UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND DEVELOP OF SMART FLOOD CONTROL DEVICE

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BACHELOR OF DEGREE ENGINEERING TECHNOLOGY (PRODUCT DESIGN) WITH HONOURS

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A thesis submitted
in fulfillment of the requirements for the degree of
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DECLARATION

I declare that this thesis entitled " Design and development of smart flood control device " is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : JYE

Name : YON CHOW JYE

Date : 10/01/2024

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Degree Engineering Technology (Product design) with Honours.

Signature : ....

Supervisor Name : TS. DR. HAMBALI BIN BOEJANG

Date : 10/07/2024.

DEDICATION

This report is dedicated to my parents for their boundless love, unwavering support, and constant encouragement throughout my journey. I am immensely grateful for their presence in my life. I would also like to express my heartfelt appreciation to my supervisor, TS. DR. Hambali Bin Boejang, whose guidance has been invaluable in helping me complete this project. I am sincerely thankful for your unwavering support and for providing me with invaluable advice that contributed significantly to the successful completion of this endeavor.

ABSTRACT

This research endeavors to address the persistent issue of flooding in Malaysia by proposing the development of smart flood control devices. The primary objectives encompass the design, development, and physical testing of innovative flood control devices to enhance the efficiency and resilience of community drainage systems. The region faces recurring flooding, primarily attributed to natural reservoir overflows and inadequate drainage systems, culminating in substantial economic losses, infrastructure vulnerabilities, and environmental degradation. Employing a comprehensive methodology involving meticulous project planning, extensive data collection, literature review, conceptualization, engineering design, coding, prototype development, and rigorous testing, this study integrates diverse techniques such as New Product Development (NPD), surveys, Internet Of Things (IoT) integration, sensor selection, and iterative refinement. The findings reveal the significant impact of recurring flooding on communities, highlighting challenges associated with heavy rainfall and inadequate drainage systems. Stakeholders responded by advocating for improved flood management strategies, such as stormwater management systems and urban planning initiatives. Rigorous individual testing is required during the prototyping phase when incorrect pin connections cause problems with component functionality. The system relies heavily on input data streams, including water level, flow rate and raindrop measurements, highlighting the need for reliable data for effective flood control. Although the performance of this system is moderate, further exploration of its functionality and environmental considerations will be critical for practical implementation. In order to realize the full potential of the multifaceted prototype for flood protection, continuous refinement and documentation is required. Overall, this research project aims to address the ongoing challenges posed by flooding by developing smart flood protection devices. The success of the project's system operation and automation highlights its potential to improve and expand the application in the future, transitioning from manual control to leveraging IoT technology. However, there is an urgent need for further extensive research on topography, technology, and collaboration among stakeholders to effectively respond to flood hazards.

Keywords: Flood, Flood control device, Drainage system, Resilience, Survey, New Product Development (NPD), Engineering Design, Internet Of Things (IoT)

ABSTRAK

Penyelidikan ini berusaha untuk menangani isu banjir yang berterusan di Malaysia dengan mencadangkan pembangunan peranti kawalan banjir pintar. Objektif utama merangkumi reka bentuk, pembangunan dan ujian fizikal peranti kawalan banjir yang inovatif untuk meningkatkan kecekapan dan daya tahan sistem saliran komuniti. Rantau ini menghadapi banjir berulang, terutamanya disebabkan oleh limpahan takungan semula jadi dan sistem perparitan yang tidak mencukupi, yang memuncak dengan kerugian ekonomi yang besar, kelemahan infrastruktur dan kemerosotan alam sekitar. Menggunakan metodologi komprehensif yang melibatkan perancangan projek yang teliti, pengumpulan data yang meluas, kajian literatur, konseptualisasi, reka bentuk kejuruteraan, pengekodan, pembangunan prototaip, dan ujian yang ketat, kajian ini menyepadukan teknik yang pelbagai seperti Pembangunan Produk Baru (NPD), tinjauan, Internet Of Things (penyepaduan IoT), pemilihan penderia dan penghalusan berulang. Penemuan mendedahkan kesan ketara banjir berulang ke atas komuniti, menonjolkan cabaran yang berkaitan dengan hujan lebat dan sistem perparitan yang tidak mencukupi. Pihak berkepentingan bertindak balas dengan menyokong strategi pengurusan banjir yang lebih baik, seperti sistem pengurusan air ribut dan inisiatif perancangan bandar. Ujian individu yang ketat diperlukan semasa fasa prototaip apabila sambungan pin yang salah menyebabkan masalah dengan kefungsian komponen. Sistem ini sangat bergantung pada aliran data input, termasuk paras air, kadar aliran dan ukuran titisan hujan, yang menonjolkan keperluan untuk data yang boleh dipercayai untuk kawalan banjir yang berkesan. Walaupun prestasi sistem ini sederhana, penerokaan lanjut kefungsiannya dan pertimbangan alam sekitar akan menjadi kritikal untuk pelaksanaan praktikal. Untuk merealisasikan potensi penuh prototaip pelbagai rupa untuk perlindungan banjir, penambahbaikan dan dokumentasi yang berterusan diperlukan. Secara keseluruhannya, projek penyelidikan ini bertujuan untuk menangani cabaran berterusan yang ditimbulkan oleh banjir dengan membangunkan peranti perlindungan banjir pintar. Kejayaan operasi sistem dan automasi projek menyerlahkan potensinya untuk menambah baik dan mengembangkan aplikasi pada masa hadapan, beralih daripada kawalan manual kepada memanfaatkan teknologi IoT. Walau bagaimanapun, terdapat keperluan mendesak untuk penyelidikan lebih lanjut mengenai topografi, teknologi dan kerjasama di kalangan pihak berkepentingan untuk bertindak balas secara berkesan terhadap bahaya banjir.

Kata kunci: Banjir, Peranti kawalan banjir, Sistem saliran, Ketahanan, Tinjauan, Pembangunan Produk Baharu (NPD), Reka Bentuk Kejuruteraan, Internet Of Things (IoT)

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First of all, I would like to express my deep gratitude and highest respect to my mentor, TS. DR. Hambali Bin Boejang, for his valuable advice and guidance throughout the project. His unwavering support and encouragement played a key role in ensuring the smooth and successful progress of this work. I would also like to extend my sincere thanks and appreciation to my dear family who have been a source of motivation and inspiration through challenging times and trials. Their unwavering trust in me fueled my determination to overcome obstacles and achieve my goals. Last but not least, I would like to express my heartfelt thanks to all my friends and classmates who have offered help and advice unselfishly. Their kindness and support will always hold a special place in my heart, and I sincerely thank you for your unwavering support throughout this journey.

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LIST OF SYMBOLS AND ABBREVIATIONS

IPCC	-	Intergovernmental Panel on Climate Change
GIS	-	Geographic Information Systems
MNDWI	-	Modified Normalized Difference Index
HEC-HMS	-	Hydrologic Engineering Center - Hydrologic Modeling System
NPD	-	New Product Development
BAH	-	Booz, Allen & Hamilton
IoT	-	Internet Of Things
ρ	-	Density
v,V	-	Velocity
∇	-	Divergence
P	-	Pressure
f	-	External Force
μ	-	Dynamic Viscosity
u	-	Initial Velocity
t	-	Time
X, Y, Z	-	Distance
Re	-	Reynolds Number
D	-	Density
mm	-	Millimetre
m	-	Meter
s	-	Second

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CHAPTER 1

INTRODUCTION

This chapter illustrates the discussion of the project. This includes the background of the flood, problem statement, research objective, project scope and the limitations.

1.1 Background of the flood

The increasing trend of snowmelt rate, along with the land overdevelopment, rising pollution index and hydraulic climate change, exacerbates the likelihood that societies will become more vulnerable to natural catastrophes (Sava et al., 2023). Yet, compared to the standard over the previous three decades, the number of globe-wide catastrophes has been on an upward trend in the past decade, having an extensive effect on various aspects of society (Farooq et al., 2023). Natural catastrophes are still an obstacle that humans cannot yet control and prove difficult to resolve. The cumulative variety of fatalities, especially economic losses, seems incalculable, but these will continue endlessly. In 2017, the World Health Organization states inundation or flood are frequently brought on by prolonged periods of heavy rain, quick melting of the snow, or storm surges from tropical cyclones or catastrophes in coastal regions. Floods may wreak havoc over a large area, result in loss of life, damaging privately owned property, also destroying essential public health infrastructure. Despite the persistent issue of flood management, human efforts have largely revolved around risk mitigation and remote sensing for detection. The lack of sophisticated equipment that allow specialists to assess the entire magnitude of inundates and conduct thorough evaluations quickly seems to be a major problem at the moment (Sava et al., 2023). The efficacy of such efforts in quelling the ferocity of the inundating floods was notably limited.

To substantially decrease the destruction that floods inflict on humanity, particularly to people's homes, organizations, infrastructure, and the environment, flood control is crucial. Flooding occurs when water cannot be retained in a river or when a river's flow gets obstructed, causing the streams to overflow and inundate the surrounding region (Permana et al., 2022). Some of the typical techniques used by humans to prevent flooding include flood barriers and levees, channelization, storage and retention ponds, wetland restoration, and flood forecasting and warning systems. Particularly, the channelization method signifies engineering work destined to change a river's slope, width, depth, or conveyed sediment load, although it varies based on the hydrological and the kind of a river reach (Szarek-Gwiazda et al., 2023). Another effective technique is the dry dam, which is designed to let the channel flow naturally under normal circumstances in order to lessen catchment and greater flood discharge (Jehandyah Erma Pahlevari, 2022) In short, coordination and collaboration between multiple entities and stakeholders is critical for effective flood control initiatives.

According to the inherent complexity of floods, their severity is frequently ascertained by several variables, including the value of damage carried out, the depth of the water, and the number of fatalities. Malaysia experienced one of the worst flooding in recent memory in 2021, which drove the military to mobilise and cost 54 valuable lives. A catastrophe of this magnitude can, as is frequently the case, lead to a serious public health emergency (Xuan, 2021). The Yangtze River Flood of 1931, which killed over 3.7 million people and destroyed all the crops in the floodplain zone, is usually regarded as the worst flood in recorded history. This further added to the suffering of the devastated population. There was a huge increase in population density in certain areas because of many people being compelled to move to core cities like Nanjing and Shanghai in order to survive. Urban public health quickly declined because of the very extreme restrictions on access to quality drinking water. The problem was made worse by the massive amounts of debris, organic matter that had begun to decompose, and human waste that were washed away in the wake of the deluge. Civilians were unable to properly bury the deceased in certain particularly hard-hit locations, which led to widespread contamination and a serious public health danger. These circumstances created a favourable environment for a variety of illnesses when coupled with widespread population relocation and poor sanitation. The enormity of flood disasters demands our utmost attention, and a robust flood management strategy is imperative to mitigate their ruinous effects.

Concisely, the challenge of flooding continues to vex humanity, presenting an intractable problem of vast proportions. With annual losses on an astronomical magnitude, the negative effects of floods are immeasurable. Moreover, this project is to design and develop a smart flood device for damage reduction. Figure below shows the picture before, during and after the flood in Yong Peng, Johor.

