation of adaptation measures; and monitoring and evaluation of adaptation (UNFCC Adaptation Committee,2014). Even though the institutional level adaptation is crucial for adapting to the existing climate variations, it must face many challenges like concentrations of the central government in the policy formulation, ineffective implementations, non-inclusive nature of the government, the inadequate governance etc. For example, in the case of the Kyoto Protocol 180 countries ratified the protocol but the United States has not and there are many issues evolved regarding the large amount of the reduction in the emissions (Ampaire, et.al, 2017; Ostrom, 2009). So, in contrary to the collective action proposed by the classical many economists like the Elinor Ostrom raises the idea or the slogan “Think Globally but Act Locally”, in essence it means the adaptation should be focus on the micro level that is from the individuals, families, community and the society (act locally) because the more vulnerable groups of the climate change will be the local communities (Ostrom, 2009).

In the study related to climate change adaptations of coastal communities in South India by Thomson explains how Governance and Institutional constraints act as one of the barriers to climate change adaptation. It includes institutional constraints, missing legal basis, administrative structure, institutional governance issues along with institutional fragmentation (adaptation strategies depend on the interaction of various sectors and policy levels) and different institutional settings and standards (Artistic Report, 2019).

1.5 Institutional level adaptation and sustainable development goals

The Sustainable Development Goals (SDGs) are a universal framework established by the United Nations in 2015, comprising 17 goals aimed at addressing global challenges such as poverty, inequality, climate change, environmental degradation, peace, and justice. These goals are part of the 2030 Agenda for Sustainable Development, which seeks to transform the world by ensuring that all people enjoy peace and prosperity while protecting the planet (<https://www.undp.org>). In the context of this study the question is that which is the most appropriate SDG in relation with institutional level adaptation. Within the 17 SDGs, Sustainable Development Goal 12 (SDG 12) emphasizes the necessity of ensuring sustainable consumption and production patterns as a fundamental approach to addressing environmental challenges and promoting sustainability is accurate to this context. This goal is crucial for adapting to environmental changes and mitigating resource depletion. SDG 12 aims to achieve several targets by 2030, including halving per capita global food waste at retail and consumer levels and achieving the environmentally sound management of chemicals and all wastes throughout their life cycle (United Nations, 2023). The effective implementation of SDG 12 requires collaboration among governments, businesses, and consumers to foster practices that reduce waste generation, enhance resource efficiency, and promote sustainable practices across various sectors (Bengtsson et al., 2018).

2. Method of the study

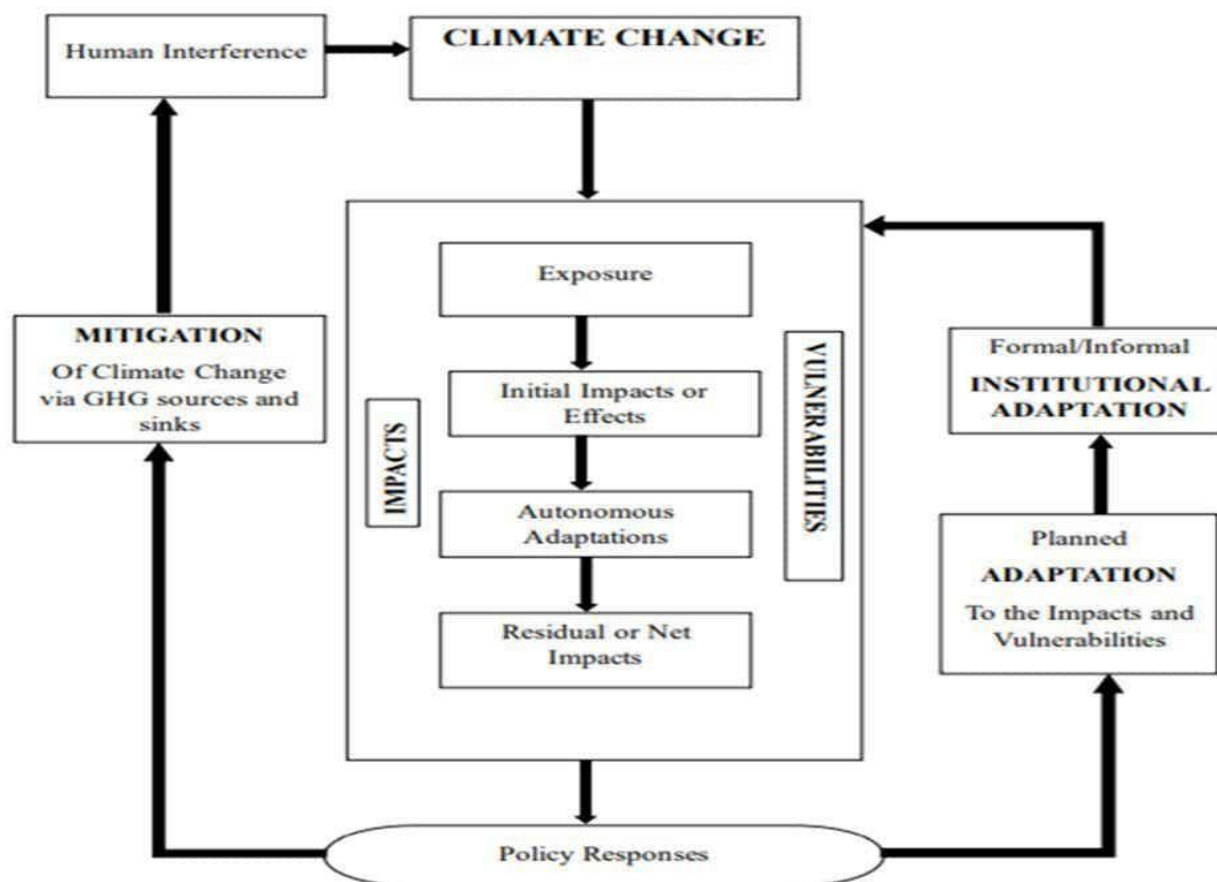
This study focuses on institutional adaptation and three public institutions are selected which are models to a certain extent in adapting eco-friendly projects. They are MG University (State Public University), Kochi Metro Rail (State-Central Project) and CIAL (State- Pvt. Participation). Both secondary and primary data are used in this study, but the former one is prominent. The study is related to the eco-friendly projects of the above-mentioned institutions. Economic valuation of technical data provided by these institutions are used for

data analysis other than the usual descriptive statistics. Fisher's exact test is used in certain cases. The conceptual frame of the study outlined in the 2.1.

2. 1 Conceptual framework

As mentioned in section 1.1, the deviation from the equilibrium of nature can occur due to natural and anthropogenic factors. The former factor has a prolonged tradition but the latter is relatively new. Climate change is one of the serious ramifications of the human intervention on environment. As climate change is a long run phenomenon it can generate long lasting impacts on earth. The impacts cause temporary or sustainable changes in the ecological system. When the living and non-living communities are exposed to such impacts the members of the community and the system itself would try to adapt to the impacts in due course of time. The preliminary impacts or effects may be naturally adjusted (autonomous adaptation) which may culminate in restoring the equilibrium. It need not happen always. However, such adaptations will not be sufficient to meet all the impacts especially those with sustainable effects. If the remaining impacts have a negative dimension the climate change would result in scenarios of vulnerabilities. In fact, vulnerabilities are the negative residual effect of climate change. In certain circumstances a policy maker or community can foresee such vulnerabilities and can adopt early interventions. To minimise the expected vulnerabilities flood control measures and shifting coastal inhabitants to a reasonably distant location from the coast are two examples of early action. This falls under mitigation measures. All the impacts cannot be foreseen so that policy makers and communities need to make schemes to minimise the occurred vulnerabilities. Adaptations beyond autonomous are relevant in this context. Adaptations can be done at personal, household, community and formal institutional level. The first two types of adaptation can be done at micro level and the latter two can adopt at macro or meso level. In the present study adaptations by a few formal institutions are accounted that falls under planned adaptations. Such adaptations are the results of policy responses.

