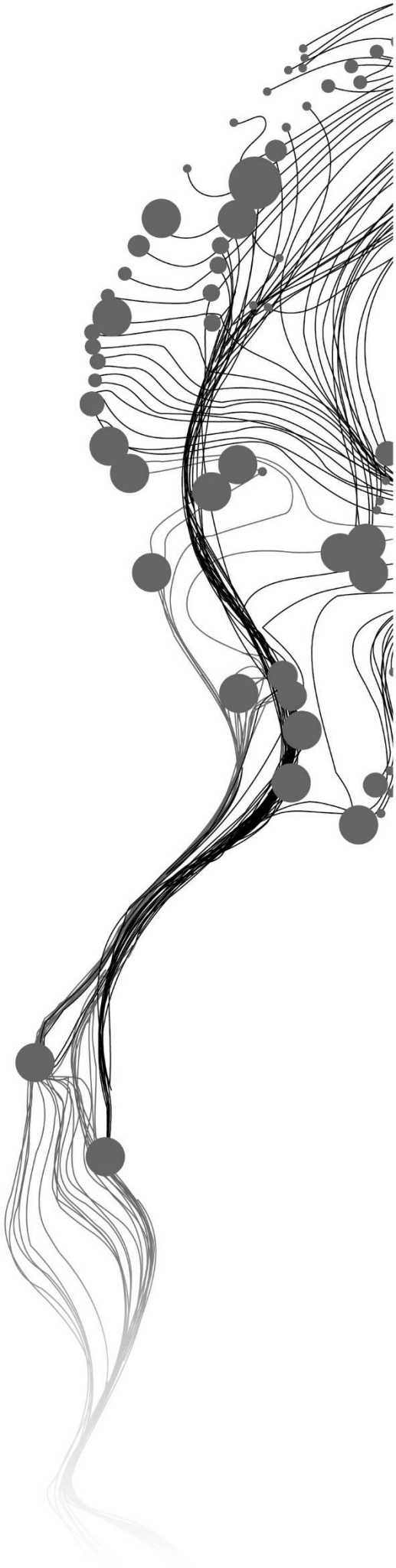
Impact of Solid Waste and the Health Effects During Extreme Floods. A Case Study from Kerala (India)

ABHISHEK MISHRA
August 2022

SUPERVISORS:
Dr. C. Anthonj
Prof. Dr. C. J. Westen

ADVISORS:
Drs. N. C. Kingma
Dr. L. K. Sekhar



Impact of Solid Waste and the Health Effects During Extreme Floods. A Case Study from Kerala (India)

ABHISHEK MISHRA
Enschede, The Netherlands, August 2022

A thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation.
Specialization: Natural Hazard and Disaster Risk Reduction (Earth Observation System)

SUPERVISORS:
Dr. C. Anthonj
Dr. C. J. Westen

ADVISORS: `
Drs. N. C. Kingma
Dr. L. K. Sekhar

THESIS ASSESSMENT BOARD:
Prof. Dr. J Blanford (Chair)
Dr. S. Amer (External Examiner)

ABSTRACT

Disasters are an increasingly common phenomena in today's world, which urge society for the strengthening of disaster management systems. The disaster management cycle (DMC) is represented by four main stages, mitigation, preparedness, response, and recovery. This thesis deals with the fourth stage of DMC "recovery" in which solid waste management (SWM) and its health impacts are considered. Waste management is the core process during the recovery phase that focuses on collection, segregation, cleaning, transportation, recycling, reuse, and dumping. Volumes of waste that are generated by a disaster on an average are 5 to 15 times more than regular annual waste collected in the normal times. Proper management of this waste becomes a challenge because of large volumes of waste spread all over and its poor management leads to severe impacts on human health and the environment. There is still limited literature available on the development of disaster waste management.

The main objective of the research is to analyse the impact of solid waste produced during extreme floods through a forensic analysis of the types, volumes, and health impacts of the waste produced during the 2018 floods in Kerala, India, and the development of a working framework for flood waste management. To achieve this objective information was collected in form of primary data, for which target groups such as, Kudumbashree,[1] Sanitation workers[2], and volunteers [3]were surveyed and health officials, disaster manager and local authorities were interviewed followed by open discussions.

The research is developed in four parts. The first part is to analyse the solid waste produced in the 2018 Kerala floods and the second part post-flood solid waste management and its resulting health impacts. I have analysed data collected during a field survey, written interviews, and open discussion in three settlements that are characteristics for different geographical units (upland, midland, and lowland) located in the Pamba basin, in Kerala, India. In these two parts the research deals with the types of waste, sources of waste, the quantification of waste, health effects, health literacy, and waste management by the local administrations. The third part of the thesis focuses on the wicked problem of lack of waste collection sites and aims to provide a solution to the problem by analysing, potentially suitable waste collection sites using spatial multi-criteria evaluation (SMCE). The fourth part of the thesis is to develop a post-flood waste management working framework, and the framework has been developed with the support of the Kerala State Disaster Management Authority (KSDMA). This framework developed in the research is the first draft and still needs to be developed further, to serve the purpose of the thesis the first draft was developed based on the United Nation Environment Programme (UNEP), Disaster management guidelines, shortcomings of the 2018 Kerala floods waste management and with the input of stakeholder's expertise and involved in 2018 Kerala post flood waste management.

[1] Kudumbashree is a poverty eradication program in which women are given jobs and paid. The role of Kudumbashree was very prominent in 2018 flood waste management as they supported society to clean up.
[2] Sanitation workers are the employed workers by the administration for the process of cleaning and others.
[3] Volunteers also known as (Harith Karma senna) is totally devoted the waste management pan Kerala.

ACKNOWLEDGEMENTS

After each phase of life, it is support of numerous people who might directly or indirectly push you towards the goal. Similarly, for me, the chapter of MSc in Geo-Information Science and Earth Observation at ITC, The Netherlands, was the contribution of a lot of people who supported me to begin my journey, who helped me be consistent with it, and the ones who helped me to complete this journey with the everlasting grace that will be forever in my memories.

I am indebted to my supervisor, Dr. Carmen Anthonj, Prof. Dr. Cees Van Westen, Prof. Dr. Justine Blanford (Chair), and my Advisors, Drs. Nanette Kingma and Dr. Sekhar Lukose Kuriakose for their endless guidance and support from scratch till the end. It was incredibly challenging for me to complete this piece of document as words would be less to describe your support and willingness to make this possible. I remember it was ambitious to complete and bring together different components of the thesis, but with your support and guidance, I was able to complete it, and from the bottom of my heart, I thank you for believing in me and my ability. Your everlasting trust, inspiration, and right approach made me make this possible. Supervised meetings were the best time during the entire process where I could bring my ideas and you all could add on and provide feedback, but I would like you all to know they were not supervised meetings but a span of time which made the bonding and deeper understanding amongst us. Believe me, I have learned a lot from each of you and I promise I will always keep them intact.

I would also like to acknowledge the support of Wan Bakx, Aqual research theme at ITC Faculty, for allowing me and funding the fieldwork and Kerala State Disaster Management Authority (KSDMA) to provide me extended support and guidance to accomplish the fieldwork. I thank the people, colleagues, and administration of Kerala. Dr. Sekhar, Dr. Anish, Mrs. Amrutha, and Vera Glas for being so supportive and cooperative. Also, special thanks to all those who helped me in my fieldwork directly or indirectly. A special thanks to Ir. Bas Retsios for supporting and helping me with the ILWIS software, the ethical committee for giving clearance to the questionnaire, and Dr. S. Amer for being my external examiner.

I dedicate my thesis to my sister and my mother, as my sister has been the backbone of my life, and it is because of her, I could make my way to ITC and do my masters. She always asked me to read and write, but I took it for granted. Now that I have written the thesis solely based on my ability and reading, I want her to know that a bit late, but your brother started reading and writing both. My mother, who loves me a lot as every mother does, I understand it was tough for her to be away from her child, but mom, I got this hard work to you, your and dad's love had made me come this far I took distance as strength and made this possible.

Finally, I must thank the almighty for blessing me with such friends "Sri, Ruhi, Vaibhav, Mrunalini, Tamanna, Kasandra, Taseer, and Anna," who became my family. It was tough to be away from home, but who thought I would get a home away from home? I had faced a lot of ups and downs in these two years of my master's, emotional, health, and academics, but friends like you made these two years as if they were yesterday. I thank you all for constantly being with me and cheering me. It would not have been easy for me without you all. I would also thank Avashesh and Anshu for being my elder brothers and always being there to help me.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Abbreviations:

COPD: Chronic Obstructive Pulmonary Disease
DM: Disaster Management
DMC: Disaster Management Cycle
DEM: Digital Elevation Model
HPS: Hantavirus Pulmonary Syndrome
KG: Kilograms
KSDMA: Kerala State Disaster Management Authority
MSME: Micro, Small & Medium Enterprises
PPE: Personal Protective Equipment's
PDNA: Post Disaster Need Assessment
QOSM: Quick Open Street Map
SW: Solid waste
SWM: Solid waste management
SPM: Supply chain mechanism
SDG: Sustainable Development Goals
SMCE: Spatial Multi-Criteria Evaluation
UN: United Nation
UNDRR: United Nation Disaster Risk Reduction
UNEP: United Nations Environment Programme
UNOCHA: United Nations Office for the Coordination of Humanitarian Affairs
WASH: Water Sanitation and Hygiene

Keywords:

Diseases, Floods, Health, Kerala, Post-Disaster, Solid Waste Management

"The call for action on 'Waste-Wise Cities' asks communities, cities, and towns worldwide to rethink, reduce, recycle, refuse, and reuse waste."
By- United Nations

CHAPTER 1: INTRODUCTION

1.1. Background

A disaster is define as "a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability, and capacity, leading to one or more of the following: human, material, economic and environmental losses, and impacts" (UNDRR, 2020).

Disaster can generate large volumes of waste depending on the severity and the nature of hazard (Brown et al., 2011). When disaster strikes, it causes many direct and indirect impacts. One of the impacts is generation of waste, which may be in many forms, some of which are topic and harmful for health and other hinder the post disaster response activities. Globally there are limited investigation, discussion, and frameworks on solid waste generated from disasters. It is essential that lessons are learned, best practices are documented, and household to nation-level guidelines are derived and continuously updated to achieve resilience.

The United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) has issued "Disaster Waste Management Guidelines" and has urged all countries to adopt the guidelines to their respective requirement (OCHA; UNEP, 2013). However, many countries currently lack such guidelines including India which is where the thesis will focus on currently.

Figure 1: Disaster Management and waste management cycle (SPREP, 2020).

In 2008, The United States Environment Protection Agency (USEPA) identified several types of waste that pose a threat to human health from biological, chemical, and physical source. The waste types include, hazardous material, human and animal remains, debris, building rubble, vegetation and medical waste (USEPA, 2018).

The presence of disaster waste results in an obstruction in the emergency response and recovery phases. The accumulation of waste can hamper the accessibility to evacuation sites and water and sanitation systems. The waste generated during, and post-disaster poses a risk to public health. Uncontrolled dumping of healthcare waste in relief camps pose serious risk to the local population and to the victims such as spread of diseases and infections. The waste produced during disaster impacts the drinking water supplies and increases the risk of vector borne diseases (K. Laikuritzen, 2018). Due to blocking of drainage channels, logging becomes a crucial problem that can lead to a rise in vector-borne diseases

post-disaster (Brown et al., 2011). Response and recovery are two stages in figure 1 where waste management plays a vital role in the disaster (waste) management cycle. Still, it is also important to address waste management from the first stage of the disaster management cycle. So that the waste to be generated can be reduced and during prevention and mitigation stage planning can be done to control the waste management so that the health and environment impacts can be reduced. At stage of response and recovery the immediate collection and cleaning process will help build back better and will reduce the risk of diseases spread amongst the community as shown in the Figure 1.

The generation of solid waste is one of the most visible and challenging issues during and after disaster or any emergency. This is often overseen in disaster response and recovery, as the essential concern is the restoration of normal livelihood, and due to this, proper management of post-flood solid waste is leftover and results in environmental and health impacts (Reed & Mena-Moreno, 2016). Post-disaster waste management frameworks are needed to smooth and strategically manage solid waste generated by disasters, these frameworks are the leads that will help the administration disaster mangers and relevant stakeholders to better plan and manage the waste given the understanding of disaster management guidelines and available international guidelines on the disaster waste management.

Each disaster creates various kinds of waste, which have other effects and impacts on the environment. For example, flooding can generate many types of waste, such as debris, carcasses of animals, e-waste, food waste, mangled furniture, chemicals, building waste, etc. Therefore, specific strategies should be adopted to treat the waste according to its type. For example, waste that needs immediate action and should be managed within hours like, carcasses of animals or e-waste can directly affect health. Furthermore, the build-up of debris and mud can block water flows and sanitation systems, causing further flooding (OCHA; UNEP, 2018). The waste types and characteristics of different disasters are shown in Table 1.

Table 1 : Disaster and its generated waste characteristics

Disaster	Characteristics of waste
Floods	Animal carcasses, mud, clay, gravel, household, tree, electronics, liquid and petroleum, vehicles (Waste generated is huge in volume, is mixed, and difficult to manage) Reduces the accessibility for response and recovery
Earthquake	Building rubbles, debris, asbestos (Waste quantities are more in incident place and both hazardous and nonhazardous waste is mixed
Tsunami	Infrastructural damage, debris mixed with soil, trees, bushes, vehicles, animal carcasses, and other (waste generate in quantities is higher and difficult to manage)
Volcanoes	The waste is in form of ash and pumice stone (The waste mix with the existing routine waste and creates problem in managing the waste)
Hurricanes typhoon cyclones	Roof tearing, collapsed walls, Huts and houses built with poor construction materials, ships, and boats are the major waste (the waste generated is average and is also difficult to manage because of mixing with normal waste)
Droughts	Animal carcasses, dried crops (Do not produce much waste)

Whether manmade or natural, disasters can generate large quantities of waste that can be either solid or liquid. The waste generated during disasters and the post-disaster recovery phase can directly threaten the environment and people living nearby as the waste accumulated can contain hazardous materials (OCHA; UNEP, 2018). After floods, waste management becomes the most essential and crucial step toward recovery as it creates and poses another threat of slow to fast-spreading diseases in societies. For the same

efficient waste management with the proper equipment and administration support, the people should be helped and guided so that initiatives can be taken and health effects can be reduced (Nayantara Narayanan, 2018).

The United Nations Office for the Coordination of Humanitarian Affairs (OCHA), and the United Nations Environment Programme (UNEP), have created specific guidelines for disaster waste management plans that focus on minimizing harmful impacts on public health and the environment. During a disaster, existing waste management systems are disrupted, with added waste generated during the disaster and recovery phase, thus creating an extra burden on the current system. This can result in a collapse of the waste management systems as waste piles up in different areas and is left open and unattended. In situation where the waste management do not exist the situation becomes worst and the additional burden on the neighbouring states or international help is given to manage such situations.
According to Brown et al. 2011, the basic categorization of flood-generated waste is as follows:

- Debris related to green vegetation and trees
- Stones, rocks, and soil
- Hazardous and non-hazardous waste generated from the household
- Debris from the demolition of damaged structures and construction wastes.
- Fuel products, industrial discharge (toxic chemicals)
- Perishable items
- Waste like vehicles and other mediums of transport
- Recyclable goods, electrical and electronic items
- Pre-existing waste before the disaster (Bio-degradable, Non- biodegradable, Toxic, Non -toxic)
- Dead bodies of human and animal

1.2. Research Problem : Waste management in Kerala

Kerala, the south-western state of India, experienced severe floods in 2018. This state which leads the country in many social development indicators, is equally suffering from the issues related to solid waste management. That creates extra burden on health system due to disease and infection spread.

Solid waste management is a severe problem for highly populated regions prone to disaster. India has many regions exposed to disasters, leaving lots of unwanted, unattended waste piled everywhere after a disaster strikes. The government in such areas is already falling short of waste management capabilities; for example, in Kerala, India, this leads to mismanagement and shortfall of resources, which is amplified when disasters hit such regions(Devasia, 2018a). India experience several floodings in many districts of India such as, Bihar, Kolkata, West Bengal Maharashtra, and Kerala. All of these state face flooding and after flooding face the problems related to waste management and the health impact. Certain districts like Bihar Kerala face flooding every year but still facing problems related to waste management as the normal waste management system also get hamper dure to overflow of after flood waste.

Kerala lacks a documented post-disaster SWM working framework, which can be especially useful in the recovery phase. After disaster, the waste collected is neither properly segregated nor recycled and is often dumped, burnt, or flushed in rivers, affecting the climate and human health. Similarly, the floods of 2018 resulted in an additional 30.7 tonnes of solid waste in month of August. (Local Self Government Department, 2019).

The state's people collectively cleaned up household and public spaces in the shortest possible time. However, a major part of the waste went to landfill sites untreated and accumulated there, resulting in many health and environmental issues. At the same time, the state's human capital and the social collective worked efficiently. They approached the problem without a pre-defined framework or without ensuring

the personal safety of the sanitation workers and the volunteers. The waste of the 2018 floods can still be seen in dumping sites left unattended, and the workers and volunteers still face the prolonged effects. Therefore, the experience of the post-Kerala flood could be critically analyzed to understand the solid waste management inefficiency and lack of post-disaster solid waste management framework and guidelines.

Post-disaster SWM is challenging for Kerala. The state and district administration cannot manage the daily waste in normal time, 8,000 to 10,000 tonnes. The state is not equipped with enough logistics to handle the day-to-day waste. (Anjali Singhal, 2018). The major hurdle in Kerala's solid waste management post-disaster is the unavailability of space to collect and segregate waste. As the regular waste collection sites are already overflowing with waste; therefore, there is a need to find more sites to solve the post – flood problems of waste management. There is a need for optimization of proper transportation and handling of waste. Hence, handling waste generated during floods is a great challenge for Kerala. It is also very difficult to identify or designate such places as the area is densely populated, and inhabitant also resists creating such sites in nearby localities (Devasia, 2018a).

Post–floods SWM has long-term and short-term impacts on the workers and volunteers associated with managing waste. The people, especially workers involved in waste management, may be exposed to chemicals and biological organisms, which get mixed with water bodies and sanitation channels; the effects of which are not explicit in the short term but are seen after years. Therefore, finding the health risk problems and traces from 2018 can be used for future preparedness.

The public health risk such as injuries, infections, transmission of disease, spread of viruses and vector borne diseases, becomes challenging due to the diverse types of waste piled in public and individual locations. Hazardous waste like solvents, asbestos, oils, and pesticides can directly affect the inhabitant also indirectly from vector-borne diseases transmitted through flies, mosquitoes, etc., that develop in stagnant water due to blockage in water channels and sanitation systems. (OCHA; UNEP, 2013).

1.3. A case study of Kerala, India

The floods of 2018 in Kerala were exceptionally heavy and produced a vast amount of waste, including plastic and damaged electronic devices, piled up in compounds; household waste such as food waste, utensils, clothes, mattresses, books, and furniture. Amongst the waste generated by floods, the most problematic were carcasses of animals that died during the floods, which were not disposed of or treated; hence went to the drains and rivers, and water channels resulting in blockages and leading to health issues(Devasia, 2018a). The waste and the flood caused several diseases, leptospirosis, diarrhea, elephantiasis, and cholera. Flood waste resulted in skin allergies, infections, and injuries.

Table 2 : Sources of waste in Kerala in volume (Koshy, 2010)

Type of waste	Percentage
Household waste	49%
Hotels, Marriage Hall, Institutions	17%
Shops & Markets	16%
Street sweepings	9%
Construction	6%
Hospitals	2%
Slaughterhouse	1%

Kerela has been facing the problem of SWM for years as it is densely populated and faces difficulties in managing solid waste in general. It is because of the scarcity of collection and segregating sites. The state declared the 2018 floods the worst ever disaster since 1924. Table 2. shows the sources of waste in Kerala during regular times in the year 2010. Kerala still lacks a good framework for post-disaster SWM as no national or regional documentation has been made earlier for the optimization.

Kerala follows the decentralized waste management system where each LSG is responsible for its waste management except the biomedical waste, which is managed by the central government's centralized process (Waste Management | Local Self Government Department, 2016).

The major problem is lacking the segregation process, where the waste is not segregated and is left mixed (Waste Management in Kerala: Government Charting New Course, 2022). To strengthen the solid waste management process from source to end, the Kerala government has taken many initiatives and formed specific departments which handle solid waste management. Significant initiatives include Suchitwa Keralan rural and urban[4], HaritKeralam- Sanitation and waste management sub-mission[5], and the Volunteer group, Harith Karma sena[6].

The government contracted with private companies to collect and segregate waste and send it to different states near Kerala due to a lack of space within the state. In the first 11 days, 2020 tonnes of biodegradable and 2290 tonnes of non-biodegradable waste were collected from urban and rural areas (Devasia, 2018a).
It is worrying as the state has big ponds and lakes as the primary water sources water in these primary sources is mixed with the floodwater and resulting in health issues caused by contaminated water. To study the dynamics of SWM and understand its health impact, a detailed case study will be done on the three selected study areas after data collection, hence a best framework is necessary to manage and handle tonnes of post-disaster SWM properly.

The thesis deals with the post-floods solid waste management and the health effects for which there are no available datasets that can be used for the analysis or to understand how the waste generated by floods was managed

Following are the research gaps that are addressed by the research:

1. To Understand the types, sources, and spatial distribution of waste generated by floods.
2. Analysis of health impacts derived from flood waste and spatial patterns in diseases prevailed by the same.
3. Lack of post-disaster SWM framework for Kerala, India.

1.4. Research Objectives and Research Questions:

Primary Objective: The primary objective of this research is to analyse the impact of solid waste produced during the extreme floods of 2018 in Kerala through a forensic analysis of the types, volumes, and health impacts, and development of a framework for flood waste management.

Sub-objective 1.

Conduct an analysis of the solid waste produced during the 2018 Kerala flood events, focusing on three geographical units (High land, Mid land, and Lowland) within Pamba basin:

Q1. What were the impact of flood in Pamba basin?
Q2. What are the different sources, types, and quantities of waste originated during the flood in different altitudes (High land, Midland, and Lowland)?
Q3. How the volumes of waste can be quantified for the floods of 2018 in Pamba basin?

Sub-objective 2.

Conduct a forensic analysis of the post-flood solid waste management and its resulting health impacts for the 2018 Kerala flood event focusing on the Pampa basin:

Q1. How did households, neighborhoods, and the local administration manage the 2018 flood solid waste?
Q2. What were the health impacts on waste workers involved in rapid solid waste collection, and were the health facilities available and accessible during and post floods?

Q3. Was there any protection (safety gears) for waste managers and households to prevent the health risk?

Q4. What are the recommendations proposed by stakeholders to ensure the personal safety of people, sanitation workers, and volunteers?

Sub-objective 3.

To propose potentially suitable site location to collect the post flood solid waste in Pamba basin:

Q1. Which location will be suitable sites for solid waste collection post floods?

Sub-objective 4.

To Develop Framework for the solid waste management post floods:

Q1. How can a framework be created with the data collection, analysis, and outputs to manage future flood-derived solid waste with a practical approach?

1.5. Conceptual Framework

The different objectives in Figure 2. are linked to describe the link of one objective to another. After analysing the effects of 2018 flood in terms of waste, the data collected for acquiring types, quantity, and sources of waste are considered in quantifying the waste. Survey data is used for understanding the impact of flood waste on households, waste workers and local administrators. Therefore, understanding waste management takes us to realize and incorporate the information received as input by target groups that determine the reported health risk impact. To support the existing system and inadequacy, we propose potentially suitable sites for waste collection after emergencies. A framework that denotes where, when, and how what must be done pre-flood, during a flood, and post flood and dos and don'ts are given for different target groups to prevent the generation and conversion of goods into waste.

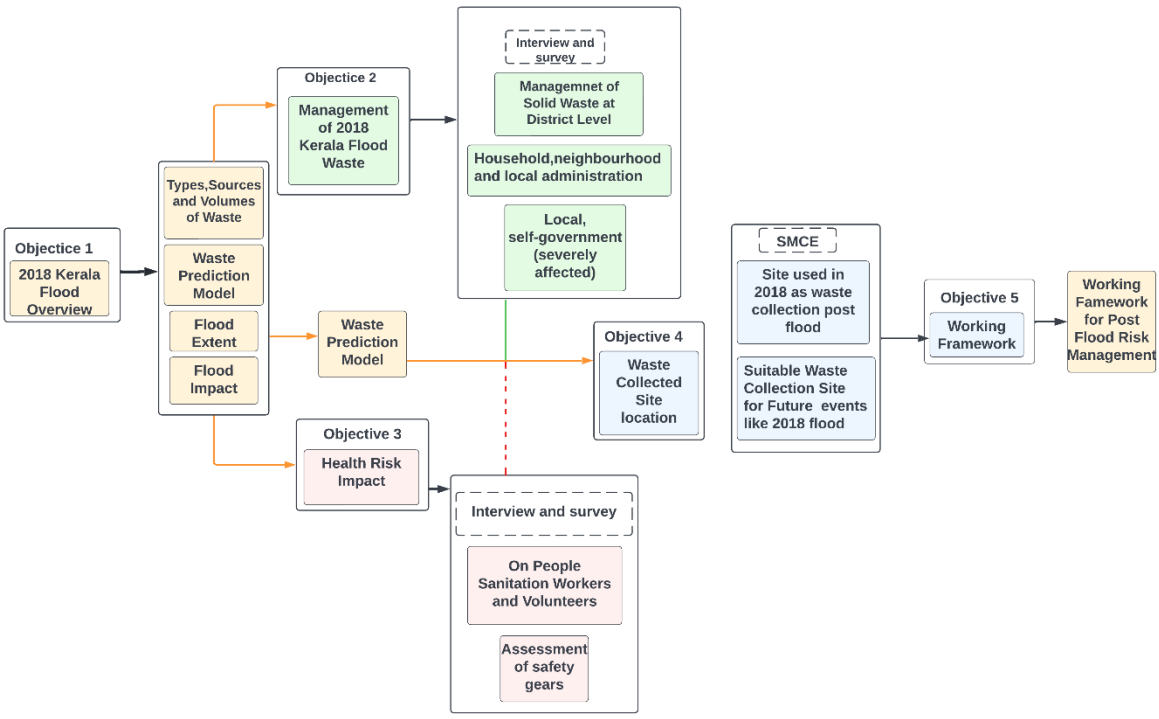


Figure 2: Conceptual Framework

1.6. Organization of the thesis

The thesis is organized into eight chapters

Chapter one gives the background and introduction to the research, research problem, case study of Kerala, India, research objectives and questions, conceptual framework, and the organization of the thesis.

Chapter two is a description of the study area describing the flooding event of 2018 and the datasets used in the research.

Chapter three is a literature review where different concepts and themes are introduced which are used in the research.

Chapter four discusses the impacts of the flood on the Pamba basin in terms of societal and environmental problems. It discusses the different types of waste generated and their sources. Chapter quantify the waste generated by floods of 2018 in Pamba basin with the use of ground data collected during field work.

Chapter five provides a descriptive and statistical analysis that in detail describes the post-flood solid waste management by the individual households, sanitation workers, volunteers, and local administrations. It is based on both literature review and fieldwork. It also illustrates how the general people collaborated controlled in uncontrolled situations. The chapter also discusses the impacts of floods and their derived waste impact on human health, focusing on general people, sanitation workers, and volunteers. It explicitly discusses the different diseases and health risks that are perceived and reported by target groups in response to the predefined questionnaire. Discussion and conclusion are based on the literature review and fieldwork.

Chapter six is to find the potentially suitable sites for flood-derived solid waste collection. The site selection is made for the Pamba Basin based on different criteria and factors.

Chapter seven develops a framework for the stakeholders involved in managing floods, solid waste, and health. The framework has been designed in collaboration with Kerala State Disaster Management Authority (KSDMA) and relevant state stakeholders. It is an output of a literature review and different brainstorming sessions considering international guidelines focusing on post-flood solid waste management.

Chapter eight discuss the results of all the objectives as how far the objectives and their research questions have been addressed. Also discusses the future scope for the research. And the limitations.

1.7. Ethical Considerations:

Ethical approval was issued from the following committees:
1. Faculty of Geoinformation Science and Earth Observation, University of Twente, Enschede, The Netherlands.
2. Kerala State disaster management authority (KSDMA), India.

As data collection was done during the pandemic all the prescribed precautionary measures for Covid-19 were followed. The relevant authorities and stakeholders associated with the field work were informed on the daily processes and weekly plans for the survey and information. Henceforth all the concerns raised by the local authorities were considered and potentially worked out. The researcher tried his best to avoid personal conversation and clear all misunderstandings that would have developed during fieldwork.

The information collected through field work was collected and used anonymously and after the formal consent was received in digital and analogue forms. No personal names or identities were used in the research.

The collected data was stored in my personal computer and in the KSDMA repository.

CHAPTER 2: STUDY AREA AND DATASETS

2.1 The 2018 floods in Kerala

The motivation of doing something for my country resulted in research in Kerala, India. Kerala is a state with 14 Districts, 6 Municipal corporations, 87 Municipalities, 77 Taluks, 152 Blocks, and 941 Gram Panchayats, home to 34.8 million people (Census Of India, 2011).

The state of Kerala is vulnerable to multi-hazards. The changing climate, and its geolocation where one side boarders the Arabian sea, and on the other side, the mountains of Western Ghats make the state prone to many natural hazards such as, floods, landslides, drought, soil piping, coastal erosion and many more (KSDMA, 2020). Floods and landslides are widespread and frequent disasters because of the humid tropical climate. The state primarily receives 90 percent of rainfall within six months of the monsoonal period in two phases, South–West monsoon (June to September) and North-East monsoon (October to December) (State Relief Commissioner, Disaster Management, 2018). Approximately 14.8 % of land is prone to floods, which can reach as high as 50 percent in some districts. Landslides are mainly confined to four districts, Idukki, Wayanad, Kottayam, and Kozhikode. Floods are the most common disaster that hit the state due to sea surges and heavy rainfall (Kerala State Disaster Management Authority, 2018).