Figure 1.1 Dataran Yong Peng before flood

Figure 1.2 Dataran Yong Peng during flood

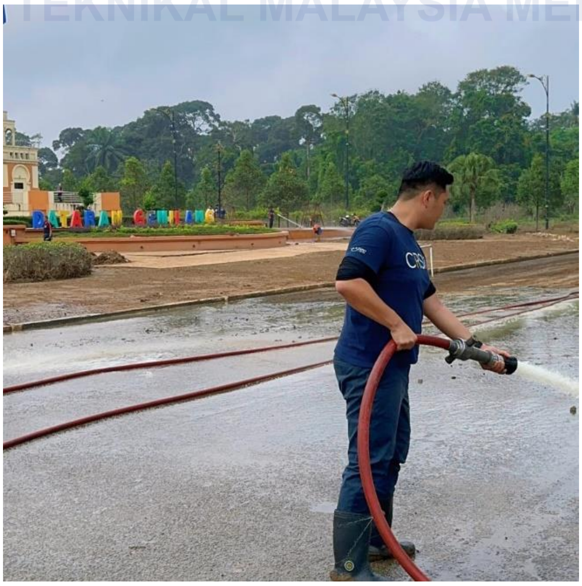


Figure 1.3 Dataran Yong Peng after flood

Floods in Malaysia can be classified into two main types, namely monsoon floods and flash floods. The distribution of rainfall in Malaysia is largely influenced by seasonal wind flow patterns and local topographic features (Buslima et al., 2018). Specifically, the Northeast Monsoon season in Malaysia starts in October and ends in March, bringing with it heavy rainfall that often leads to flooding in the east coast states of Peninsular Malaysia as well as western Sarawak. The southwest monsoons, on the other hand, are relatively drier for most parts of the country, except the state of Sabah in East Malaysia. During this season, most states typically experience minimal monthly rainfall, usually between 100 - 150mm. In additional, Peninsular Malaysia receives an average of 2420 mm of rainfall annually, while Sabah and Sarawak receive 2630 mm and 3830 mm respectively stated by Department of Irrigation and Drainage Malaysia. The eastern coast of Peninsular Malaysia and the coastal regions of Sabah and Sarawak experience heavier precipitation. Figure below shows the two types of monsoons in Malaysia:

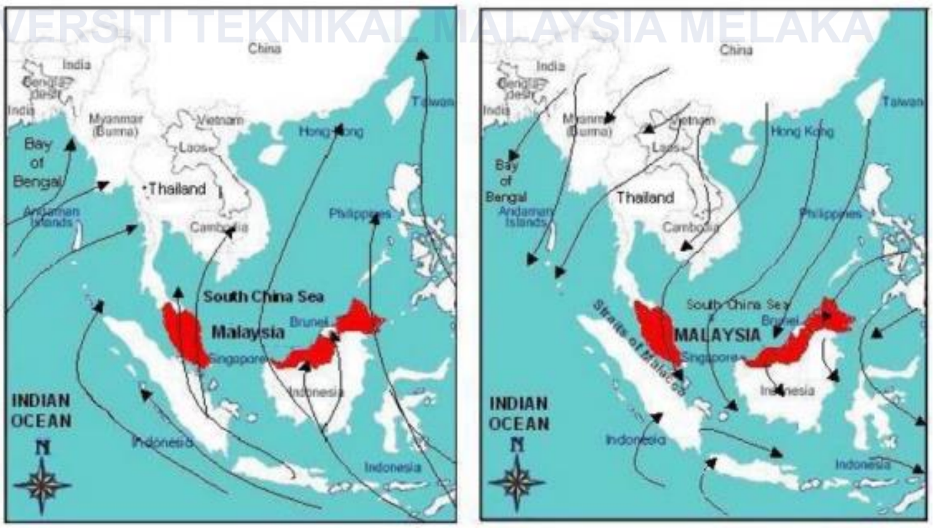


Figure 1.4 Southwest (left) and northeast (right) monsoons around South-East Asia

Specifically, Terengganu, a state located on the east coast of Peninsular Malaysia, experiences severe floods almost every year during the Northeast monsoon period between October and March. The floods in Terengganu are caused by a combination of physical factors such as elevation and proximity to the sea, coupled with heavy rainfall during the monsoon season. Floods in this region are termed as coastal flooding due to their location. Muar River Basin has also experienced frequent flooding over the years, with a total of 29 flood events recorded between 1980 and 2010 (BarzaniGasim et al., 2014). Additionally, a devastating flood occurred in four states in Peninsular Malaysia, namely Melaka, Johor, Pahang, and Negeri Sembilan. The flood disaster, caused by the Northeast monsoon, resulted in the destruction of Kota Tinggi, Johor. The flood occurred in two waves: December 2006 and January 2007, with the latter having a return period of over 100 years. It caused significant damage to property and infrastructure, forced over 100,000 people to evacuate, and resulted in the loss of 18 lives (BarzaniGasim et al., 2014). Figure below is showing the flooding history in Malaysia past two decades:

No.	Year	Floods Incidence	The effects of disasters
1	1996 [8]	Floods brought by Tropical Strorm Greg in Keningau, Sabah	• 241 people were killed • Estimated more than USD 97.8 million damage to infrastructure and property • Destroyed thousands of houses
2	2000 [8]	Floods caused by heavy rainfall in Kelantan, Terengganu and northern Peninsular Malaysia	• 15 people were killed in Kelantan and Terengganu • More than 10,000 evacuees affected in northern Peninsular Malaysia
3	2001 [9]	Floods brought by Tropical Storm Vamei in eastern Malaysia	• Storm causes flooding and landslide in eastern Malaysia • Five people were killed • Estimated USD 3.6 million damage
4	April & Oct 2002 [10]	Flash Flood	• Flash flood that affected Kuala Lumpur
5	Oct 2003 [10]	Flood in the northwestern Peninsular Malaysia	• Flood that affected a large area in the northwestern Peninsular Malaysia covering states of Kedah, Penang and northern Perak
6	Dec 2006 & Jan 2007 [8]	Flood in Johor	• 18 people were killed • Estimated USD 489 million in damage
7	2008 [8]	Flood in Johor	• 28 people were killed • Estimated USD 21.19 million damage
8	2010 [8]	Flood in Kedah and Perlis	• four people were killed • Estimated 45,000 hectares of paddy fields were destroyed • More than 50,000 evacuees affected in Kedah
9	2013 [11]	Flash Flood in Cameron Highlands	• Flash flood caused by the water released from Sultan Abu Bakar dam • Three people were killed • 80 houses affected and 100 vehicles damaged
10	Dec 2014 & Jan 2015 [12]	Flood in Peninsular Malaysia	• Several states in Peninsular Malaysia were affected; Kelantan, Terengganu, Pahang, Perak, Sabah, Negeri Sembilan, Johor, Perlis, Kedah and Sarawak • More than 200,000 people were affected with 21 people were killed • Estimated more than RM 1 Billion damage
11	May 2016 [13][14]	Flash Flood in Kuala Lumpur and Selangor	• Flash flood that affected four main roads in Kuala Lumpur • 15 cars were submerged and hundreds more were trapped in Kuala Lumpur • More than 300 evacuees affected at Dengkil, Selangor

Figure 1.5 Flooding history in Malaysia (BarzaniGasim et al., 2014)

1.2 Problem Statement

Malaysia is not an exception to the devastation caused by the plague of floods, which is a worldwide ailment. Flooding is frequently caused by the overflow of water from natural reservoirs like rivers and lakes when the water spills over the normal limits of the embankments owing to siltation or other circumstances (Singh et al., 2018). Flooding can also occur because of an excessive build-up of inundated rainwater on the ground or poor drainage, encroachment, or sedimentation in bodies of water. Flooding may have a wide range of negative effects, including loss of life, destruction of property and infrastructure, interruptions to transportation, erosion and sedimentation, agricultural destruction, water contamination, and substantial economic repercussions. Floods also occur at the community level as well. Community-level flooding is often the result of localized factors and conditions that contribute to water accumulation and inundation. Some specific problems statement stated as below :

a) Inundated water, also known as excessive or high water levels, is one of the primary causes of flooding. Floods occur when the volume of water exceeds the capacity of the natural or man-made drainage systems, leading to the overflow and inundation of surrounding areas.
b) Improper disposal of rubbish in drainage systems causes blockages, reduced water flow, and increased flooding risks, leading to environmental pollution, infrastructure damage, and public safety concerns (Widjaja et al., 2020).
c) Available flood pumps may be outdated, lacking modern technologies and features that improve their performance and efficiency. A shortage of modern water pumps hinders effective flood management and can lead to poor drainage.

1.3 Research Objective

The main aim of this research is to design and develop of smart flood control device. Specifically, the objectives are as follows:

a) To design and develop smart flood control device that ameliorate and innovate the drainage device in community.

b) To fabricate and conduct physical testing for smart flood control device.

1.4 Scope of Research

The project aims to design and develop an innovative flood control device with a smart drainage accelerator system, focusing on monitoring and controlling water flow and water levels during heavy rains to alleviate stagnant water conditions. The project emphasizes exploring the causes and effective solutions to flooding, including a critical literature search and review. Key to its success is identifying potential flood triggers and gaining a deep understanding of real-life water flow systems. Comprehensive monitoring using tangible prototypes to track flow, water levels and weather conditions allows for comparative analysis to assess the functionality and effectiveness of flood defences. An initial community survey informed the necessary functionality and measured equipment requirements, culminating in the creation of a prototype designed for rigorous physical testing to validate the concept and provide real-time results for the flood protection equipment. This holistic approach ensures the device is appropriate, practical and effective in addressing community flooding issues.

However, it is important to acknowledge some of the inherent limitations of this project. The complexity stems from the need for relatively large machines, posing challenges in terms of time, cost and physical test experiments. Additionally, assumptions play a crucial role in accounting for factors such as river structure, density, and impurities during data collection and analysis. Despite these challenges, the project remains committed to its core goals of investigation, innovation, and problem-solving. The focus is to improve its functions, theories, mechanisms, and effects, and contribute to improving the level of flood control technology.

1.5 Summary

Overall, the main goal of the project is to develop an advanced flood protection device that can effectively manage water flow and mitigate flood losses. The device is equipped with IoT technology, but is not limited to monitoring water conditions. The project aims to promote innovation in community drainage systems by introducing smart flood protection equipment. Subsequent phases will involve comprehensive physical testing to confirm the effectiveness and functionality of the device in typical community settings.

CHAPTER 2

LITERATURE REVIEW

This chapter provides an in-depth discussion of all relevant research related to this project, including flooding, the methods used and their applications.

2.1 Background

A flood is a type of natural disaster that happens when a region is flooded. Heavy rains, snowmelt, or the overflow of rivers, lakes, or oceans are the usual culprits. Floods can also happen when dams fail or when water is released suddenly from reservoirs. They are among the most frequent and pervasive natural disasters, affecting millions of people annually all over the world.