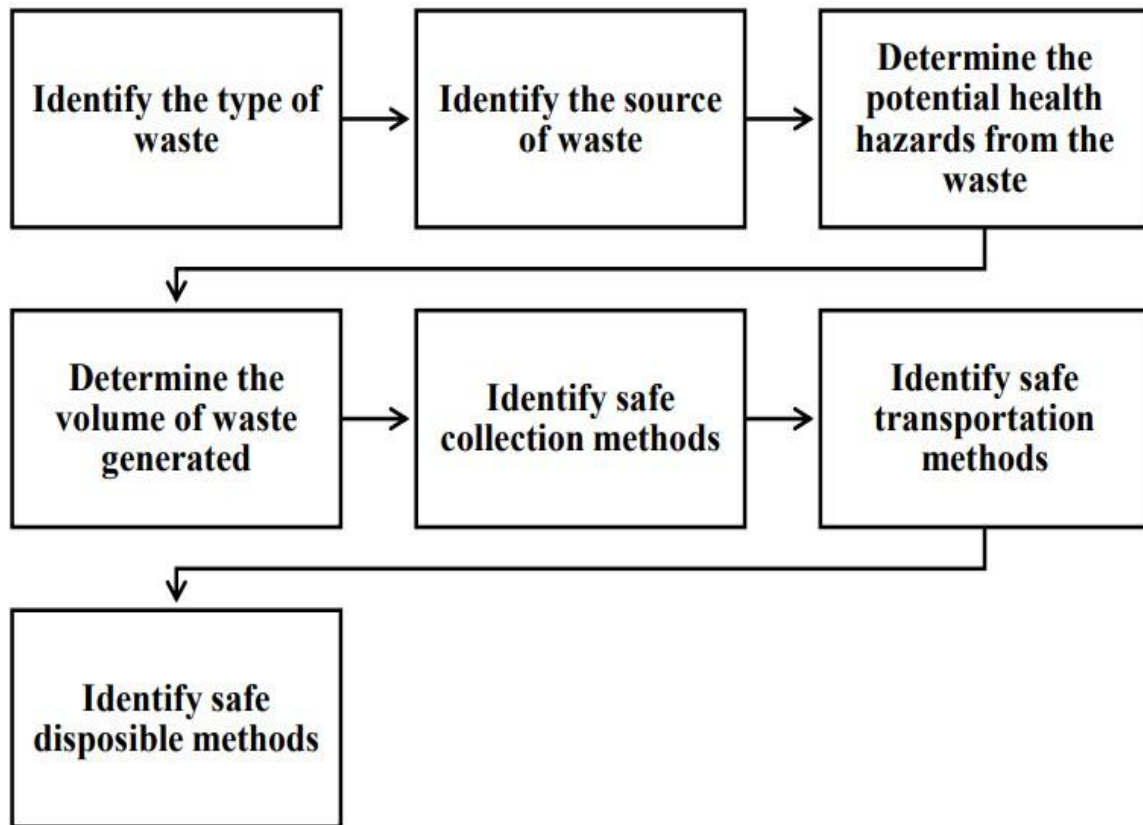
Figure 2.1: Conceptual Framework for Climate Change, Mitigation and Institutional Adaptation



Source: Adapted from Africa Climate Change Ambassador Program (Youniz,2022)

Human interventions including formal institutions generate residues (waste). Policy responses must be able to minimise residue formation or the system should be able to dispose it properly. European Commission has excellently compiled its procedure (2025). This study also refers to steps in the solid waste management envisaged by European union for analysing the food residue disposal/conversion discussed in the data analysis Section 3.1.1. Figure 2.2 represents the different steps involved in solid residue management from identifying types of residues, its source, possible health hazard, its volume to its safe collection, transportation & safe disposal methods. This procedure is part of transforming from unsustainable to sustainable stage. The figure 2.3 indicates the environmental unsustainability and sustainability dynamics discussed in this study. Specially in the context of eco-friendly projects and resource conservation projects of selected public institutions. As already mentioned in the introduction the concepts.

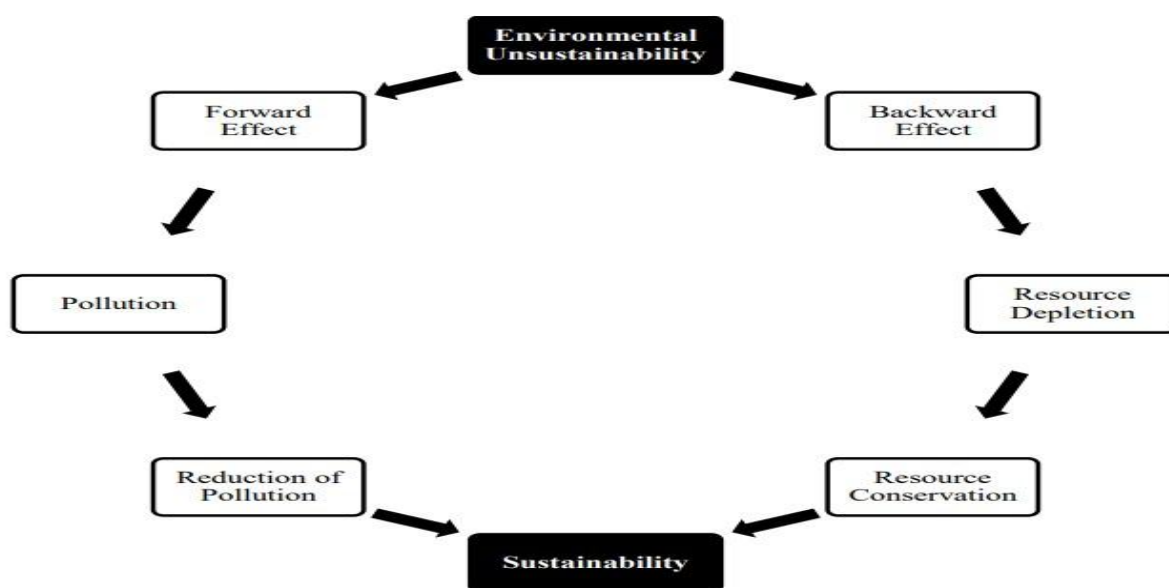
Figure 2.2: Alpha to Omega of Residue Formation and its Disposal



Source: European Commission, (2025)

described in this section come under the SDG 12 which deals with responsible consumption and production.¹ (<https://www.un.org/sustainabledevelopment/>). The unsustainability phenomena like global warming, deforestation etc. have both forward and backward effects. Pollution is an example of forward effect while resource extraction is a case of backward effect. If solid residue dumping is unsustainable, its safe disposal is sustainable. Meanwhile, resource conservation is (ex. Rain harvesting and tree planting) is a sustainable action from the backward side. Institutional adaptations can occur in this backdrop.

¹ Goal 12 is related to ensuring sustainable consumption and production patterns, which is core to sustain the intergenerational livelihoods

Figure 2.3: From Unsustainable to Sustainable

Source: Conceptualised from Ekins, 2000

The scenario in figures 2.2 and 2.3 can be observed from another angle too. The circular economy method and institutional adaptation strategies are two critical approaches for addressing climate change. The circular economy focuses on sustainable resource use, while institutional adaptation involves structural changes to enhance societal resilience towards climate change. Together, they offer a framework for reducing emissions and building adaptive capacity.