The extreme rainfall that led to the devastating flooding in August 2018 was varying over the state, ranging from 23% (Kannur district) to 180% (Idukki district) more than average rainfall in month of August. For the whole Kerala, the Rainfall in August was 92% above the average. As shown in Annex 1 the rainfall recorded between three months of the South-West monsoon in 2018 is already in excess. Similarly, it can be seen in Annex 2 August 2018 that the recorded rainfall was more than 90 percent of than actual.

Kerala recorded very high rainfall from 1st to 19 August 2018, Annex 1 & 2., leading to the worst ever flood since 1924. That affected approximately 5.4 million people, accounting for one-sixth of the Kerala population. Thousands of houses were damaged by the floods and landslide both as shown in Figure 3. The extreme precipitation brought floods to more than five districts as shown in Figure 5. and triggered landslides in more than four districts as shown in Figure 4 , which contributed to debris-flows and sediments in the floods (Alex George, 2020). This cascading hazard had a large impact on the state and its people, as mentioned in Table 3, where the administration tried its best to cope and manage the emergency with the help of aid within the country and externally. The flood water inundated several state districts for more than two weeks and some for three weeks. Inundation of water was due to heavy rainfall and the opening of all five dams with all gates. Idukki dam, all gates were open for the first time in the past twenty-six years, which led to massive flash floods and landslides in districts located in the Western Ghats (State Relief Commissioner, Disaster Management, 2018).

Table 3 : Area and population exposed in 2018 (Tithal Parmar & Manchikanti, 2020)

Hazard	Exposed Area (Km^2)	Population Exposed
Floods	6789.5	7,795,816
Landslides	5619.7	2,799,482

Source: KSDMA

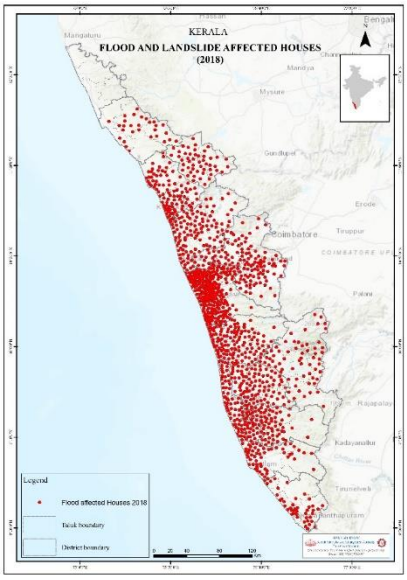


Figure 3: Flood and Landslide affected houses

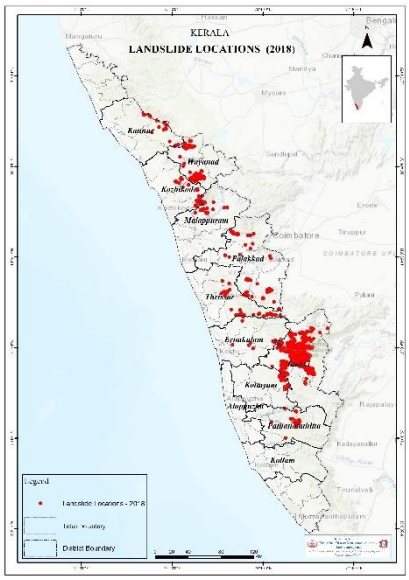


Figure 4 Landslide location of 2018

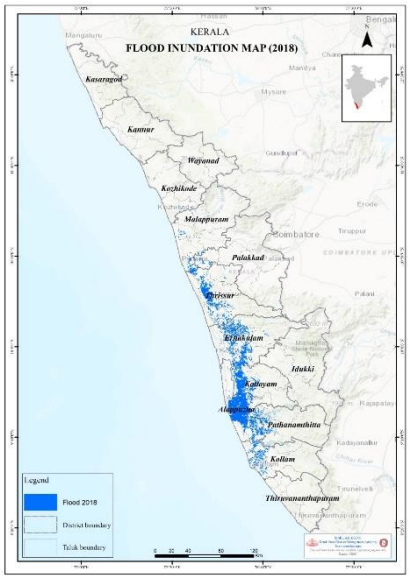


Figure 5 : Flood inundation 2018

The Kerala government organized several assessments to estimate the impacts of the 2018 disasters in the months of September and October. The World Bank and United Nations supported this and complimented the Post Disaster Need Assessment (PDNA) report, which states total damages to be around 26,718 Crore. That included infrastructure sectors like Sanitation, water and hygiene, transportation, power, and irrigation. Both floods and landslides with the infrastructure affected a large part of vulnerable groups women, children, senior citizens, and people with disabilities. It was reported that long- and short-term impacts on the environment, public health, and the administration (PDNA, 2018).

As Kerala is prone to multi-hazard, disasters like floods, landslides, and cyclones contribute significantly to solid waste generated after a disaster. The waste collected by Clean Kerala Company in Kerala between 27th August 2018 to 5th September 2018 after the 2018 flood was 26451 tonnes (Clean Kerala; Company, 2018), as shown in (Table.4).

Table 4 : Summary of waste collected post floods

District	Waste collected in tonnes
Alappuzha	398
Kottayam	80
Thrissur	963
Malappuram	23
Ernakulam	380
Kozhikode	526
Wayanad	661
Idukki	235
Kozhikode	54
Palakkad	28
Kozhikode	867
Palakkad	14
Malappuram	23
Pathanamthitta	18650
Alappuzha	785
Berhampur Landfill	2762
Total in (Tonnes)	26451

2.2 The Study area: the Pamba basin and three sample areas

After the detailed reading and understanding of the 2018 disaster event that took place in Kerala, the Pamba basin was selected as a representative example of a watershed that originates in Western Ghats, and flows to Arabian sea, and which was heavily affected by the floods and landslides in 2018. Within the Pamba basin watershed three sample areas were selected. Which were representative of the three elevation zones: upland with landslide and flash flooding, midland with extensive flooding and the lowland with costal as well as normal flooding. The same has been represented in a Digital Elevation Model (DEM) in Figure 6. Impact of disasters like floods in major and landslides in minor on the study area and how they influence the waste management post-disaster. All three sample areas fall either in the Pamba river flow direction or in one of its streams.

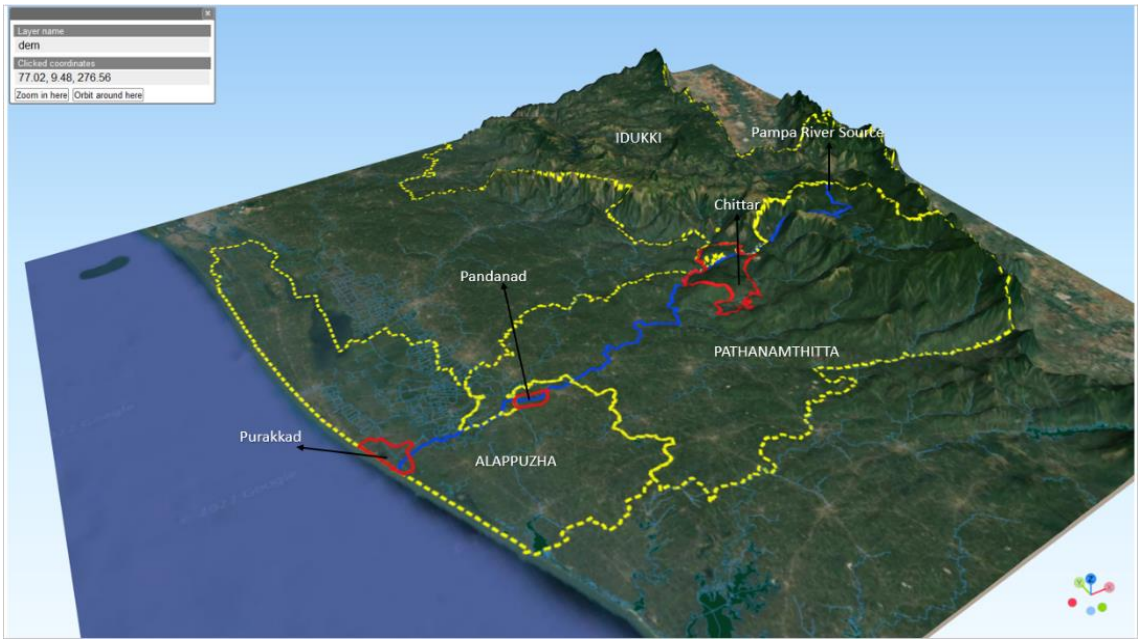


Figure 6: Three sample areas in the Pamba River basin, Kerala India, (DEM)

.

The state generates 3.7 million tons of SW annually (Integrated Solid Waste Management Strategy, 2018). According to the Clean Kerala company, the total waste collected from the state had a significant share from Alappuzha and Pathanamthitta districts as all the flood water receded in these two districts, and with the water, the overflow of waste happened and resulted in significant waste (Clean Kerala; Company, 2018). Hence, to study the post-disaster SWM, three sample areas have been chosen to do the forensic analysis (Ranni Perunadu, Pandanad, and Purakkad) as shown in Figure 6. These areas are in the same drainage basin of the Pamba River.

Alappuzha district, Figure 7, also called "Venice of the East," has a total area of 1414km² with 2.12 million people (CensusIndia; 2011). The community lies within coastal regions, making it more vulnerable to floods and waterlogging in the midlands. Pamba, Manimala, and Achancovil are the rivers that flow through the state and drain into Vembanad lake (Roy et al., 2018)

.

The **Pathanamthitta** district of Kerala has a total area of 2642 km² with a population of 1.20 million (Census Of India, 2011). This district is highly susceptible to landslides in the upper part. The landslide materials accumulate into the drainage network of the Pampa Basin. Pathanamthitta is a geologically

unique district consisting of three geographic zones Upland, Midland, and Lowland. The area also receives high rainfalls of 1780.0 mm(annually) and 306.0 mm, especially in June, July, and August (Weather & Climate, 2018). As shown in Figure 7.

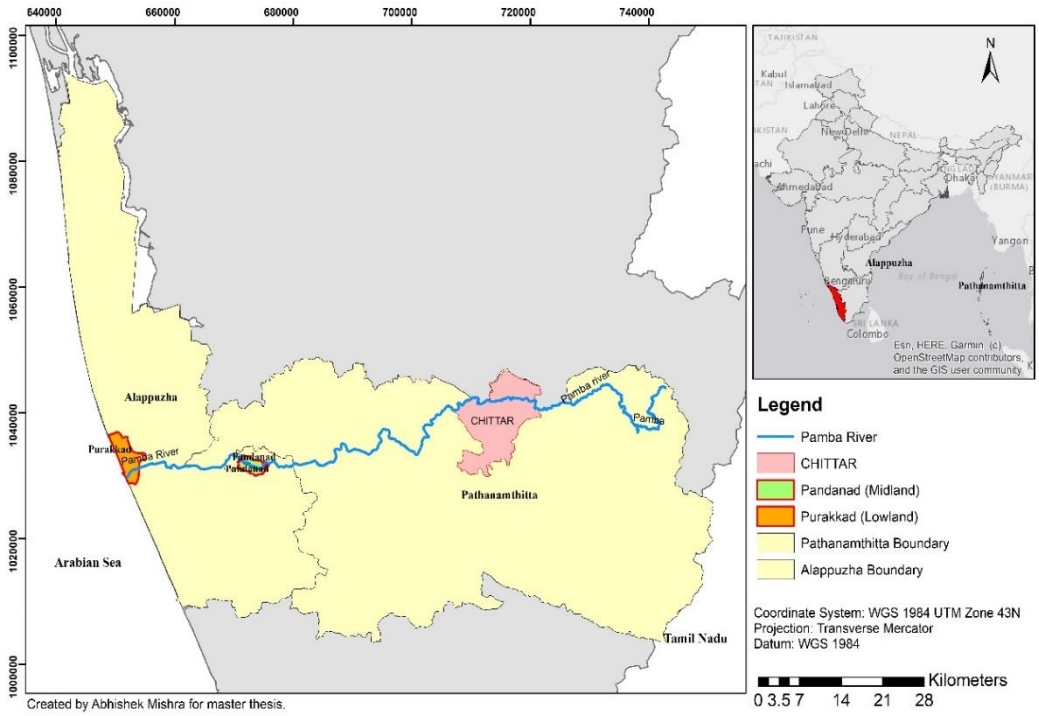


Figure 7: Study area and the sample areas map

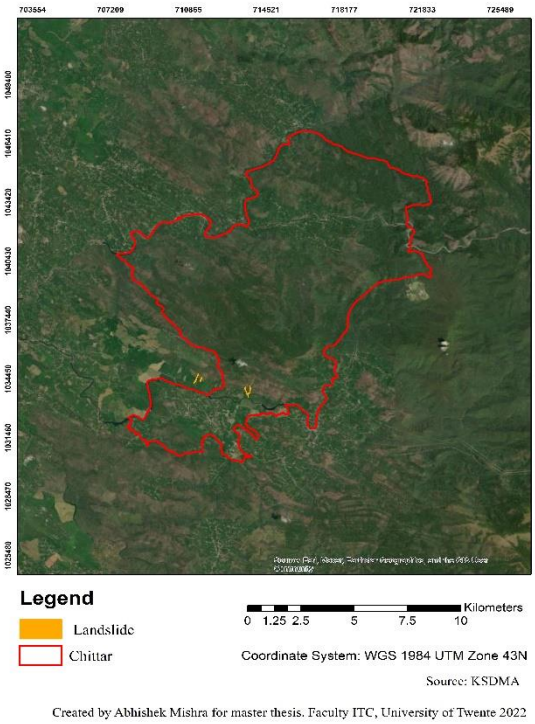


Figure 8 : Sample area (Upland)

Chittar Gram Panchayat (local self-government) is susceptible to landslides (CMDT, 2019). In the dataset, this panchayat had several landslides. Two landslides are close to river Pampa as shown in Figure 8. The debris might have entered the river networks flowing towards the midlands. This also denotes that the debris from the upland part mixed with the river flowed downstream and contributed to solid waste produced during the 2018 floods in the downstream areas. This area was selected to study what kind of waste is generated in the uplands. The waste composition is expected to be mainly debris but also other waste that might have mixed with it. Managing this kind of waste is difficult, as segregation takes time. A lot of generated waste was accumulated in the region and deposited parallel to the Pampa River.

Pandanad is a Gram Panchayat (local self-government) of the Ambalapuzha block. Pandand has its administration boundaries on both sides of the Pampa River, as shown in Figure 9. Floods are the most common hazards in this region. In the 2018 floods, this area was also one of the worst-hit local self-governing bodies in the Alappuzha district. Due to the blockage of canals, the Pampa River flooded (Alex George, 2020). A government document also mentions that vast quantities of domestic waste went into the river through these canals and caused the blockage. Therefore, this area is suitable for analysing the type of waste generated and its management by different stakeholders.

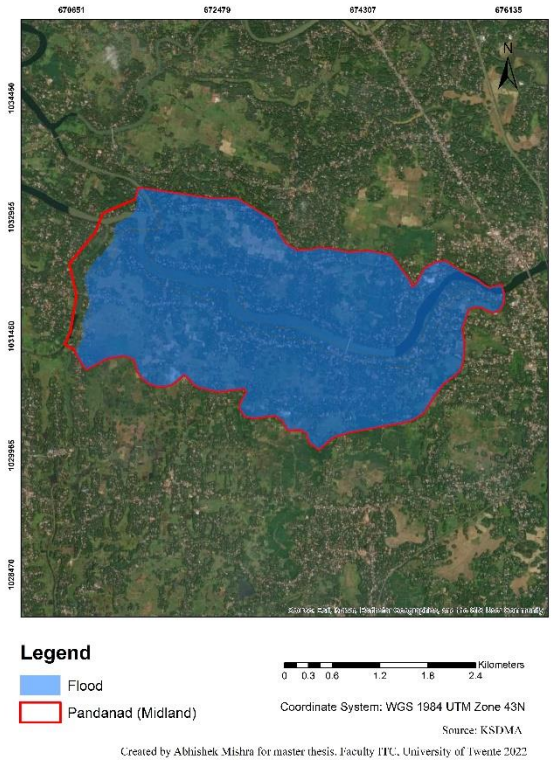


Figure 9 : Sample area (Midland)

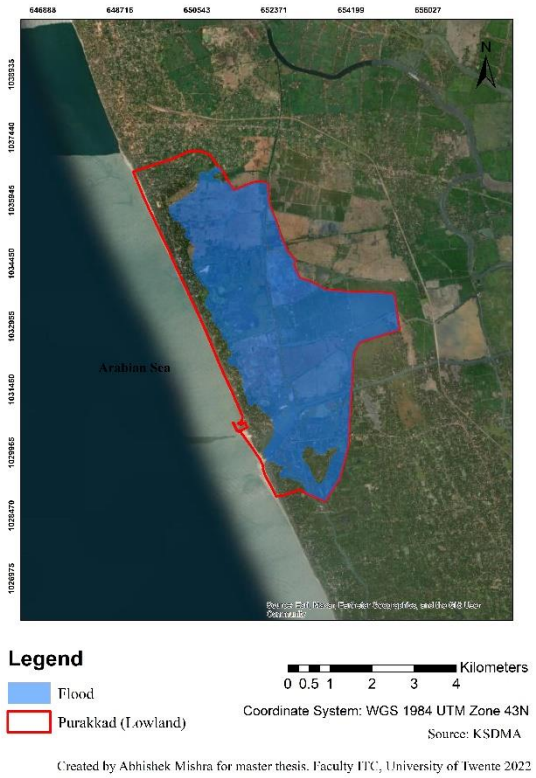


Figure 10 : Sample area (Lowland)

Purakkad is a gram panchayat located in the Alappuzha district's Ambalapuzha block, as shown in Figure 10. Geologically, it is very prone to flood hazards as Purakkad has an 8.40km long coastline. The area's total population is 2.97 million (Purakkad Village Population - Ambalappuzha - Alappuzha, Kerala, 2011). The area is flooded both by the Pamba River and coastal flooding. The area has many connecting water channels. Purakkad is a lowland area where water bodies merge with the Arabian sea. The area is also densely populated, making the area of study more critical for forensic analysis of SWM. This area is also suitable as Purakkad is situated downstream of the pampa basin.

2.3. Datasets Used

The data sets used in the research are shown in Table 5. the main datasets used for research are flood and landslide damage house inventories, flood extent, watershed, land use, landslides, DEM and the waste types, waste management, health impacts (Solid waste management data) collected during field work. Other dataset used are road networks, admin boundaries.

Table 5 : Datasets used for the research

S. NO.	Dataset	Data Type	Data Sources	Remarks
1	Flood	Shapefile Polygon	Kerala State Disaster Management Authority (KSDMA) https://sdma.kerala.gov.in/	Total flood of 2018 from July-September. Extracted flood extent for the research study area Purakkad and Pandanad Panchayat
2	Landslide	Shapefile Polygon	KSDMA https://sdma.kerala.gov.in/	2018 Total Landslide inventories of Kerala and extracted landslide inventories for study area Ranni Perunadu Panchayat
3	Watershed	Shapefile Polygon	KSDMA https://sdma.kerala.gov.in/	Pampa River Basin
4	Study Area Boundaries	Shapefile Polygon	QGIS Quick-Open Street Map https://qgis.org/en/site/	Extracted from OSM for the boundaries of study area Alappuzha and Pathanamthitta district and Pandanad, Purakkad and Ranni Perunadu, Panchayat and Pamba river
5	Administrative Boundaries (Kerala & India)	Shapefiles	DIVA GIS https://www.diva-gis.org/	Extracted from DIVA GIS for the administrative boundaries of India and Kerala state
6	Land Use	Tiff, Raster	ESRI2020 https://www.arcgis.com/home/item.html?id=d6642f8a4f6d4685a24ae2dc0c73d4ac	10m resolution, Extracted from ESRI2020 by ArcGIS online Pro
7	Elevation	Raster	SRTM https://earthexplorer.usgs.gov/	30m Resolution
8	Damage House Inventories	Shapefile	KSDMA https://sdma.kerala.gov.in/	Polygons of houses affected by 2018 floods and landslides
9	Road Network	Shapefile	QGIS Quick-Open Street Map https://qgis.org/en/site/	
10	Solid Waste	Excel csv.	Fieldwork	Data collection for sources, types, and quantity of waste in each study area.
11	Solid Waste Management	Excel csv.	Fieldwork	Data collection for the management of waste generated by floods in each study area at different levels.
12	Building footprint	Shapefile	BB Bike (OSM) https://extract.bbbike.org/	The dataset consists of maximum building footprint compared to other dataset still there are buildings which are not available in the dataset

CHAPTER 3 : LITERATURE REVIEW

The state of Kerala has been trying hard to control the system efficiently; for example, the Alappuzha district waste management model was recognized by UNEP in December 2017 as a "solid approach to waste". Alappuzha did it by the waste management at the source, which means to end household waste at source, and for houses with smaller areas, centralized hubs are built for waste collection, and proper management has been established for the commercial waste that comes from hotels and industries (UNEP, 2017). The Alappuzha model is now being reviewed and adopted by different states in India. It is something which is practiced in normal times and failed in floods of 2018 due to overflow of waste.

The decentralized system of waste management is also not efficient in regular times, and that is the fact which leads to the pressure and difficulties for the authorities and the people to manage the waste post emergencies as the waste is in large quantities and for which there is no captative system that could hold such huge loads.

Flood and waste management: Systematic and scientific SWM is necessary for pre- and post-floods-disasters. Inefficient waste management before floods can create or increase the chances of flooding; once flooded, it will increase the level of water due to blockages resulting accumulation of waste (Lamond et al., 2012). Inappropriate management of SW post floods will lead to difficulties like, lack of accessibility for rescue teams and the people to escape. It will also result in many water-borne diseases and other health problems, which might turn to be extra suffering for society. Basic wash facilities will get affected, and proper sanitation and hygiene will not be followed, resulting in disease or health issues like diarrhoea, cholera, and others. The critical point to be considered while managing disaster/flood waste is to make sustainable management without hampering the environment and human health (Habib et al., 2022).

Flood and health: Every year, disasters impact a large number of people; among them, floods are a very frequent disaster that impacts roughly 102 million people every year (de Freitas & Ximenes, 2012). Flooding as a disaster just not affect people, society and administration but also hampers the health which makes the situation worse and more difficult for individuals and health authorities to cope up with. Health impacts of flood varies in relation to topography and time as the effects or impact can be short term, medium term and long-term. Flood also causes immediate, short term health effects such as injury, cuts, breathing problem, hypothermia, animal bites fever, respiratory and rashes. The mid- term impacts of floods on health are Infections, diarrhoea, cholera, typhoid, mental health, wounds, Leptospirosis, communicable diseases, loss of health workers, infrastructure, essential drugs and supplies (Aruna, 2018). The long-term health impacts because of flooding are psychological, dermatological, chronic diseases, malnutrition, disability and mental health (Huu Bich et al., 2011).

India is one of the most flood prone country in world with this also accounts for one fifth global deaths due to floods and its aftermaths such as health impacts and improper solid waste management (Aruna, 2018). Flood and its generated waste related health impacts act different on different age group people and becomes very harsh on pregnant women's, senior citizen, and people with disability. Ability of individual also reduces because of emergencies. Accessibility to nearest aid such as community health centre, medical shops, and first aid also gets in operational either because of unavailability of health workers or because of infrastructure damage. Disasters like floods increases the risk of transmissions of the below described communicable diseases:

Flood water related health effects: The most obvious cause of waterborne disease both during and post floods is the contamination of water in centralised supplies or in individual water sources (Okoth Okaka & Odhiambo, 2018). In case of Kerala, especially wells. The flood water transports the bacteria, viruses, and parasites to clean water, and this is what leads to the emergence of waterborne diseases. Widely it is an increased risk of the infections, dermatitis, ear -nose and throat infections. Major risk factors of for the outbreak is linked to the water contamination that results in typhoid fever, cholera, leptospirosis, and hepatitis A and skin diseases. Floods also increases the range of vector habitats which results in the increase in vector borne diseases. Generally, after rainfall and floods the water gets accumulated in different places which gives shelter to mosquitos to breed. Hence this leads to potential threat to the rescue, health teams and also to the population which is already going through a catastrophe (Aruna, 2018). The development of the vectors is very much affected by the changes in precipitation. Incidents related to mosquito infections increase with an increase in precipitation and develops new shelters for the mosquitos to reproduce an increase the spread of infections like, Rift Valley Fever, West Nile Fever, and malaria.

Rodent borne health effects: The rodents are said to be reservoirs of number of human diseases that act as intermediate infected host or arthropod vectors ex. Ticks and flea (Center For Disease Prevention, 2020)**.** Like vector borne diseases, Risk of Rodent borne diseases also increase with the increase in rainfall and flooding reasoned the change in patterns of human – pathogen rodent contacts. These contacts increases due to floodwater (Diaz, 2015). The major link between flooding and rodent borne diseases is the heavy rainfall that flourish the large amount of wild grass seed production and the heavy rains led flood carry these rodents very close to human settlements mixed with debris and other unwanted material (Okoth Okaka & Odhiambo, 2018). The most common rotten borne diseases are Hantavirus Pulmonary Syndrome (HPS) a respiratory disease spreads in humans through contact with urine, saliva, and rodent droppings. Leptospirosis- Rat – Bite Fever (RBF) primarily transmitted by the rats and an individual is infected by bites, scratches, and skin contact. Salmonellosis is transmitted in more than one way; this disease can be spread through any contact with feces or contact with the animal which is infected. Tularaemia is spread due to bacterium Francisella Tularensis that is transmitted by fly and tick bites or by coming in contact with other animals like muskrats, beavers and rodents (Fill et al., 2017).

Waste-Related Health Effects: Waste and health have special relationship which outstands each other if manged properly. Well manged SWM is itself a boon for good health and its effects. On the other side improper solid waste management have adverse impact not only or environment but also very negative impacts on human health. As the poor waste management leads to the contamination of water, soil and cause air pollution (World Health Organization Regional Office for Europe, 2015). Similarly, the waste generated by floods is left all over around the surroundings and the population; localised near the waste face consequences. Finding better ways and approaches to manage waste is essential as the current options are landfill and incinerations, uncontrolled burning and dumping of flood derive waste will together only lead to long term health impacts such as asthma, respiratory problems, and dermatological problems. Even though the flood will recede but the health issues rising because of rodents and vectors will have more higher chances to breed (Alam & Ahmade, 2013). According to WASH in Emergencies Problem Exploration Report, SW is a very crucial problem within an emergency which is neglected but the aftermath is unseen and often neglected. As poor SWM pose adverse health risk and safety issues to the population and to the people who works for waste management. The most profound health effects and risks are; Injuries and infection from direct and indirect contact with solid waste, Accidents and injuries, Building rubble, Contaminated air, Fire and explosions, Spread of diseases by vectors and other animals, Diseases like diarrhoea- cholera-dengue-leptospirosis, Scavenging and most important ground water contamination (Reed & Mena-Moreno, 2016).

Health Literacy/ Awareness: Health literacy plays an important role in community as we all live in a world which is vulnerable to numerous diseases and health risk. In that case having some knowledge and awareness about the diseases or a health risk that are very common in our regions will be a big step towards minimising the risk and the impact of the health effect. Higher the health literacy associates with lower levels of risk. The awareness helps to prevent in coming in contact of any disease or make full use of available health facilities if needed (Sarhan et al., 2021). Health literacy is ability to understand and prevent the possible health effect. The measurement of health literacy is still a subject of discussion and difficult to address mostly the surveys and parameters are used by individual nations to demarcate their health literacy (Heide, 2015). A lot of 2030 SDG agenda focuses on improving health life expectancy on other side it is to empower people so that they can access and make better use of facilities and lead healthy life. Key to productive world is to have a good health so that we can resume back to normal after the emergencies and can go back to work and school. SDG 16 Peace, Justice and strong institutions stats People who have high level of health literacy are empowered to count on their governments to access to health facilities including essential medicines, Universal: health coverage (Menabde, 2016).

WASH in times of floods and Post-Floods: "Ensure access to water and sanitation to all" The SDG6 of UN sustainable goals has set eight targets to reach this goal by 2030 (United Nations, n.d.-b). Kerala is the state with the highest Human Development Index in India, also progressing toward achieving SDG6 and was hit by the worst ever floods in 2018 due to increased precipitation all over the state that resulted in obstruction and destruction in WASH facilities and led to severe impacts like lack of safe and pure drinking water, open defecation. The health departments and local administration's first and foremost challenge during and after post-flood was providing clean and pure water to all, especially in the flood-affected regions (EXPRESS, 2018). A larger group of the population drinks water from wells in their daily life that got contaminated by the flood water and the waste generated, increasing the salinity and iron in the water.

UNICEF played a vital role in WASH assessment and accessibility as UNICEF was working in the frontline with the support and coordination of the Kerala government, KSDMA, Water Authority, organization public support, and a UNICEF WASH team of Tamil Nadu state (Tithal Parmar & Manchikanti, 2020). The worst affected Alappuzha, Pathanamthitta, Thrissur, Ernakulam, and Wayanad districts faced both floods and landslides, because of which the septic tanks and toilets overflowed, and sludge was everywhere. Also, the collected sludge and fecal were dumped into canals and rivers. This practice also imposed severe threats to water and vector-borne diseases. The most crucial concern post-flood was the people's access to clean water, sanitation, hygiene, and health facilities. Accessibility to a centralized water system was affected, which served 20-30 percent of the population. Most people used wells to drink water. Approximately 317000 wells were contaminated and damaged, and 95146 toilets were unfunctional, which led to the weakening of WASH facilities in the state of Kerala (UN CERF, 2013), and full-fledged support was given by UNICEF to estimate the recovery cost, renovation, and strengthen the WASH facilities to bring life back to normal (UN Organisations; Asian Development Bank; Government of Kerala; The World Bank; European Union Civil Protection; Humanitarian Aid, 2018).