2.1.1 Flood

The significance of water in sustaining all living beings and serving as a fundamental cornerstone for life on our planet cannot be overstated. Nonetheless, mismanagement of this precious resource can result in serious repercussions, such as devastating floods or prolonged droughts, due to unpredictable rainfall patterns. The effects of water scarcity have resulted in droughts in various regions across the globe, while excessive water has led to colossal flooding (Singh et al., 2018). As our world sees increased urbanization and more extreme weather events, the consequences of mismanaging our water resources become ever more dire. Tragically, millions of lives have been lost due to catastrophic flooding, and the economic losses have reached tens of billions of dollars annually (X. Wang et al., 2023). The intensification of extreme precipitation events (Tabari, 2020) and the increasing exposure of populations to water-related hazards only exacerbate these issues. Additionally, as populations migrate to urban centres and hydroclimate patterns shift, societies become even more vulnerable to natural hazards (Sava et al., 2023) . This is expected to bring unprecedented climate extremes, including floods, droughts, heat waves, cold snaps, and storms in various parts of the planet (Manandhar et al., 2023) . In fact, some regions have already experienced unprecedented rainfall, leading climatologists to believe that climate change is a contributor. It is crucial that we prioritize responsible water management to mitigate these risks and protect our people and planet (Singh et al., 2018) .

2.1.2 Definition of flood

The phenomenon of flooding entails a multifaceted process whereby water overflows its customary limits and inundates a typically dry terrain (Singh et al., 2018). This event arises when a river channel's capacity to confine water proves inadequate, impeding its natural flow and leading to water breaching its boundaries, consequently submerging adjacent areas commonly referred to as floodplains (Permana et al., 2022) .

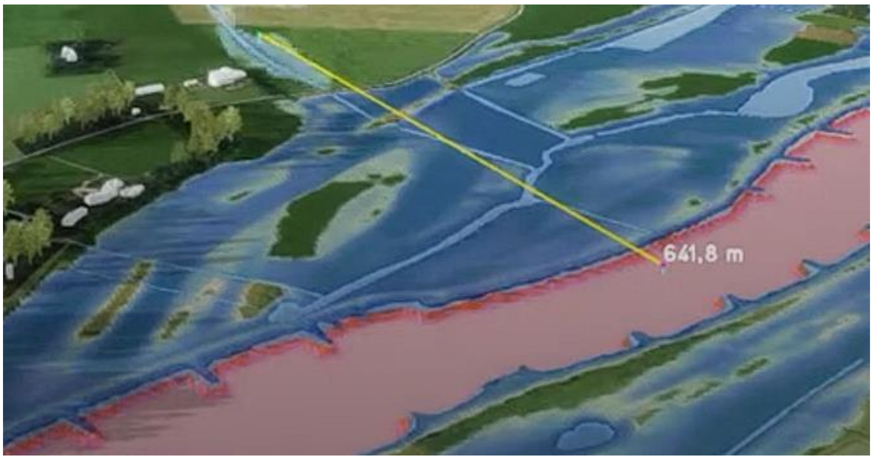


Figure 2.1 Water breaching its boundaries (Tygron, 2019)

2.1.3 Reason of flood

One of the recurring disasters that plagues society is the devastating floods that continue to wreak havoc. These catastrophic events are on the rise in terms of severity, duration, and frequency, largely due to changes in infrastructure, population growth, and the far-reaching effects of climate change. With alterations in rainfall patterns and increased intensity of the water cycle, many regions are gearing up for heavy rainfall and the subsequent flooding events (Manandhar et al., 2023) . Additionally, researchers, development specialists, and scientists all agree that the floods that caused over 500 fatalities and rendered others homeless were primarily due to years of unlawful building practices and poor urban planning. Water surges can break the containment of a body of water, such as a river or lake, causing flooding when barriers that limit water are breached. The accumulation of sediment, referred to as siltation, leads beyond the usual water boundary, resulting in flooding events (Encarta Dictionary, 2009). Inadequate drainage mechanisms, erosion, deposition of lakebed sediments, or the accumulation of rainwater on saturated terrain can also contribute to water overflow (Singh et al., 2021).

In Pakistan, flooding is a recurring phenomenon during the monsoon season, primarily caused by heavy rainfall in the upper basins of the country's major rivers, namely the Indus and Chenab (Cobbinah et al., 2023; Sajjad et al., 2023). This phenomenon can be attributed to the intricate interplay of various climate change effects (Kemter et al., 2023) , wherein the impact of climate drivers on flood patterns exhibits variability depending on the intensity of the flood itself. Coupled with the topographical and geographical features of the area (Permana et al., 2022) , these factors contribute to flood vulnerability. It should be noted that during the rainy season, when precipitation increases, heavy rainfall during concentrated periods increases runoff discharge, further exacerbating the risk of flooding. Land use changes have profound effects on flood dynamics.

These changes can impact the hydrological properties of specific regions, especially when they promote increased surface runoff and exacerbate the scale of flooding (Farid et al., 2021) . Changes in upstream land use, often spurred by development pursuits, can also undermine the ability of rivers to resist flooding. The periodic flooding that plagues the Rongkong River is mainly due to sediment deposition, which reduces the river's ability to manage flood flow. According to the findings of Puslit bang Lingkungan Hidup (UNHAS 2017), the main sources of sediment include dilatational landslides that occur on mountain ranges, mountain and river cliffs, and erosion of farmland upstream (Permana et al., 2022).

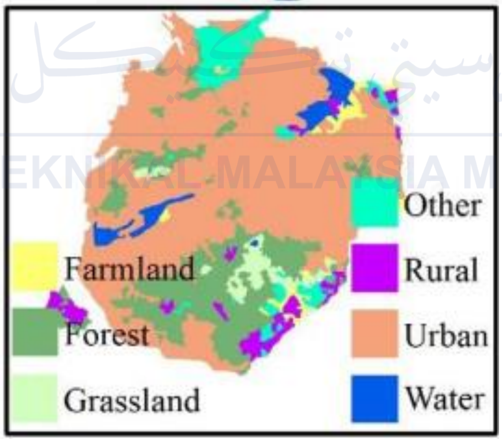


Figure 2.2 Land use map (L. Wang et al., 2022)

Floods in Malaysia may be caused by both natural and anthropogenic factor. The following are some common causes of floods in Malaysia:

Table 2.1 Common cause of flood in Malaysia

Natural factor	Natural geological
	Climate change
	Inadequate river capacity
	Localised continuous heavy rainfall
	Tidal backwater effect
Anthropogenic factor	Urbanisation
	Drainage system
	Dam
	River modification
	Loss of flood storage
	Siltation in waterway channels

In December 2021, a sudden catastrophe of a massive mudslide known as "banjir puing" destroyed villages and holiday homes along rivers in the Malaysian state of Selangor. According to the study, excess rainfall exceeded the absorption capacity of the ground and soil, leading to more than 1,000 landslides along the Titiwangsa range. Along with more than a hundred mudslides, these landslides cascaded downstream, carrying trees, rocks and other debris with them. Strong currents flooded rivers, causing them to overflow their banks and damaging anything in their path. The study identified four main components of the disaster: upstream landslides and mudslides in the forests of the Titiwangsa Range Reserve, mudslides in highland agricultural areas, lowland mudslides affecting villages along the river such as those in Hulu Langat, as well as monsoon floods affecting estuaries in urban areas such as Taman Sri Muda, Shah Alam and Kuala Lumpur. The researchers believe this is a natural geological phenomenon, although it has been exacerbated by human impact on the highlands. Contrary to social media accusations of rampant logging in Pahang and other highlands, the study suggests that logs found in damaged homes and towns were uprooted by rushing water during the incident. While human activity may have contributed to the magnitude of the disaster, the researchers said that the unprecedented amount of rainfall and the resulting natural geological processes were largely responsible (Rahman, 2022).

Some have made the case for attributing recent floods and other weather-related events in Malaysia to climate change. Geologists acknowledge that the extreme weather phenomena now associated with climate change occur periodically over long periods of time. The key difference, however, is that climate change has human-related causes, while geological processes occur naturally over longer periods of time. Human-induced climate change can accelerate these natural processes, leading to more frequent occurrence of extreme weather events. Still, it's important to understand that not all extreme weather events can be directly attributed to global warming or rising temperatures. For the December 2021 floods in Malaysia, climate change may have played a role by enhancing the impact of Typhoon 29W and altering its usual path. However, whether climate change, especially global warming or greenhouse gas emissions, was the immediate and primary cause of the floods remains uncertain. Further scientific research and analysis is necessary to determine the extent to which climate change affects flood severity and the specific mechanisms involved (Rahman, 2022).

Respondents from different kampungs in Segamat, Malaysia, believed that the urbanization of low-lying areas was the main cause of flooding in the area. They highlight the lack of government oversight and haphazard planning in building homes and businesses in vulnerable areas. Contrary to previous research showing that residents are unaware of the link between urbanization and flooding, respondents in this study demonstrated a broad knowledge and understanding of the impact of urbanization on flood risk. By mapping the topography, they provided detailed information on urbanized areas and low-lying areas and emphasized that flooding was not caused solely by heavy rainfall and low-lying areas, as other studies have suggested. These findings demonstrate that local people have a deep understanding of the complex factors that lead to flooding, highlighting the importance of incorporating community perspectives into flood management and urban planning (Sach et al., 2019).

Malaysia's increasing urbanization has resulted in insufficient drainage systems to cope with heavy rainfall. This is exacerbated by the buildup of trash and waste that blocks the flow of water through the gutters during floods. Residents often dump their rubbish into open drains, further exacerbating the problem. It is believed that drainage maintenance should be the responsibility of the community. Overall, there is recognition of the need to address drainage issues and improve waste management to mitigate the impact of flooding (Sach et al., 2019).

2.1.4 Effect of flood

The IPCC's Sixth Assessment Report has projected a higher probability of riverine flooding in various land regions, with a greater level of confidence in Africa, Asia, and Europe. The report indicates that under a scenario of 1.5°C global warming, heavy precipitation and associated flooding are projected to occur more frequently and intensify. The assessment also projects an increased likelihood of compound flooding due to the combined effects of sea level rise, storm surges, and excess rainfall. Without appropriate adaptation measures, flood losses are projected to increase significantly, with a medium level of confidence in the projections (Manandhar et al., 2023). As global temperatures continue to rise, the atmosphere will hold more water, leading to an escalation in the severity of precipitation events over the continental United States (Kemter et al., 2023). Such an escalation can have adverse consequences, including property damage, human casualties, and negative impacts on local economies (Sava et al., 2023) .

Floodplains have far-reaching effects on individuals' lives, their property, and the overall economic fabric of the nation (Sajjad et al., 2023). Floods can cause significant damage to structures, infrastructure, public health, supply chains, and transportation networks (Farooq et al., 2023) . The loss caused by floods can be divided into direct and indirect loss, where direct damage occurs when floodwaters directly contact individuals, property, or belongings (Farooq et al., 2023) . The agricultural sector is also vulnerable to flooding, with setbacks resulting in significant losses for the sector (Singh et al., 2018).

Based on the figure 2.3(a) shows the population in each state in Peninsular Malaysia which the Selangor consist of largest number of people which greater than 7000000, for Malacca and Perlis are listed the least number of people which less than 1000000. The figure 2.3(c) illustrates the number of victims evacuated during the flood from 17 Dec 2021 to 10 Jan 2022. Johor, Kelantan, Malacca, Negeri Sembilan, Pahang, Selangor be implicated in flood 2021 – 2022. From 19 Dec to 25 Dec, Selangor and Pahang had record more than 30000 people evacuated but on 2 Jan, people evacuate in Selangor had record 0. During the same period, Johor had usher in the flood and recorded highest number of evacuees on 4 Jan (Tew et al., 2022).