The European Union's approach to solid waste management is fundamentally linked to its circular economy initiatives, which aim to transition from a linear economic model to one that emphasizes sustainability and resource efficiency. The Waste Framework Directive (2008/98/EC) establishes a comprehensive regulatory framework that prioritizes waste prevention, reuse, recycling, and recovery, mandating specific recycling targets for member states. Through such actions, the waste transform to residue which promotes sustainable design and value addition (European Commission, 2020).

3. Selected cases

Mahatma Gandhi University (MGU), established on October 2, 1983, is a prominent public educational institution located in Kottayam, Kerala, India. The university is situated on a 110-acre campus in Priyadarsini Hills, Athirampuzha. It serves a diverse student body, including both national and international scholars, through its comprehensive range of academic programs across various disciplines. In the context of residue (waste) generation and disposal methods, MGU has undertaken significant initiatives aimed at promoting eco-friendly practices. The university's commitment to sustainability is exemplified by its Advanced Centre of Environmental Studies and Sustainable Development (ACESSD), which focuses on interdisciplinary research and education in sustainable resource management and residue management practices.

The KMRL project is one of Kerala's influential public transport systems. It was inaugurated on June 17, 2017, marking the commencement of passenger services on the 13.2 km Aluva Palarivattom corridor and now it is extended to Thrippunithura railway station. KMRL aims to make Kochi the first city in the country where the entire public transport system: the metro, the buses, the boats, the auto-rikshaws and the taxis work together as an integrated system; with a common timetable, common ticketing and centralised 'command and control.' Complementing KMRL is the Kochi Water Metro Limited, launched in December 2021, India's first water metro project, designed to integrate water transport with existing urban transit systems, further improving connectivity across the region.

The Cochin International Airport Limited is the first ever fully solar powered airport in the world which was started its operations on 25th May 1999, owned and operated by Cochin International Airport Limited (CIAL). It is the first airport in India built under Public Private Partnership (PPP).

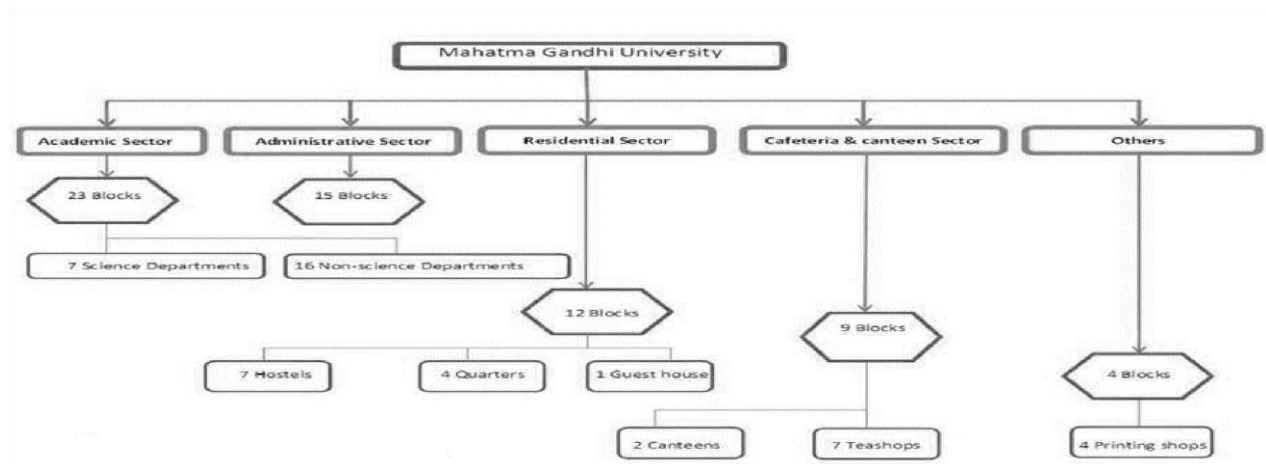
Now green initiatives of these three institutions can be considered starting with MG university.

3.1 Mahatma Gandhi University

MGU has implemented innovative residue management strategies that convert organic residue generated on campus into valuable products such as plant food and potting mixtures through aerobic composting. Such initiatives not only address residue disposal challenges but also contributes to the university's sustainability goals by transforming residue into a source of revenue. Through these efforts, MGU exemplifies how educational institutions can lead in

adopting ecofriendly practices while simultaneously providing economic benefits. Also, the water storage and distribution system and management of other types of waste items are commendable. Figure 3.1 provides an overview of the organisational structure and facilities available at the institution and each produces distinct types of residues, and the intensity varies.

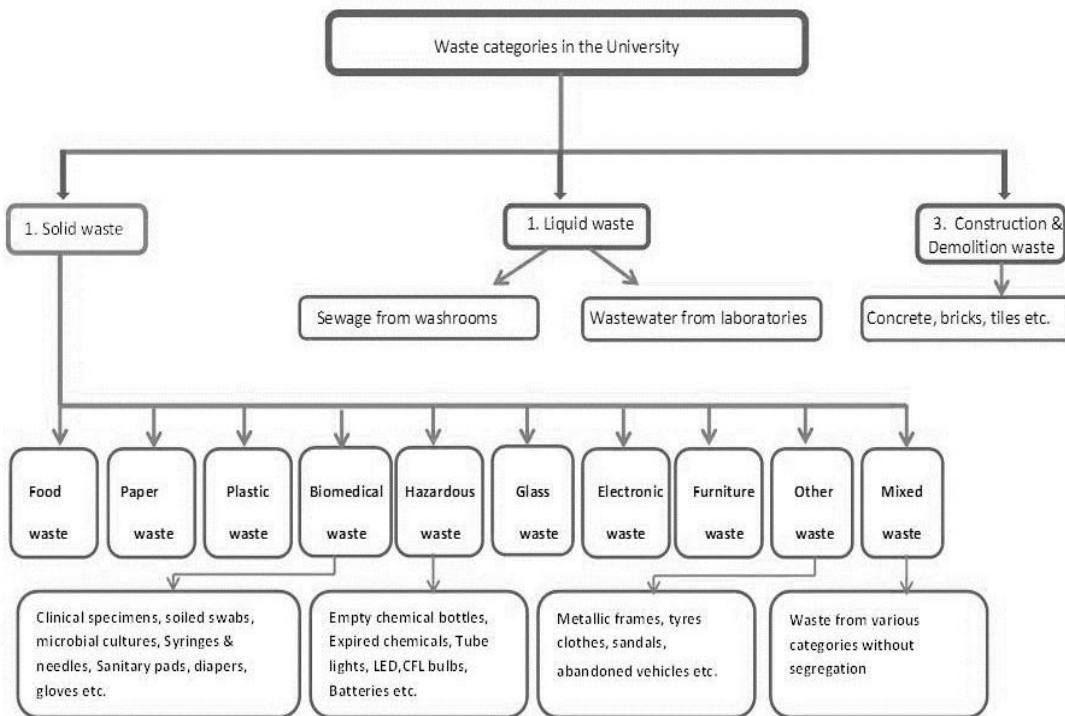
Figure 3.1 Organisational Structure Mahatma Gandhi University