CHAPTER 4 : ANALYSIS OF THE SOLID WASTE PRODUCED DURING THE 2018 KERALA FLOOD EVENTS

4.1. Introduction

Disasters does not come alone it brings with it series of problems, which impact the society. Hence, in this chapter of the research the waste produced by floods is addressed, describing the sources, types, and quantities of waste in the Pamba basin. The 2018 flood water receded but what it left behind was the large amount of waste. It is interesting to know that how does flood produce waste. The composition of the waste that is produced is generally of normal routine waste but what adds later are the materials that are either inside the houses or in the vicinity. The flood water generally acts as a medium of transportation of waste from uplands to midlands and to the lowlands (Chen et al., 2007). So basically, the flood is carrier of existing material that gets affected or carried by the water to the different region and becomes waste. The flood generated waste includes the municipal solid waste, industrial waste, medical waste, and other petroleum waste (National Institute for Environmental Studies, 2015). Here in the research and in the chapter, we only focus on the solid waste produced during and post floods. The types of that are produced by floods are mentioned below in Table 6.

Table 6 : Categories and types of waste produced by floods

Source: (OCHA; UNEP, 2018)

Category	Characteristics of flood waste
Green wastes	Vegetation such as fallen trees, soil, agriculture products, farms, and timbers
Building rubble	Timber, wood chips, waste wood (such as column, beam wall-material), bulky items, cables
	Concrete/bricks *Asbestos should be categorized as
	Steel, rebar, aluminium material, etc.
Household material	Food wastes, wastes mixed with fibres, paper, wood chips, packaging materials, household furnishing and belongings, other wastes (such as plastics, cardboard, paper)
Mixed waste	Mixed wastes consisting of a small amount of concrete, wood chips, plastics, glass, soil, and sand, etc.
Electrical appliances	Televisions, washing machines, and air conditioners discharged from affected houses, which are damaged by disasters and become unusable
Automobiles	Vehicles, motorcycles, and bicycles that are damaged by disasters and cannot be used
Vessels	An unusable ship damaged by a disaster
Waste difficult to treat properly	Dangerous goods, such as fire extinguishers, cylinders; and items which are difficult to treat at local government facilities, such as pianos and mattresses (including radiation sources for non-destructive inspection), fishing nets, gypsum boards, etc.
Hazardous waste	Hydrocarbons, such as oil and fuel; paint; varnishes and solvents; pesticides and fertilizers; medical waste in debris; waste posing healthcare risks; asbestos-containing waste; PCB; infectious waste; chemical substances; toxic substances, such as chlorofluorocarbons, CCA (waste using chromium

	copper arsenic wood preservative), and tetrachloroethylene; pharmaceuticals; pesticides hazardous waste; solar panels and accumulators; etc.
Mementoes waste	Photos, albums, cash, precious materials
Industrial waste, commercial waste	Food waste, raw materials, fertilizers, machinery, equipment's, shops specific waste
Household waste	Daily waste, discharged from the households
Waste from evacuation centres	Waste from relief camps and evacuation centres
Excreta	From temporary toilets fixed to facilitate WASH

4.2. Methodology

To find out the types of waste, sources and quantity of waste that generated from the floods of 2018 in Pamba basin required several datasets such as, the sanitation data including waste and its types, admin level data and limited literature or proofs that can be used to identify the types of waste. Several months were spent on arranging datasets from the LSG but at last it was found that sanitation data is not available.

The research approaches are a mix method approach as the existing dataset was not available on LSG level hence need to use the different methods and tools for acquiring the data Figure 11. To overcome and fulfil the need of the data survey and written interviews were prepared as tool to be used for data collection in fieldwork. The data was collected from all the three geographical units as shown in Figure 8, 9and 10. The tools were developed based on the required data for the research as survey too was multiple-choice, and few open ended questions for feedback and suggestions. For the written interviews, the questions were open ended and with scope of discussions after the completion of interview. For both the tools questions were predefined.

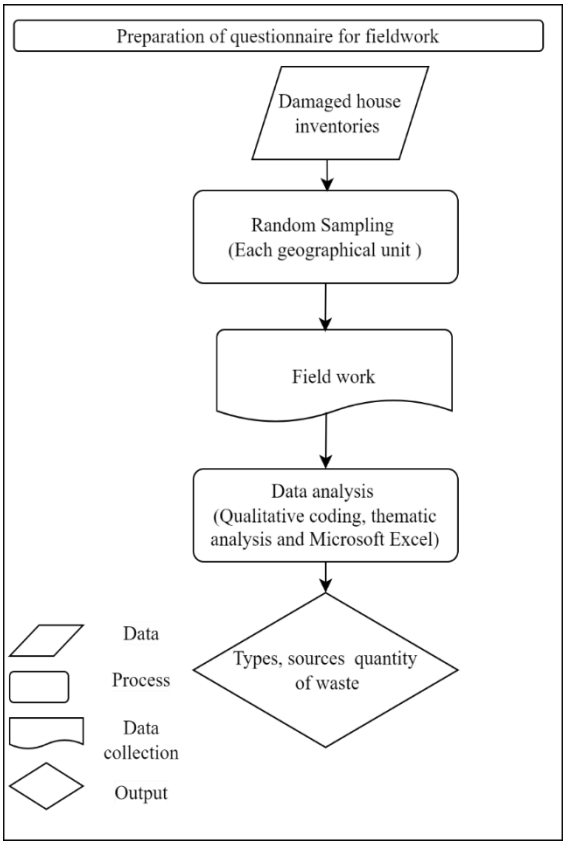


Figure 11 : Methodology for types, sources, and quantity of waste in study areas.

For the fieldwork pretest was not done due to lack of time and availability of the responders. Also, the data to be collected was huge and did not permit to do a pertest of the survey tools. Considering the fact questionnaire were developed in a way that information should not be limited and is useful for research.

To conduct the field work 2018 flood damaged house inventories was used to perform the sampling. Here stratified random sampling [7]was used, to take the 33 percent of all the damage house in the study areas

[7] Stratified sampling is a method of random sampling where the dataset is divided into smaller subgroups (strata) depending on the characteristics and then the samples can be selected randomly representing the whole dataset (J. Simkus, 2022).

shown in Figure 8,9 and 10. Once the 33 percent of random sampling was performed than again the same process was done on each sampled class considering only 10 percent of houses in each damage class (strata's). Annex 3. The random sampling best suits for the selection of samples as it allowed sample of houses that best represented the entire damage inventories in study areas. The sampling involved statistical references which made use of a subset called damage class or percentage. Below in Table. 7 is the sample frame that is result of sampling done.

Table 7 : Sample frame for damaged house inventories

Study Area	Purakkad (Low land)	Pandanad (Midland)	Chittar (Upland)	Total Houses Surveyed
Damage Class/ Percentage	No. of Houses			
15%	29	14	1	
16%-29%	16	16	8	
30%-59%	6	14	5	
60%-74%	3	5	1	
75% and above	1	0	1	
Total	55	49	16	120

Data collection was done for the households in form of survey questionnaire. The questionnaire used for the data collection were predefined. To make the survey form maptionnaire software was used which is compliant to General Data Protection Regulations (GDPR). The Question asked from the households are below in Table 8.

Table 8 : Questions asked to households

No.	Questions
1	Mark your location
2	Select your panchayat:
3	Choose type of building
4	Total no. of floors
5	Did you experience 2018 floods
6	Did you experience 2018 floods in this building
7	What was the level of water during 2018 floods
8	Was your house damaged by floods of 2018
9	Select the percentage of damage
10	What from below listed you discarded as waste during and after 2018 floods and select the quantity:
11	What are the sources of waste

The questions asked to households are very general but very informative for the research as mentioned earlier that there is lack of data for waste types, sources, and quantity of waste produced at LSG level. These questions were drafted in accordance with the research objectives, sub objectives and the research questions. The location of each house surveyed was necessary to be collected to later estimate the waste produced in Pamba basin. Panchayat is the local body which denoted that the respondent is a resident of the study area. Type of building, no. of floors is used to understand the building type and how the waste is generated from different buildings. Flood experience, Within the same house and the water level is collected to verify the amount of waste that and individual has reported also to see what extent of flood can lead to which type of waste. Percentage of damage is to see verify the data sampled and to observe

whether the damage corresponds to the reported responses. The question what from below listed you discarded as waste, provides information on types of waste and their quantities that each individual household reported in responses in an open ended question about the sources of waste was identified to see what the major sources of waste are and how they can be planned for preparedness.

The data pre-processing and analysis was done using Microsoft excel where all the data was processed and cleaned for the further analysis. The data collected with help of maptionnaire generated several copies of same responses, which were corrected in Microsoft excel. Once the data was cleaned the pre-defined qualitative codes [8]given to each option of the questions shown in Table 8. Were analysed and based on codes the responses were observed and calculated in excel for defining the impact of flood, waste types and quantities. Thematic analysis was used for the open ended question such as waste sources where common responses were clubbed together in each study area and the major sources of flood related waste were identified. The qualitative codes given to each option are shown in Table 9. below.

Table 9 : Qualitative codes given to options of each question

Q.no	Question	Responses	Code
1	Select your panchayat	Purakkad	P1
		Pandanad	P2
		Chittar	P3
3	Choose type of building	Residential	BR1
		Commercial	BC2
		Both	BB3
4	Total no. of floors	Ground floor	GF
		1 Floor	1F
		2 Floor	2F
		3 Floor	3F
		4 Floor	4F
		5 Floor	5F
		More than 5 floor	5>
5	Did you experience 2018 floods	Yes	Exp 1
		No	Exp 2
6	Did you experience 2018 floods in this building	Yes	Exp H1
		No	Exp H2
7	What was the level of water during 2018 floods	On Ankle	FL 1
		On Knee	FL 2
		Above Knee	FL 3
		On Waist	FL 4
		Above Waist	FL 5
8	Damage percentage	15%	D1
		16%-29%	D2
		30%-59%	D3
		60%-74%	D4
		75% and above	D5

[8] Qualitative coding is a process of coding qualitative data which helps to identify different themes and relationships in data.

The second part of the methodology is to quantify the waste produced by floods for the Pamba basin by using the ground truth data collected during field work.

To quantify the waste per LSG, building footprint, LSG admin boundaries and quantity of waste per household (field data) was used as input data and was clipped with Pamba basin layer. After the clipping process centroids were mad with the building layer within the LSG, which provided the count of number of buildings per LSG. Then a spatial join was performed to join the building centroid with quantity of waste Figure 12.

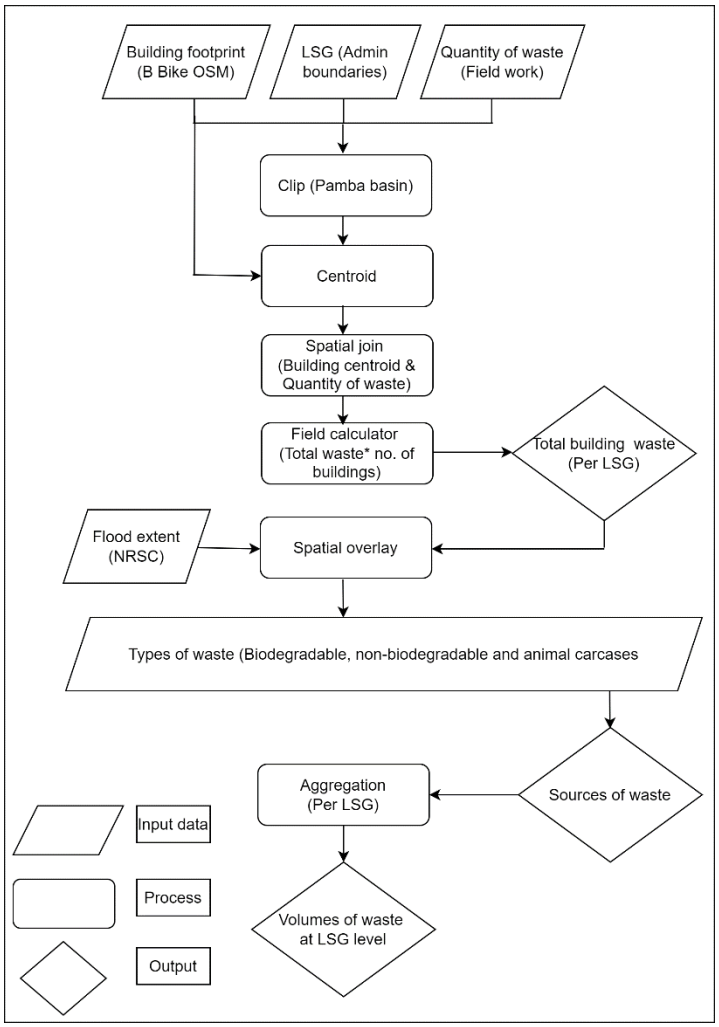


Figure 12 : Quantification of waste at LSG level in Pamba basin

Thereby the field calculator was used to calculate the waste per building in an LSG. To do the calculation the total number of buildings in a LSG was multiplied by the average waste produced by a house in (ground data). This gives us waste per building. By using the field calculator, the total amount of biodegradable, non-biodegradable and animal carcasses waste is also estimated per LSG and then to see the effect of flood extent on the waste produced a spatial overlay was performed where the flood extent data from 2018 floods was overlayed on total building waste per LSG.

After performing the spatial overlay, the types of waste (Biodegradable, non-biodegradable and animal carcases are quantified per LSG in tonnes. Then the sources of waste and the types and quantities of waste are aggregated per LSG, and total amount of waste is given that is produced by floods by floods of 2018 in Pamba basin. The amount of waste per LSG and the total waste is not validated as there is no available data or proofs that can be used for the validation of the quantity of waste that are given in the result section.

4.3. Results and Discussion

The results of this chapter are based on the field data analysis describing the types, sources and quantity of waste produced in each study are and then describes the quantity of waste produced by Pamba basin per LSG. The section first mentions the impact of the flood and then go through the various type of waste and their sources and volumes.

4.4. Impact of 2018 Floods in Kerala on Pamba Basin

The major impact of the flood was on the buildings as 20 percent of Kerala rural housing is at very high risk of floods (Khan et al., 2022), most of these houses either were flooded or got damaged due to the floods of 2018. The districts which surfed the major impact of floods are Pathanamthitta, Alappuzha, and Idukki these all three districts are located within the Pamba basin. The buildings were affected due to the heavy rainfall, inundation of water, landslides and velocity of the water which also affected the road networks, health infrastructure.

To analyse the damage and the impact of the flood as mentioned a field work was done in different geographical units of Pamba basin. As shown in Figure. 13 below that all the three study areas are highly affected by the flood as the highest flood level was reported in Pandanad panchayat as it is a flat low lying area located in the plains of river Pamba. Chittar panchayat is in higher altitude and hence the flood water did not inundate and moved towards the low lying areas of Pandand and Purakkad. The people were still in the house when flooding took place and caused lot of causalities and loss of life.

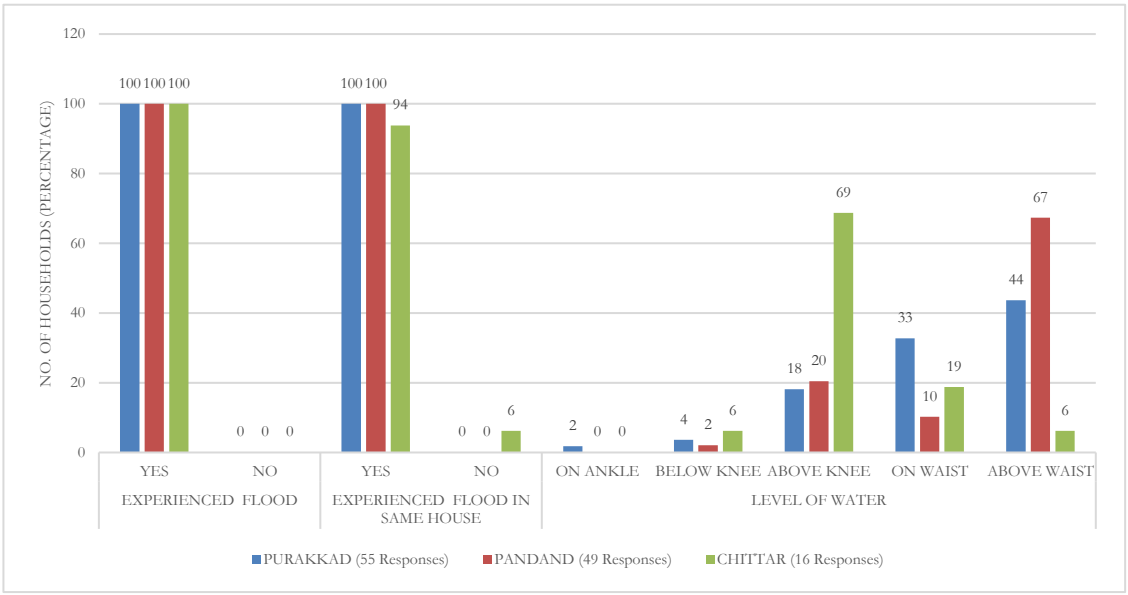


Figure 13 : Flood affected household

Approximately all the houses were affected by the floods and were in water for more than three weeks. The water in Chittar panchayat receded in seven hours and impacted the panchayat massively, the flash flooding and heavy rainfall triggered the landslide and resulted in damaging the houses and other infrastructure. All the house materials, wood, debris, and boulders were transported by flash floods the Pandanad panchayat in just couple of hours. The impact of flooding can be related to the percentage of house damaged as shown in Figure. 16 the houses in Chittar are mostly damaged 16-29 percent these are the houses near to the roads and in hilly terrains. There are houses

Figure 14: House damaged by landslide in Chittar panchayat

in category of 75 percent and above are the houses that got totally damaged due to sudden landslide as shown in Figure14.

In Pandanad panchayat house damaged varies with distance to river as Pamba river flows between the panchayat and hence buildings both side near the river were highly damaged as shown in Figure 13. Most of the houses are damaged between 16 to 29 percent and the others in category of 15 percent are damaged due to inundation of flood water in paddy fields the water inundated for more than three weeks in some places, an example of flood water is shown in Figure 15.

Figure 15 : Flood water mark Pandanad panchayat

In Purakkad panchayat the water inundated from two sides one from the Arabian sea and other from the Pamba river and many water channels that got blocked due to the debris and boulders. The houses damaged in this panchayat are mostly 15 percent damage due to the less velocity of water as water was stagnant for two weeks which went inside the buildings and caused damaged. The house damaged in Purakkad are also with more than 75 percent these were the houses which are built 50 meters away from the sea and got totally damaged.

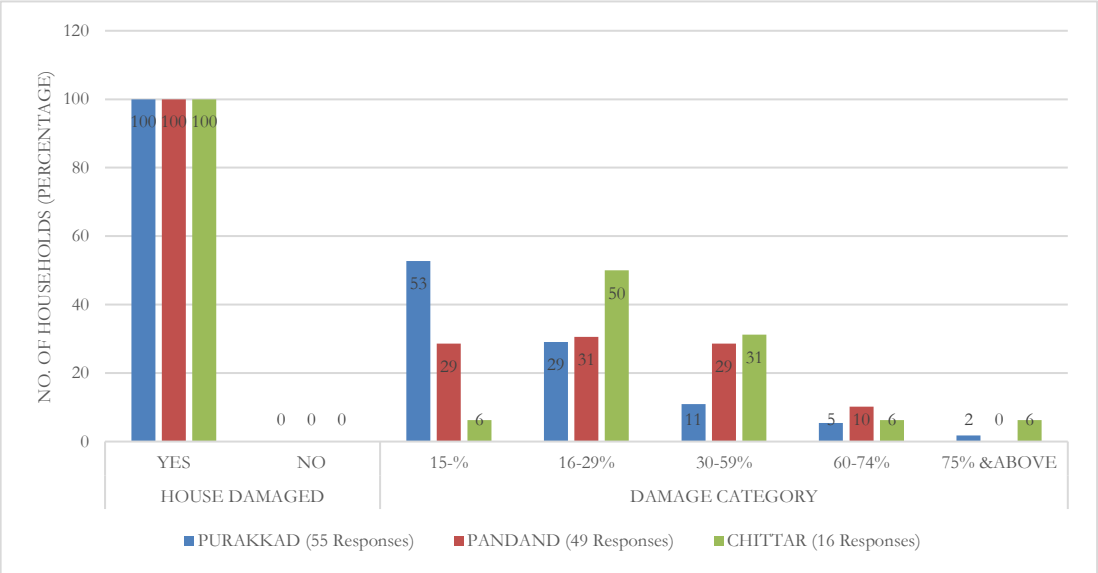


Figure 16: Flood damaged houses

The impact or damaged caused in the houses are due to the floods but also depends upon the construction material of the building and how old the building is. Majorly the number of floors in house were on ground floor and that led to the water in the houses and no place for people to escape in areas where flood water was more than 2 meters. In next section the types and sources of waste are discussed which depends on the impact of the flood.

4.5. Types, Sources and Quantity of Waste Generated in Each Geographic Unit (Low Land , Mid Land and Upland)

The flood generates different kinds of waste at different locations, it totally depends upon the interaction of flood with various things or materials that come on its way. For instance, flash flood in hills bring woods, debris, soil, and boulders with-it if the region also has some settlements, it will also bring the materials outside the houses and in some cases even from inside the house. The waste keeps adding with flow of water and whatever comes in between becomes waste. The similar situation took place in Chittar, Pandanad and Purakkad in August 2018. To describe the waste types and sources below are the results from the fieldwork.

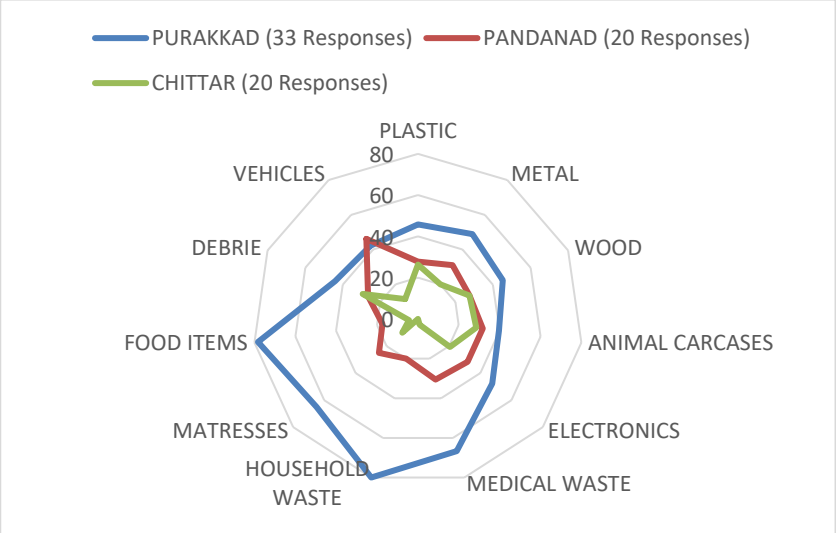


Figure 17 : Types of waste collected post floods

The types of waste shown in the Figure 17. were the waste types that were collected by the sanitation workers, volunteers and Kudumbashree post floods. As mentioned, each geographic unit generates different kind of waste and the different amount. In Purakkad the major waste collected is food items and household waste which includes furniture, vessels and others followed by medical waste, electronics, debris, vehicles, wood, plastic, metals, and animal carcasses. In Pandanad the major waste collected is vehicles followed by mattresses, metal, household waste, debris, electronics, medical waste, animal carcases and woods. In Chittar debris were the major waste because of landslides, followed by household waste, wood, animal carcasses, electronics, and plastic.

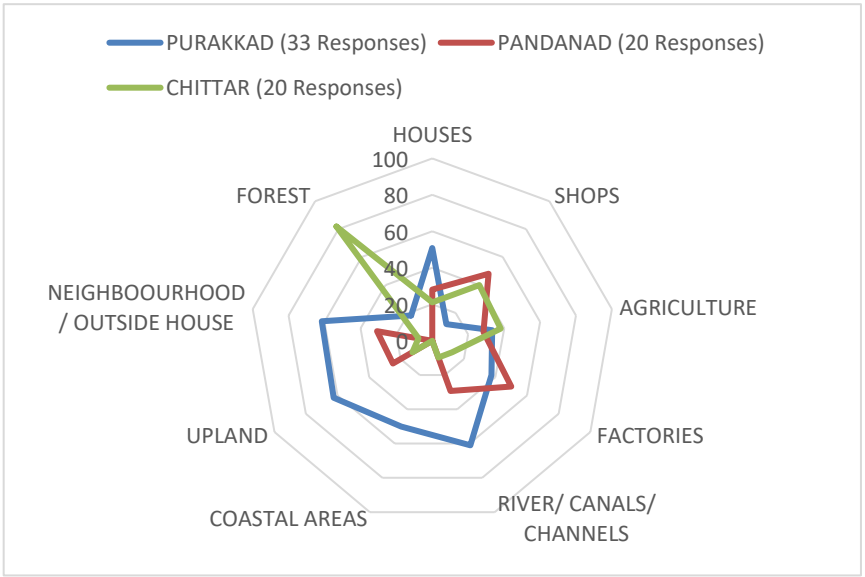


Figure 18 : Sources of waste

The source of the waste is the point from where the waste is originating. In Figure. 18. The sources of waste are shown which are result of data collected in field work. In Purakkad most of the waste collected is the waste sourced from uplands Chittar and Pandanad, the waste sources in Purakkad are also the houses, agricultural lands, neighbourhood, and water channels. In Pandanad major source of the waste were Factories, upland, houses, shops, neighbourhood, and agriculture. In Chittar the major source of the waste are forest, agriculture, plantations, houses, and neighbourhood.

The sources of waste each geographical units are similar but their percentage in specific sources are higher. As Chittar major source of waste was forest because large number of woods and crops turned out to be waste. In Pandanad the major waste come from factories and shops as lot of vehicles and food items were collected in Purakkad major source turns out to be upland as all the waste is transported by the moving water to lowlands and generates pile of waste.

Table 10 : Quantities of waste generated by households in study area

Furniture (Nos)	
Bed	254
Chair Wooden	375
Chair Plastic	298
Table	168
Almira's / Cupboards	111
Other Furniture	33
Vehicles (Nos)	
Cycles	98
Two Wheelers	73
Four Wheelers	21
Three Wheelers	12
Other Vehicles	9
Electrical Appliances (Nos)	
Fridge	76
Washing machine	40
Oven & Microwaves	22
Mixers & Grinders	39
Television	75
Electronics	
Computers / Laptops	47
Mobile & Tablets	129
Other Electronics Appliances	89
Animals (Nos)	
Cow	55
Buffalo	13
Dog	46
Cat	10
Horse	5
Elephants	1
Other Animals (Goats, Ducks & Hen)	314
Food (KG)	
Rice	2721
Wheat	1472
Cereals	945
Others (Seeds)	125

The total quantities of waste generated by all the households surveyed are shown in Table 10. The data shown are in exact number as reported by the respondent. This data is further used to quantify the waste per building and per LSG in Pamba basin.

4.6. Quantification of Solid Waste

Quantification of flood waste for Pamba basin is done with the help of ground truth data shown in Table 10. The data from study area was used to estimate the quantities of waste for reference refer to Annex 4 (Quantified waste per LSG). There by the waste is classified into broader types as biodegradable, non- biodegradable and animal carcasses and quantified as shown in Table 11.

The waste quantities are not compared due to lack of waste dataset. No quantification or reporting were done to estimate the waste.

Table 11 : Waste types and quantity

Waste	In tonnes
Total biodegradable waste per LSG	125537.5047
Total non - biodegradable waste per LSG	222615.0056
Total animal carcasses per LSG	215460.063
Total waste Pamba basin	715926.058

The waste generated by per LSG in tonnes is shown in Figure 19. It clearly shows the flood affected areas generates large amount of waste in comparison to less affected areas. There are as in map that are with white colour show no data as building footprints were not available for those specific areas. The area with dark red colour in centre

and in the left are most affected regions by flood as shown in figure 6 & 7. The amount of waste in these areas is also higher as the water inundated for more than 2 to 3 weeks which led the deuteriation of furniture, food, electronics, and other kind of materials.