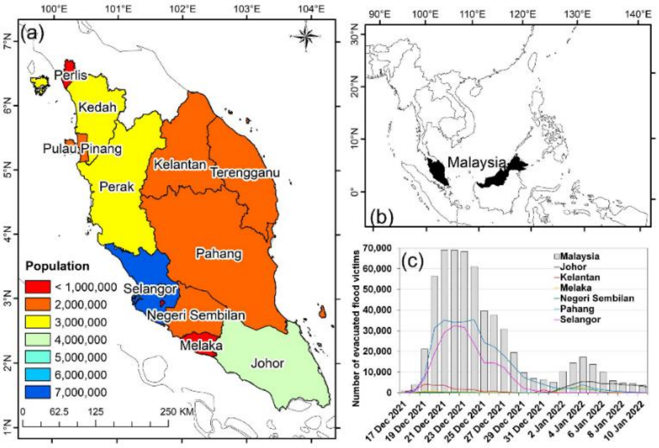


Figure 2.3 (a) Populations of states in Peninsular Malaysia; (b) Location of Malaysia in Southeast Asia; (c) Number of victims evacuated during flood events. (Flood 2021-2022) (Tew et al., 2022)

2.1.5 Flood control

a) Flood mapping

The proficient monitoring and evaluation of flood occurrences, dissemination of reliable flood-related information, and issuance of effective alerts are crucial measures for loss prevention and mitigation. These procedures serve as crucial safety mechanisms for keeping the public informed and providing the responsive community with valuable insights. The implementation of efficient remote sensing-based flood risk mapping is a cost-effective approach to acquiring comprehensive data, encompassing all phases of flood risk, and enabling precise flood mapping. Satellites and aerial data are widely utilized due to their ability to provide high-resolution spatial data with multispectral capabilities, which can be used for pre-flood, during, and post-flood assessments. Additionally, remote sensing affords a comprehensive meteorological view of the Earth, providing valuable environmental data, ranging from vast continental extents to urban areas, with spatial pixel resolutions varying from kilometres to centimetres (Sava et al., 2023) . Figure 2.4 illustrate the example of flood mapping in johor area.

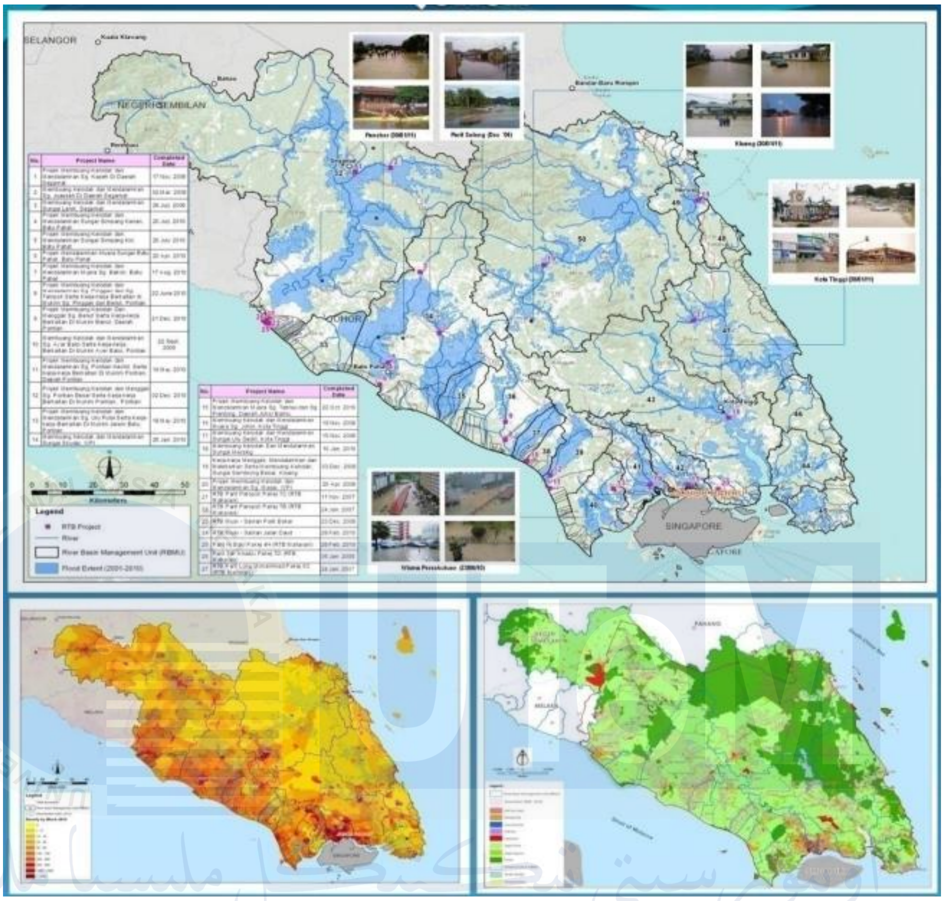


Figure 2.4 Flood mapping Johor (By Ir Wong Wai Sam Ir Mazura Nor Zulkifli Cheok Hou Seng, 2012)

A comprehensive assessment can be performed through floodplain mapping, remote sensing, geographic information systems (GIS), hazard analysis, socioeconomic analysis, infrastructure assessment, and community engagement (Farooq et al., 2023) . These assessments entail simulating flood scenarios, assessing likely impacts, increasing community preparedness knowledge, and developing strategies to mitigate the impact of flooding and successfully respond to disasters. Significant progress has been made in the construction of embankments, reservoirs, flood storage, and flood detention areas. Currently, there are 490 communities under protection, with the primary goal of protecting 637 cities from flooding (Sava et al., 2023) .By utilizing the MNDWI (Modified Normalized

Difference Index) derived from satellite imagery, flood zones can be accurately delineated. The water index provides valuable insights and provides a systematic approach for accurate flood mapping. This approach is effective in reducing false positives and highlighting areas affected by flooding. In addition, the information obtained from this analysis can greatly assist Dera Ghazi Khan District in choosing the best emergency flood protection measures in case of flood hazard (Sajjad et al., 2023) .Hydraulic models are designed to simulate different flood scenarios, which help identify flood-prone areas and estimate water depth and possible flooding (Brouwer, T, 2016). A characteristic of hydraulic models is that they replicate flow according to the topography of channels and floodplains by applying the laws of physics to fluid motion with varying degrees of complexity and minimal parameterization requirements (Sava et al., 2023). Forecasting rainfall can aid in emergency decision-making, but short-term forecasting is challenging due to the complex relationships and rapid changes in meteorological variables that occur during events. Additionally, the computational complexity of physics-based models makes it difficult to provide real-time predictions. In order to mitigate flood risk, it is crucial to understand how compound flooding affects an area. Assessing compound flood risk for coastal cities can aid in identifying vulnerable areas and formulating effective flood prevention measures (Manandhar et al., 2023) . Figure 2.5 shows the before- and during-flood (2021-2022) satellite images in Kuantan city, Pahang.

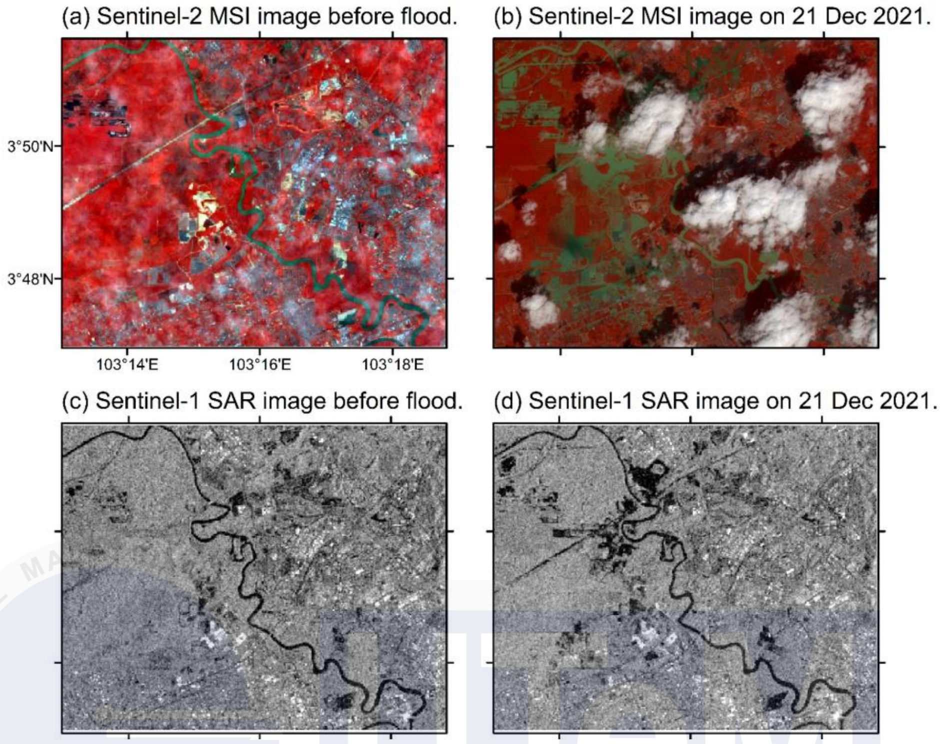


Figure 2.5 Before- and during-flood (2021-2022) satellite images in Kuantan city, Pahang (Tew et al., 2022)

Deployment of flood protection equipment within communities requires a nuanced and collaborative approach that relies on a deep understanding of local geography, potential flood vulnerability and regulatory frameworks. Collaboration with local authorities, environmental experts and relevant agencies facilitates a thorough analysis, using historical data and terrain insights to pinpoint high-risk areas. Particular attention is paid to areas close to water sources, low-lying areas and critical infrastructure such as schools and hospitals, as these areas are more vulnerable to flooding. Integrating flood protection into urban planning and development plans involves a focus on sustainable practices and advanced stormwater management systems. The process also requires strict compliance with local regulations and active community engagement, with local insights playing a key role in decision-making. Having a routine maintenance schedule is critical to ensuring the continued functionality of your flood defenses. This comprehensive, collaborative approach not only increases community resilience to potential flooding events, but also highlights the synergies between engineering solutions and sustainable land use practices for long-term effectiveness.