Source: Waste Audit Mahatma Gandhi University 2024

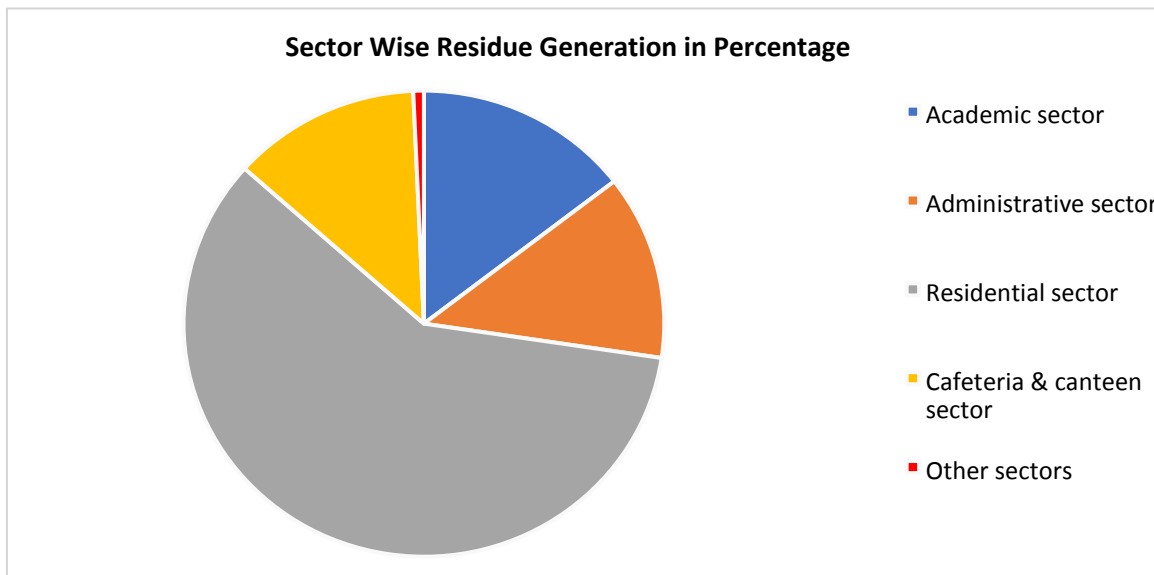
The university generates diverse categories of residue, reflecting the varied activities within its campus. These include solid residue, such as food, paper, plastic, biomedical, hazardous, glass, electronic, furniture, and mixed waste, often comprising clinical specimens, chemicals, and discarded materials (Figure 3.2). Figure 3.2 exhibits the residue categories. This study uses secondary data from the 'Waste Audit' conducted by Mahatma Gandhi University in 2024 along with the primary data for detailed analysis. In the context of this study, the items referred to as waste in the original study are redefined as residue. According to WHO waste is defined as any substance or object that the holder discards, intends to discard or is required to discard and here the discussion is related to value addition and effective management of the mentioned items, which keep them out of the conventional definition of waste as waste is something that is problematic in day-to-day life.

Figure 3.2



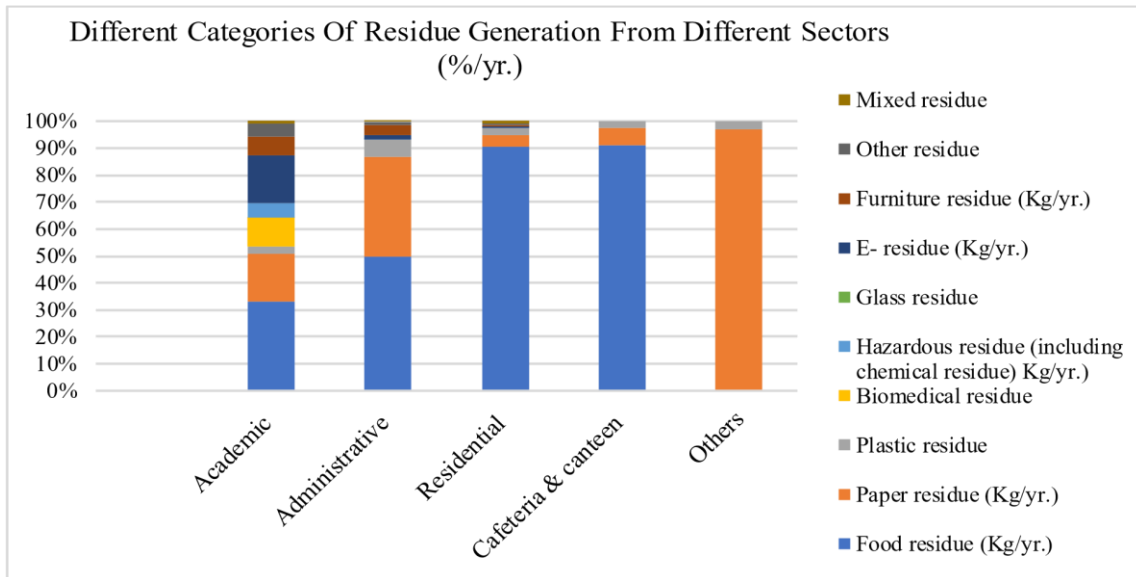
Source: Waste Audit, Mahatma Gandhi University 2024

Figure 3.3: Sector Wise Residue Generation In Percentage



Source: Waste Audit, Mahatma Gandhi University, 2024

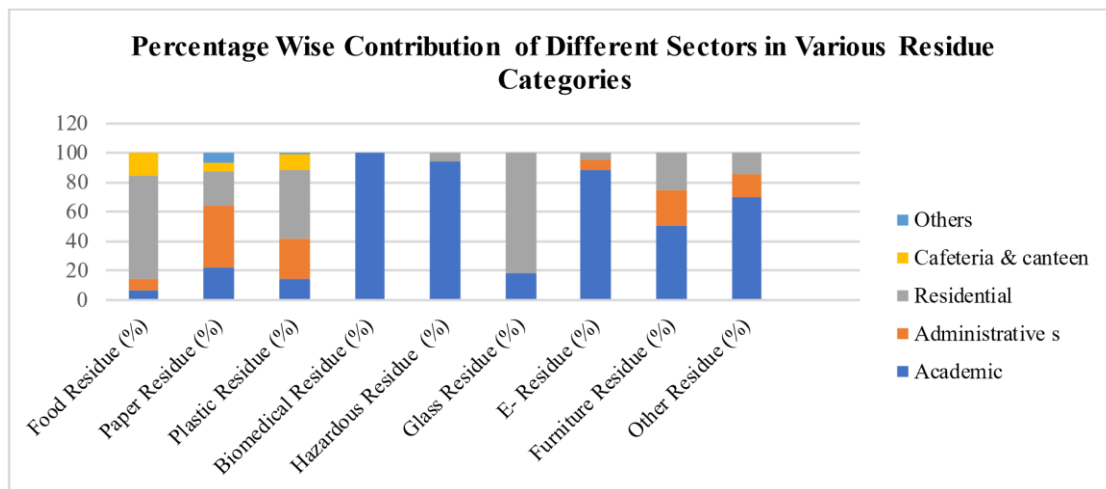
Figure 3.4: Different Categories of Residue Generation From Different Sectors (%/yr.)



Source: Waste Audit, Mahatma Gandhi University 2024

The pie diagram (Figure 3.3) shows the overall sector-wise residue generation in percentage, highlighting that the residential sector is the largest contributor to campus residue generation, followed by the cafeteria and Canteen sectors. The figure 3.4 complements the facts by displaying the share of different categories of residue generation from different sectors of the university. The data (Figure 3.4) reveals the predominance of food residue in most sectors, particularly in the cafeteria and canteen and residential sector.