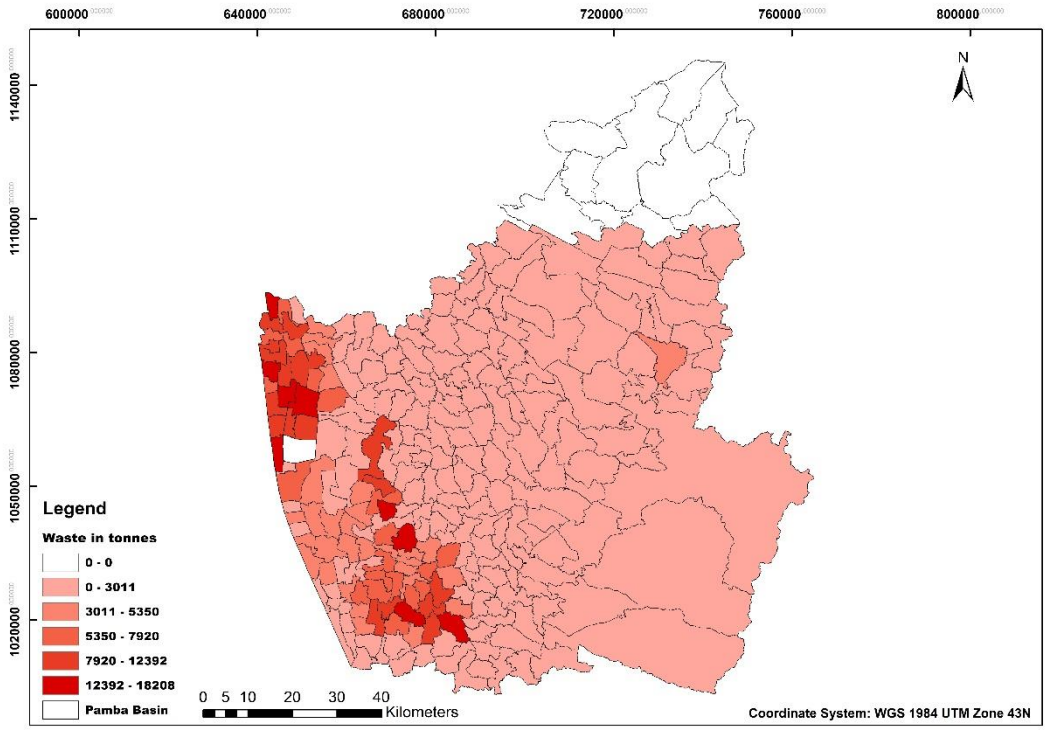


Figure 19 : Waste in tonnes per LSG

4.7. Conclusion:

Flood waste is a waste that interacts with water and is transported from one region to another. That transforms the normal goods into waste. While the water moves from higher altitudes it brings with it all possible materials that are not even waste. Flood waste are of various types as mentioned in the chapter. The sources vary from type of waste the major waste types are households waste which can be managed on individual levels. Electronics appliances and gadgets shall be managed by keeping on acetic. The amount of waste that is produced by the floods or any hazard event can be controlled or reduced by the proper managements and early warnings. In case of Kerala if early warnings are issued immediately actions shall be taken to manage the possible materials, items that might convert into waste once flooded. Individual to administrations can better plan the strategies to minimise the flood waste at regional LSG levels to reduce the waste generation.

CHAPTER 5: POST-FLOOD SOLID WASTE MANAGEMENT AND ITS RESULTING HEALTH IMPACTS

5.1. Introduction

Flood water may eventually recede, leading to many challenges as tons of wastes are produced, impacting not only the environment but also human health and inducing financial losses (Habib et al., 2019). Solid waste management (SWM) is one of the most significant responsibilities to be fulfilled during the recovery phase. (WHO & WEDC, 2013).

In terms of public health, the waste generated during the 2018 floods in Kerala posed various health threats like bacterial infections and leptospirosis affecting the states different region. Post-flood waste management was also a challenge to public health, posing various threats like bacterial infections and rat fever affecting the state's different regions. The health effects of floods and their generated waste varied depending on factors such as topography, characteristics of the built environment, and human demographics (Du et al., 2010).

Sustainable Development Goal (SDG) 12 focuses on environment-friendly waste management through reduction, reuse, recycling, and prevention in targets 12.4 and 12.5, and reducing food waste in targets 12.3 (United Nations, 2018b). Similarly, the waste generated by floods shall be managed without hampering the environment and human health. SDG3, target 3.3 combating water borne disease is very relevant as flood water leads to expose of larger population to disease like dengue and malaria (United Nations, n.d.-a). SDG 11 targets 11.5 focus on the flood-derived waste health effects that targets to proper management of the flood waste (United Nations, 2018a). This makes it very clear even though we know what challenges and problems, yet our priorities are something else. Hence in this part of the research, a close relation between post-flood solid waste management and its resulting health impacts is discussed.

To study the post flood waste management and the health implications a field survey was conducted in sampled areas of Pamba basin. The data collection was done for flood and landslide affected houses, Target groups such as, sanitation workers, Kudumbashree, volunteers were surveyed, and local government administrators and health authorities were interviewed. The data collection took place in month of March' 2022 and lasted for four weeks approximately. The data collection was a with a mixed method research approach and data cleaning and sorted using different software.

5.2. Methodology

Fieldwork is an integral to societal and scientific research as it helps researchers understand and relate scientific theories and methods to real life. The thesis deals with the solid waste management post floods and the health effects, and the waste that is generated by floods, for which there are no available datasets that can be used for the analysis or to understand how the waste generated by floods was managed. Two tools were developed to collect the post-flood waste management data: surveys and written interviews.

Survey forms can be easily created in maptionnaire but with more technicalities which will help to reduce the time spent on analysis. Written interviews were developed based on information needed for the research and what are the experiences of people on the ground. The written questionnaire and surveys are a good combination for inter-validation data collected in the field.

Survey forms were developed in loop of the information required for the research. The questionnaire was developed in software maptionnaire. The tools developed for the survey for households and the sanitation workers and volunteers are survey which are either multiple choice based and, in some cases, open question base. For the stakeholder's interview as tool was developed to gather as much information as possible. These interviews were followed by the informal discussions. As the information gathered can be discussed further if needed.

The data collection was done with a software maptionnaire to develop survey tools for the different target groups, Households, Sanitation workers, and volunteers, respectively. All the information collected with maptionnaire is in adherence to the General Data Protection Regulation (GDPR) from the European Union and follows the principles of the Netherlands Code of Conduct on Research Integrity.
The data collection was done in two parts, one for the households and the other for the Sanitation workers and volunteers.

Data Collection (Household):
The household data for post-flood solid waste management were collected from three different geographical units, Purakkad (Low land), Pandand (Midland), and Chittar (Upland). To survey the houses in each study area, stratified random sampling was performed on flood-damaged house data for 2018 Annex 3. The sample size chosen was 33 percent based on statical standards for each damage category, as shown below Table 13. The data was collected focusing on post-flood solid waste management and its health implication in three study areas represented by different target groups.

Table 12 : Questions asked to households

Did you manage flood-generated waste at the source?
In how many days did you remove the waste?
How did you collect and remove waste?
Did you use safety gear for personal safety while managing waste:
Are you aware of any health effects associated with floods? If yes, please specify.
Did you face any health effects from removing the waste:
How long the health effects lasted?
Was healthcare accessible during and post floods 2018?
How far you travelled for getting access to healthcare during the times of 2018 floods?

The above mentioned Table 12. questions helped to investigate the impact of flood and waste on health. How did people prevent themselves from the health risk? It also gives us insight on health literacy, accessibility, and availability to healthcare facilities.

In the household survey, major themes related to waste management are how authorities managed the post-flood solid waste with no support from local self-governments, how did households manage the waste, how many days they were involved, how they removed or clean waste, and what challenges the faced by managing it on their own. Also, themes related to health are they aware of any health effects due to floods, waste management, duration, and accessibility to healthcare and facilities.

Table 13: Household Survey Composition of Houses in Different Damage Classes

Study Area	Purakkad (Low land)	Pandanad (Midland)	Chittar (Upland)	Total Houses Surveyed
Damage Class/ Percentage	No. of Houses			
15%	29	14	1	
16%-29%	16	16	8	
30%-59%	6	14	5	
60%-74%	3	5	1	
75% and above	1	0	1	
Total	55	49	16	120

Data Collection (People, Sanitation workers, Kudumbashree, Volunteers):
The post-flood solid waste management carried, and health effects faced by people, sanitation workers, Kudumbashree, and Volunteers post-flood in different geographical units were surveyed on convenience-based sampling, which was moreover based on the availability of target groups. The question asked to the target groups are in Table 15. To collect the data certain arrangements, were made with the local governments, to fix the availability of target groups, transportation. which helped to reach out to the target groups. Based on convenience sampling, no. of people surveyed can be seen in Table 15

Table 14 : Question asked to target groups

Did you work for waste collection, removal during and post 2018 floods?
Did you experience the 2018 floods?
From where you were collecting waste?
Check the type of waste collected
For how many days you engaged in managing the waste?
Did you segregated (biodegradable, non-biodegradable and carcasses) the waste while collecting?
What kind of challenges did you encounter while removing waste?
Are you aware of any health effects associated flood generated waste?
Did you face any health effects from removing the waste?
Was healthcare accessible during and post floods 2018?

The questions mentioned in Table 14 are the question for which the target groups were surveyed. These questions led to the understanding and analysis of how did these groups managed? How was there experienced with the flood of 2018, it also describes about the number of days different target groups worked. What health impacts they face by the floods and by the waste management.

In the sanitation workers survey, major themes linked to waste management are the no. of days everyone worked, segregation and challenges faced. Also, themes related to health are they aware of any health effects due to floods, waste management, duration, and accessibility to healthcare and facilities.

Table 15 : Waste Workers Survey Composition of Different Target Groups

Study Area	Purakkad	Pandanad	Chittar	Total No. of People Surveyed
Target Groups	No. of Peoples			
Sanitation Workers	4	1	0	
Kudumbashree	17	6	7	
Volunteers	12	13	13	
Total	33	20	20	73

Data Collection for (Local Self Governments-Health Authorities & Disaster Manager):
The tool used for the collection is written interviews followed by discussions. An interview questionnaire was drafted for respective study areas. The respondents were panchayat presidents and secretaries who have been in administration for the past few years and managed the community during and after the floods in 2018. From each panchayat, two respondents were for a written interview and many others for followed discussion. Similarly, one health representative from each study area and one health representative and one Disaster manger was interviewed from the state, as shown in Table 16.

The questionnaire was designed in accordance with the literature and data gaps that was filled by the written interviews. The questions were also based on the survey questionnaire so that the information gathered through survey can also be validated. Questions related to the experience of respective authorise and their involvement in 2018 event provide information about the overall situation.

Table 16: Stakeholder Written Interview Composition

Study Area	State (Kerala)	Purakkad	Pandanad	Chittar	Total No. of People Surveyed
Stakeholders	No. of Respondents				
Disaster Manager	1	_	_	_	
Health Authorities	1	_	_	_	
LSG President & Secretary	_	2	2	2	
LSG Health Authorities	_	1	1	1	
Total	2	3	3	3	11

Data Pre-Processing/ Cleaning:
The data collected is a huge dataset combining General questions, Floods, Waste management, Types, sources and Quantity of waste, Health impacts, Guidelines, Suggestions, and recommendations. This was collected for both 120 households and 73 people involved in waste management. To pre-process the data collected, Microsoft excel was used, which helped to prepare and sort raw data into different themes and classes using qualitative coding. Thereby the cleaned data was used to calculate the sum, mean and standard deviation for respective themes Table 17.

Table 17 : Qualitative coding for field-collected data

Q.no	Question	Responses	Code
1	Select your panchayat	Purakkad	P1
		Pandanad	P2
		Chittar	P3
3	Choose type of building	Residential	BR1
		Commercial	BC2
		Both	BB3
4	Total no. of floors	Ground floor	GF
		1 Floor	1F
		2 Floor	2F
		3 Floor	3F
		4 Floor	4F
		5 Floor	5F
		More than 5 floor	5>
5	Did you experience 2018 floods	Yes	Exp 1
		No	Exp 2
6	Did you experience 2018 floods in this building	Yes	Exp H1
		No	Exp H2
7	What was the level of water during 2018 floods	On Ankle	FL 1
		On Knee	FL 2
		Above Knee	FL 3
		On Waist	FL 4
		Above Waist	FL 5
8	Damage percentage	15%	D1
		16%-29%	D2
		30%-59%	D3
		60%-74%	D4
		75% and above	D5

The written interviews were analysed by using grounded theory where the questionnaire was structured in different concepts that brought the different themes together. These were later used for the generating the literature for the thesis as the available literature are limited. The LSG interviews were compared with one another in terms of management and experience. Interview with health and disaster manger stand alone as only one respondent in each case. Hence were individually analysed.

5.3. Results and Discussions

The major themes covered in this section are waste management, use of safety gears, health risk and impacts, availability, and accessibility to healthcare and optimal recommendations.

Waste Management by the worst affected Local Self Governments:

Purakkad

It was first time the Panchayat faced such intense flood. From the West along the coast of the Arabian sea storm surges have resulted in flooding of the coastal areas and from East the area is affected by the flooding from the Pamba River. It was a situation that Lsg's were not prepared for but still did the best they can. The administration tried to manage the Thattappaly spill way which is major door to Arabian sea and Pamba river to meet. The flood receded in three weeks after that the volunteers' teams were organised and were sent to help the households in panchayat to remove and clear the waste. Help was requested from different NGO's and organization from different cities and states of India. Waste management post floods was the most severe problem as no one had clue how to begin with. Waste was of all kinds even unidentifiable that LSG collected mixed waste and decided not to segregate. The total collected waste was around 25 tonnes according to president of panchayat. The waste was initially collected near the rivers and open spaces like parks and playgrounds. This collected waste was transported to the cluster where other LSG's also collected their waste and then the state municipality handled it.

Pandanad

Pandanad panchayat was flooded for more than two weeks and experienced a large influx of waste from the Chittar panchayat in huge amount. The panchayat president mentioned that it was almost next to impossible to manage the flood waste. Due to lack of manpower and due to lack of any guidelines and procedures. This Panchayat face floods regularly but this was an unexpected one. Pandand had major destruction as large number of houses were fully damaged and some partially, lot of animals died. Due to floods all the silt and mud accumulated in the panchayat because of terrain being flat. The major waste was bed, pillow, clothes, cushions, and carcases of animals. Initial days post flood the administration failed to find a place for waste collection. Then later few weeks waste was collected and directly transported to other panchayats and LSG's. The animal carcasses were disposed of within panchayat with the help of veterinary Dispensary. For all other kind of waste agencies were hired which directly picked the waste and transported out of the panchayat. Lot of volunteer's snatiation workers were organised to clear mud and trees and all other waste that was hindering the reconstruction.

Chittar

Chittar panchayat suffered floods and landslides both which made the panchayat situation worse and was badly affected. More than 25 house were fully flooded and more than ten landslides triggered during the same times which partially damaged the houses. The flood water receded in six to eight hours. The houses which were damaged for them the volunteers were sent to clean and remove waste. NGO's and volunteers helped the neighbourhood to clean roads, agriculture lands and removed waste from different households. Although the panchayat was managing waste, but it was not coming to an end as lots of debris, electronics, animal carcases and big trees were almost everywhere which pose and extra huddle to manage waste. The panchayat did not even have any aid from that very point to support the residents. About 15 tonnes of total waste were collected without segregation. After collection waste was piled on open grounds and from there was given to the regional municipalities.

Availability and use of safety gears:

Personal Protective Equipment's (PPE) has become the very familiar word to every individual throughout the world because of COVID-19. COVID-19 is also a disaster that confronted the world with health problems and then to prevent these health effects and prevent COVID-19 what everyone used like, gloves, mask, haircap, face shield, eyeglasses and many more. These all counts under safety gears.

During and after a disaster it is important for emergency rescuers, and health workers is to have proper safety gears that protect them before they protect or rescue someone else. Likewise, sanitation workers and volunteers can protect their health by minimum safety gears like mask, gloves, gumboots, boots, and eyeglasses. In the study areas it was found that households were not at all aware about what safety gears are also if some of them were aware than they only knew mask and gloves. In the survey for sanitation workers survey it was observed that some of them were aware about the safety gears and some did not
Its houses, neighbourhood and vicinity which get damage and all the surroundings get full of debris and other materials that are waste and must be cleared. So, situation occurs in such a way that when people return to their homes post-floods what they find is chunk of waste and they must clear it on their own. Here comes the interesting twist which is already vulnerable people who just came out of exposure of so many diseases and health risk are again exposed to rodent borne, vector borne, snake bites and other kind of diseases. But there is no other possibility as there are no arrangements done to tackle such kind of problems. Hence forth people started cleaning their homes, surroundings and volunteers started cleaning open places, houses, and others. To see what kind of safety gears were used by whom let us look specifically:

Households: In household survey data analysis it came out that out of the 120 respondents only 16 were aware of safety gears and even used them. The safety measure that these households' members used were gloves and masks as shown in Figure 20. The question arises why rest 104 houses did not use any is due to lack of health literacy, assistance and in some cases financial situation. Interesting fact which was in

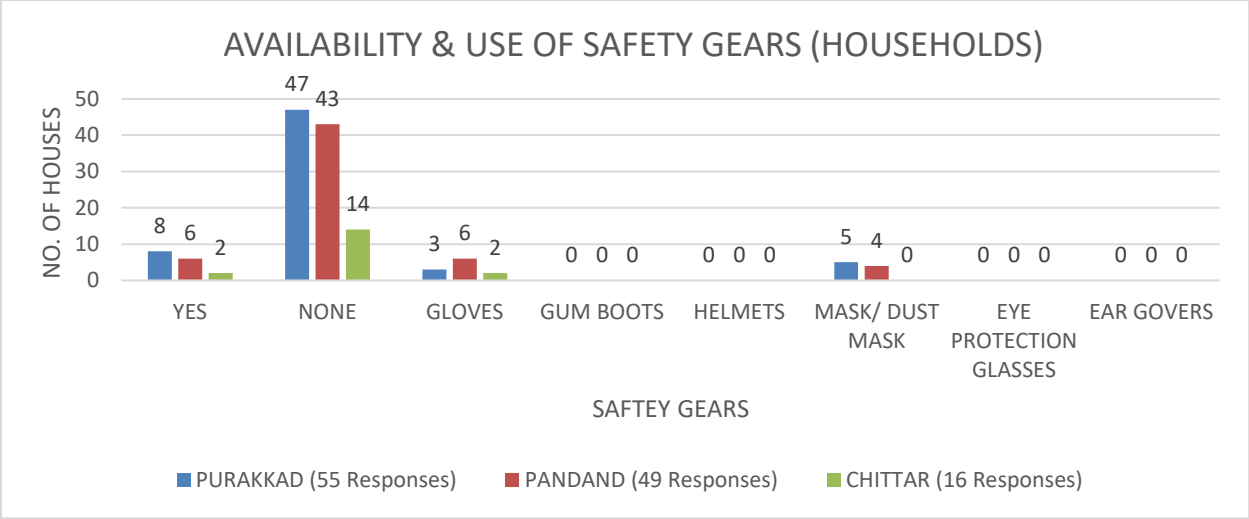


Figure 20: Availability & use of safety gear by (Households)

discussion was the need of using safety gears when we can manage bare hands. There is the gap which can only be filled by creating and emphasizing on health literacy.

Waste Workers: In the analysis of the survey results from waste workers survey data analysis it was seen that there are differences in use of safety gears by different target groups working for the same cause. In total out of 73 respondents 58 respondents used the basic to average safety gears. Amongst waste workers there are three groups Kudumbashree, who used safety gears like gloves, mask, gumboots, and helmets. Sanitation workers, who used Gloves, face mask, gumboots and only one used eye glass and Volunteers (Harith Karma Sena), used generally face mask and gloves, Figure 21. given to them by non-governmental organization.

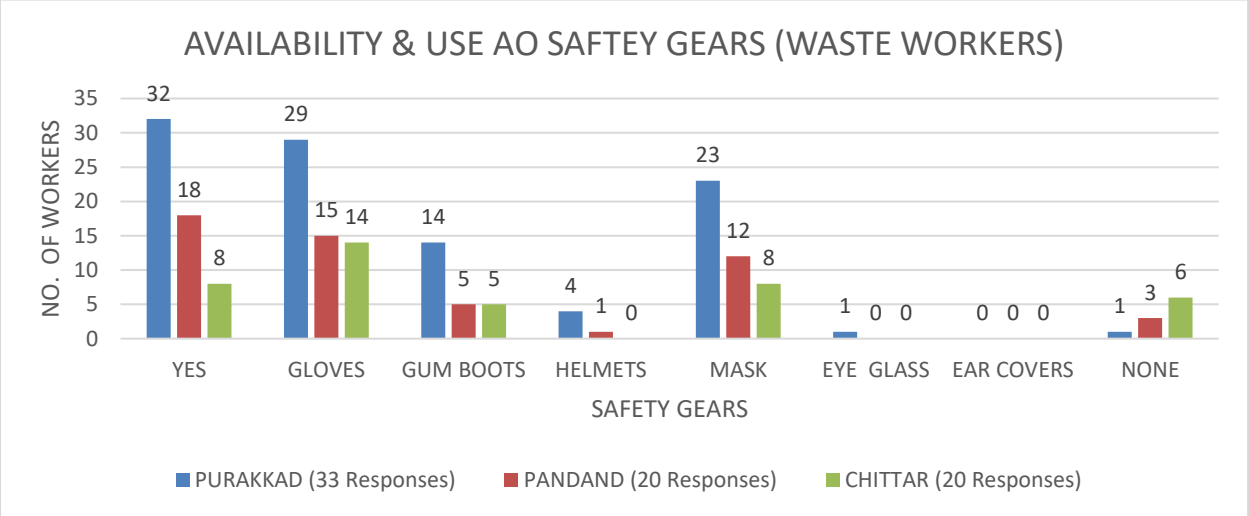


Figure 21: Availability & use of safety gears by (Waste workers)

It is important to protect oneself and to protect oneself in time of emergencies or during community works like post flood solid waste management its necessary to use safety gear. Its provident from above paragraphs that health literacy's important, accessibility to safety gears is important and the most important is to make the use of safety gears. Administration is expected to aid its people and support in terms of reducing risk to their health.

Post flood solid waste management by Households and Target Groups (Sanitation Workers, Volunteers and Kudumbashree):

Floods of 2018 in Kerala was sudden act of nature that lavished the god owns country under water. The floods were not region specific, but the flooding took place everywhere in different time and duration. For example, in uplands flood were for 6 -8 hours and in midland and low land floods were for more than 2-3 weeks. This flooding brought huge tons of waste from all over the Kerala to lowlands. Heavy rainfall resulted in flash floods in uplands which transported the waste to midlands and lowlands. During the floods residents were evacuated and were taken to relief cams till water receded. Hence coming back for the people was not so happening as their houses and assets were all damaged either partially or fully. Post – flood waste management was not easy for the people as they faced huge mental, social, and financial trauma. Lot of people lost their valuables and loved ones

Waste management was not only difficult because they lost their valuables but also as the people were not capable of handling such amount of waste. Hence the neighbours collectively helped each other in waste management and meanwhile also shared their homes with each other. The residents also approached the local administration to seek help in managing waste, but the problem had no solution. Meanwhile

administration raised their hands saying situation is out of control and urged people to support and help each other.

Therefore, the volunteers came up organising different clean up rides in scheduled manner pan Kerala, these volunteers cleaned and removed waste from individual hoses and from the roads, agricultural lands, and others. Sanitation workers were involved in the management of water channels with the fire department. Kudumbashree the self-help group lead the clean and waste management rides in different villages and at government institutions. While the waste weas collected or removed it was not segregated and after collection was transported to different regions within Kerala and outside Kerala.

There were lots of challenges and hindrance while manging waste major challenges include.

- Lack of administration support
- Lack of equipment's to collect and mange waste
- Snake and Reptiles bites:
- Lack of guidelines and trainings
- Accessibility to pure and clean water
- Accessibility to different places obstructed
- Foul Smell/ Irritation and Skin diseases

The households were involved in the waste management from the moment they return their homes. Figure 22. Provides a summary of the number of people interviewed and foe how many days they worked. Chittar panchayat sixty-nine people worked for o-10 days, nineteen houses worked for eleven days and six people they dink work as they were old or had some disease.

The results are quite different for the target groups Figure 23. In the uplands area of Chittar, which was flooded only for less than a day it took 20 days to clean up. In Pandanad it took 30 days and in Purakkad all workers required up to 40 days to for clean-up.

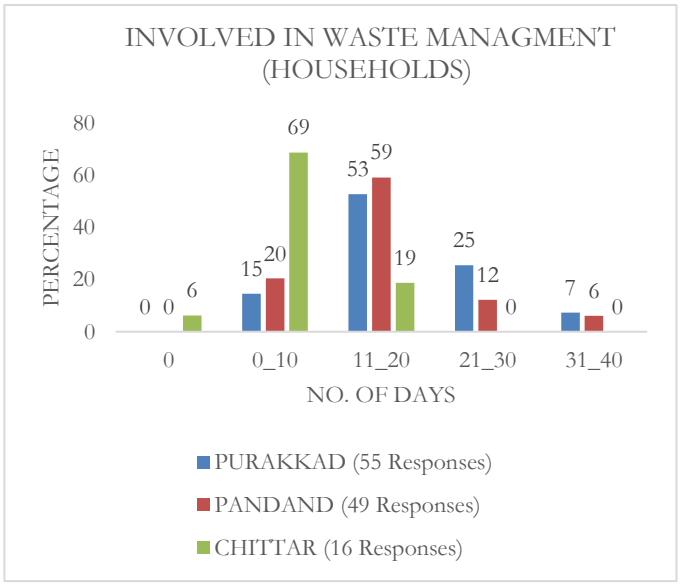


Figure 22: No. of days Waste workers worked for waste management

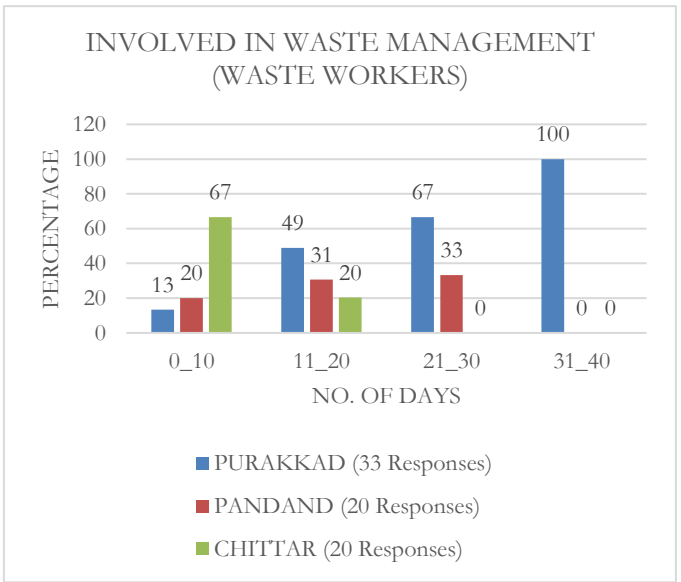


Figure 23: No. of days Households worked for waste management

Health Risk and Impacts of Flood and Flood generated Waste on Households and Target group:

. Most common diseases that can generate from floods and its waste is, cholrea, diahrea , dengue, hepatitis A , leptospirosis, chiknguniya, breathing problrms and also skin diseases.

A health expert interviwed in this research addressed the 2018 floods to be one of the worst devastating on people of Kerala. "He said it was ver well known that real issues are going to emerdge once the flood levels go down" it was confirmed that health authorites were prepared for the basic support to extensive care for impacted people. But there are problems like below mentioned which people might face and have to seek nearest health care for assistance. Direct injuries because of floods and landslide, Airborne infections like measles in children as many people from different families are living in common shelters, Infectious disease like hepatitis and diarrhoea occurring because of drinking contaminated water, Leptospirosis because of the longstanding contact with contaminated water and Dengue and other mosquito bone diseases, Injuries, electrocution, and snakebite while the families go back, Long standing mental health issues and post-traumatic stress disorders.

The survey results for the households in the upland , midland and lowland areas resulted in similar problems. The most common disease witnessed by households were fever, Dengue, Cholre, Leptospirosis and Diahrea. The disease cholrea wasmostly concentrated to Panadnd Panchayat where as phycological problems were mostly concentrated to the Chittar panchayat , as shown in (fig.7). Emergency rescue teams tried best possible to rescue the maximum number of people from all affected regions to minimise the looss of life and reduce the health impacts.

The sanitation workers were more exposed to generated waste health effects as. Some of the waste workers namely sanitation workers and trained volunteers were engaged in opening and clearing of blocakges of water channels. The waste workers worked for removal of waste in flood stagnant water which also impacted their health. Amongst the waste workers most common diseases that were found are fever, skin problem, respiratoary problems, injuries in all the three study areas. Also there were rare cases of leptospirosis, dengue and diarrhea amongst waste workers, asa shown in Figure 24. below.

In interview with local health authorites the most reported cases of flood health effects were; Waterman feet anhands, Intertigo rashes, acute exaceberation of Asthma/Chronic obstructive pulmonary disease (COPD).