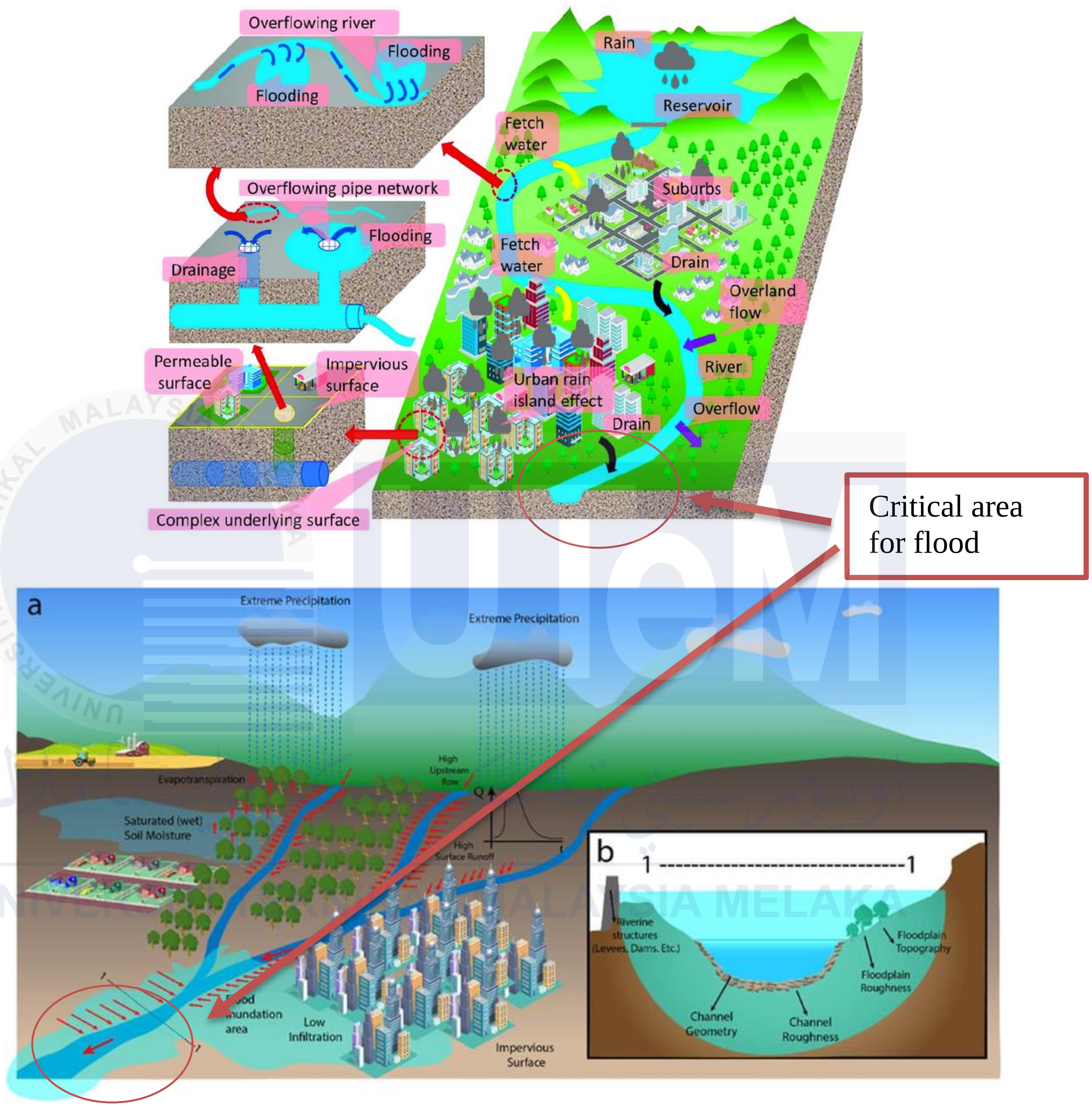


Figure 2.6 Schematic diagram of rain flood(Li et al., 2022)

Basic hydrological principles emphasize the inherent tendency of water to flow from higher to lower elevations. During periods of heavy rainfall, water flow slows significantly compared to current flow, which can cause rivers to reach saturation point, leading to overflow into low-lying areas and subsequent flooding. The success of external flood protection interventions is closely related to wise choice of location. Figure 2.6 provides a visual representation, emphasizing that judicious river water treatment, including measures to manage flow dynamics and discharge rates, is a key strategy. This strategic intervention not only reduced pressure on the river system, but also reduced the severity of flooding throughout the surrounding area. This nuanced approach emphasizes the key role of precise and targeted action in flood prevention approaches, acknowledging the multifaceted challenges posed by flood scenarios.

b) Channelization

In order to enhance the hydraulic efficiency of rivers and minimize runoff, it is crucial to increase their channel capacity. This is of utmost importance in safeguarding public infrastructure and residential areas (Singh et al., 2018) .Channelization, which involves altering the slope, width, depth, or sedimentation of a river, is implemented using a variety of techniques that are tailored to the specific characteristics of the river segment and its hydrology (Korpak, J.; Lenar-Matyas, A.; Radecki-Pawlik, A.; Plesi´nski, K. ,2021). Typically, channelized rivers exhibit unique attributes in comparison to natural rivers, such as uniform width and depth, predictable curvature, and protective bank linings that prevent lateral erosion. Additionally, slope control structures are employed to mitigate bank erosion and regulate sediment movement within the riverbed, thus ensuring vertical stability of the channel section. Upon inspection, it was found that the drainage system was not functioning properly, primarily due to waste being dumped in multiple channels. Furthermore, the lack of stormwater drainage in suburban areas such as Tambaram, Sriperumbudur, and Ambattur indicates that the government has not given sufficient attention to drainage. Despite the city's extensive 882km of storm drains, these basic infrastructure elements are regrettably absent in the suburbs.

c) Dry dam

The concept of a "sponge city" was initially proposed in China in 2012 as a way to improve urban resilience to climate change-induced rainfall and adapt to environmental changes (Guan et al., 2021). While the creation of sponge cities is a long-term initiative that requires substantial upfront investment, prior research has demonstrated that these cities can effectively decrease urban waterlogging (Hou et al., 2020; Nguyen et al., 2019; Wang et al., 2022). In the Kupang watershed, numerous flood protection measures have been implemented, including the construction of barriers and embankments on the lower Logi River, as well as the investigation of active weirs downstream of the river. Reducing the flow rate in upstream reservoirs is a flood management strategy for the Kupang River, which can be accomplished by constructing a small or dry dam. Using the HEC-HMS model, the current scenario predicts a flood flow of 641.6 m^3/s for the Kupang River. Implementing the small dam proposal to reduce the flow rate to 379.7 m^3/s would result in a 261.9 m^3/s flood reduction or 40.8%. Similarly, the dry dam scheme predicts a flood discharge of 225.6 m^3/s, resulting in a flood reduction of 416 m^3/s (64.8 percent). Further research is required to comprehend the morphology of the Kupang River in the presence of dry dams and to evaluate sedimentation and erosion, which are maintenance costs associated with dry dams (Jehandyah Erma Pahlevari, 2022).

2.1.6 Constrain of the flood control

The ability of experts to quickly assess flood magnitudes with high precision is currently limited. These professionals often rely on laborious, costly, and time-consuming methods such as manual field measurements conducted by surveyors, numerical model readings, and river level monitoring. Moreover, these evaluation platforms encounter significant limitations in optimal weather conditions and direct sunlight. Airborne platforms, in particular, face challenges in extracting information rapidly due to their sensitivity to weather conditions. Typically, multiple high-altitude flights are required to observe large, flooded areas, and the information they provide is limited to the visible part of the electromagnetic spectrum (EM) (Sava et al., 2023).

2.1.7 Resilience of flood

Resilience of a system pertains to its inherent ability to recover functionality after an outage. Resilience has been defined as “the ability of social, economic and environmental systems to maintain their essential functions, characteristics and frameworks in the face of hazardous events and disruptions to adapt to adverse situations”. It encompasses the ability to effectively mitigate, reduce and address shocks. It represents the ability to respond to and recover from disaster without succumbing to systemic breakdown (Mehryar & Surminski, 2022) .The authors underscore the significance of resilience. Specifically, resilience is linked to the system's ability to recover from flooding in the context of severe climate-related events such as excess precipitation. In order to minimize the consequences of flooding and improve the ability of communities to recover from such events, there is mounting emphasis on employing resilient strategies for flood risk management (Manandhar et al., 2023).

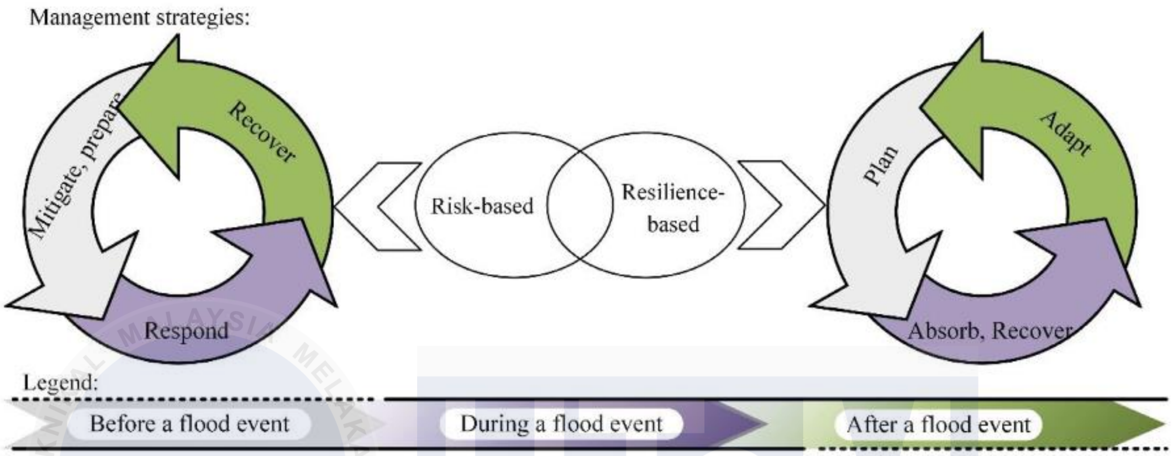


Figure 2.7 Risk-based and resilience-based flood management strategies (L. Wang et al., 2022)

Referring to Figure 2.6, a risk and resilience-based flood management strategy consists of three main parts, namely before, during and after a flood event. In the pre-flood phase, the risk-based approach emphasizes mitigation and preparedness, while the resilience-based strategy focuses on planning. During flood events, risk-based strategies prioritize response, while resilience-based approaches aim to absorb impacts and promote recovery. In the post-flood phase, risk-based strategies center on recovery efforts, while a resilience-based perspective emphasizes adaptation to prevent similar situations in the future. Together, these strategies form a comprehensive framework for responding to floods, including proactive measures, immediate response, and long-term recovery and adaptation.

2.1.8 Recommendation of flood control

The urgency to improve understanding of these critical situations, while enhancing public awareness and awareness of risks, early warning systems, preparedness measures, emergency response capabilities, and risk insurance coverage for such situations and their consequences cannot be overstated. It is crucial to create a clearer distinction between issuing weather forecasts and initiating emergency response. Disaster prevention and reduction management system need to be improved, inter-departmental and multi-party collaboration strengthened, and the response speed of government departments expedited. A rescue team with the necessary resources to find survivors, provide medical assistance to the injured, distribute essential supplies, and manage temporary shelters is critical (Manandhar et al., 2023) . Previous investigations indicate that addressing the occurrence of flood events is crucial (da Silva et al., 2020). It is therefore essential to develop forward-looking flood management strategies to mitigate adverse impacts and effectively deal with increasingly complex flood scenarios (L. Wang et al., 2022) .To enhance the analysis of flood risk, machine learning techniques, especially artificial intelligence, and deep learning models, are strongly recommended. These advanced methods allow for more accurate prediction of flood events and comprehensive assessment of flood risk. Additionally, the use of remote sensing techniques, such as satellite imagery and other innovative tools, should be enhanced to effectively estimate flood risk over large geographic areas and provide early warning of impending flooding (Farooq et al., 2023) .Despite the recurring nature of devastating floods that cause significant hazards and require preparation and effective mitigation of their impact, implementing a robust post-flood monitoring program is critical (Sajjad et al., 2023).