Figure 3.5: Percentage Wise Contribution of Different Sectors in Various Residue Categories

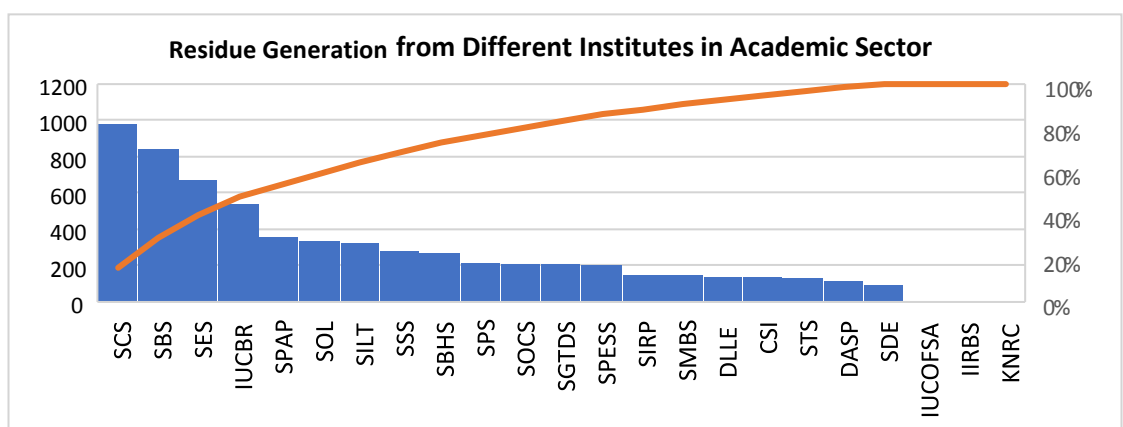


Source: Waste Audit, Mahatma Gandhi University, 2024

The figure 3.5 depicts the percentage-wise contribution of different institutional sectors to various residue categories, highlighting distinct patterns in residue generation. The residential sector dominates in food residue generation followed by Cafeteria & Canteen sectors, while Academic and Administrative sectors contribute significantly to paper, biomedical, and hazardous residue, reflecting their operational activities. Additionally, e- residue is primarily linked to academic activities. This information underscores the need for tailored residue management strategies that address the specific residue profiles of each sector to promote sustainability and efficiency.

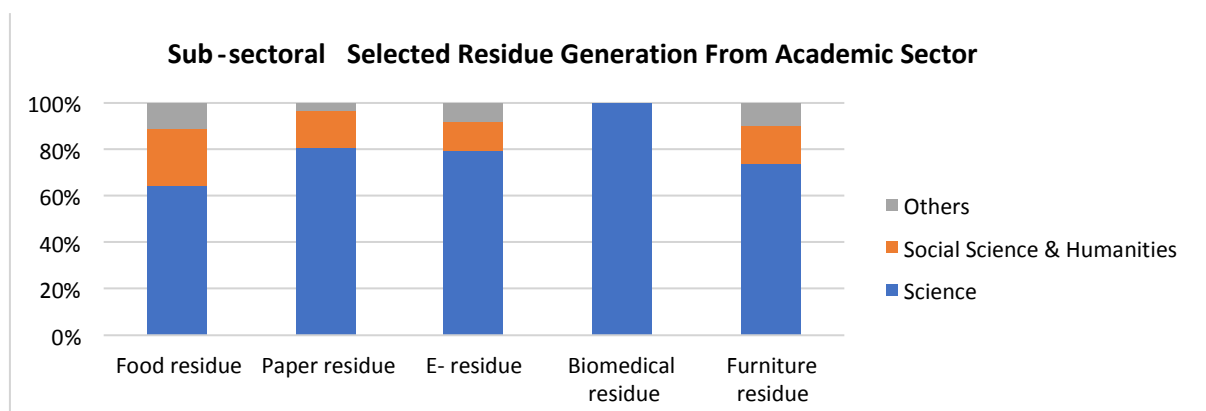
The academic sector has its contribution in the generation of every type of residue even if it varies in the amount. Further analysis is associated with academic sector.

Figure 3.6: Residue generation from different institutes in academic sector



Source: Waste Audit, Mahatma Gandhi University, 2024

The Pareto chart in figure 3.6 depicts residue generation from various institutions in the academic sector, with the bars showing the quantity (in descending order) and the cumulative line indicating the percentage contribution of each institute to the total. It highlights that a few institutes, such as SCS, SBS, and SES, contribute significantly to the overall waste, while the others have comparatively lower contributions. Then for deriving more insights, the academic sector is divided into 3 subsectors and 5 major residues are selected from these subsectors. Such selected residues have weight more than 1000kg/year.

Figure 3.7: Sub-sectoral Selected Residue Generation from Academic Sector

Source: Waste Audit, Mahatma Gandhi University, 2024

² The full forms of names of different academic institutions in figure 3.6 are given in the appendix I

Within the selected residues from all the departments, statistically significant result is found in the case of paper residue according to the fishers exact test (table 3.1).The test is used to overcome the constraints in data for running chi Square. The paper residue generaton is significant at 5% level which seems in tune with a learning centre. In the case of other residues, no significant differences are found.

Table 3.1: Institution-wise paper residue generation

<i>Department</i>	<i>Paper</i>		<i>Total</i>
	High	Low	
Others	0	5	5
Science	6	4	10
Social Science & Humanities	1	7	8
Total	5	18	23

Fisher's Exact Test P-Value=0.02843

Source: Waste Audit, Mahatma Gandhi University 2024

The paper residue acts as a source of income as it consists more than 68 % amount received through sales of residue by open tender and, considering the quantity of the residue, above 81% consist of different types of paper residue. The quantities and amounts are given in the table 3. 2.

Table 3.2: Scrap value of residue in rupees (June 2021 - April 2022)

Sl No	Type	Items	Weight (Kg)	Price/Kg ² (Rs)	Amount (Rs)
1		Carton	4130	14	57820
2		Valued Answer Sheet (VAS)	26985	14	377790
3	Paper Residue	Waste paper	8670	14	121380
4		Old question paper	3280	14	45920
5		News paper	587	19	11153
6		Iron	8134	29	235886
7	Other/furniture Residue	Aluminum	230	160	36800
8		Tire-Vehicles	1270	10	12700
9	Total				899449

Source: Waste Audit, Mahatma Gandhi University, 2024

The table 3.2 showcases the scrap value of residues collected from different sectors of the university, providing insights into the potential for recycling and waste management as part of institutional adaptation to environmental issue like climate change. The total estimated income comes about 9 lakhs during the period. The data highlights the type, weight, and corresponding monetary value of different residues sold, indicating the economic and environmental benefits of resource recovery.

The Valued Answer Sheets (VAS), with a weight of 26,985 kg and a scrap value of Rs. 3,77,790, represent the largest contributor to the total revenue, showcasing the significant potential for recycling paper products. Similarly, iron contributes ₹2,35,886 with a weight of 8,134 kg, indicating the value of metal recovery from institutional residue. Materials such as used paper, old question papers, and cartons collectively add substantial value, with combined revenue exceeding

Rs. 2,25,000, despite their relatively lower price per kilogram. These items emphasize the importance of systematic collection and recycling of paper residue. Items like aluminium, furniture residue, although smaller in quantity (230 kg), fetch a high price per kilogram (Rs.160), contributing significantly to the overall revenue (Rs. 36,800). This highlights the

² Data regarding price was collected from scrap shop in kolani, Thodupuzha, Kerala. The Analysis is based on the current price of the scrap. As per the collected information there is no notable fluctuation in the price of these items during the past 3-4 years.

importance of proper segregation³. Tyres from vehicles, with a price of Rs.10 per kilogram, represent the least lucrative category in terms of unit value, but their presence underscores the institution's commitment to managing all types of residues.