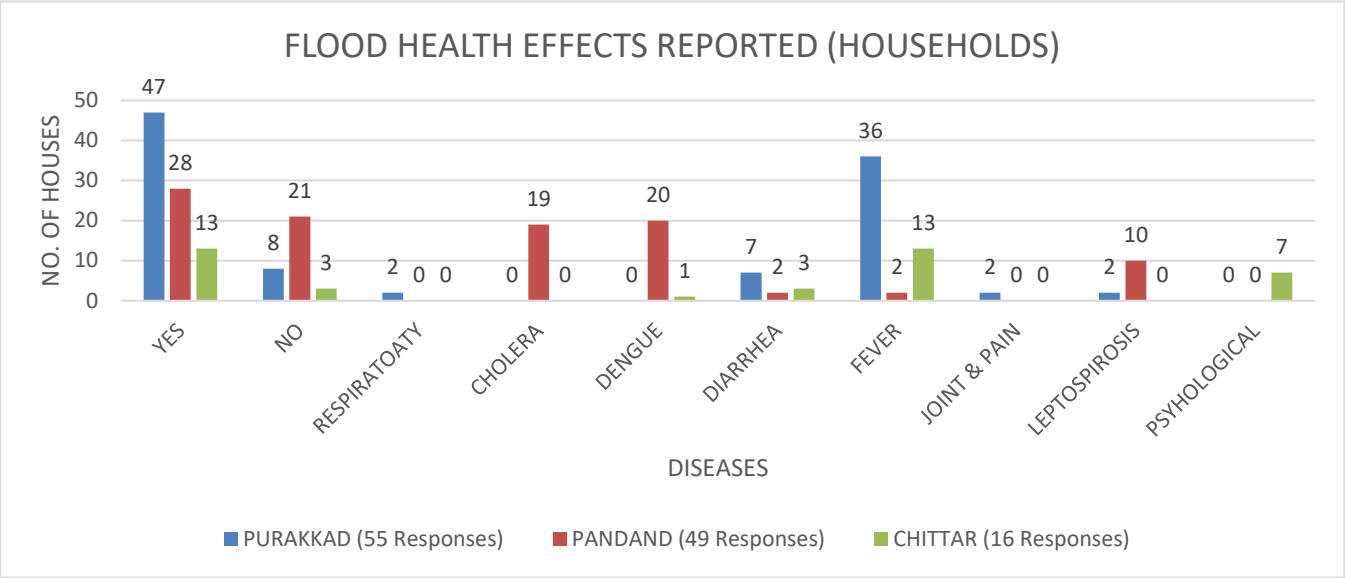


Figure 25: Flood-induced health effects (Households)

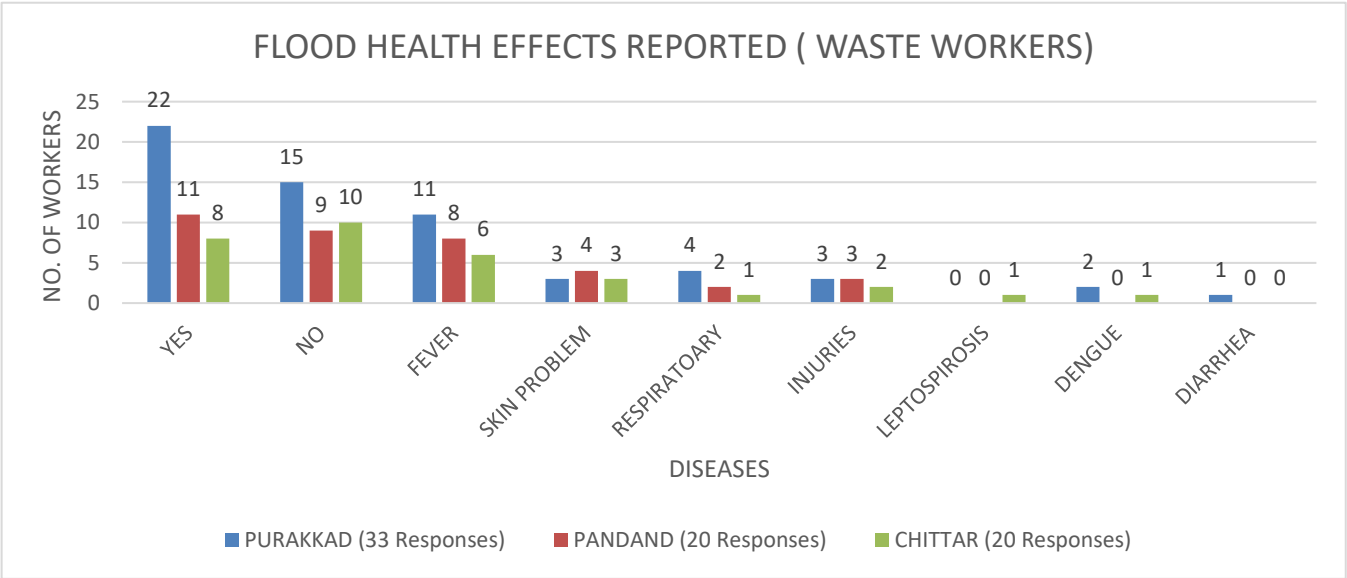


Figure 24: Flood-induced health effects (Waste workers)

Flood Generated Waste Health Effect (Households and Target Groups): Flood generated SW can have very varied kind of health effects which many a time are overseen or neglected. Similarly, this happened in Kerala post – floods, after a while when cleaning and removing of waste was over the number of cases reported with community health centre regarding skin diseases and respiratory problems drastically increased.

Injuries and cuts are not much reported as mentioned earlier its often neglected but the interesting fact about this is that these injuries and cuts many a times can be the cause behind skin problems. During survey it was also observed and noted that lot of home remedies are being used in cases of cuts and rashes but in some cases, it worked and in some cases it did not. Even still there are ongoing skin diseases that people will carry probably life long as per their doctor's view, as shown in Figure 26.

Figure 26: Skin diseases (Captured in Pandanad panchayat)

During an interview with a regional health worker, it was noticed that there were more cases of skin diseases because of handling flood waste without any safety gears and of respiratory problems as piled waste accumulated with dust along the houses for more than two weeks led to the foul mud in air and caused severe breathing problems. Other reported diseases were, Bronchi's, Asthma's COPD. Few cases of leptospirosis, dengue, and cholera. The other concern was for biodegradable generated by flood will end up in contamination of water and might spread water borne diseases. Non – biodegradable waste like plastic will collect and get mix with water and other materials and then will lead to outbreak of dengue and other vector borne diseases. Liquid waste contaminated by human excreta and animal excreta, urine also got tremendous consequences of leptospirosis, cholera etc.

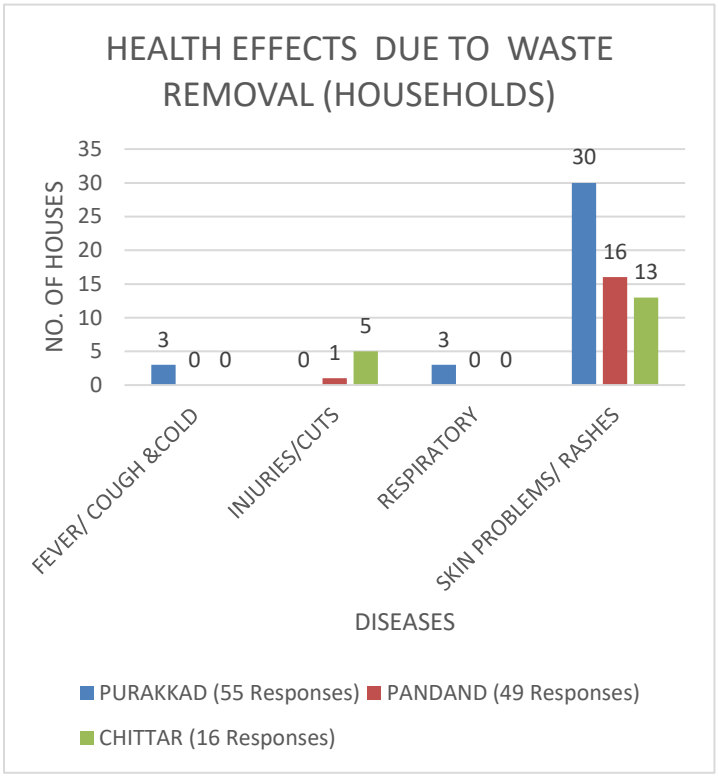


Figure 28: Flood waste-induced health effects (Households)

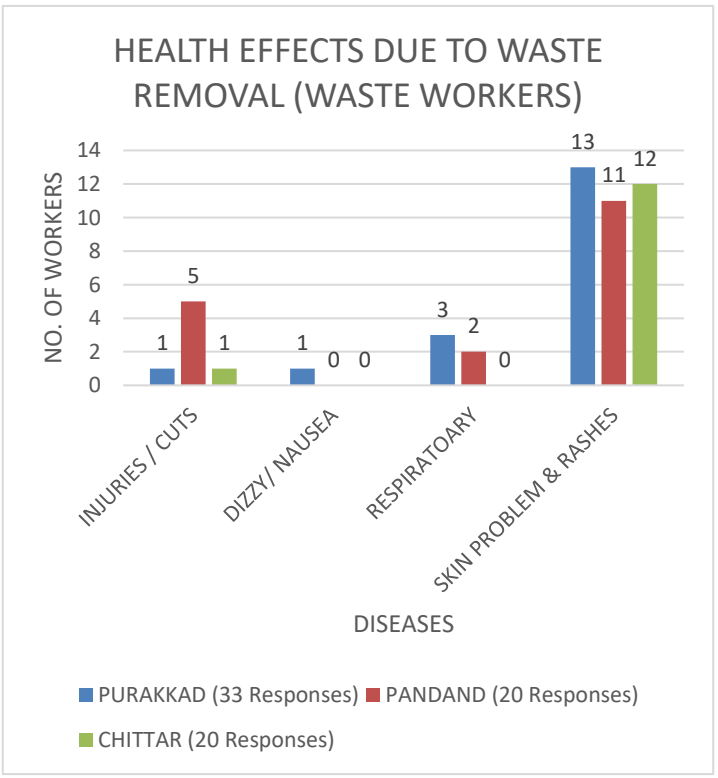


Figure 27: Flood waste-induced health effects (Waste Workers)

Availability- Accessibility to and quality of Health Care Facilities Before

Both accessibility to healthcare and facilities within healthcare are very significant factors that denote the wellbeing of person during an emergencies like 2018 flood and in normal times. As mentioned in page 32 & 33 the health effects from floods and its generated waste are vide any very significant. The health effects from both flood and its generated waste can be short term, medium term, or long term. To reduce or minimise this term the accessibility is very important that to with good facilities, treatment, and cure. The number of hospitals in Kerala are 209.000 and the average population served per hospital is 27,873,000 (Goverment of Kerala, 2005). Overall health care in state of Kerala is efficient and have all the basic to severe disease treatments facilities.

The 2018 floods were so devastating that they destroyed bridges and damaged the roads, The connectivity to the major cities, from many rural areas was greatly reduced. Which resulted in the reduce in accessibility of not just healthcare but also the rescuing help. During floods of 2018, the healthcare facilities were provided to people by the help of boats, cables, and helicopters. Post floods situation did not improve much as still the reconstruction was yet to begin and people were left either to walk down towards nearest health care or come by their own transportation.

Accessibility and Rating of Healthcare facilities By Households:

Kerala is densely populated, according to the 2011 census there are 860 people/hectare per sq. To provide healthcare and other facilities to such a densely populated state is a difficult task. The households surveyed in the three different regions have different topographic than means of transportation to access to this healthcare also differs.

In Purakkad Panchayat the health care facilities are well maintained and functional both during and after floods. To get access to proper treatment people had to wait long hours and in some situation days because of the no communication and dysconnectivity due to floods and broken bridges. Especially in wards 7, 12 and 15 face huge challenges and difficulties as these areas fall next to the flooded river Pamba and only through boats the extended medical help could be provided. Most interesting and thing to learn from the people living here as they used their own small boats to get the help from nearest healthcare as the water level reduced. This can also be seen in Table 18. And Figure 29. that there is very minimal change in the percentage of accessibility. The facilities rating has shifted from good to excellent which is because of facilities been provided to people and their families which were no more connected with mainland and were isolated.

Pandanad was the worst affected panchayat in Kerala and the most prone to leptospirosis diseases. The hospital managed the healthcare nicely as the health care could be provided to people with the help of boats and helicopter. As this region is plain and mostly agricultural and houses are in cluster which helped the health authorities and emergency teams to reach the affected people. Health facilities were affected during floods but not on a large scale, health facility was provided using the boats in which minimum basic aid was available.

This Chittar is panchayat located in the mountains and faced both flash floods and landslides, which affected the normal life of society. The accessibility to many essential facilities was disrupted due to flash floods and landslides for more than two days. The healthcare access in Chittar is quite inaccessible as the mode of travelling for the majority of resident is walking or by personal transport except those who lives close to the centre of villages where public transport

facilities are available. In a case an ambulance was sent 4 Km and then the patient had to be carried 2 km on a handmade stretcher by his family. There are areas from where healthcare is even limited in normal times. Hence health literacy is very important which self-explanatory in the example given of handmade stretcher. People had to travel a long distance even to get basic healthcare as shown in (Table 18). In terms of facilities in health centres they provide minimum basic health care and for severe health issues people must travel additional 5 to 7 km fort treatment. Therefore Figure 29. shows a major decrease in health facilities rating during and post floods than before floods.

Table 18: Accessibility to Healthcare (Households)

Healthcare accessibility (percentage)										
	Distance travelled during and post 2018 floods					Distance travelled before 2018 floods				
Panchayat	Less than 1km	2km	3km	4km	More than 5km	Less than 1km	2km	3km	4km	More than 5km
Purakkad (55 Responses)	0	44	25	15	16	4	42	44	27	9
Pandanad (49 Responses)	9	16	10	10	55	8	20	6	13	53
Chittar (16Responses)	6	13	75	13	6	6	38	50	0	6

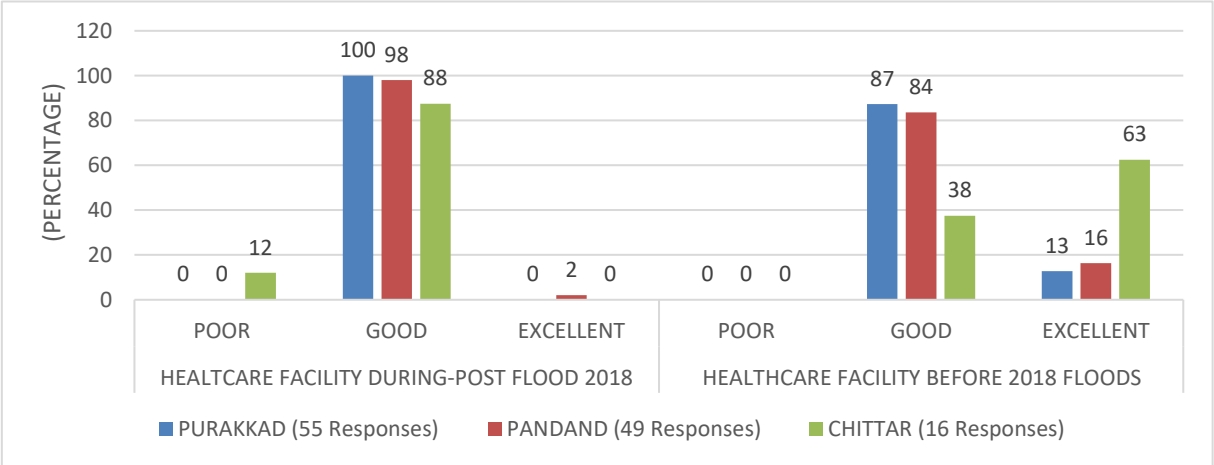


Figure 29: Healthcare Rating by (Households)

Optimal Recommendation to Ensure Personal Safety (Based on stakeholders' responses):

The floods of 2018 led so much devastating impacts on the society that if the lessons are not learnt the events that might occur in future will be worse than the one faced. Although thew the state and national emergency forces were on duty. But the flood management and its generated waste which led to enormous health impacts were not expected by anyone. Like every problem this also need a solution and people together with support of different non-government organization took the lead to manage the blockages and waste that generated but this all was done without adhering to any guidelines and improper management which lead to different problems related to lack of pure and clean water, proper sanitation and the dreadful health impacts which traces can still be found on field.

To reduce these uncertainties and health risk amongst below target groups and stakeholder, came up with the optimal recommendation to ensure personal safety of the people involved in the management of floods and its generated waste to reduce the health risks.

People-Sanitation Workers &Volunteers– Health Workers & Emergency Response Team:
People were working in direct contact with floods and its generated waste. Health workers and emergency response teams were engaged both during and post floods and had direct and indirect contact with the floods and its generated waste. Lots of slug and rodents and sharp materials that could easily cause injury to people were found. To prevent the target groups and stakeholders following optimal recommendations are suggested:

- Use of safety gears is must while managing the waste. The safety gears include, Basic safety gears includes, Mask, gloves, gumboots, ear covers, helmets and eye protection glasses
- People should take care of clean and pure water if not available shall use boiled water
- Basic sanitation and hygiene shall be considered both for people managing the waste and the people in the relief camps, by using safety gears and hygiene measures
- Injured with sharp objects including waste sharp shall immediately consult the doctor
- While collecting waste try to segregate waste. With full safety measures and equipment's.
- While visiting camps health care workers and general people shall use PPE to prevent themselves from any kind of bacteria and viruses
- Do not work or engage yourself if fallen ill or injured
- Seek help and guidance whenever needed
- Do not consider fever as normal do consider visiting health care
- Before helping others, help yourself

5.4. Conclusions

The waste management is huge problem that occur after the floods as the amount of waste generated is difficult to manage. After the floods of Kerala in 2018 the huge piles of waste were left over for more than 20 days that resulted in many injuries while managing waste. The risk of getting infected by a disease or allergy is very prevalent in all the three sample areas. There are various diseases which are prevalent are diarrhoea, cholera, dengue, skin diseases and fever. These diseases traces can be seen in sample areas. Health prevention majorly rest with the people as there was lack of safety gears that would have helped people to prevent themselves from disease. Lack of safe drinking water resulted in disease of cholera and diarrhoea. While managing the waste post floods the basic measures taken by people were using of face mask, wearing gloves but in some cases the management was done bare hands.

There are differences between the different target groups is volunteer come from the general people, who offer to serve the society, the volunteer was not provided with any trainings and nor safety measures sanitation workers are appointed by the administration and are provided with safety gears and training how to manage the waste and other substances and Kudumbashree are the self-help group which work for community and are provided with the safety measures.

The difference between the sample areas is in the accessibility to healthcare as in uplands the accessibility is reduced because of blockage and in midlands because of disconnected from mainland. In low land the health care is accessible. Disease was almost similar in all the three study areas. Major health effects were in form of mental traumas.

A paradigm shift has occurred from disaster response to disaster risk management which include, early warning system, weather forecasting. The major changes in the approach of disaster management now must be considered for amendments as post disaster is a major concern as it still lacks the proper frame works and guidelines. The waste generated post disaster and especially floods in this context is a real threat as its management is just not next to impossible but also a very sever threat on human health. Lots of lots of disease spread in the society during the floods and more post floods because of improper waste management.

Healthcare is another aspect to strengthen as the total wellbeing of human is majorly depending on healthcare during and post disasters and yes if the can offices, schools, industries, and the administration must go back to normal scheduling than the accessibility, facilities and safety measures are very important grounds to work and strengthen on.

As Climate change is a real and visible change on planet and its increasing influence will only cause more and more disasters and mor e disasters will trigger more calamities and resulting in excess amount of waste and leading to health risk and effects on human and environmental health. It is an alarm for all of us to enhance our knowledge about the natural calamities, basic health care and how an individual can control or at least minimise the impact.

The lessons that can be taken from the Kerala case is that proper management of waste is necessary to reduce the impacts on environment and the human health. The time is to strengthen and learn from past so that future is safe and health risk free.

CHAPTER 6 : SUITABLE SITE LOCATION FOR SOLID WASTE COLLECTION AND PROCESSING POST FLOODS

6.1. Introduction

Kerala often faces floods that generate large volumes of waste. There is a problem with its management because of the scarcity of land and the suitable sites where this waste could be collected and segregated. Hence to address the problem a study is done on the location of potential suitable waste collection sites with the help of Spatial Multi Criteria Evaluation (SMCE). It is a process that translates a series of criteria into spatial decisions that can be used by relevant stakeholders based on a set of geographical data (Alkema, and Boerboom, 2012).

Spatial Multi Criteria Evaluation is an GIS application which assists in doing multi criteria evaluation spatially. The multi criteria evaluation requires the factor maps. The factor maps are grouped into criteria. Criteria are weighted and standardized in the criteria tree (Roudgarmi et al., 2008). The standardization is the first step in SMCE which includes performance table and score for criteria. After standardization weighting is given and weights are decided by Analytical Hierarchical Process (AHP). The AHP plays important role in decision making (Ma, 2011). Thus, ‚SMCE helps in planning and decision making by using the criteria of same area and evaluating them based on the weightage given(Roudgarmi et al., 2008). Spatial Multi Criteria Evaluation is an GIS application which assists in doing multi criteria evaluation spatially. The multi criteria evaluation requires the factor maps. The factor maps are grouped into criteria. Criteria are weighted and standardized in the criteria tree (Roudgarmi et al., 2008). The standardization is the first step in SMCE which includes performance table and score for criteria. After standardization weighting is given and weights are decided by Analytical Hierarchical Process (AHP). The AHP plays important role in decision making (Ma, 2011). SMCE helps in planning and decision making by using the criteria of same area and evaluating them based on the weightage given (Roudgarmi et al., 2008).

The state of Kerala is suffering from the scarcity of land due to its dense population and infrastructure. This problem links to the weak system of waste management and the volume of increasing waste becomes a challenge for the administration to cope with. The situation becomes more devastating when disaster like 2018 floods hits. The waste generated by these flood events led to the collapse of waste management system due to the scarcity of storage infrastructure. Hence to provide a solution to towards a wicked problem SMCE was performed for the Pamba Basin which includes four districts, Alappuzha, Pathanamthitta, Kottayam and Idukki, respectively.

6.2. Methodology

The overall process of SMCE is shown in Figure 31. The overall methodology can be observed to see the steps taken to select the potential sites. The analysis was done using the software ILWIS 3.3.6. The SMCE is useful tool for performing suitable site selection as it facilitates the expert advice, field knowledge, and use of the software extensively.

Before performing the SMCE a field visit to the flood -affected areas was conducted where many discussions lead to the different ideas and suggestion on possible criteria to use in the analysis. This was done using available literature that used SMCE for suitable site locations that helped to create the criteria's that enable the evaluation to select the potential sites for the waste collection.

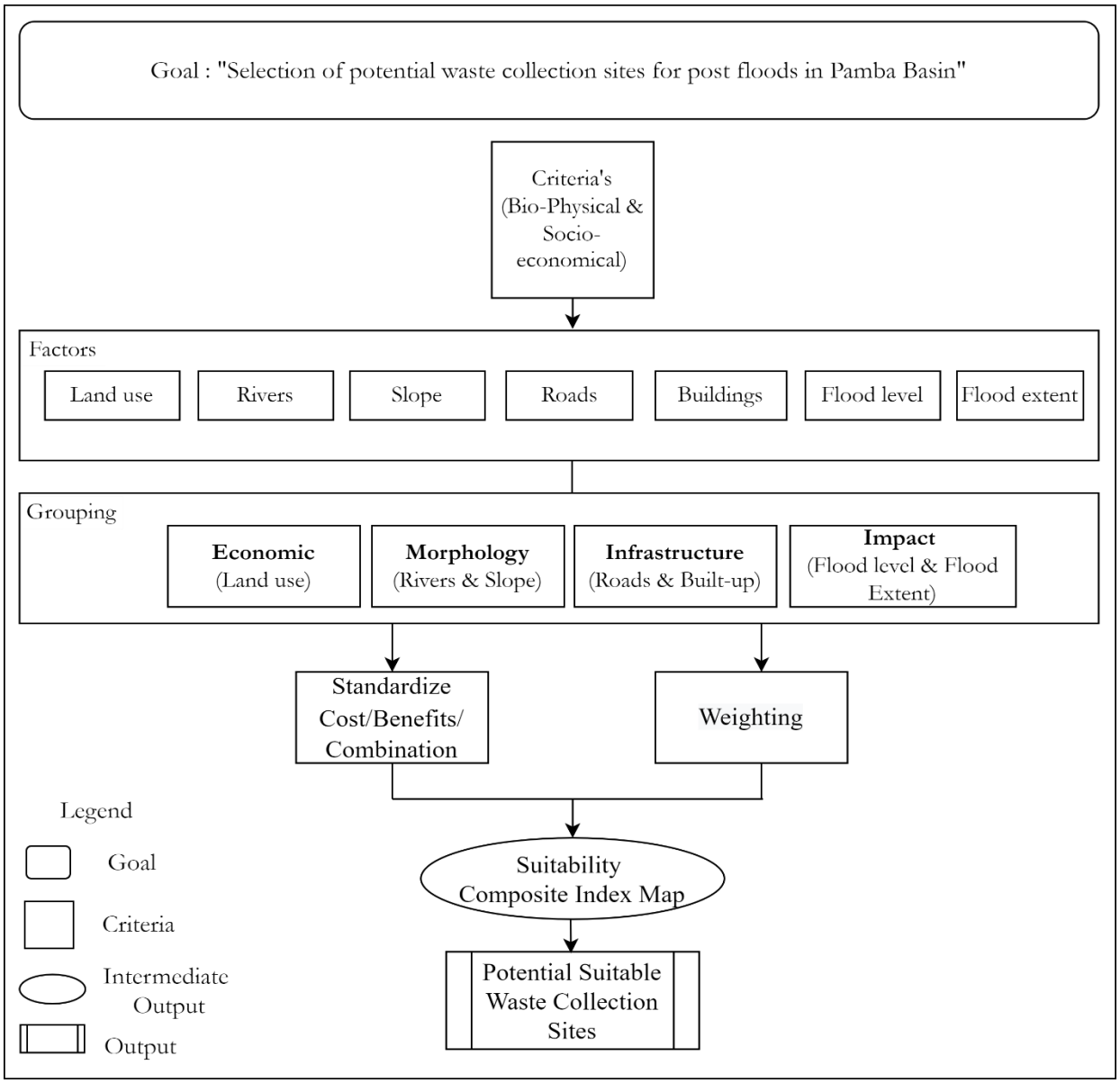


Figure 30: Methodology for selecting potential waste collection sites

Below are the criteria considered for the analysis:
Physical Criteria:

1. Waste collection sites should not be constructed in landslide-prone areas
2. They shall be located on a terrain with a slope less than 20 degrees: So that the steep slopes are avoided in order to avoid flash floods or landslides.
3. They should at least be 2km away from the rivers or any other water channels: A the water should not enter the waste collection sites so that the waste is not transported from the collected sites by flood water.

4. They should be located within 2km of a residential area but further than four hundred meters: So that the harmful effects have less impact on human health and is convenient for people to themselves collect waste at collection sites.
5. Flood level: Only if flood level is less than 1.5 meter: The areas to be potentially shall be long term solution and not short term. Even if regular monsoon flooding occur sites shall not be flooded, or the water shall not enter the sites.
6. Flood extent: Areas nearest to flooded location should be prefer: It is so that the waste can be easily transported from the flooded zones.

Socio-Economic Criteria's:

1. Waste collection site should not be constructed in areas with economic value but shall also consider in case of agricultural lands that are used for seasonal purposes and are between the built-up. In this case to find the sites in only land use which is not of much value for someone shall be considered.
2. Once the site is introduced the foul smell, pollution, and other effects will change in the vicinity, Hence the effects on the environment shall be minimized and the impact on society as a whole should be curbed.
3. Accessibility to sites should be in walking distance of people and for authorities to take motorized vehicles.
4. Regular disinfection processes shall take place.

From the above-mentioned criteria's, the following factor maps were generated:

- Economy (Land use): In this map each pixel was classified in one of the fourteen land use class such as, agriculture, barren land, built up, crops land used less than two months, fallow land, forest, grassland, mining abandoned, rural, tree, urban vegetation / open area, water, wetland and other.
- Morphology (Rivers & Slope): In ricer map proximity to river was calculated where suitable site shall be 2 km away from the river or any water body, the values are stored in meters. In slope map for each pixel average slope of area are saved in form numerical in degree and were classed as, Level gentle, moderately slopping, moderately steep to steep, strongly slopping and very steep sloping.
- Infrastructure (Roads & Buildings): Distance to road maps is generated where each pixel nearest to road and in distance to buildings map each pixel nearest the building till 400meters and within 2km are stored in meters.
- Impact (Flood level & Flood extent): Distance to flood maps is generated where the sites closest to flood extent which is not flooded above 1.5 meters is stored in meters.

According to the above criteria's the criteria tree is developed shown in Figure 32.

Standardization and Weighting:

In Special Multi-Criteria Evaluation the standardization is performed to evaluate the criteria in criteria tree. Standardization starts with the selection of multi criteria evaluation operation. During standardization, the values get converted into 0 and 1. The goal method plays important role in standardization of the criteria. The cost and benefit are used to compare the criteria with each other. Thus, the criteria show the value from 0 to 1 after standardization. The values are positive after performing benefit and cost tree (Roudgarmi et al., 2008).

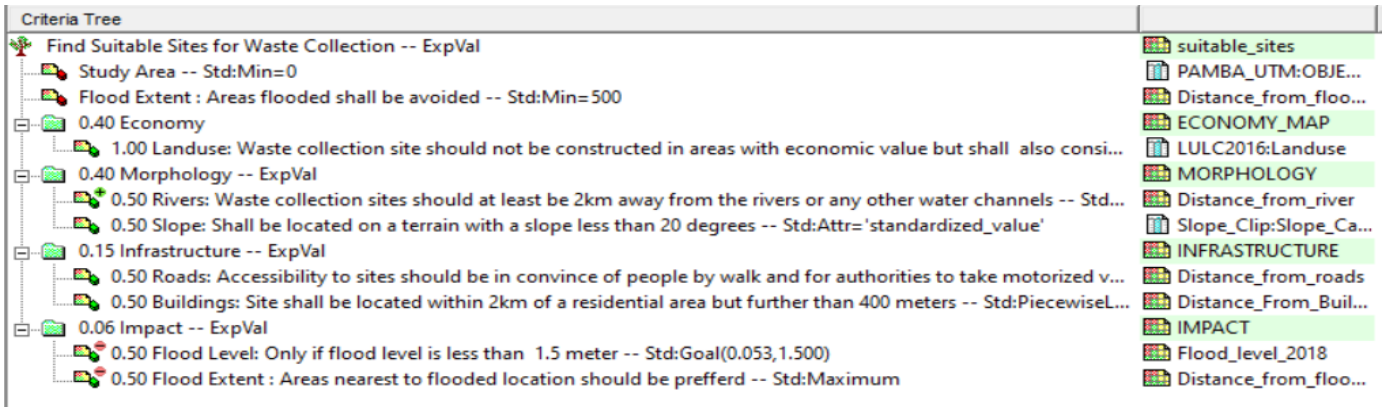


Figure 31: SMCE Criteria tree

The factors shown in criteria tree Figure 32. are standardized to perform the multi criteria evaluation. Each factor map was standardized by ranking order between 0 and 1. Land use map was standardized with the ranking method where different classes of land use were grouped with similar ones and then were ranked based on preference of land class that is most suitable for the suitable site. Distance to river map was standardized by considering it as benefit and method used for standardizing is goal. As the sit further from the river is suitable and this the goal as well. Slope map is standardized with the ranking order with expected values in the maps. As the classes of slope suitable for sites preferred is level gentle. Road map is considered as combination of cost and benefit and the method used for standardizing the map is piecewiselinear5 where the distance prefer as per criteria is marked on graph. Building map is also considered as combination due to the nearness of site till 400 meter is suitable and more than 2 km is not suitable the method used to standardize the map is piecewiselineae5. Flood level flood extent are standardized by the goal and maximum methods.