2.1.9 Existing products for flood systems and stations

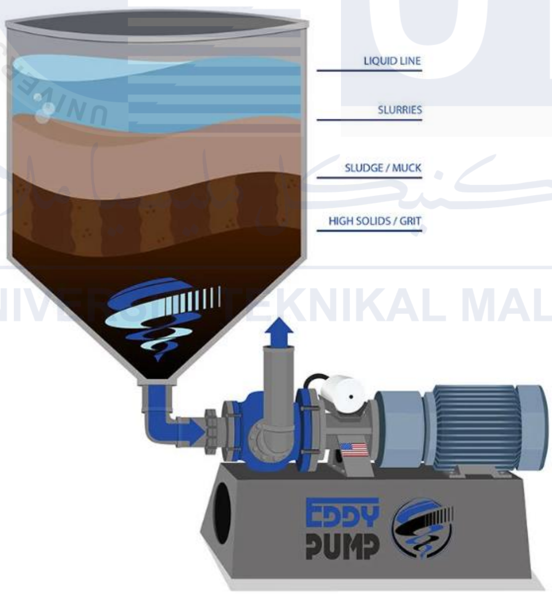
Existing flood protection systems and stations utilize various pump designs to move water from flooded areas to designated locations at specific flow rates. Strategically located near water bodies and flood-prone areas, these systems are designed taking into account factors such as hydraulic characteristics, topography, and required water delivery capacity. Pumps and systems are resilient, with features such as adjustable flow control and redundant arrangements for reliable operation during flood events. The main objective is to effectively manage water levels and mitigate flood impacts. Table 2 serves as an illustrative reference and provides an overview of the various systems and stations and their respective functions and capabilities.

Table 2.2 Specification of flood system ans stations

No	Type of system and station	Function
1	 Stormwater pump stations https://www.xylem.com/en-my/solutions/municipal-water--wastewater/stormwater--flooding/	Pumping away large volumes of water

2	 Storm Water Management Systems https://www.xylem.com/en-my/solutions/municipal-water--wastewater/stormwater--flooding/stormwater-handling/brands/	Pumping solutions to move wastewater through the collection network and into a wastewater treatment plant
3	 Mobile emergency pump https://modernpumpingtoday.com/high-volume-pumps-meet-flooding-challenge/	Handle excess river water when water levels are high

4	 Water pump https://www.alamy.com/water-pump-set-for-pumping-from-water-bank-to-drain-water-out-of-the-area-to-reduce-flooding-image341231740.html	Pumping from water bank to drain water out of the area to reduce flooding
5	 Floating Pump AL https://etecinternational.com/irrigation-floating-pump-al.aspx	Applications Where large volumes of water need to be pumped.

6	 BBA Pumps BA600G D743 https://www.bbapumps.com/en/ba600g-d743-high-capacity-flood-control-pump-diesel-driven-sound-attenuated-canopy.html	Used for pumping large volumes of water where the discharge head is of lesser importance. With more than 6000 m3/h, this is the perfect pump for tackling high water during heavy rains or flooding.
7	 Flooded suction pump https://eddypump.com/education/what-you-need-to-know-about-flooded-suction-pumps	Used to move liquids from one point to another

8	 Boerger Rotary Lobe Pumps https://www.boerger.com/en_UK/sectors/disaster-relief/thw/mobile-flood-pump.html	As mobile, self-priming rotary lobe pumps on vehicle trailers when needed fast in the event of a flood, canal work, pumping station support, wastewater treatment and for disasters.
9	 Flood Drainage Project in Thailand http://defupump.com/profile/thai-government-drainage-projects/171503/0/	Self-priming pumps (DEUTZ diesel engine) with the flow of 700m3/h

10	 Submersible propeller Flygt PL7121 pumps https://gotesco.com/project/high-efficiency-pumps-for-flood-control-in-flood-prone-areas-of-valenzuela/	Establish 12,600 m³/h flow rate and 5 m (7 PSI) head and are used to prevent or minimize floods in flood-prone areas

2.2 New Product Development (NPD)

New product development is the methodical process of creating and introducing fresh products to the market. For this project is mainly based on the sequence to execute in order to meet the project's objective. From the strategy and idea generation to prototype and real product.

2.2.1 The new product development process

The process of new product development (NPD) encompasses a variety of activities that firms engage in to create and launch new products (Bhuiyan, 2011). This process typically progresses through a sequence of stages, beginning with the evaluation of product concepts and culminating in product launch (Booz, Allen &Hamilton, 1982). Each stage represents a series of information gathering and evaluation activities that allow firms to make better decisions about new products, by reducing risk and avoiding investment in products that are likely to fail. Over time, researchers have continued to refine the NPD process, moving from the earlier BAH model (Booz, Allen & Hamilton, 1982) to the more widely used generic NPD process (Ulrich & Eppinger, 2012). The BAH model is closely tied to financial performance, particularly in the pre-development stages of initial screening, preliminary market analysis, and business analysis. Conversely, the generic NPD process places greater emphasis on engineering design and production engineering. Figure below is showing the Booz, Allen &Hamilton, 1982 Model.

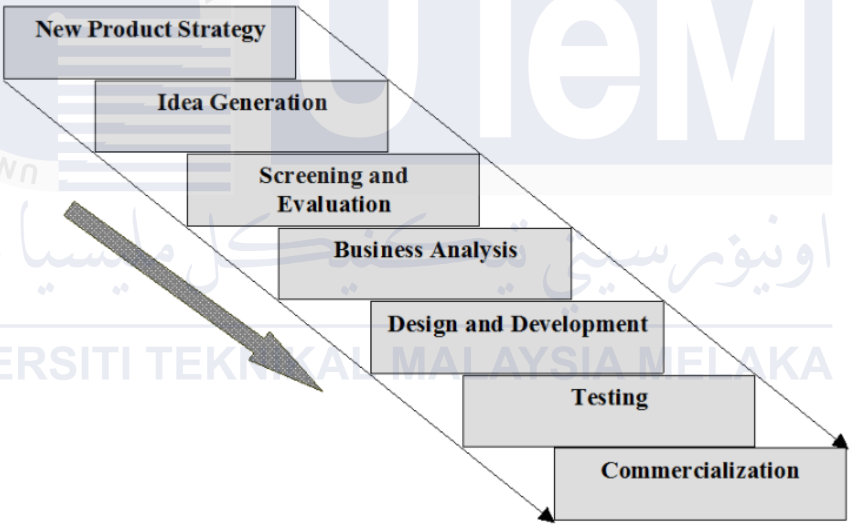


Figure 2.8 Booz, Allen &Hamilton, 1982 Model

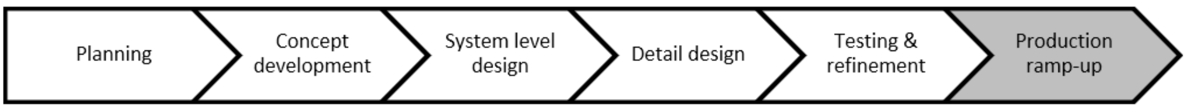


Figure 2.9 Generic new product development process (Ulrich & Eppinger, 2012). The grey marked step for production ramp-up is not feasible in low-volume manufacturing industries (Javadi, 2015)

1) Planning

"Planning" is the initial stage in which the formulation of the final product concept and definition takes place, based on thorough research and analysis. It involves undertaking a diligent effort to transform the product idea into a tangible reality. Planning also including coming up with brainstorming about the solution approach and market strategy which effectively on the market once the product is completed launching, pricing models that make sense of the product and the customer will be satisfied.

2) Concept development

Current step is a crucial stage in the product development lifecycle where a detailed and comprehensive description of the intended form, function, and distinctive features of the product is crafted. This involves defining a set of intricate specifications and conducting an economic feasibility study to provide a robust justification for the project's potential profitability and success. The process requires sophisticated skills in ideation, critical thinking, and strategic planning to ensure that the concept can be effectively executed and delivered to the market. Mostly the process conducted by information gathering from survey, research and generate the concept sketching in the end.

3) System design

This stage requiring comprehensive and complex planning of the product's structure and organization which have to include designing a detailed assembly layout, outlining the product's construction process, and breaking down the product into various subsystems and components, each with specific and well-defined functional specifications. A clear goal is to be the guidance for a design in order to optimize the efficiency, effectiveness and reliability, enabling the product to fulfil its intended purpose with the highest precision and quality.

Therefore, the process needed expertise in advanced engineering and design principles, as well as a meticulous analytical approach to problem solving.

4) Detail design

The complete specifications part's geometry, materials and the tolerances have been defined in the stage. This including the identification of all standard part that need to be purchased and establishing the process plan and tooling that utilized to create the product.

5) Test and refinement

This stage is mostly using the software to construction and evaluation of multiple pre-production versions of the product or what called simulation. Such as the meshing is using the approach of transcribing a 3D object into a series of mathematical points that can be analysed for the testing purpose. Those advance software beneficial to economic issues, modification on the parts immediately also adapt to the various type of testing and analysis field. The physical testing also might be carried out by the engineer which is prototype. The prototype is usually referred to as a minimum viable product which is basically like the final product that will helping to gain a sense of how is work and identify the area that should be improved.

6) Production ramp-up

This is the final step for the NPD process and also stated previously which the production ramp-up is not feasible for the small volume manufacturing. Normally, the product is made using the intended production system that planned in pervious stages of the NPD process. The process also involves training the workforce and addressing any remaining issues or challenges that may arise in the production processes.

2.3 Engineering design

Engineering design is the process of using the theories and methods of many engineering disciplines to solve practical problems is called engineering design. To create a system, product, or process that meets specified specifications and achieves intended goals requires the application of scientific knowledge, mathematical analysis, and engineering judgment. For this project study, engineering design is used to calculate and explain the problem faced. For this project study, engineering design is utilized to analyze and address the encountered issues, involving concept design, system-level design, and detailed design stages.