In short scrap value demonstrates the institution's effort to minimize residue accumulation by facilitating chances of recycling and reuse practices. By segregating materials and monetizing them, the institution contributes to reducing landfill use, conserving natural resources, and promoting sustainable practices and the data reflects the institution's proactive approach to addressing environmental issues through efficient residue management strategies.

3.1.1 Nirmalam MGU

Nirmalam MGU is a green protocol project initiated by Mahatma Gandhi University (MGU) in Kerala, aimed at transforming organic residue into valuable resources. There are other resource management initiatives under this programme. This initiative emphasizes sustainable agriculture, indicating how residue management can lead to economic opportunities (Value Addition) while promoting environmental sustainability (<https://www.mgu.ac.in/nirmalam-mgu>). This represents the safe disposal method of solid residue management as part of the final step in SR management as shown in figure 2.2. The major roles of this initiative are.

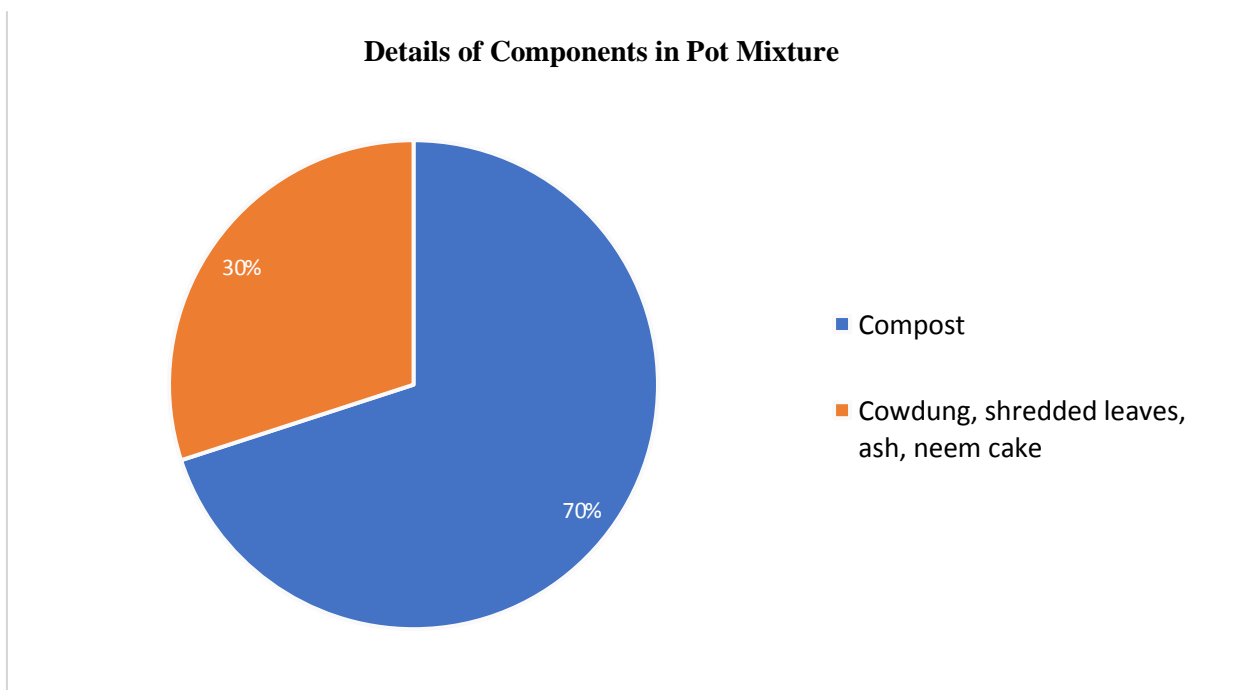
- **Resource Conversion:** The project transforms various types of organic residue into marketable products, demonstrating the potential for economic viability in residue management (Figure 3.8 and 3.9).
- **Skill Development and Environmental Stewardship:** It provides students with practical skills that are essential for careers in environmental science, agriculture, and entrepreneurship. The project promotes a sense of responsibility among students and the community towards environmental conservation and sustainable practices (Figure 3.9).
- **Research and Innovation:** Nirmalam MGU fosters research initiatives that explore new methods for residue management and sustainable agriculture, contributing to academic knowledge and practical applications. University is in the process of achieving this objective.

³ In the absence of proper sorting or segregation the scrap dealers follow a policy of a 'distress price' (alarmingly low price generally). In this context the university would have got a few thousands (approximately 5000 to 6000). However, the university earns a huge amount because of segregation (see Figure 2.2) of the mentioned residues.

- **Economic Opportunities:** By creating products from residue, the initiative opens new avenues for income generation for students and local communities (Figure 3.9).

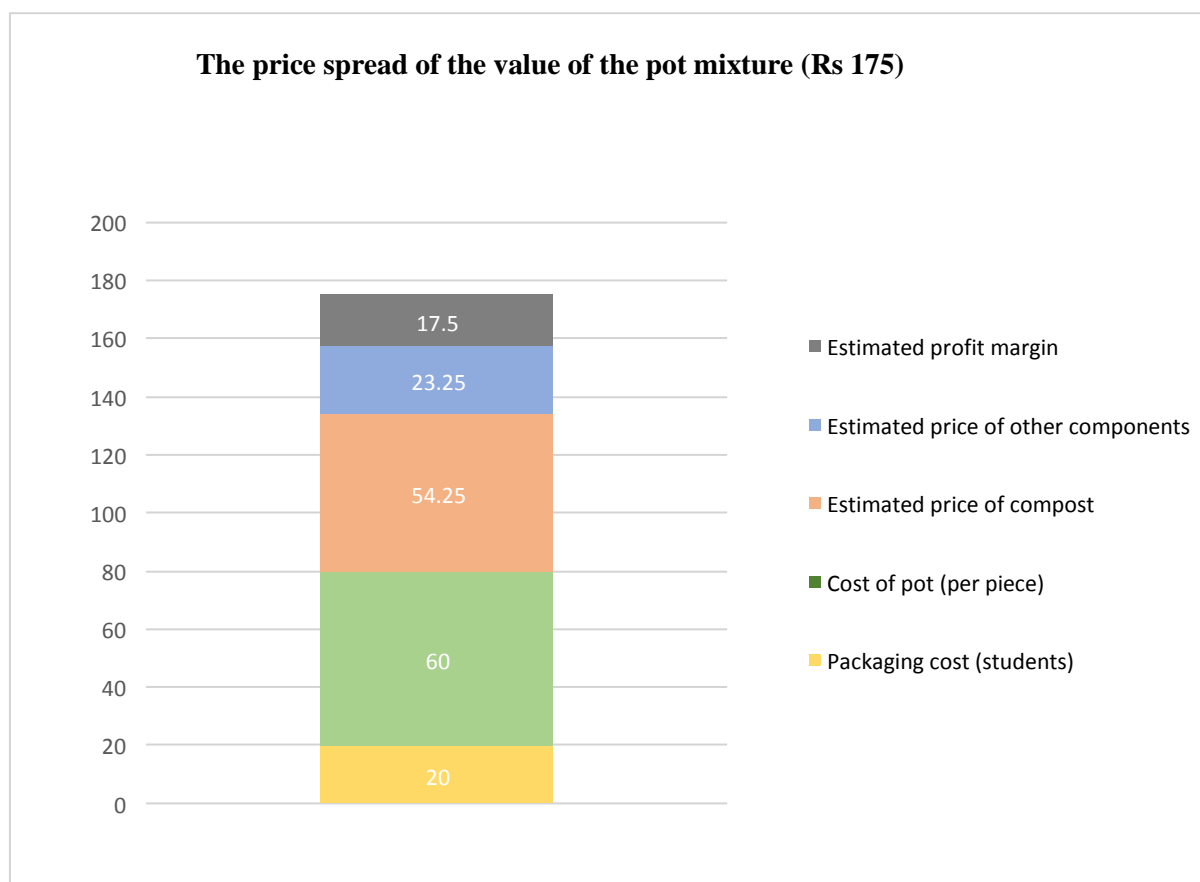
The major scheme with in the nirmalam project is the aerobic compost and the products created using the compost made of the food residue generated within the university. The associated details are given in the figure 3.8.