After standardization of all the factor maps the weight were given to all the factors maps and the factor class. The weights are given based on discussion with solid waste management expert from Kerala and with the self-insights The given weight in Table 19

Table 19 : Weights given to factor map and class

Factor Class	Class weight
Economy	0.40
Morphology	0.40
Infrastructure	0.15
Impact	0.06

Factor Class	Factors	Weight
Economy	Land use	1.00
Morphology	Proximity to rivers	0.50
	Degree of slope	0.50
Infrastructure	Proximity to roads	0.50
	Proximity to buildings	0.50
Impact	Flood level	0.50
	Distance from flooded area	0.50

These weights are given to make sure that a single factor does not influence the evaluation and each factor influence can be as per the criteria ranking and weights given in the standardization process.

During the weights process all the factors class and its factors are given weights, but the constraints are not weighted as these are just to direct that no potential sites should be considered for in areas with constrained and the results as final map should be within the boundaries of interest as study area.
This final potential suitable site map is a combination four factor class maps, Economy (Land use), Impact (Flood level & extent), Infrastructure (Roads & Buildings) and Morphology (River & Slope). These maps are shown in Annex 5.

6.3. Results and Disussions

The Potential waste collection sites Figure 36. in form of suitable and not suitable. Where colour "Red" denotes the area that are not suitable for location of waste collection site whereas colour "Green" denotes the areas which are very suitable for locating waste collection sites. These locations in red and green colour are produced with no of criteria and factor maps that are standardize and weighted according to the experts and field knowledge.

The areas that are green are the areas which are 400meters away from the buildings and within 2km of building range. These areas are very close to road for the proper accessibility to both localities and administration. Rivers are 2km away from the sites so that if river water level increases it do not enter the sites. Similarly, the sites area is located where the flood level of 2018 floods was not more than 1.5 meters and the areas that got flooded are avoided. The land use was one of the main factors as the density of buildings and scarcity of land was main influencer and the areas which are shown green are in barren,

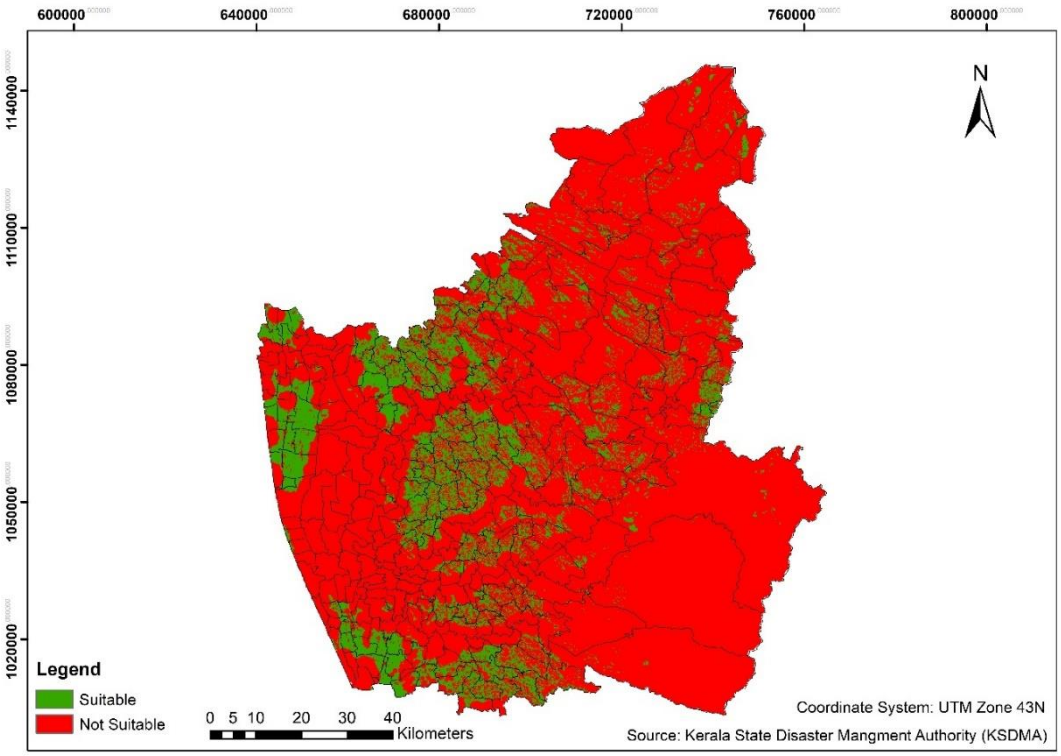


Figure 32: Potentially suitable waste collection sites in Pamba basin

fallow, cropped less than 2 months, abandoned mining and open areas land classes. The sites are in located in slope of less than 20 degree that make sure the sites are no situated in steep slope or terrain.

The red area is not suitable area where the water body, buildings are very close, the steepness is more than twenty degrees, roads are in distance flood level is more than 1.5 meters and the areas are flood extent is more. The land use classes in these areas of very high economic value such as evergreen, deciduous, temperate forest, inland waterways, agriculture land with kharif, rabi and Zaid crops. Hence these areas are red in colour.

The waste management is a daily growing problem that needs immediate attentions through the world seeing the massive problem which becomes out of control during any emergencies need to be prioritized and managed. To enable the copying capacity, it is very useful for the affected nations to plan the holding capacity of routine waste site and to what extent the extra waste they can uphold. In accordance this chapter closely looked towards the unforeseen problem of mis management of flood waste that was scattered all around in Kerala. The selection of suitable sites will help the management to consider these potential areas into waste collection site and will give solution to problems like lack of waste collection centres that can be used to collect waste in normal time but especially be used for the emergency purpose. The director of solid waste management in Trivandrum also suggested to fix these areas with the systems that enable in site cleaning and segregation so than the waste can be manged as normal waste.

6.5. Conclusion

Coming so far it has been realized the amount of waste that disaster generates are unpredictable as it depends on the intensity of floods as well as the occurring disasters. To increase the coping capacity and improve the management of waste it is very important to use the Geographic Information Systems (GIS) which has made the data analysis and computing very easy. One of the important functions that can be used for supporting the decision and policy making to relevant stakeholders and administration is Spatial Multi Criteria Evaluation (SMCE). This function helps to rank the factors that influence or have an impact on selecting the suitable sites. SMCE allows to incorporate the expert advice, factors, constrains and the criteria's that influence the site selection. Combing the technology with the human input is extraordinary method that is helpful for the decision and policy makers to find solution for the real world geographical problems that solves the societal problems that needs immediate actions.

The potential sites selected in this chapter can be further verified and analysed to find the specific locations for the waste collection that can also be used in times of no disasters.

CHAPTER 7: FRAMEWORK FOR SOLID WASTE MANGMENT POST-FLOODS

7.1. Introduction

A disaster waste management framework describes a series of activities that are arranged in a way that they will improve the capability to protect against, prepare for, respond, and recover from an extreme disaster event that generates different types of waste which is harmful to society. Frameworks are a useful tools that guide state and local governments in handling the situation in a better way and reducing the adverse impact of disasters on society (Bells, 2016). The disasters generate large amount of different types of waste that needs a proper scientific approaches to manage the same, waste management frameworks are required to address problems so that the waste management post floods become smooth and effective (Karunasena et al., 2010).

Many countries around the globe are looking for the solutions on how to deal with disaster waste, considering the different types of waste mentioned in Table 5. and their impact. However, hardly any document could be found that discusses the framework of managing disaster waste. The United Nation Environment Programme, The World Bank, and other organizations and scholars have provided guidelines and procedures to follow (See chapter 1), and this research attempted to give a contribution towards the after flood solid waste management framework in Kerala.

7.2. Methodology

To develop the framework for waste management detailed study of the most prominent literatures that explicitly mentions about the disaster waste by UNEP, OCHA, World Bank, UNDRR and Asia Pacific were done. The literature was used to obtain insights and develop an understanding of what framework should include.

Considering the outcomes and challenges of the 2018 floods waste management, informal discussions were arranged to discuss the shortcomings in system and also to figure out the potential stakeholders that are truly relevant for the waste management in Kerala. After two weeks of informal discussions a number of stakeholders Table 19. were chosen and invited for a stakeholder brainstorming meeting which was held on 8th of April' 2022. In Trivandrum.

The stakeholders were identified based on the relevant departments that actively work with the waste management or worked in 2018 post floods SWM. The information was arranged from State Disaster Management Authority SDMA with support of District Disaster Management Authority (DDMA). An email to assign the contact person from various places mentioned in Table 20. were sent on 15th of March 2022. The contact person assigned by the departments were than given the information with briefing of what is going to be discussed and what is expected from the stakeholders.

The agenda of the meeting were sent beforehand to gather extensive information regarding, the drawbacks of 2018 post flood SWM, How the system can be strengthened for the future, what are the dos that will support the system and also ensure that minimum waste is generated, which areas will be suitable for the

potential sites for waste collection after floods. How the volunteer system can be used to manage the waste after floods anymore.

The meeting was conducted in online mode given the Covid19 protocols. The total number of participants reached 75 which was more than we invited but this added more value and concepts as real problems could be seen from the different representatives from different affected regions. The meeting continued for three hours. The communication in the meeting was mostly in Malayalam language and hence to comprehend the information KSDMA assigned an individual to translate the recorded meeting.

The gathered information was compiled in form of notes. These notes were than combined with the guidelines UNEP, OCHA and The World Bank to frame the first draft of the framework. The information gathered closely related to the problems faced due to lack of proper management of solid waste and what impacts it could leave. The difficulties of the sanitation workers and the unavailability of equipment's were the major discussion. Thereby all the ideas concepts and links were then put together and were compiled to get the first draft. The draft was sent to the stake holders and inputs were received and there by the first draft was made ready.

Table 20 : List of stakeholders involved in the development of the Flood Waste Framework

S.NO	DESIGNATION	PLACE
1	Panchayath President, Secretary	Pandanad, Alappuzha
2	LSG DM Plan Coordinator	Alappuzha
3	Fire Rescue	Alappuzha
4	Municipality, Alappuzha	Alappuzha
5	Panchayath President, Secretary	Purakkad, Alappuzha
6	CARE India	Delhi
7	Geohazards International	Delhi
8	District Programme Manager, Organization & MF, Kudumbashree District Mission	Pathanamthitta
9	Research Assistant (District Planning Officer)	Pathanamthitta
10	Regional joint Director Municipality	Pathanamthitta
11	Fire Rescue	Pathanamthitta
12	DDMA Pathanamthitta	Pathanamthitta
13	LSG DM Plan Coordinator	Pathanamthitta
14	Panchayath President, Secretary	Chittar, Pathanamthitta
15	Junior superintendent, Collectorate	Idukki
16	Programme Manager Urban Planning & Disaster resistance, Sustainable cities team WRI - INDIA	Kochi & Trivandrum
17	President, Good Governance India Foundation	Trivandrum
18	Secretary (KSDMA)	Trivandrum
19	Suchitwa Mission	Trivandrum
20	Clean Kerala Company	Trivandrum
21	NGO (PLANET EARTH) Representative	Trivandrum,
22	Executive Director (THANNAI)	Trivandrum

The draft was than shared with the Kerala State Disaster Management Authority (KSDMA) for the proofing by the Member Secretary who gave approval for the first draft. The approved daft by KSDMA has been attached as first output for waste management working framework.

7.3. Result and Discussion

From existing literature, the drawbacks and the loopholes that were found in the waste management of Kerala floods 2018 were discussed with the stakeholders and special focus were given to opportunities for improvement on how to make those areas stronger and more effective.

The most important drawbacks were:

- No planning for waste management in advance
- Lack of priorities as waste was neglected and after flood resulted in huge problem
- No immediate action was taken to manage the waste after flood and was left unattended
- No records of volunteers that might be an extended help to clear waste after floods
- Lack of clean and safe water for the people, no arrangements were planned
- Lack of proper sanitation and hygiene, people houses were damaged, and the sanitation became really a problem and made difficulties for the inhabitants to follow hygiene
- Lack of waste collection site for waste collection due to poor management in system
- Lack of administrative support as the government lack the infrastructure as well as no clue how to manage the waste
- Lack of safety gears for volunteers and sanitation workers

The framework provides direction and way of being ready for an event that might occur in future it describes stage wise that what needs to be done when and how. The framework also adheres to the guidelines given by UNEP, OCHA for the disaster waste management. As it describes the step-by-step approach towards better planned waste management: To discuss the framework in detail it is divided in three situations:

In the **Pre Floods** situation, the most important task to be performed is the mapping and demarcation of all the flood hotspots, water bodies and infrastructure that is in proximity in accordance with it is also important to allocate waste collection sites for example one site for 3-4 LSG's. After this what is of utmost importance is training of relevant stakeholders, authorities involved and mostly the waste workers and the community for the proper collection, segregation and then storing the waste in designated collection sites. Once the warning has been issued the material around and within buildings should be kept safe and away from flood water, all the water channels shall be cleared to avoid blockages and ease the flow of water. Meanwhile all the potential sites should be regularly monitored. All the final checks shall be done by the respective stakeholders before the flooding commences. Also, the warning system shall be strengthened for the moving of humans, animals, and others to highlands. Multiple multi-stakeholder teams shall be designated for the flood and its waste management.

During the floods, the most important activity is the supply of clean and safe drinking water as water channels and ponds will be contaminated. It is also important in this stage to make sure the healthcare is accessible and available to the community and the waste that is being generated by the relief work itself is handled properly. So that the waste from the relief camps and health facilities does not add on to the waste caused by the floods, as the waste generated from camps and hospitals can be extremely harmful for

the people who are already going through the catastrophe. Once that it can be confirmed the water starts to recede the sites allocated for the waste collection shall be checked and first and foremost cleaned and equipped with all the facilities that will facilitate the proper management of waste generated. Once the sites have been checked the teams shall be formed for different areas and departments shall be allocated for the planning of caring proper waste management in affected areas concisely looking at accessibility to places that need to be cleaned. Thereby the roles and responsibilities shall be shared by responsible departments to pass on and execute the plans.

The activities proposed **after the floods** are the most important and essential part of the framework as it is the execution step where all the planning needs to be implemented on the ground with the help of people in the form of volunteers, Kudumbashree, sanitation workers and all other waste workers, who just come out of catastrophe and survived an extreme event. Initially the authorities shall verify the list of volunteers and existing staff who are going to work on the ground so that the list can be updated and more support in form of human resource can be accessed. The arrangements of equipment's and all the necessary safety gears as mentioned in (chapter 5), shall be made available before the start of the waste collection. As soon as the required accessories are arranged the demarcation of areas that need immediate action shall be mapped to identify and prioritize where to act first. Waste workers shall thereby be given the location and transportation to the respective areas preferably hospitals, administrative offices and then accordance with the need. Extended aid shall be given to senior citizens, house with women's only, families with small children, people with disabilities, low income families and other disadvantaged groups. The collected waste shall be stored only in the designate sites (See chapter 6), for which the facility shall be provided for the transportation of waste from streets to sites and then the waste shall be segregated by the trained workers and cleaned and once the waste is dry and ready for the transportation, shall be channelised to normalised processing units such as recycling, dumping, incinerating ant etc. The waste collected in the sites and transported for the further processing shall be quantified to prepare for the future.

Below are the recommended do's for minimizing the waste generation and its aftereffects:

Pre-Floods:

Family:

- Clear the materials from outside,
- Keep all the goods in a safer place that cannot be reached by floods, like on the second floor or the roof and keep them covered.
- If there is any flood warning take all valuables like electronics, certificates, official documents, and vehicles above the High Flood Level (HFL)
- Ensure the safety and relocation of the animals to safer and higher places
- Keep basic first aid and medicines for emergency use
- Keep safe clean water ready to drink in case of warning issued

MSME:

- Ensure infrastructure and carry out a safety check
- Ensure the assets are kept in a safe place which should be above HFL
- Strictly ensure there is no leakage of dangerous chemicals and liquids
- Once the warnings have been disseminated the stored liquids and chemicals should be shifted to high elevated areas

Government

- Shall give warning and alert as soon as possible
- Clear the water channels
- Notifying people living along downstream riverbanks about opening of hydropower dams

- Planning of emergency relief locations
- Planning for safe water supply
- Identify the flood heights based on experience and inform localities (Households and MSME)
- Training for waste management to manage the waste to its best practices after the floods
- Follow the instructions mentioned in the orange book (Monsoon preparedness and response guidelines)
- Estimation of the waste coping capacity including normal times
- Allocate permanent waste collection site
- Plan to make sure that medical assistance reaches the one in need

During Floods situation:

Households:

- Families that shift to relief camps shall make sure they keep all valuables in safer places and take their essential documents and required or ongoing treatment medications with them.
- Families who stay back to face floods in the house shall shift their valuables and all assets to acetic.
- Shall ensure minimum discarding of household assets including electronics, furniture, animals, and food.

MSME:

- If possible, shall look for managing the goods and other products shall not mix with flood water

Government:

- Major channels should be prevented from blockage
- Relief camps should be established and equipped with proper waste management infrastructure, health infrastructure
- Waste generated from relief camps should be transported properly

Post-Flood situation:

Households:

- Ensure the personal safety while cleaning the houses and premises
- Prioritize what needs to be done as per feasibility
- Remove and cleaning of waste should be done carefully
- Make sure to use safety gears
- Try to segregate waste into biodegradable and non-biodegradable waste also try to keep electronic waste separately
- Put all waste at a place allocated by the LSG

MSME

- Prioritize waste management based on types of waste. Given the harmful impacts of each.
- Proper removal and collection based on standard segregation according to the goods produced or stored.
- Put all waste at a place allocated by the LSG

Government

- Shall provide proper safety gear to the public, and especially to garbage clean-up volunteers, sanitation workers
- Allocate temporary and permanent sites for waste collection
- Ensure proper segregation into different categories and try to refurbish the waste
- Plan on transportation of the waste to respective sites depending on the nature of the waste
- Create more waste processing units in the state

The post flood framework in Figure 37. was developed in collaboration with KSDMA and the states different stakeholders such as, director of solid waste management, three different municipalities, Harith karma sena, Kudumbashree, fire department, clean Kerala company and various NGO;'s which worked during, and post 2018 floods as mentioned in Table 19. The framework covers all the short comings and lessons learnt from the event of 2018 as identified during the stakeholder meeting.

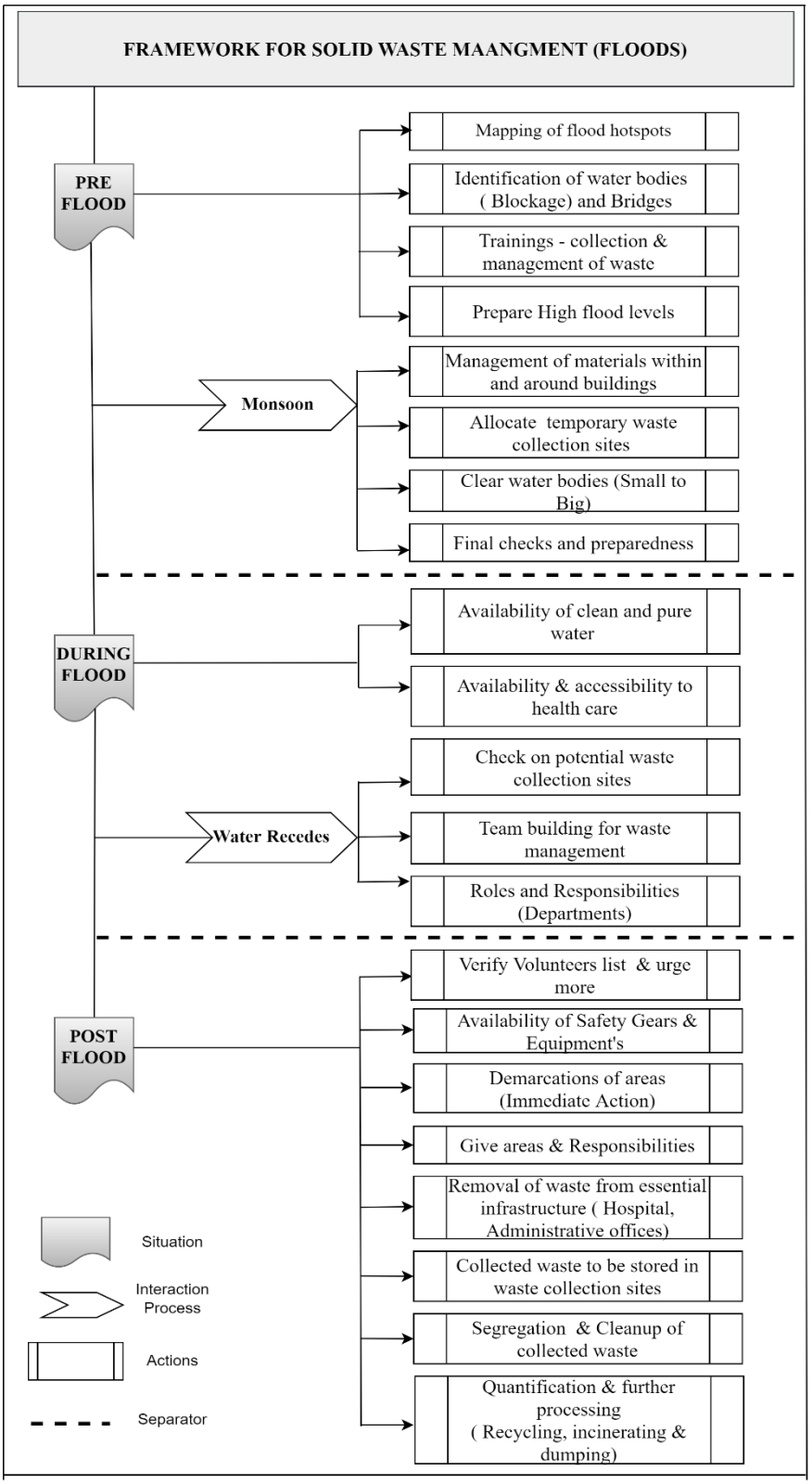


Figure 33: Working Framework for post-flood solid waste management

.

7.4. Conclusion

A waste management framework is a plan of activities that the administration can use for an improved management of the waste generated during floods. The framework describes how to prepare and which activities to implement in three different phases. It clearly focuses on the minimisation of waste and its aftermaths such as health and environmental impacts. In Kerala there are still many deficiencies with respect to disaster waste management. Lack of planning, unavailability of local to national level legislation, lack of guidelines and frameworks that can support the management. The resources and plans that help the communities to manage waste are often lacking the communication and coordination among the institutions and society and that remains problematic. For instance, many new companies in Kerala emerged just to tackle the waste but due to lack of communication and proper guidelines many resulted in fail. Hence it is essential to have proper solid waste, management guidelines and framework that can direct the free flow of processes that are to be done in the scientific way to manage waste after disasters.

The first draft of working framework is an output that will be further developed to make it a suitable framework for pan Kerala state.

CHAPTER 7: DISCUSSIONS, LIMITATIONS & FUTURE SCOPE

7.1. Discussions

The types, sources and quantities of waste are discussed. In three different geographical units. The waste generated and the types are similar but their composition in respect to different sample areas are different. The source of waste for highland is majorly forest, and for the midland and upland is households, agriculture, and the neighbourhood. The types of waste generated is also slightly different in all the study areas as in uplands the trees, debris, and household materials, the waste type found in midland and lowland is households waste majorly and the waste from the neighbourhood, which is transported by the water channels. The type and quantities of waste were used to quantify the waste per building and then an average waste per building was used to quantify the total building waste in Pamba basin.

The waste management and its generated health effects are explicit in all the three sample areas. The waste management in the different areas is done differently but what was common is not using any preventive measures to prevent themselves from the health risk. The flood and the waste generated by floods has different health effects, as diseases caused by floods in the study areas is Leptospirosis, cholera, Diarrhoea the no. of cases are not same in each sample area, but the differences can be traced. Flood water related health impacts are injuries, infection, rodent borne diseases which were also seen as major flood generated health effects in the sample areas. Accessibility to healthcare facilities is slightly reduced in the Chittar panchayat and increased in Purakkad and Pandand as the healthcare facility were made available with the use of boats and the cables to reach the victims. The major health impact was mental / psychological that people are facing after so many years.

The potential waste collection sites are produced for the Pamba basin with the use of various physical and societal criteria that influenced the suitability. The section analysed the potential suitable sites that are safe to use post floods to collect the solid waste which is mix of both hazardous and non-hazardous waste. The sites have been proposed based on land use, slope, distance to river, roads, and proximity to households. The suitable sides are produced with criteria's that make these areas suitable if the flood level is 1 meter. The Study area is frequently floods in each monsoon season and hence such sites are the necessity.

The last section of the thesis produced a framework that will strengthen the post flood solid waste management systems, The framework is divided into three sections, pre-floods, during-floods, and post-floods all the section lays the activates to be done in specific times. The framework is built in combination of stakeholders and the international guidelines. Te framework is useful for state like Kerala as it explicitly has bed drafted in first phase considering the shortcomings of the 2018 flood waste management.

7.2 Limitations:

The major limitation to conduct this research was the lack of datasets such as, Flood data which re available from different sources have major shortcoming and inaccuracy. The damaged house data of 20218 acracy was also low as upon conducting the fieldwork the exact sample houses could be located. The data consisting of the waste that got generated by the floods of 2018 are also not available and hence for the same fieldwork was done. The building data used is from Bike source of OSM which was found in

last moth o thesis and hence all the footprints representing building types were considered as houses and depending on these same the quantification was performed. Th research has been scaled up from the small sample areas to River basin (Pamba Basin), Hence the accuracy might be less.

7.3 Future Scope

The study in this research focused on the Types, sources, and quantification of waste that got generated in the Pamba basin. In this part of the research the possible future research scope is to make a waste prediction model that can predict waste based on different flood return periods. Thereafter the research focused on the waste management and its health impacts; In this the scope of research is to figure out the data sets and perform literature reviews that can enable the future researcher to get more excess literature. The studies related to disaster waste are limited and needs more scholars to develop this field. The section which deals with suitable site location for waste collection have greater research scope as the use of more criteria's and including more factors that can give permanent solution to the wicked problem are much needed. The last section of the research deals with the frameworks for post flood solid waste management that are required for the better disaster waste management, there is lot of scope in this section as this topic is hardly addressed by the researchers.

LIST OF REFERENCES

Alam, P., & Ahmade, K. (2013). Impact of Solid Waste on Health and the Environment. *International Journal of Sustainable Development and …*, *2*(1), 165–168. http://irnet.sg/irnet_journal/IJSDGE/IJSDGE_doc/IJSDGE_V2I1,2_papers/31.pdf

Alex George. (2020). *Kerala flood mitigation: Chengannur canal case study*. DownTo Earth. https://www.downtoearth.org.in/blog/water/kerala-flood-mitigation-chengannur-canal-case-study-69649

Alkema, and Boerboom, S. F. and L. C. (2012). *6.4 Spatial Multi-Criteria Evaluation*. Caribbean Handboook on Risk Information Mangment. http://www.charim.net/print/93

Anjali Singhal. (2018). *As flood water retreats, waste management next big concern for Kerala | Development Channel*. Devlopment Channel. https://www.developmentchannel.org/2018/09/05/kerala-what-to-do-with-waste-after-the-flood-retreats/

Aruna, R. (2018). *Health impacts of flooding and risk management | National Health Portal Of India*. National Health Portal of India. https://www.nhp.gov.in/health-impacts-of-flooding-and-risk-management_pg

Bells, A. (2016). *REPUBLIC OF PALAU NATIONAL DISASTER & RISK MANAGEMENT FRAMEWORK 2010 Communities in Palau*. *2010*(Amended). https://www.refworld.org/pdfid/5b42f19f4.pdf

Brown, C., Milke, M., & Seville, E. (2011). Disaster waste management: A review article. *Waste Management*, *31*(6), 1085–1098. https://doi.org/10.1016/J.WASMAN.2011.01.027

Census Of India. (2011). *Census of India 2011 Provisional Population Totals*. https://censusindia.gov.in/2011-prov-results/paper2/data_files/india2/1. data highlight.pdf

CensusIndia; 2011. (n.d.). *Alappuzha District Population, Kerala, List of Taluks in Alappuzha*. Retrieved December 2, 2021, from https://www.censusindia2011.com/kerala/alappuzha-population.html

Center For Disease Prevention. (2020). *Rodent-borne diseases*. European Centre for Disease Prevention and Control. https://www.ecdc.europa.eu/en/climate-change/climate-change-europe/rodent-borne-diseases

Chen, J. R., Tsai, H. Y., Hsu, P. C., & Shen, C. C. (2007). Estimation of waste generation from floods. *Waste Management*, *27*(12), 1717–1724. https://doi.org/10.1016/J.WASMAN.2006.10.015

Clean Kerala; Company. (2018). *1/10 3026090/2018/(dc) lsgd* (Issue Dc).

CMDT. (2019). KERALA STATE BIODIVERSITY BOARD IMPACT ASSESSMENT OF flood/landslides on biodiversity and ecosystem of pathanamthitta district and tribal livelihood in idukki and pathanamthitta districts centre for management development thiruvananthapuram 695 014 kerala. *kerala state biodiversity board*.

de Freitas, C. M., & Ximenes, E. F. (2012). Enchentes e saúde pública: uma questão na literatura científica recente das causas, consequências e respostas para prevenção e mitigação. *Ciência & Saúde Coletiva*, *17*(6), 1601–1616. https://doi.org/10.1590/S1413-81232012000600023

Devasia, T. (2018a). *Kerala, After The Flood: Piling waste raises risks to health, environment; management by local bodies is need of hour-India News , Firstpost*. Firstpost. https://www.firstpost.com/india/kerala-after-the-flood-piling-waste-increases-risks-to-health-environment-management-by-local-bodies-need-of-the-hour-5094141.html

Devasia, T. (2018b). *Kerala, After The Flood: Piling waste raises risks to health, environment; management by local bodies is need of hour-India News , Firstpost*. https://www.firstpost.com/india/kerala-after-the-flood-piling-waste-increases-risks-to-health-environment-management-by-local-bodies-need-of-the-hour-5094141.html

Diaz, J. H. (2015). Rodent-borne infectious disease outbreaks after flooding disasters: Epidemiology, management, and prevention. *American Journal of Disaster Medicine*, *10*(3), 259–267. https://doi.org/10.5055/AJDM.2015.0207

Directorate CENTRAL WATER COMMISSION, H.-S. (2018). *Central Water Commission Hydrology (S) Dte*.