2.3.1 Definition of engineering design

Engineering design is a dynamic and constantly evolving profession, which is defined by the Accreditation Board for Engineering and Technology (ABET) as "the methodical creation of systems, components, or processes to fulfil specific requirements." ABET stresses that design is an iterative and insight-driven undertaking that combines the natural, mathematical, and applied sciences (engineering) to attain stated objectives in the best possible manner. The engineering design procedure comprises a series of steps that engineers adhere to when faced with a problem, with the aim of developing a well-conceived solution. It necessitates a systematic approach to problem-solving, beginning with problem identification and culminating in a comprehensive solution. While the exact stages of the design process may differ by industry, consistent sequential progression is a key aspect of most design endeavours (Hurst, 1999). Figure below showing the Pahl and Beitz's model of the design process:

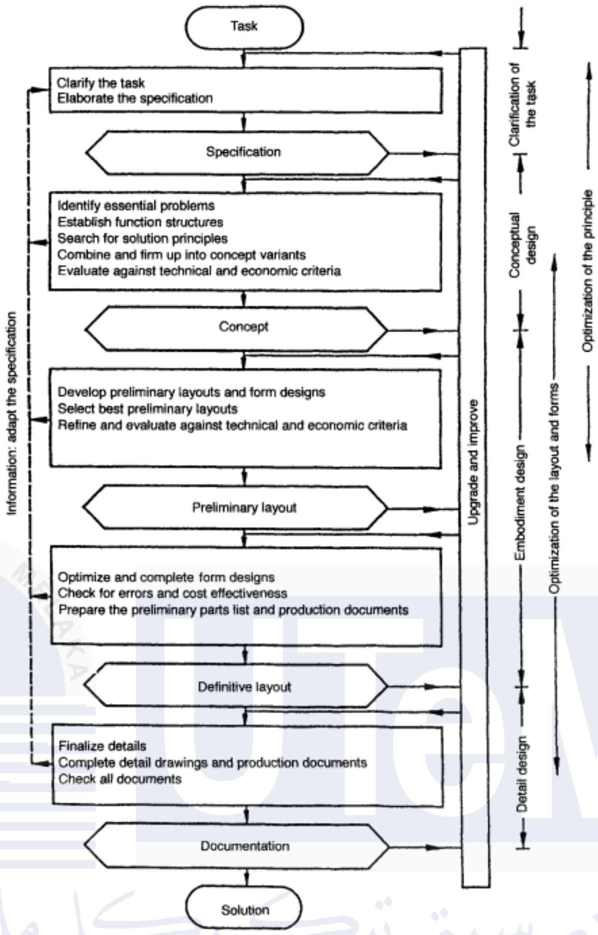


Figure 2.10 Pahl and Beitz's model of the design process

The systematic design process, also known as the Pahl and Beitz model, is a well-established framework for product design that is commonly used in design and engineering education. The model consists of several stages that guide designers through the process of creating new products. Here is an overview of the Pahl and Beitz design process model:

<u>Clarification of the task</u>

This initial phase involves identifying the design problem and articulating the project's requirements and constraints. This includes understanding client needs, conducting market research and defining design objectives.

Conceptual Design

In this phase, the designer generates and develops ideas or concepts to meet the design requirements. They explore possibilities and alternatives while considering factors such as function, aesthetics, feasibility and cost.

Embodiment Design

During this stage, the concepts selected in the previous stage are further developed and refined. Create detailed design solutions including specification, material selection, and defining the form, structure, and components of a product.

Detailed Design

The detailed design phase involves developing and finalizing all components, dimensions, tolerances, and manufacturing processes needed to produce the product. It includes the creation of technical drawings, models and prototypes.

2.4 Survey

A survey is a research method used to gather information and collect data from a targeted population or sample. By conducting a survey that able to know able the community's opinions and the suggestions through their angle.

2.4.1 Research process (questionnaire)

In a societal subset, there are two main approaches to gather data: quantitative and qualitative research. Quantitative research aims to identify cause-and-effect correlations or results from a post-positivist perspective (Mattos-Vela et al., 2023). The results are descriptive and empirical, and they are extrapolated to larger populations using probability sampling. This kind of study frequently combines experimental techniques with survey or questionnaire procedures. On the other hand, qualitative research emphasizes the production of in-depth, high-quality research and is grounded on constructivist knowledge claims. It uses interviews, focus groups, and open-ended questions to thoroughly study issues. Smaller sample sizes are frequently used in qualitative research, allowing for a more in-depth examination of individual experiences and viewpoints.

Table 2.3 Different between quantitative research and qualitative research (Gcu, 2021)

Quantitative research	Qualitative research
1. Observing behavior -A detailed viewing on the particular sample of individual that been selected for investigate to take notes on the activity.	1. Depth interviews – Interview that assesses individual’s activities, behavior, psychological and so on in detail.
2. By experimentation (in laboratory or in the field) – investigate the relationship between two matters or variables.	2. Focus groups – a group discussion with samples for information gathering.
3. Questioning people – By survey, the information collected which able to translate	3. Sampling – Select the group to conduct the research (more reliable)

into analytical form in order to get a result.	

Surveys are frequently employed as tools for collecting both quantitative and qualitative data. The selection of the survey method, such as telephone, mail, or face-to-face interviews, is determined by the type of study being conducted and by the specific study objectives (Scheuren, 2004). Sample size is determined by the study design and objectives. Standard operating procedures were used to ensure that all respondents were consistently given the same questions. However, there are clear differences in the questionnaire designs used for quantitative and qualitative research. Closed questionnaires are used in quantitative research to provide structured responses that allow for statistical analysis. This approach aims to achieve a complete understanding of the sample, producing information that reflects the situation as accurately as possible. In contrast, open-ended questionnaires are the foundation of qualitative research, which encourages respondents to provide comprehensive and personalized responses based on their knowledge and skills in the relevant topic. This method allows for a more careful investigation of individual opinions and adds insightful information to the investigation. Consequently, questionnaires are used in both quantitative and qualitative research, whether through statistical analysis or non-statistical surveys, to objectively examine various situations and to utilize the collected information for research or problem-solving (Mattos-Vela et al., 2023).

2.5 Background of Internet of things (IoT)

The term "Internet of Things" (IoT) refers to the network of actual physical objects, including machinery, vehicles, appliances, and other items, that are equipped with sensors, software, and connectivity to collect and exchange data online as shown as the figure below. The Internet of Things is the idea of connecting common objects to the internet so they can talk and interact with each other.

Figure 2.11 Internet of things

The term "Internet of Things" now pertains to the condition where multiple objects, devices, sensors, and everyday items are connected to the internet and possess computing power. With the advancement of technology, the Internet of Things has made significant progress and had a disruptive impact on numerous industries and fields. The Internet of Things has now become ubiquitous and seamlessly integrated into our lives, revolutionizing the way we interact with the world around us, thanks to the speed of invention. In 1999, British technology pioneer Kevin Ashton coined the term "Internet of Things" (IoT), introducing a system in which tangible things could be connected to the internet via sensors (Patel et al., 2016). This notion was first introduced in the development community of radio frequency identification (RFID). The expansion of mobile devices, ubiquitous connectivity, embedded systems, cloud computing, and data analytics have all significantly enhanced the importance of IoT over time (Rose et al., 2015). The phrase "Internet of Things" (IoT) describes a network of actual physical items that go beyond computers and encompasses a broad range of smaller and larger gadgets, automobiles, cell phones, household appliances, toys, cameras, medical equipment, industrial systems, animals, people, and even buildings. Through well-defined protocols, these linked things exchange information and communicate with one another. The purpose of this interconnection is to facilitate smart functions, such as real-time online monitoring, updates, process management and administration, as well as intelligent features like reorganization, positioning, tracking, safety, and control measures. In summary, IoT enables the seamless integration of a variety of items, allowing them to communicate, share data, and perform intelligent tasks in a connected environment.

2.5.1 Definition

The term "Internet of Things" (IoT) refers to the expansion of connectivity and processing capabilities to objects, sensors, and everyday items that are not typically considered computers. This network includes a wide variety of items, such as household appliances, cars, cell phones, toys, cameras, medical equipment, industrial systems, and more. The core idea behind IoT is to enable these gadgets to create, share, and use data with little or no human intervention (Rose et al., 2015). IoT is a method of interaction between the physical and digital worlds, facilitated by various sensors and actuators. This paradigm involves integrating computing and networking capabilities into real-world objects, enabling them to link and communicate with other projects and systems through networks and computers. Essentially, virtually any object can be used in this way (Mr.M.Anantha Guptha, 2021). Figure below showing the application of IoT that connected people’s life closely that cover every things including the transport, home, agriculture, cities and so on :

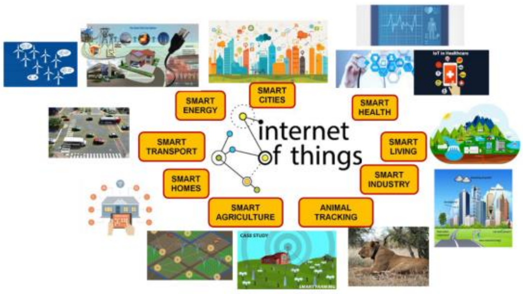


Figure 2.12 Application of IoT (Triwahyuni & Triwahyuni, 2020)

2.5.2 Connectivity models

The Internet of Things (IoT) is a concept that extends connectivity and processing capabilities to objects, sensors, and everyday items that are not traditionally considered computers. In this network, various items such as household appliances, medical equipment, and industrial systems can create, share, and use data with minimal human intervention (Rose et al., 2015). The integration of computing and networking capabilities into real-world objects enables them to link and communicate with other projects and systems through networks and computers. The Internet Architecture Board has identified four popular communication models, including device-to-device, device-to-cloud, device-to-gateway, and backend data sharing, which demonstrate how IoT devices can interact with and benefit consumers in various ways. Supporting technologies such as wireless sensor networks, sensor networks, 2G/3G/4G, GSM, GPRS, RFID, WI-FI, GPS, microcontrollers, and microprocessors make it possible to realize the Internet of Things (Patel et al., 2016).

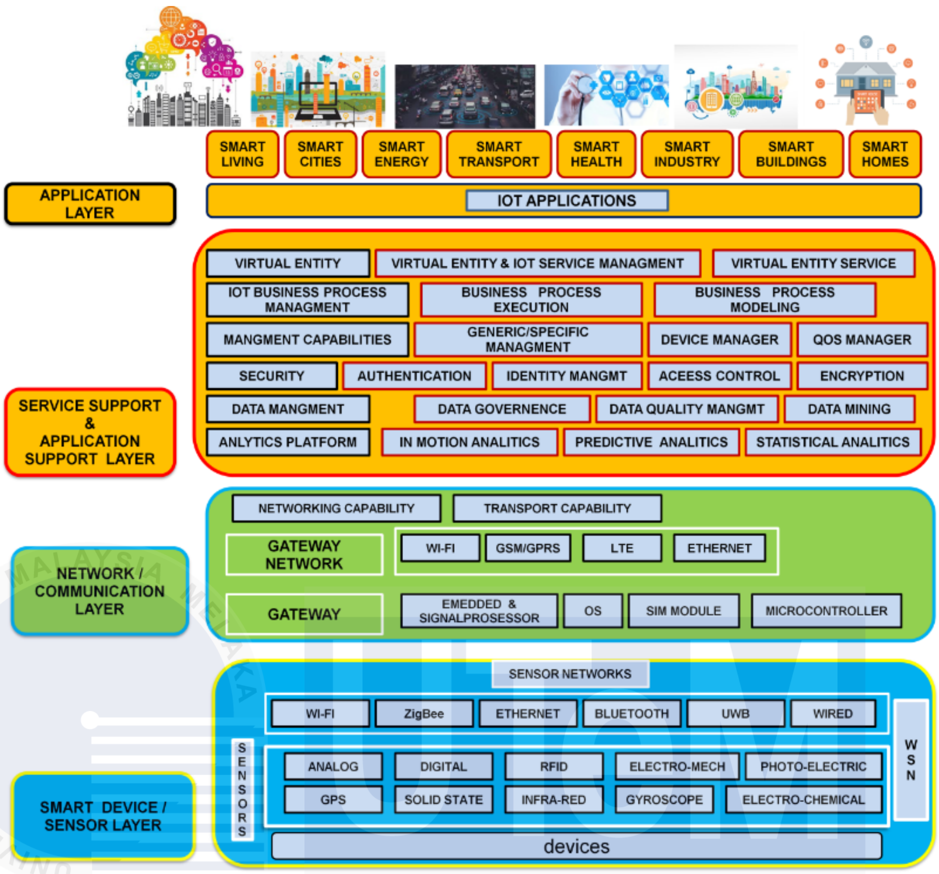


Figure 2.13 IoT architecture (Patel et al., 2016)