Figure 3.8: Details of components in pot mixture



Source: Coordinator, Nirmalam MGU

Figure 3.8 displays the composition of pot mixture provided under Nirmalam MGU. 70% of the mixture constitutes compost generated by Nirmalam while the balance consists of shredded leaves from the university, cow dung, ash and neem cake from outside from university. The compost comprises of food waste, dry leaves, cardboard and cocopeat, in which the first three components are procured from the university and the latter from outside the university. The monetary value of the pot mixture is shown in figure 3.9.

Figure 3.9: The price spread of the value of the pot mixture (Rs 175)

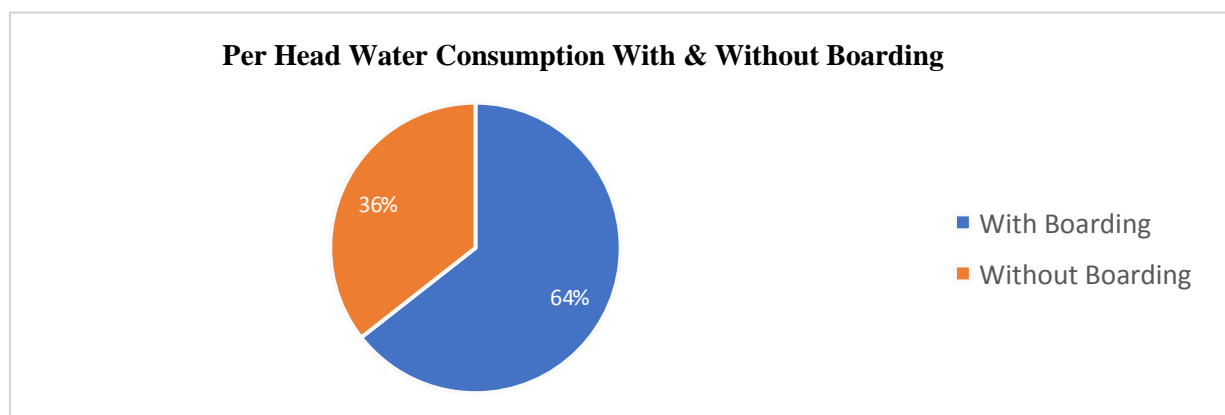
Source: Coordinator, Nirmalam MGU

The pot mixture is charged at Rs.175 for 5 kgs. The price of all the components of the mixture could not be ascertained properly. Hence, the value of certain components are estimated by considering the weight and comparable market price. The packaging is done by students of the university who are paid Rs. 20 per pot. This shows that the organizers of Nirmalam include students of the university to take part in sustainability practices and they are paid for their services. The price of the pot also provided as Rs. 60. However, the price of the other components are not directly available but their values are estimated. The price of the compost per kg near MG University is Rs.16 which is assigned to the compost portion of the materials of the pot mixture (i.e. $16 \times 3.5 \approx \text{Rs } 54.25$). As other materials like cow dung, shredded leaves etc, comprise 30% of the pot mixture, the balance value except 10% profit margin is attributed to the other materials (i.e. Rs. 23.25). The total compost generated during six months is computed as 3500 kg which is equal to Rs. 56000. This is equal to Rs. 1,12,000 per year.

3.1.2 Raveendra sarovaram

Raveendra Sarovaram is a reclamation project of Mahatma Gandhi University which was named after Sri. N. Raveendranadh, former pro Vice-Chancellor of the University who monitored the project. The foundation of this water reservoir emerged as part of quarrying during the initial days of inception of the university. The place was abandoned for being useless and later the idea of reclaiming and converting it into a giant rainwater reservoir emanated. Besides the natural down streams, rainwater directed through pipes from some twenty buildings located around it kept on enriching Sarovaram. Among these twenty buildings the Silver Jubilee Pareeksha Bhavan with a roof area of 25,000 Sq. ft offers the most. The reservoir can accommodate 4.5 crore Liters of water and has the potential to meet almost entire demand of the university (mgu.ac.in/nirmalam/, 2025).

Figure 3.10: Per Head Water Consumption With & Without Boarding



Source: Coordinator, Nirmalam MGU

As per a data provided by central ground water authority, government of India the per head water consumption in an educational institution with boarding is 135 liters and without boarding is 45 liters. And in the case of MG University that number comes 194400 liters and 107370 liters for with boarding and without boarding respectively. On that basis the total consumption is 301770 liters ($1440 \times 135 + 2386 \times 45$), that means 64% of the water in the campus is consumed by those who are residing inside the campus (figure no). This is the daily water consumption of the campus, and the annual water consumption of the campus is more than 11 crore liters. Raveendra sarovaram with a storage capacity of 4.5 crore liters can satisfy this requirement once replenished by a normal monsoon.

3.2 Kochi Metro Rail Limited (KMRL) and Kochi Water Metro Limited (KWML)

The KMRL needs 20 Mega Watts (MW) per day to operate and currently around 11MW of electricity, which is more than 50% of the total energy requirement sourced from its own solar plants. It has solar panels on the roof of metro stations with a capacity of 2.67MWp and Ground mounted solar panels at Muttom within 40000 sq.m land area with a capacity of 2.719MWp.

Together it has a capacity to generate 5.389MWp.

Table 3.3: Details of solar power generation in physical and monetary terms

1	2 Roof Top Solar Project	3 Ground Mounted Solar Project	4 Roof Top and Ground Mounted Solar Project	5 Total 5=2+3+4
Capacity (MWp)	2.67	2.719	5.19	10.57
Avg. daily generation (KWh)	8735	10575	18234	37544
CO2 equivalent (tons)	7.1627	8.6715	14.95188	30.78608
Carbon saving (Rs)	12176.59	14741.55	25418.196	52336.336
Avg. annual generation (KWh)	3188275	3859875	6655410	13703560
CO2 equivalent (tons)	2614.3855	3165.0975	5457.4362	11236.9192
Carbon saving (Rs)	4,444,455.35	5,380,665.75	9,277,641.54	19,102,762.64

Source: Kochi Metro Rail Limited, 2024

KMRL is one of the model examples for formal institutional adaptations in Kerala. For example, 50% of the energy requirement of KMRL is from renewable energy, i.e. solar power. The solar power is generated from three models: roof top solar project, ground mounted solar project and roof top & ground mounted solar project. Almost half of (49%) of the solar power generation is from the third model and the least (23%) is from the first model. The annual CO2 equivalent carbon saving is 11236.9192 tons and its monetary value is about Rs 2 crore (table 3.3)