Du, W., Fitzgerald, G. J., Clark, M., & Hou, X. Y. (2010). Health impacts of floods. *Prehospital and Disaster Medicine*, *25*(3), 265–272. https://doi.org/10.1017/S1049023X00008141

EXPRESS, I. (2018). *Kerala flood: Providing clean potable water poses big challenge- The New Indian Express*. THE NEW INDIAN EXPRESS. https://www.newindianexpress.com/states/kerala/2018/aug/21/kerala-flood-providing-clean-potable-water-poses-big-challenge-1860521.html

Fill, M. M. A., Moncayo, A. C., Bloch, K. C., Dunn, J. R., Schaffner, W., & Jones, T. F. (2017). Evaluation of a spotted fever group rickettsia public health surveillance system in Tennessee. *American Journal of Tropical Medicine and Hygiene*, *97*(3), 789–794. https://doi.org/10.4269/AJTMH.16-0765

Goverment of Kerala. (2005). *Government Hospital: Kerala: Number of Hospitals | Economic Indicators | CEIC*. Census and Economic Information Center. https://www.ceicdata.com/en/india/health-infrastructure-government-hospitals/government-hospital-kerala-number-of-hospitals

Habib, M. S., Maqsood, M. H., Ahmed, N., Tayyab, M., & Omair, M. (2022). A multi-objective robust possibilistic programming approach for sustainable disaster waste management under disruptions and uncertainties. *International Journal of Disaster Risk Reduction*, *75*. https://doi.org/10.1016/J.IJDRR.2022.102967

Habib, M. S., Sarkar, B., Tayyab, M., Saleem, M. W., Hussain, A., Ullah, M., Omair, M., & Iqbal, M. W. (2019). Large-scale disaster waste management under uncertain environment. *Journal of Cleaner Production*, *212*, 200–222. https://doi.org/10.1016/j.jclepro.2018.11.154

Heide, I. van der. (2015). *Health literacy: an asset for public health Iris van der Heide*.

Huu Bich, T., Ngoc Quang, L., Thi Thanh Ha, L., Thi Duc Hanh, T., & Guha-Sapir, D. (2011). Impacts of flood on health: epidemiologic evidence from Hanoi. *Global Health Action*, *4*(1), 6356. https://doi.org/10.3402/gha.v4i0.6356

Indian Metrological Department. (2018). *Government of India Earth System Science Organization Ministry of Earth Sciences India Meteorological Department*. 3.

Integrated Solid Waste Management Strategy. (2018).

J. Simkus. (2022). *Stratified Random Sampling | Definition, Steps & Examples*. Simply Psychology. https://www.simplypsychology.org/stratified-random-sampling.html

K. Laikuritzen, E. (2018). Disaster waste management. *Construction, Demolition and Disaster Waste Management*, 203–273. https://doi.org/10.1201/b20145-6

Karunasena, G., Amaratunga, D., & Haigh, R. (2010). Waste management strategies during post disaster phase: a case of Sri Lanka. *CIB World Building Congress 2010 - Building a Better World, 10-13 May*, *January 2014*.

Kerala State Disaster Mangment Authority. (2018). REBUILD KERALA DEVELOPMENT PROGRAMME A Resilient Recovery Policy Framework and Action Plan. *Rebuild Kerala*, 19.

Khan, A. A., Khatoon, S., & Rafi, S. (2022). *A Review of Disaster and Development Interface : Performance of Critical Infrastructure during Kerala Floods (2018)*. *9*(2), 42–52. https://doi.org/10.13140/RG.2.2.19306.59841

Koshy, P. (2010). *Welcome to Universal EcoServices*. Universal Eco Services. http://www.universalecoservices.com/wastemanagement_in_kerala.cfm

KSDMA. (2020). *DISASTER RISK AND VULNERABILITY CONFERENCE 2020 DISASTER RISK AND VULNERABILITY DISASTER RISK AND VULNERABILITY CONFERENCE 2020 Associates DRVC 2020 Disaster , Risk and Vulnerability Conference*.

Lamond, J., Bhattacharya, N., & Bloch, R. (2012). The role of solid waste management as a response to urban flood risk in developing countries, a case study analysis. *WIT Transactions on Ecology and the Environment*, *159*(April 2016), 193–204. https://doi.org/10.2495/FRIAR120161

Local Self Government Department, G. of K. (2019). *Solid Waste Management Initiatives-Kerala Local Self Government Department Government of Kerala*. 1–103.

Ma, Y. (2011). *Regional Scale Multi-hazard Susceptibility Assessment: a case study in Mtskheta-Mtianeti, Georgia*. 76 p.

Menabde, N. (2016). *Health literacy and the SDGs - Sustainable Goals*. UNA-UK. https://www.sustainablegoals.org.uk/health-literacy-and-the-sdgs/

National Institute for Environmental Studies. (2015). Flood Waste Management Guidelines for Bangkok. *Center for Material Cycles and Waste Management Research*, 4. https://www.apn-gcr.org

Nayantara Narayanan. (2018). *Kerala floods: To prevent disease outbreaks, tackle health problems, state is pulling out all stops*. https://scroll.in/pulse/890944/flooded-kerala-is-pulling-out-all-stops-to-tackle-health-problems-and-prevent-disease-outbreaks

OCHA; UNEP. (2013). *UNITED NATIONS OFFICE FOR THE COORDINATION OF HUMANITARIAN AFFAIRS EMERGENCY PREPAREDNESS SECTION Disaster Waste Management Guidelines*. www.msb.se/en

OCHA; UNEP. (2018). *Disaster Waste Management Guideline for Asia and the Pacific* (Vol. 5). https://www.unocha.org/sites/unocha/files/DWMG.pdf

Okoth Okaka, F., & Odhiambo, B. D. O. (2018). Relationship between Flooding and Out Break of Infectious Diseasesin Kenya: A Review of the Literature. *PubMed Central*. https://doi.org/10.1155/2018/5452938

PDNA, K. G. (2018). *Kerala* (Issue October).

Purakkad Village Population - Ambalappuzha - Alappuzha, Kerala. (2011). Census 2011. https://www.census2011.co.in/data/village/628231-purakkad-kerala.html

Reed, B. J., & Mena-Moreno, R. (2016). *WASH in emergencies problem exploration report: Solid waste management*. 38. https://www.elrha.org/wp-content/uploads/2016/01/Solid-Waste-Management-WASH-Problem-Exploration-Report.pdf

Roudgarmi, P., Khorasani, N., Monavari, S. M., & Nouri, J. (2008). Alternatives evaluation in EIA by spatial multi-criteria evaluation technique. *Journal of Food, Agriculture and Environment*, *6*(1), 199–205.

Roy, C. M., Manoj, E., Joy, H., Ravi, S., Roy, A., & Student, U. G. (2018). *DEVELOPMENT OF FLOOD HAZARD VULNERABILITY MAP FOR ALAPPUZHA DISTRICT*. *5*, 2394–0697.

Sarhan, M. B. A., Fujii, Y., Kiriya, J., Fujiya, R., Giacaman, R., Kitamura, A., & Jimba, M. (2021). Exploring health literacy and its associated factors among Palestinian university students: a cross-sectional study. *Health Promotion International*, *36*, 854–865. https://doi.org/10.1093/heapro/daaa089

SPREP. (2020). *Regional Factsheet National Disaster Waste Management Plans : Benefits of Having Disaster Waste Management Plans and Planning To Pacific*.

State Relief Commisioner, Disaster Management, G. of K. (2018). *2018 Kerala Floods*. *September*, 40. https://en.wikipedia.org/w/index.php?title=2018_Kerala_floods&oldid=916905601

Tithal Parmar, S., & Manchikanti, R. A. (2020). Building Back Better: Kerala Addressing Post-Disaster Recovery Needs. *WASH FIELD NOTE*.

UN CERF. (2013). *Resident / humanitarian coordinator report on the use of CERF funds Lebanon rapid response: conflict-related displacement*. https://cerf.un.org/sites/default/files/resources/18-RR-ZWE-32288-NR01_Zimbabwe_RCHC.Report.pdf

UN Organisations; Asian Development Bank; Goverment of Kerala; The World Bank; European Union Civil Protection; Humanitarian Aid. (2018). *Kerala Post Disaster Needs Assessment Floods and Landslides-August 2018*. https://sdma.kerala.gov.in/wp-content/uploads/2019/03/PDNA-report-FINAL-FEB-2019_compressed.pdf

UNDRR. (2020). *Disaster | UNDRR*. United Nation Office for Disaster Risk Reduction. https://www.undrr.org/terminology/disaster

UNEP. (2017). *Solid approach to waste: how 5 cities are beating pollution*. United Nation Environment Programmae. https://www.unep.org/news-and-stories/story/solid-approach-waste-how-5-cities-are-beating-pollution

United Nation. (n.d.-a). *Goal 3: Good health and well-being - The Global Goals*. Retrieved July 18, 2022, from https://www.globalgoals.org/goals/3-good-health-and-well-being/

United Nation. (n.d.-b). *Goal 6: Clean Water and Sanitation - SDG Tracker*. SDG TRACKER. Retrieved July 24, 2022, from https://sdg-tracker.org/water-and-sanitation

United Nation. (2018a). *SDG 11.5: Reduce the Adverse Effects of Natural Disasters | ICCROM | Our Collections Matter*. https://ocm.iccrom.org/sdgs/sdg-11-sustainable-cities-and-communities/sdg-115-reduce-adverse-effects-natural-disasters

United Nation. (2018b). *UN Urges Tackling Waste Management on World Habitat Day | News | SDG Knowledge Hub | IISD*. https://sdg.iisd.org/news/un-urges-tackling-waste-management-on-world-habitat-day/

USEPA. (2018). Planning for Natural Disaster Debris. United States Environmental Protection Agency (EPA), 2008. *United States Environmental Protection Agency*, *March*, 1–94. http://www.epa.gov/wastes/conserve/imr/cdm/pubs/pndd.pdf%5Cn

Waste management | Local Self Government Department. (2016). Government of Kerala. http://lsgkerala.gov.in/en/waste-management

Waste Management in Kerala: Government charting new course. (2022). SQUARE YARDS. https://www.squareyards.com/blog/waste-management-in-kerala

Weather & Climate. (2018). *Average monthly rainfall and snow in Pathanāmthitta (Kerala), India (inches)*. Weather & Climate. https://weather-and-climate.com/average-monthly-precipitation-Rainfall-inches,pathanamthitta-kerala-in,India

WHO, & WEDC. (2013). *Not used_Solid waste management in emergencies*. *July*, 1–4. https://www.who.int/water_sanitation_health/emergencies/WHO_TN_07_Solid_waste_management_in_emergencies.pdf?ua=1

World Health Organization Regional Office for Europe, W. (2015). *Waste and human health: Evidence and needs WHO Meeting Report*. http://www.euro.who.int/pubrequest

Glossary:

Blocks: Block is a district sub-division for the purpose of rural development department and Panchayati Raj institutes

Catastrophe: an event causing great and usually sudden damage or suffering; a disaster.

Districts: A district (zilā) is an administrative division of an Indian state or territory.

Gram Panchayat: Gram Panchayat (English: Village council) is a basic village-governing institute in Indigenous villages. It is a democratic structure at the grass-roots level in India. It is a political institute, acting as cabinet of the village.

Municipal Corporation: A municipal corporation is a type of local Government in India that administers urban areas with a population of more than one million.

Municipalities: a town or district that has local government.

Post Disaster Framework: A framework that says how the waste should be managed in emergencies with proper management and handling.

ANNEXURE

Annex 1 : District-wise rainfall between 1st June - 22 August 2018 (Directorate Central Water Commission, 2018).

Districts	Normal Rainfall (mm)	Actual Rainfall (mm)	Departure from Normal (%)	
Kerala State	1701.4	2394.1	41	Excess
Alappuzha	1380.6	1784	29	Excess
Kannur	2333.2	2573.3	10	Normal
Ernakulam	1680.4	2477.8	47	Excess
Idukki	1851.7	3555.5	92	Large Excess
Kasargode	2609.8	2287.1	-12	Normal
Kollam	1038.9	1579.3	52	Excess
Kottayam	1531.1	2307	51	Excess
Kozhikode	2250.4	2898	29	Excess
Malappuram	1761.9	2637.2	50	Excess
Palakkad	1321.7	2285.6	73	Large Excess
Pathanamthitta	1357.5	1968	45	Excess
Thiruvananthapuram	672.1	966.7	44	Excess
Thrissur	1824.2	2077.6	14	Normal
Wayanad	2281.3	2884.5	26	Excess

Annex 2: District wise monsoonal Rainfall 1 - 30 August 2018 (Indian Metrological Department, 2018).

District	Actual Rainfall (mm)	Normal Rainfall (mm)	Percentage Departure (%)	
Thiruvananthapuram	373.8	142	163	Large Excess
Kollam	644.1	258.7	149	Large Excess
Pathanamthitta	764.9	352.7	117	Large Excess
Alappuzha	608.2	343.1	77	Large Excess
Kottayam	619.2	386	60	Large Excess
Idukki	1478.9	527.3	180	Large Excess
Ernakulam	648.3	401.3	62	Large Excess
Thrissur	734.7	440.1	67	Large Excess
Palakkad	848.8	333.8	154	Large Excess
Malappuram	913.7	395.3	131	Large Excess
Kozhikode	836	500.9	67	Large Excess
Wayanad	1053.5	592.9	78	Large Excess
Kannur	665.3	540.9	23	Excess
Kasargode	636.9	636.3	0	Normal
TOTAL	821	419.3	96	Large Excess

Annex 3: Sampled houses for fieldwork (Random sampling)

SR. N	SL No	ward No	House No	Percentage	Random
1	106	9	2	15% Damage	0.408098
2	181	11	107	15% Damage	0.703656
3	136	9	93	15% Damage	0.286855
4	166	10	275	15% Damage	0.029639
5	30	5	243	15% Damage	0.368418
6	102	9	190	15% Damage	0.499973
7	43	6	229	15% Damage	0.471759
8	38	6	219	15% Damage	0.153693
9	158	10	23	15% Damage	0.280063
10	129	9	5	15% Damage	0.765397
11	224	12	85	15% Damage	0.746242
12	98	9	129	15% Damage	0.35873
13	197	12	21	15% Damage	0.088529
14	85	8	234	15% Damage	0.242018
15	59	7	186	15% Damage	0.773027
16	51	7	109	15% Damage	0.757702
17	173	10	37	15% Damage	0.055461
18	228	13	189	15% Damage	0.86485
19	6	2	217	15% Damage	0.996021
20	246	7	87	15% Damage	0.475446
21	163	10	259	15% Damage	0.092392
	SL No	ward No	House No	Percentage	Random
22	104	9	282	16 - 29% Damage	0.00086
23	121	10	170	16 - 29% Damage	0.002303
24	88	8	81	16 - 29% Damage	0.004094
25	126	10	234	16 - 29% Damage	0.00935
26	17	2	260	16 - 29% Damage	0.011979
27	106	9	286	16 - 29% Damage	0.013069
28	131	11	207	16 - 29% Damage	0.013145
29	20	2	295	16 - 29% Damage	0.018879
30	71	7	55	16 - 29% Damage	0.01989
31	150	12	13	16 - 29% Damage	0.02692
32	58	7	183	16 - 29% Damage	0.043805
33	163	12	70	16 - 29% Damage	0.044416
34	146	11	98	16 - 29% Damage	0.069558
35	130	10	75	16 - 29% Damage	0.073054
36	111	9	77	16 - 29% Damage	0.074833
37	57	7	180	16 - 29% Damage	0.082651

38	176	12	163	16 - 29% Damage	0.094795
39	129	10	5	16 - 29% Damage	0.100927
40	165	12	94	16 - 29% Damage	0.109443
	SL No	ward No	House No	Percentage	Random
41	104	10	173	30%- 59% Damage	0.004741
42	22	5	136	30%- 59% Damage	0.005993
43	153	12	51	30%- 59% Damage	0.027507
44	115	10	224	30%- 59% Damage	0.028063
45	73	9	144	30%- 59% Damage	0.030902
46	116	10	226	30%- 59% Damage	0.033437
47	109	10	194	30%- 59% Damage	0.03361
48	77	9	159	30%- 59% Damage	0.033807
49	80	9	310	30%- 59% Damage	0.039168
50	168	13	149	30%- 59% Damage	0.041261
51	159	13	177	30%- 59% Damage	0.046086
52	53	7	222	30%- 59% Damage	0.046848
53	40	6	231	30%- 59% Damage	0.049954
54	47	6	266	30%- 59% Damage	0.056256
55	19	3	45	30%- 59% Damage	0.06145
56	49	7	110	30%- 59% Damage	0.063171
57	18	3	217	30%- 59% Damage	0.06998
	SL No	ward No	House No	Percentage	Random
58	13	3	143	60%- 74% Damage	0.0
59	1	1	288	60%- 74% Damage	0.0
60	2	1	37	60%- 74% Damage	0.0
61	37	8	163	60%- 74% Damage	0.1
62	61	12	101	60%- 74% Damage	0.1
63	22	5	255	60%- 74% Damage	0.1
64	60	11	143	60%- 74% Damage	0.1
	SL No	ward No	House No	Percentage	Random
65	129	6	193	15% Damage	0.01
66	94	4	127	15% Damage	0.01
67	139	6	311	15% Damage	0.02
68	220	11	119	15% Damage	0.02
69	241	11	411	15% Damage	0.02
70	153	6	507	15% Damage	0.03
71	51	2	316	15% Damage	0.03
72	199	7	444	15% Damage	0.03
73	57	2	450	15% Damage	0.03
74	116	5	164	15% Damage	0.03

75	92	4	117	15% Damage	0.03
76	157	6	519	15% Damage	0.05
77	60	2	468	15% Damage	0.06
78	39	2	167	15% Damage	0.06
79	272	13	262	15% Damage	0.06
80	6	1	172	15% Damage	0.07
	SL No	Ward No	House No	Percentage	Random
81	79	6	362	16 - 29% Damage	0.031187
82	13	2	409	16 - 29% Damage	0.033246
83	88	6	512	16 - 29% Damage	0.055585
84	114	7	404	16 - 29% Damage	0.061212
85	97	7	153	16 - 29% Damage	0.062803
86	11	2	272	16 - 29% Damage	0.065377
87	25	3	31	16 - 29% Damage	0.07409
88	153	12	243	16 - 29% Damage	0.078549
89	24	3	208	16 - 29% Damage	0.082397
90	14	2	432	16 - 29% Damage	0.08357
91	83	6	398	16 - 29% Damage	0.084261
92	82	6	397	16 - 29% Damage	0.096638
93	18	2	484	16 - 29% Damage	0.107624
94	90	6	506	16 - 29% Damage	0.127799
95	92	6	523	16 - 29% Damage	0.128488
96	158	12	422	16 - 29% Damage	0.140424
	SL No	Ward No	House No	Percentage	Random
97	59	12	361	30 - 59% Damage	0.010318
98	37	6	469	30 - 59% Damage	0.011023
99	14	4	101	30 - 59% Damage	0.011924
100	50	7	509	30 - 59% Damage	0.016194
101	41	6	71	30 - 59% Damage	0.032888
	SL No	Ward No	House No	Percentage	Random
102	8	6	90	60 - 74% Damage	0.04127
103	4	2	53	60 - 74% Damage	0.088369
	SL No	Ward No	House No	Percentage	Random
104	12	3	1	15% Damage	0.007073
105	54	6	367	15% Damage	0.024297
106	42	8	104	15% Damage	0.030169
107	4	12	153	15% Damage	0.041936
108	23	5	333	15% Damage	0.070328
109	7	12	351	15% Damage	0.075079
	SL No	Ward No	House No	Percentage	Random

110	**22**	**5**	**492**	16 - 29% Damage	0.578773
111	**11**	**3**	**105**	16 - 29% Damage	0.642487
112	**26**	**6**	**47**	16 - 29% Damage	0.151435
113	**8**	**2**	**335**	16 - 29% Damage	0.295361
114	**113**	**6**	**523**	16 - 29% Damage	0.128488
115	**29**	**5**	**238**	16 - 29% Damage	0.410874
	SL No	**Ward No**	**House No**	**Percentage**	**Random**
116	**10**	**10**	**137**	30 - 59% Damage	0.042541
117	**2**	**12**	**151**	30 - 59% Damage	0.065454
	SL No	**Ward No**	**House No**	**Percentage**	**Random**
118	**1**	**11**	**15**	60 - 74% Damage	0.623549
	SL No	**Ward No**	**House No**	**Percentage**	**Random**
119	**1**	**1**	**305**	>75% Damage	0.667929
120	**2**	**11**	**110**	>75% Damage	0.632678

Annex 4 : Waste per LSG in Pamba basin

S.no	District	LSG Name	AREA_SQ_KM	Total houses (OSM)	Waste (Per LSG) in Kilogram	Waste (Per LSG) in Tonnes	Animal Carcasses (Per LSG) in Tonnes	Biodegradable waste (Per LSG) in Tonnes	Non-Biodegradable waste (Per LSG) in Tonnes
1	Idukki	Jonahed	73.796793	369	611802	611.802	184.12362	107.27937	190.23795
2	Idukki	Idukki Kantikoy	90.196378	486	805788	805.788	242.50428	141.29478	250.5573
3	Idukki	Kamakshy	18.887029	39	64662	64.662	19.46022	11.33847	20.10645
4	Idukki	Mariyapuram	67.932405	294	487452	487.452	146.70012	85.47462	151.5717
5	Idukki	Vathikudy	51.919801	109	180722	180.722	54.38882	31.68957	56.19495
6	Idukki	Vazhathope	139.149561	158	261964	261.964	78.83884	45.93534	81.4569
7	Idukki	AyyappanCoil	31.336577	80	132640	132.64	39.9184	23.2584	41.244
8	Idukki	Erattayar	25.130857	143	237094	237.094	71.35414	41.57439	73.72365
9	Idukki	Kanchiyar	61.299923	360	596880	596.88	179.6328	104.6628	185.598
10	Idukki	Kattappana Municipality	57.620657	2009	3330922	3330.922	1002.45082	584.07657	1035.73995
11	Idukki	Alakode Idk	21.739485	53	87874	87.874	26.44594	15.40869	27.32415
12	Idukki	Karimannoor	57.317843	675	1119150	1119.15	336.8115	196.24275	347.99625
13	Idukki	Kodikulam	27.820348	304	504032	504.032	151.68992	88.38192	156.7272
14	Idukki	Kudayathoor	26.882803	506	838948	838.948	252.48388	147.10938	260.8683
15	Idukki	Udumbanoor	142.484372	211	349838	349.838	105.28478	61.34403	108.78105
16	Idukki	Vannappuram	51.249561	129	213882	213.882	64.36842	37.50417	66.50595
17	Idukki	Velliyamattom	50.655889	80	132640	132.64	39.9184	23.2584	41.244
18	Idukki	Arakulam	99.288661	96	159168	159.168	47.90208	27.91008	49.4928

19	Idukki	Edavetty	18.910671	487	807446	807.446	243.00326	141.58551	251.07285
20	Idukki	Karimkunnam	22.238576	191	316678	316.678	95.30518	55.52943	98.47005
21	Idukki	Kumaramangalam	22.920014	169	280202	280.202	84.32762	49.13337	87.12795
22	Idukki	Manakkad	22.049976	81	134298	134.298	40.41738	23.54913	41.75955
23	Idukki	Muttom	25.751549	840	1392720	1392.72	419.1432	244.2132	433.062
24	Idukki	Purapuzha	22.311221	89	147562	147.562	44.40922	25.87497	45.88395
25	Idukki	Thodupuzha Municipality	27.886221	1635	2710830	2710.83	815.8323	475.34355	842.92425
26	Idukki	Elappara	111.7846	731	1211998	1211.998	364.75438	212.52363	376.86705
27	Idukki	Kokkayar	52.356818	48	79584	79.584	23.95104	13.95504	24.7464
28	Idukki	Kumily	874.820222	518	858844	858.844	258.47164	150.59814	267.0549
29	Idukki	Peermade	82.732504	472	782576	782.576	235.51856	137.22456	243.3396
30	Idukki	Peruvanthanam	72.266417	56	92848	92.848	27.94288	16.28088	28.8708
31	Idukki	Upputhara	78.600045	198	328284	328.284	98.79804	57.56454	102.0789
32	Idukki	Vandiperiyar	44.935293	104	172432	172.432	51.89392	30.23592	53.6172
33	Idukki	Chinnakanal	66.69087	0	0	0	0	0	0
34	Idukki	Santhanpara	78.725712	56	92848	92.848	27.94288	16.28088	28.8708
35	Idukki	Chakkupallam	41.802334	243	402894	402.894	121.25214	70.64739	125.27865
36	Idukki	Vandanmedu	67.853736	204	338232	338.232	101.79192	59.30892	105.1722
37	Idukki	Karunapuram	46.375619	181	300098	300.098	90.31538	52.62213	93.31455
38	Idukki	Nedumkandam	84.064207	366	606828	606.828	182.62668	106.40718	188.6913
39	Idukki	Pampadumpara	46.759841	86	142588	142.588	42.91228	25.00278	44.3373
40	Idukki	Rajakkad	30.400664	38	63004	63.004	18.96124	11.04774	19.5909
41	Idukki	Rajakumary	45.093698	142	235436	235.436	70.85516	41.28366	73.2081
42	Idukki	Senapathy	38.373417	42	69636	69.636	20.95716	12.21066	21.6531
43	Idukki	Udumbanchola	74.05178	64	106112	106.112	31.93472	18.60672	32.9952
44	Idukki	Adimaly	154.380243	0	0	0	0	0	0
45	Idukki	BysonValley	62.327883	0	0	0	0	0	0
46	Idukki	Pallivasal	40.949609	0	0	0	0	0	0
47	Idukki	Vellathooval	70.046382	44	72952	72.952	21.95512	12.79212	22.6842
48	Idukki	Devikulam	245.449101	0	0	0	0	0	0
49	Idukki	Kanthalloor	115.393673	0	0	0	0	0	0
50	Idukki	Mankulam	76.379739	0	0	0	0	0	0
51	Idukki	Marayoor	106.179054	0	0	0	0	0	0
52	Idukki	Munnar	265.955766	0	0	0	0	0	0
53	Idukki	Vattavada	68.824609	0	0	0	0	0	0
54	Kollam	Piravanthoor	132.045023	0	0	0	0	0	0
55	Alappuzha	Mavelikara Municipality	14.194399	6540	10843320	10843.32	3263.3292	1901.3742	3371.697
56	Alappuzha	Palamel	26.445269	1742	2888236	2888.236	869.22316	506.45166	898.0881
57	Alappuzha	Mavelikara Thekkekara	20.481426	4313	7150954	7150.954	2152.10074	1253.91849	2223.56715
58	Alappuzha	Chennithala-Thripperumthura	22.14006	4727	7837366	7837.366	2358.67846	1374.28071	2437.00485