3.2.1 Recycled Plastic Furniture in KMRL

Another sustainable initiative of KMRL is the use of recycled plastic furniture in the platforms of metro stations. Recycling as mentioned in section 2 is an important strategy of adaptation. One firm named Carbon and Whales recycled used plastic to make furniture. Kochi Metro permitted the firm to place 160 slanting benches made of recycled plastics. One such furniture has a cost of Rs. 10000 and the firm put 160 such units in 15 stations. That is,

the total value comes to Rs. 16 lakh and the firm get back the value by putting advertisements on bunches placed in various metro stations. This demands accounting of carbon emission related to recycling plastic. To produce one kilogram of original plastic there is a carbon emission worth 2.90 kg. Meanwhile, the emission in the case of recycled plastic per kg is 0.38 kg which is 87% less than the manufacturing of the original plastic. It implies that each one kg. of recycled plastic causes a carbon saving of 2.52 (2.90 – 0.38) kg which is equaling to Rs. 214.2 (\$ 1 = Rs. 85 approx.) and Rs. 51.96 (World bank, 2025) in terms of exchange rate and PPP (\$PPP 1 = 20.62 in 2023) dollars (Google Finance, 2025) respectively. Thus, the money value of total saving in carbon emission of 160 recycled plastic bunch is equivalent to Rs. 1.71 crore (25 *2.52*160*20*85) and 41. 57 lakhs in terms of exchange rate and PPP dollars respectively.

Table 3.4: Details of Carbon Saving by Kochi Water Metro Limited 2023-24

Ridership (445 days)	24,28,800
Average	5458 per day
Passenger kilometres	93,46,540
No. of passenger trips	53900
Propulsion hours	21191
Idle working hours	10596
Equivalent diesel consumption	372 tons
Actual consumption	128.2 tons
Net savings in diesel use	243.8 tons
CO2 equivalent	758 tons
Per passenger -km CO2 emission savings	81.1g
Average CO2 equivalent private transport per pass -km	103g
CO2 emissions savings in modal shift	962.7 tons
CO2 emissions savings from use of electric ferry	758 tons
Net CO2 equivalent	1720.7 tons
Per passenger-km CO2 emission savings	184.1g

Source: Kochi Water Metro Limited (KWML), 2024

Passenger traffic and the resultant carbon saving under Kochi Water Metro Limited are presented in table 3.4. Passenger survey was done by the KWML during 2023-24 (445 days) to assess the magnitude of carbon saving. In 445 days about 25 lakh passengers used the Kochi Water Metro and on average, 5458 passengers per day travelled. The water metro boats covered more than 93 lakhs passenger kilometres which were close to 54000 passenger trips. The shift from diesel boats to electric ferry reduced the diesel consumption by 758 tons. CO2 emission savings in modal shift and from electric ferry are 962.7 and 758 tons

respectively, the net CO₂ equivalent becomes 1720.7 tons. This can be expressed in monetary terms as 1 ton of carbon emission is estimated as equal to \$20 (20*85=1700) (Harris, 2013). It implies that 1720.7 tons carbon saving is equivalent to Rs. 2,925,190 lakhs (around Rs.3 million). Information regarding CO₂ emission savings for per passenger-km is also available. The CO₂ emission savings for per passenger km is 184.1g and it is equivalent monetary value is Rs 54.27.

3.3 Cochin International Airport Limited (CIAL)

CIAL started its solar initiative in 2013, with a 100KWp pilot plant and by 2015 attained the status as ‘World’s first Airport to be fully powered by solar energy’ with an installed capacity of 13.1MWp. Today it has a total installed solar capacity of 50MWp. CIAL is now the 2nd largest power producer in Kerala after KSEB. It has reduced the carbon footprint by 1,60,000 metric tonnes. CIAL has generated more than 25 crores units of green power from various solar pv installations at the airport. In March 2022, a 12MWp solar plant was inaugurated at payyannur which has generated approximately one crore units of green power.

Table 3.5: - Solar power generation and carbon saving in CIAL from 2013 to 2025

Initial investment	Rs. 270 crores
Number of modules	1,60,000 nos
Power generation per month	54,00,000 units
Maintenance cost per month	Rs. 15 lakhs
Type of modules	Polycrystalline & Monocrystalline
Year of installation	Plant 1 – 1 MWp - 2013 Plant 2 – 14.4 MWp (cargo) - 2015 Plant 3 – 2 MWp (near STP) - 2017 Plant 4 – 3 MWp (hangar premises) - 2017 Plant 5 – 2.7 MWp (carport Intl) - 2017 Plant 6 – 2.6 MWp (carport domestic) -2019 Plant 7 – 7.2 MWp - 2019 Plant 8 – 5.8 MWp (Opp Trade Centre) -2021 Plant 9 – 12 MWp Payyannur - 2022
Carbon equivalent (till 2025)	176,369.76 tonnes
Carbon saving (Rs)	299,828,592 (approx. 30 crore)

Source: PRO CIAL, 2025

From the initial investment of Rs 270 crores for solar power project CIAL has generated 54 lakhs units of green power per month which is equivalent to 176,369.76 tonnes of carbon saving till date.

The carbon saving in monetary terms is approximately 30 crore ($20 \times 85 \times 176,369.76$) (Harris, 2013). It implies that CIAL could recover 11.11% of original cost in terms of the external benefits ($30/270 \times 100$). The monetary value of the residue management carbon saving and resource conservation are summarised in table 3.6. The total gain in Monetary terms is around 34 crores.

Table 3.6: Monetary value of the Residues, Scrap and Carbon Saving in Selected Institutions of the study in crores

Total scrap value (June 2021-April 2022)	0.0899449
Total value of compost (per year)	0.0112000
Money equivalent value of renewable water generation in MGU campus (per year)	0.5951000
Annual CO2 equivalent carbon saving (Rs) (KMRL)	36238762
Annual CO2 equivalent carbon saving (Rs) (KWML)	2,925,190
Total carbon saving in CIAL (2013-2025)	299,828,592
Grand Total	338,992,545.3362449

Source: Tables 3.2, 3.3, 3.4 and 3.5, Figures 3.9 and 3.10

4 Conclusion

In the three institutions under consideration the study examined the institutional level adaptation in the context of climate change. In the case of residue, the major items are food residue, e-residue, hazardous residue, paper residue and furniture residue as far as MG University is concerned. Safe disposal of these generates income to university. Along with the safe disposal method as suggested in European style, university also has resource conservation practice like rain harvesting. Carbon saving acts as a major external beneficial factor in two institutions KMRL (KWML) and CIAL. The total money generated because of institutional adaptation strategies by the selected institutions is around thirty-three crores. This realisation must be a guideline for other public institutions in Kerala as far as institutional adaptation is concerned.

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Appendix I

Full Form	Abbreviation
School of Environmental Sciences	SES
School of Gandhian Thoughts and Development	SGTDS
School of Pure and Applied Physics	SPAP
School of Letters	SOL
School of Behavioral Sciences	SBHS
School of International Relations and Politics	SIRP
School of Chemical Sciences	SCS
School of Biosciences	SBS
Institute for Integrated Programmes and Research in Basic Sciences	IIRBS
School of Management and Business Studies	SMBS
School of Computer Sciences	SOCS
School of Pedagogical Sciences	SPS
School of Tourism Studies	STS
School of Physical Education and Sports Sciences	SPESS
Directorate of Applied Short Term Programme	DASP
School of Distance Education	SDE
Department of Lifelong Learning and Extension	DLLE
Civil Service Institute	CSI
School of Social Sciences	SSS
School of Indian Legal Thought	SILT
Inter University Centre for Organic farming and Sustainable Agriculture	IUCOFSA
Inter University Centre for Biomedical Research and Super Specialty Hospital	IUCBR &SSH
K. N. Raj School of Economics	KNRSE/KNRC

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