59	Alappuzha	Chettikulangara	20.833832	6573	10898034	10898.034	3279.79554	1910.96829	3388.71015
60	Alappuzha	Thazhakara	22.545348	8748	14504184	14504.184	4365.07704	2543.30604	4510.0314
61	Alappuzha	Bharanickavu	23.491306	1037	1719346	1719.346	517.44226	301.48701	534.62535
62	Alappuzha	Vallikunnam	22.155458	317	525586	525.586	158.17666	92.16141	163.42935
63	Alappuzha	Mavelikara Thamarakulam	22.160268	367	608486	608.486	183.12566	106.69791	189.20685
64	Alappuzha	Chunakara	16.791652	2028	3362424	3362.424	1011.93144	589.60044	1045.5354
65	Alappuzha	Nooranad	21.862155	5849	9697642	9697.642	2918.53402	1700.47977	3015.45195
66	Alappuzha	Cheruthana	14.559067	1339	2220062	2220.062	668.13422	389.28747	690.32145
67	Alappuzha	Pathiyoor	15.236223	2542	4214636	4214.636	1268.40716	739.03566	1310.5281
68	Alappuzha	Kayamkulam Municipality	21.396397	1406	2331148	2331.148	701.56588	408.76638	724.8633
69	Alappuzha	Arattupuzha	21.521984	93	154194	154.194	46.40514	27.03789	47.94615
70	Alappuzha	Chingoli	6.704267	111	184038	184.038	55.38678	32.27103	57.22605
71	Alappuzha	Cheppad	12.772182	2943	4879494	4879.494	1468.49814	855.61839	1517.26365
72	Alappuzha	Devikulangara	16.680673	266	441028	441.028	132.72868	77.33418	137.1363
73	Alappuzha	Kandalloor	9.739649	47	77926	77.926	23.45206	13.66431	24.23085
74	Alappuzha	Muthukulam	11.788682	161	266938	266.938	80.33578	46.80753	83.00355
75	Alappuzha	Karuvatta	18.114504	2271	3765318	3765.318	1133.18358	660.24783	1170.81405
76	Alappuzha	Thrikkunnappuzha	11.238609	768	1273344	1273.344	383.21664	223.28064	395.9424
77	Alappuzha	Kumarapuram	11.122496	358	593564	593.564	178.63484	104.08134	184.5669
78	Alappuzha	Karthikappally	7.255323	120	198960	198.96	59.8776	34.8876	61.866
79	Alappuzha	Pallippad	16.052116	3491	5788078	5788.078	1741.93918	1014.93843	1799.78505
80	Alappuzha	Veeyapuram	13.980889	1816	3010928	3010.928	906.14768	527.96568	936.2388
81	Alappuzha	Haripad Municipality	13.6672	2209	3662522	3662.522	1102.24682	642.22257	1138.84995
82	Alappuzha	Krishnapuram	10.380288	328	543824	543.824	163.66544	95.35944	169.1004
83	Alappuzha	Edathua	21.920485	2774	4599292	4599.292	1384.17052	806.48502	1430.1357
84	Alappuzha	Pulincunnoo	33.34132	1499	2485342	2485.342	747.97102	435.80427	772.80945
85	Alappuzha	Neelamperoor	22.047365	2383	3951014	3951.014	1189.06934	692.80959	1228.55565
86	Alappuzha	Veliyanad	19.376089	2124	3521592	3521.592	1059.83352	617.51052	1095.0282
87	Alappuzha	Kavalam	41.850211	1803	2989374	2989.374	899.66094	524.18619	929.53665
88	Alappuzha	Muttar	10.854885	1656	2745648	2745.648	826.31088	481.44888	853.7508
89	Alappuzha	Kainakary	46.453905	2962	4910996	4910.996	1477.97876	861.14226	1527.0591
90	Alappuzha	Nedumudi	27.384992	3024	5013792	5013.792	1508.91552	879.16752	1559.0232
91	Alappuzha	Champakulam	23.316127	2728	4523024	4523.024	1361.21744	793.11144	1406.4204
92	Alappuzha	Thakazhy	28.666747	2117	3509986	3509.986	1056.34066	615.47541	1091.41935
93	Alappuzha	Thalavady	16.009147	3141	5207778	5207.778	1567.29618	913.18293	1619.34255
94	Alappuzha	Ramankary	17.133545	2375	3937750	3937.75	1185.0775	690.48375	1224.43125
95	Alappuzha	Chengannur Municipality	13.152514	4766	7902028	7902.028	2378.13868	1385.61918	2457.1113
96	Alappuzha	Mannar	14.31166	4003	6636974	6636.974	1997.41694	1163.79219	2063.74665
97	Alappuzha	Thiruvanvandoor	9.129453	3028	5020424	5020.424	1510.91144	880.33044	1561.0854
98	Alappuzha	Pandanad	10.903134	2658	4406964	4406.964	1326.28884	772.76034	1370.3319

99	Alappuzha	Budhanoor	15.386254	3906	6476148	6476.148	1949.01588	1135.59138	2013.7383
100	Alappuzha	Puliyoor	11.744743	3055	5065190	5065.19	1524.3839	888.18015	1575.00525
101	Alappuzha	Cheriyanad	14.46575	4692	7779336	7779.336	2341.21416	1364.10516	2418.9606
102	Alappuzha	Ala	10.964255	3227	5350366	5350.366	1610.20846	938.18571	1663.67985
103	Alappuzha	Venmoney	18.893676	6331	10496798	10496.798	3159.04238	1840.61163	3263.94705
104	Alappuzha	Mulakuzha	23.667853	6236	10339288	10339.288	3111.63928	1812.99228	3214.9698
105	Alappuzha	Mannancherry	37.766693	10982	18208156	18208.156	5479.79836	3192.79686	5661.7701
106	Alappuzha	Alappuzha Municipality	44.4137	4512	7480896	7480.896	2251.39776	1311.77376	2326.1616
107	Alappuzha	Purakkad	22.19959	2116	3508328	3508.328	1055.84168	615.18468	1090.9038
108	Alappuzha	Punnapra South	10.498709	1985	3291130	3291.13	990.4753	577.09905	1023.36675
109	Alappuzha	Ambalapuzha North	12.021005	833	1381114	1381.114	415.65034	242.17809	429.45315
110	Alappuzha	Ambalapuzha South	11.954873	2044	3388952	3388.952	1019.91512	594.25212	1053.7842
111	Alappuzha	Mararikulam South	17.793386	8017	13292186	13292.186	4000.32266	2330.78241	4133.16435
112	Alappuzha	Aryad	6.614877	418	693044	693.044	208.57364	121.52514	215.4999
113	Alappuzha	Punnapra North	9.729346	1118	1853644	1853.644	557.85964	325.03614	576.3849
114	Alappuzha	Pattanakkad	15.227059	8725	14466050	14466.05	4353.6005	2536.61925	4498.17375
115	Alappuzha	Chennam Pallippuram	27.176375	6045	10022610	10022.61	3016.3341	1757.46285	3116.49975
116	Alappuzha	Thanneermukkom	34.890178	9846	16324668	16324.668	4912.95708	2862.52758	5076.1053
117	Alappuzha	Muhamma	27.223577	5215	8646470	8646.47	2602.1807	1516.15695	2688.59325
118	Alappuzha	Kadakkarappally	8.420902	4512	7480896	7480.896	2251.39776	1311.77376	2326.1616
119	Alappuzha	Cherthala South	17.51748	7169	11886202	11886.202	3577.18762	2084.24337	3695.97795
120	Alappuzha	Kanjikuzhy	12.949218	5155	8546990	8546.99	2572.2419	1498.71315	2657.66025
121	Alappuzha	Mararikulam North	16.742579	7474	12391892	12391.892	3729.37652	2172.91602	3853.2207
122	Alappuzha	Aroor	13.138501	8214	13618812	13618.812	4098.62172	2388.05622	4234.7277
123	Alappuzha	Ezhupunna	14.49739	5318	8817244	8817.244	2653.57564	1546.10214	2741.6949
124	Alappuzha	Kodamthuruth	11.624467	4673	7747834	7747.834	2331.73354	1358.58129	2409.16515
125	Alappuzha	Kuthiathod	8.478132	5618	9314644	9314.644	2803.26964	1633.32114	2896.3599
126	Alappuzha	Thuravoor Alp	18.866316	5291	8772478	8772.478	2640.10318	1538.25243	2727.77505
127	Alappuzha	Vayalar	14.337632	5528	9165424	9165.424	2758.36144	1607.15544	2849.9604
128	Alappuzha	Perumpalam	14.977878	1715	2843470	2843.47	855.7507	498.60195	884.16825
129	Alappuzha	Arookutty	12.410423	3659	6066622	6066.622	1825.76782	1063.78107	1886.39745
130	Alappuzha	Panavally	19.635811	5897	9777226	9777.226	2942.48506	1714.43481	3040.19835
131	Alappuzha	Thycattussery	14.199756	3492	5789736	5789.736	1742.43816	1015.22916	1800.3006
132	Alappuzha	Cherthala Municipality	18.611623	10345	17152010	17152.01	5161.9481	3007.60185	5333.36475
133	Kollam	Kunnathoor	20.290615	0	0	0	0	0	0
134	Kottayam	Kaduthuruthy	34.132065	186	308388	308.388	92.81028	54.07578	95.8923
135	Kottayam	Manjoor	29.209038	671	1112518	1112.518	334.81558	195.07983	345.93405
136	Kottayam	TV Puram	14.259037	3389	5618962	5618.962	1691.04322	985.28397	1747.19895
137	Kottayam	Udayanapuram	18.695566	2830	4692140	4692.14	1412.1134	822.7659	1459.0065
138	Kottayam	Vechoor	29.737812	3630	6018540	6018.54	1811.2974	1055.3499	1871.4465

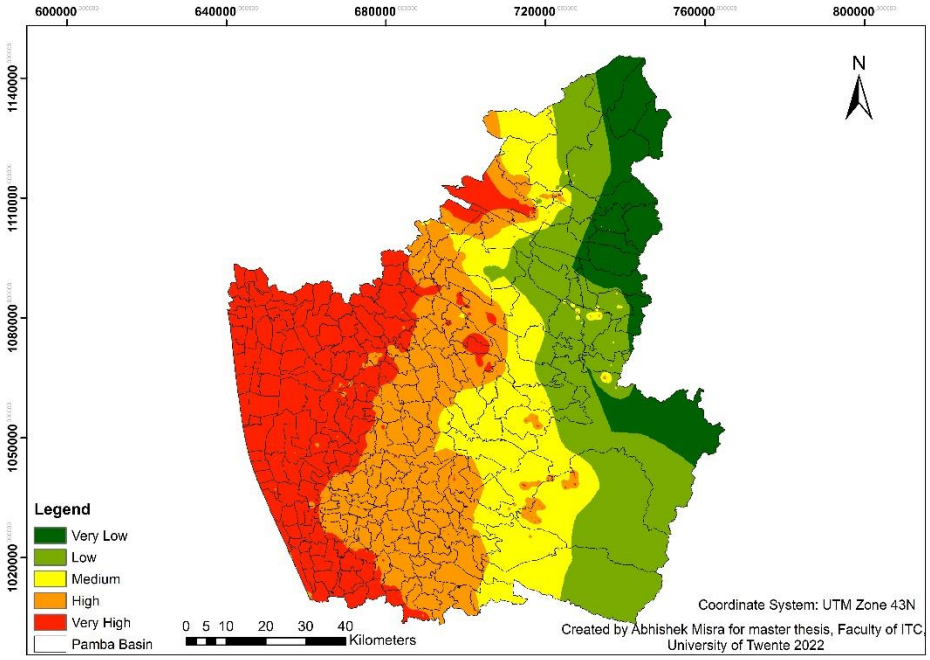
139	Kottayam	Maravanthuruthu	15.958747	2736	4536288	4536.288	1365.20928	795.43728	1410.5448
140	Kottayam	Mulakulam	28.935045	993	1646394	1646.394	495.48714	288.69489	511.94115
141	Kottayam	Vaikom Municipality	12.357894	5352	8873616	8873.616	2670.54096	1555.98696	2759.2236
142	Kottayam	Kallara Ktm	27.896271	63	104454	104.454	31.43574	18.31599	32.47965
143	Kottayam	Thalayazham	21.011962	2592	4297536	4297.536	1293.35616	753.57216	1336.3056
144	Kottayam	Neezhoor	29.132731	285	472530	472.53	142.2093	82.85805	146.93175
145	Kottayam	Velloor	18.367945	354	586932	586.932	176.63892	102.91842	182.5047
146	Kottayam	Thalayolaparambu	20.078578	305	505690	505.69	152.1889	88.67265	157.24275
147	Kottayam	Chempu	17.555744	2254	3737132	3737.132	1124.70092	655.30542	1162.0497
148	Kottayam	Bharanangana m	27.15865	268	444344	444.344	133.72664	77.91564	138.1674
149	Kottayam	Kadanad	39.564096	318	527244	527.244	158.67564	92.45214	163.9449
150	Kottayam	Kanakkary	23.446236	370	613460	613.46	184.6226	107.5701	190.7535
151	Kottayam	Karoor	36.494868	541	896978	896.978	269.94818	157.28493	278.91255
152	Kottayam	Kidangoor	23.306585	389	644962	644.962	194.10322	113.09397	200.54895
153	Kottayam	Kozhuvanal	21.374832	146	242068	242.068	72.85108	42.44658	75.2703
154	Kottayam	Kuravilangad	23.176275	281	465898	465.898	140.21338	81.69513	144.86955
155	Kottayam	Marangattupilly	30.883098	150	248700	248.7	74.847	43.6095	77.3325
156	Kottayam	Meenachil	28.724612	242	401236	401.236	120.75316	70.35666	124.7631
157	Kottayam	Thalanad	33.242086	27	44766	44.766	13.47246	7.84971	13.91985
158	Kottayam	Thalappalam	23.08566	519	860502	860.502	258.97062	150.88887	267.57045
159	Kottayam	Teekoy	35.106296	59	97822	97.822	29.43982	17.15307	30.41745
160	Kottayam	Uzhavoor	24.399715	37	61346	61.346	18.46226	10.75701	19.07535
161	Kottayam	Erattupetta Municipality	7.384782	259	429422	429.422	129.23582	75.29907	133.52745
162	Kottayam	Melukavu	27.207958	189	313362	313.362	94.30722	54.94797	97.43895
163	Kottayam	Moonnilavu	34.700483	170	281860	281.86	84.8266	49.4241	87.6435
164	Kottayam	Mutholy	19.035801	339	562062	562.062	169.15422	98.55747	174.77145
165	Kottayam	Poonjar	18.332504	33	54714	54.714	16.46634	9.59409	17.01315
166	Kottayam	Veliyannoor	18.288271	74	122692	122.692	36.92452	21.51402	38.1507
167	Kottayam	Poonjar Thekkekara	53.329256	22	36476	36.476	10.97756	6.39606	11.3421
168	Kottayam	Thidanad	42.238218	484	802472	802.472	241.50632	140.71332	249.5262
169	Kottayam	Pala Municipality	16.390403	1340	2221720	2221.72	668.6332	389.5782	690.837
170	Kottayam	Kadaplamattom	21.701792	115	190670	190.67	57.3827	33.43395	59.28825
171	Kottayam	Ramapuram	52.921249	232	384656	384.656	115.76336	67.44936	119.6076
172	Kottayam	Aymanam	30.211822	1117	1851986	1851.986	557.36066	324.74541	575.86935
173	Kottayam	Akalakunnam	35.029739	922	1528676	1528.676	460.05956	268.05306	475.3371
174	Kottayam	Athirampuzha	20.568552	370	613460	613.46	184.6226	107.5701	190.7535
175	Kottayam	Ayarkunnam	28.679636	176	291808	291.808	87.82048	51.16848	90.7368
176	Kottayam	Kooroppada	27.490453	128	212224	212.224	63.86944	37.21344	65.9904
177	Kottayam	Kumarakom	52.444332	354	586932	586.932	176.63892	102.91842	182.5047
178	Kottayam	Meenadom	11.24015	80	132640	132.64	39.9184	23.2584	41.244
179	Kottayam	Pallickathodu	23.622723	626	1037908	1037.908	312.36148	181.99698	322.7343
180	Kottayam	Pampady	30.201949	205	339890	339.89	102.2909	59.59965	105.68775
181	Kottayam	Thiruvarppu	34.048767	446	739468	739.468	222.54508	129.66558	229.9353

182	Kottayam	Vijayapuram	15.153533	525	870450	870.45	261.9645	152.63325	270.66375
183	Kottayam	Arpookara	28.221117	756	1253448	1253.448	377.22888	219.79188	389.7558
184	Kottayam	Panachikkad	22.880066	1790	2967820	2967.82	893.1742	520.4067	922.8345
185	Kottayam	Ettumanoor Municipality	27.47549	596	988168	988.168	297.39208	173.27508	307.2678
186	Kottayam	Manarcadu	17.407189	91	150878	150.878	45.40718	26.45643	46.91505
187	Kottayam	Puthuppally	22.614677	548	908584	908.584	273.44104	159.32004	282.5214
188	Kottayam	Kottayam Municipality	56.303506	6644	11015752	11015.752	3315.22312	1931.61012	3425.3142
189	Kottayam	Neendoor	21.092048	153	253674	253.674	76.34394	44.48169	78.87915
190	Kottayam	Erumely	90.291783	194	321652	321.652	96.80212	56.40162	100.0167
191	Kottayam	Kanjirappally	50.629978	1020	1691160	1691.16	508.9596	296.5446	525.861
192	Kottayam	Mundakayam	44.996699	224	371392	371.392	111.77152	65.12352	115.4832
193	Kottayam	Manimala	38.039326	224	371392	371.392	111.77152	65.12352	115.4832
194	Kottayam	Chirakkadavu	39.345978	1059	1755822	1755.822	528.41982	307.88307	545.96745
195	Kottayam	Elikulam	40.301324	582	964956	964.956	290.40636	169.20486	300.0501
196	Kottayam	Koottickal	43.601953	69	114402	114.402	34.42962	20.06037	35.57295
197	Kottayam	Koruthodu	28.930078	62	102796	102.796	30.93676	18.02526	31.9641
198	Kottayam	Parathodu	56.472798	376	623408	623.408	187.61648	109.31448	193.8468
199	Kottayam	Kangazha	25.238875	807	1338006	1338.006	402.67686	234.61911	416.04885
200	Kottayam	Karukachal	23.544514	416	689728	689.728	207.57568	120.94368	214.4688
201	Kottayam	Kurichy	16.856506	5187	8600046	8600.046	2588.20926	1508.01651	2674.15785
202	Kottayam	Madappally	24.390992	1602	2656116	2656.116	799.36596	465.74946	825.9111
203	Kottayam	Nedumkunnam	24.371032	258	427764	427.764	128.73684	75.00834	133.0119
204	Kottayam	Paippad	20.844762	1682	2788756	2788.756	839.28436	489.00786	867.1551
205	Kottayam	Thrickodithanam	11.826274	1559	2584822	2584.822	777.90982	453.24807	803.74245
206	Kottayam	Vakathanam	26.350655	1590	2636220	2636.22	793.3782	462.2607	819.7245
207	Kottayam	Vazhappally	22.814714	4239	7028262	7028.262	2115.17622	1232.40447	2185.41645
208	Kottayam	Vazhoor	30.786699	379	628382	628.382	189.11342	110.18667	195.39345
209	Kottayam	Vellavoor	24.406191	552	915216	915.216	275.43696	160.48296	284.5836
210	Kottayam	Changanassery Municipality	14.231028	8922	14792676	14792.676	4451.89956	2593.89306	4599.7371
211	Pathanamthitta	Eraviperoor	21.650174	2673	4431834	4431.834	1333.77354	777.12129	1378.06515
212	Pathanamthitta	Kadapra	18.647285	4419	7326702	7326.702	2204.99262	1284.73587	2278.21545
213	Pathanamthitta	Kaviyoor	13.317239	727	1205366	1205.366	362.75846	211.36071	374.80485
214	Pathanamthitta	Koipuram	22.665016	3913	6487754	6487.754	1952.50874	1137.62649	2017.34715
215	Pathanamthitta	Kuttoor	10.050815	2759	4574422	4574.422	1376.68582	802.12407	1422.40245
216	Pathanamthitta	Nedumpuram	8.612392	2314	3836612	3836.612	1154.63972	672.74922	1192.9827
217	Pathanamthitta	Niranam	10.253952	1410	2337780	2337.78	703.5618	409.9293	726.9255
218	Pathanamthitta	Peringara	19.479751	4152	6884016	6884.016	2071.76496	1207.11096	2140.5636
219	Pathanamthitta	Thiruvalla Municipality	25.209863	9322	15455876	15455.876	4651.49156	2710.18506	4805.9571
220	Pathanamthitta	Thottappuzhassery	15.283717	744	1233552	1233.552	371.24112	216.30312	383.5692

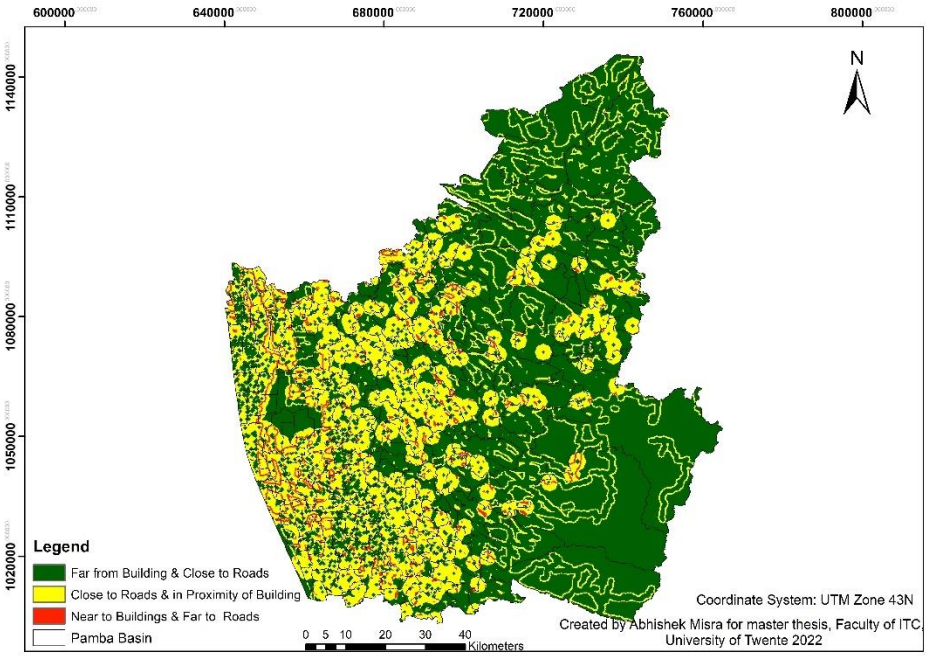
221	Pathanamthitta	Ayroor	25.252222	307	509006	509.006	153.18686	89.25411	158.27385
222	Pathanamthitta	Cherukole	16.130248	59	97822	97.822	29.43982	17.15307	30.41745
223	Pathanamthitta	Chittar	127.164639	149	247042	247.042	74.34802	43.31877	76.81695
224	Pathanamthitta	Naranammoozhy	22.593634	52	86216	86.216	25.94696	15.11796	26.8086
225	Pathanamthitta	Ranni	14.24768	73	121034	121.034	36.42554	21.22329	37.63515
226	Pathanamthitta	Ranni Angadi	20.850338	196	324968	324.968	97.80008	56.98308	101.0478
227	Pathanamthitta	Ranni Pazhavangadi	37.11892	809	1341322	1341.322	403.67482	235.20057	417.07995
228	Pathanamthitta	Ranni Perunadu	48.539564	44	72952	72.952	21.95512	12.79212	22.6842
229	Pathanamthitta	Vadaserikara	57.570332	129	213882	213.882	64.36842	37.50417	66.50595
230	Pathanamthitta	Vechoochira	33.064647	298	494084	494.084	148.69604	86.63754	153.6339
231	Pathanamthitta	Ezhumattoor	22.086657	366	606828	606.828	182.62668	106.40718	188.6913
232	Pathanamthitta	Kallooppara	17.298696	248	411184	411.184	123.74704	72.10104	127.8564
233	Pathanamthitta	Kottanad	22.414663	88	145904	145.904	43.91024	25.58424	45.3684
234	Pathanamthitta	Kottangal	22.936965	159	263622	263.622	79.33782	46.22607	81.97245
235	Pathanamthitta	Kunnamthanam	16.467762	194	321652	321.652	96.80212	56.40162	100.0167
236	Pathanamthitta	Puramattom	13.998379	758	1256764	1256.764	378.22684	220.37334	390.7869
237	Pathanamthitta	Mallappally	20.013327	109	180722	180.722	54.38882	31.68957	56.19495
238	Pathanamthitta	Anicadu	18.665053	125	207250	207.25	62.3725	36.34125	64.44375
239	Pathanamthitta	Aranmula	24.216335	1922	3186676	3186.676	959.03956	558.78306	990.8871
240	Pathanamthitta	Chenneerkara	19.44583	845	1401010	1401.01	421.6381	245.66685	435.63975
241	Pathanamthitta	Elanthoor	15.130087	190	315020	315.02	94.8062	55.2387	97.9545
242	Pathanamthitta	Kozhencherry	9.62556	380	630040	630.04	189.6124	110.4774	195.909
243	Pathanamthitta	Kulanada	19.729946	2285	3788530	3788.53	1140.1693	664.31805	1178.03175
244	Pathanamthitta	Mallappuzhassery	11.029838	128	212224	212.224	63.86944	37.21344	65.9904
245	Pathanamthitta	Mezhuveli	15.058202	932	1545256	1545.256	465.04936	270.96036	480.4926
246	Pathanamthitta	Naranganam	20.602349	212	351496	351.496	105.78376	61.63476	109.2966
247	Pathanamthitta	Omalloor	14.571672	1423	2359334	2359.334	710.04854	413.70879	733.62765
248	Pathanamthitta	Pathanamthitta Municipality	28.044684	1292	2142136	2142.136	644.68216	375.62316	666.0906
249	Pathanamthitta	Aruvappulam	459.298918	15	24870	24.87	7.4847	4.36095	7.73325
250	Pathanamthitta	Kalanjoor	57.453952	59	97822	97.822	29.43982	17.15307	30.41745
251	Pathanamthitta	Konni	32.51594	321	532218	532.218	160.17258	93.32433	165.49155
252	Pathanamthitta	Malayalapuzha	24.55239	265	439370	439.37	132.2297	77.04345	136.62075
253	Pathanamthitta	Mylapra	11.182559	86	142588	142.588	42.91228	25.00278	44.3373
254	Pathanamthitta	Pramadom	38.126767	625	1036250	1036.25	311.8625	181.70625	322.21875
255	Pathanamthitta	Seethathodu	690.395646	191	316678	316.678	95.30518	55.52943	98.47005
256	Pathanamthitta	Thannithodu	150.726811	189	313362	313.362	94.30722	54.94797	97.43895

257	Pathanamthitta	Vallicode	18.538246	927	1536966	1536.966	462.55446	269.50671	477.91485
258	Pathanamthitta	Adoor Municipality	20.832355	736	1220288	1220.288	367.24928	213.97728	379.4448
259	Pathanamthitta	Enadimangalam	31.928062	288	477504	477.504	143.70624	83.73024	148.4784
260	Pathanamthitta	Erathu	21.837337	335	555430	555.43	167.1583	97.39455	172.70925
261	Pathanamthitta	Ezhamkulam	31.067522	404	669832	669.832	201.58792	117.45492	208.2822
262	Pathanamthitta	Kadampanad	34.959654	547	906926	906.926	272.94206	159.02931	282.00585
263	Pathanamthitta	Kodummon	46.383759	520	862160	862.16	259.4696	151.1796	268.086
264	Pathanamthitta	Pallickal Pta	30.632237	420	696360	696.36	209.5716	122.1066	216.531
265	Pathanamthitta	Pandalam Thekkekara	19.33371	280	464240	464.24	139.7144	81.4044	144.354
266	Pathanamthitta	Pandalam Municipality	27.781847	8061	13365138	13365.138	4022.27778	2343.57453	4155.84855
267	Pathanamthitta	Thumpamon	7.482828	453	751074	751.074	226.03794	131.70069	233.54415
268	Idukki	Edamalakkudy	112.260051	0	0	0	0	0	0
269	Ernakulam	Arakuzha	30.017297	0	0	0	0	0	0
270	Ernakulam	Elanji	31.222121	0	0	0	0	0	0
271	Ernakulam	Kalloorkad	27.186422	0	0	0	0	0	0
272	Ernakulam	Koothattukulam Municipality	23.446956	0	0	0	0	0	0
273	Ernakulam	Manjalloor	22.510248	0	0	0	0	0	0
274	Ernakulam	Palakuzha	23.802313	0	0	0	0	0	0
275	Ernakulam	Piravom Municipality	30.207279	0	0	0	0	0	0
276	Ernakulam	Paingottoor	31.042855	0	0	0	0	0	0
277	Ernakulam	Kavalangad	70.320732	0	0	0	0	0	0
278	Ernakulam	Kuttampuzha	503.175802	0	0	0	0	0	0
279	Ernakulam	Kumbalanghi	9.09908	0	0	0	0	0	0
280	Ernakulam	Amballoor	23.921192	0	0	0	0	0	0
281	Ernakulam	Edakkattuvayal	26.340557	0	0	0	0	0	0
282	Ernakulam	Kumbalam	20.979597	0	0	0	0	0	0

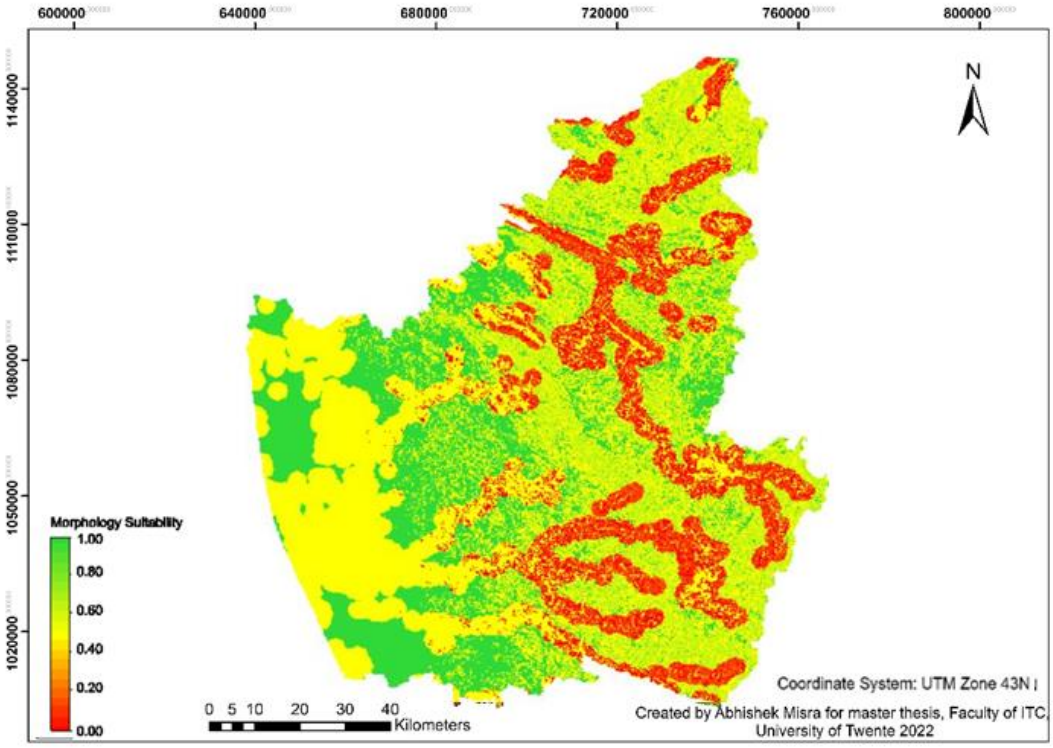
Annex 5: Impact map



Annex 5: Infrastructure map



Annex 5 Morphology Map



Annex 5 Economy Map