On the Internet of Things, network access and physical layer technology are the bottom foundation for building the Internet of Things protocol stack. Figure below is showing some IoT networking technologies to be aware of:

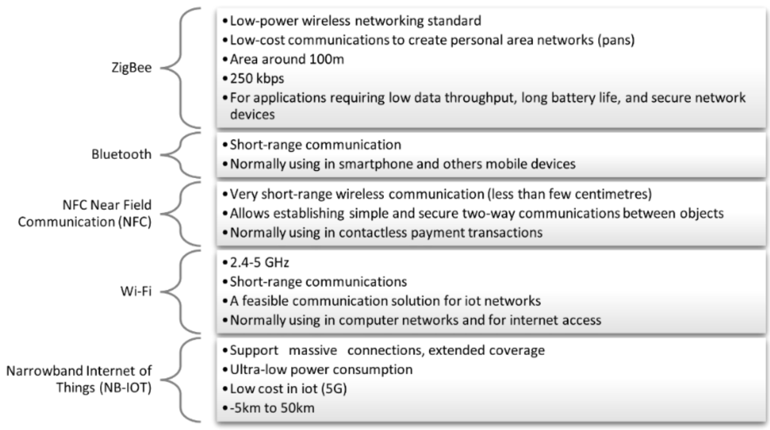


Figure 2.14 IoT networking technologies (Salisu et al., 2021)

2.5.3 Functional view of IoT

The Internet of Things (IoT) concept describes how physically identifiable things are connected to their digital counterparts in a network-like structure. IoT solutions typically include several elements such as (Patel et al., 2016) :

- Module for interaction with local IoT devices
- Module for local analysis and processing
- Module for interaction with remote IoT devices
- Module for application-specific data analysis and processing
- User interface (web or mobile)

2.5.4 Goal of IoT

The goal of IoT is to provide seamless connectivity between things, allowing them to connect with any other thing or person anytime, anywhere, using any available network or communication method and utilizing any associated service or functionality. (Patel et al., 2016)

CHAPTER 3

METHODOLOGY

In methodology, it mainly focusses on using systematic approach or set of methods and techniques to execute the project which involves the progress flow and the project planning process. The progress flow and the method were clearly stated in the coming paragraph.

3.1 Introduction

In this chapter, the methodology part describes the implementation of project in detail, to ensure that the planning to complete and success. The workflow progress is illustrated by flow chart and Gantt chart which perform in sequence and day based. This project is conducted by new product development (NPD) and internet of things (IoT) to design and develop a smart flood control system. Essentially, this project is divided into 5 phases in sequences which is planning, concept development, system level design, detail design and testing and refinement.

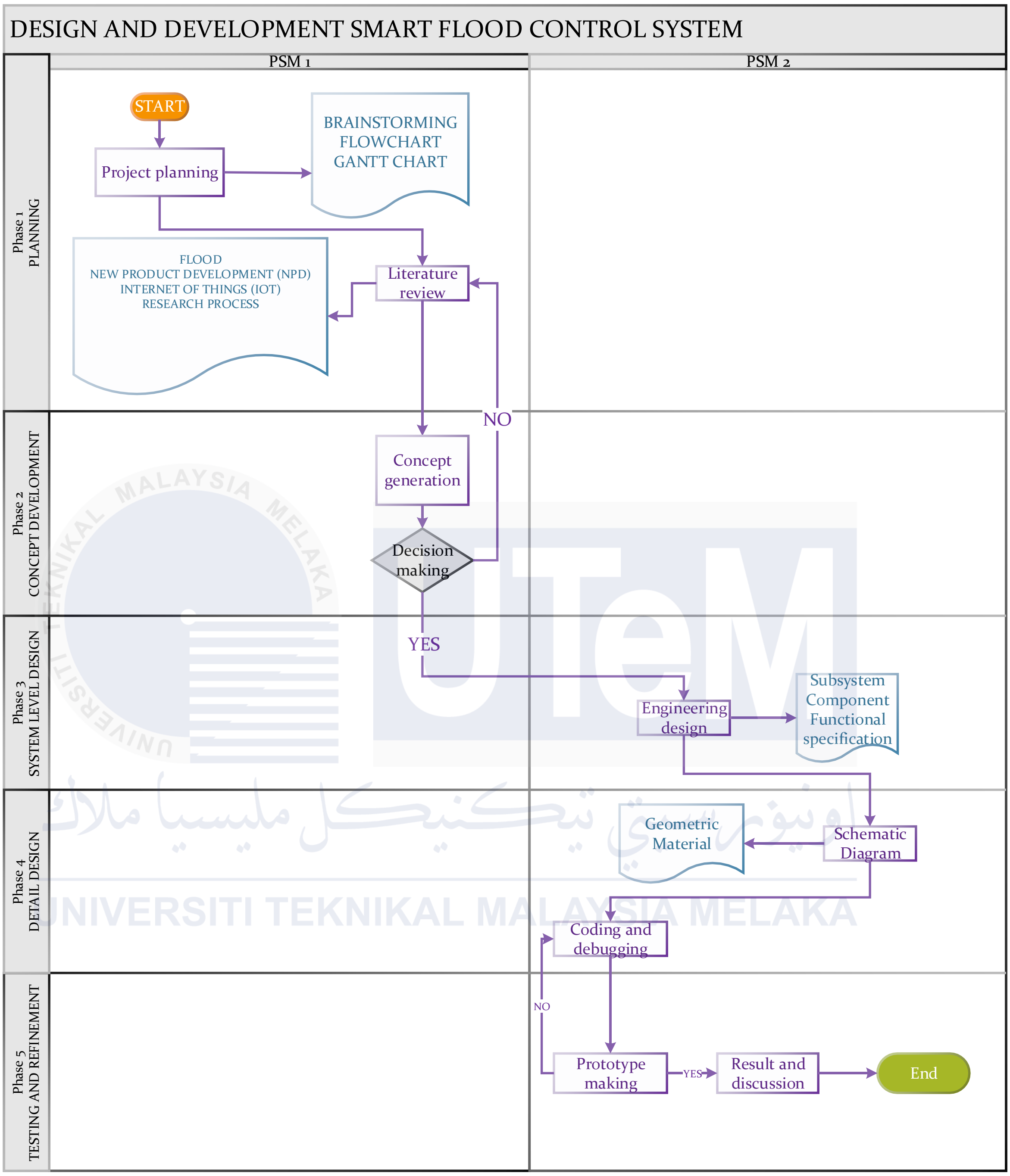


Figure 3.1 Flow chart of design and development smart flood control device

To effectively implement the project, each phase plays a significant role in the process flow, ranging from study research, concept, engineering design, schematic design, coding debug, prototype making, and ultimately, completion. The methodology flow for the entire project is depicted in the above figure.

Phase 1

The first phase of the project is called Phase 1 and covers the entire project planning process. This initial phase includes conceptualizing the solution, collecting comprehensive data, conducting a literature review, defining the product, and carefully managing the project and time. The basis for this stage is formed through preliminary research, which includes product specifications, flood background, cause and effect and existing methodologies, with reference to reliable sources such as journals, articles, theses and reliable platforms such as Google Scholar and ResearchGate. During the data collection process, the project also focused on flood research, New Product Development (NPD), Internet of Things (IoT) and fundamental research, all of which contributed significantly to the foundation of the project.

Subsequently, project implementation follows a structured study and can be divided into phases. Defining the problem statement and gathering relevant information is crucial in the initial stages of a project. The identified problems have a significant impact on human life, resulting in human deaths and huge economic losses every year due to huge expenditures on disaster relief and recovery. The development of flood defenses is therefore critical to community well-being and economic growth.

Before the experimental phase, comprehensive project planning is required, which involves the acquisition of tools, both hardware and software. The study employed two methods: primary method and secondary method. Secondary research involves traditional sources such as papers, journals, newspapers or publications. Primary research, on the other hand, includes both qualitative and quantitative methods through surveys, distinguishing between open-ended and closed-ended questions within a specific group.

Phase 2

The second phase is called the follow-up phase and focuses on the generation of conceptual ideas. After brainstorming sessions and extensive research for publications, specific conceptual ideas were developed to address the current problem, in this case flood protection. Multiple implementation ideas may arise at this stage, but determining the most feasible solution is critical. Questionnaires are the primary tool for capturing public opinion and expert insights, and can improve decision-making capabilities in addition to nurturing innovative ideas.

After completing the research and accumulating information, the project launched the community through a questionnaire survey. This approach aims to collect important suggestions and solutions that are critical to system design. The survey used two methods: open-ended questions, directed at a focus group such as experts or individuals with field experience, and closed-ended questions, which allowed community members to share their experiences of real-life situations. An example of a questionnaire design is shown in Figure 4.1.

Key issues and expert recommendations were identified based on data collection and analysis from different sources. These inputs form the basis for generating conceptual designs. In addition, each design contains its advantages and disadvantages, which are important factors in the decision-making stage to ensure product functionality and efficiency.

Figure 3.2 Example questionnaire design

Phase 3

The third phase, called system-level design, is devoted to building subsystems, components, functional specifications, and engineering elements designed to solve the identified problem. Before diving into detailed design, a comprehensive system layout is designed, utilizing Arduino, IDE software, and Blynk software during development. The framework, shown in Figure 3.2, depicts the interconnectivity and synergy between these components, with the Arduino hardware at its core and facilitating coding through an integrated development environment (IDE). Blynk IoT software assumes control and acts as an interface to enable communication and management of Arduino-based hardware systems.

Figure 3.3 Framework

After a decision is made about a function, subsystem, or feature, the subsequent stages involve system design. In this system, IoT is used for monitoring, storing data in the cloud, and generating decisions to control the system, turn it on or off. This semi-autonomous action allows for manual control via a connected device. Notable sensors selected for this project include water level detector, flow velocity tachometer and Arduino as central processing unit.

Phase 4

The fourth phase of development involves the detailed design phase, focusing on the production of comprehensive schematics. These schematics are carefully customized to meet specific requirements and contain specialized components required for different connections. This stage requires precise geometry and accurate component placement, which is critical to understanding the integration and interaction of individual components to ensure seamless product functionality. Schematics provide detailed descriptions of key components critical to the design process, including circuit boards, sensors, and libraries. The meticulous interconnection process includes labeling and annotating wires to vividly depict the circuit's configuration.

At the same time, coding tasks were carried out in parallel with these design efforts. Hardware selection remained tailored to our needs, with special emphasis on WiFi connectivity for control and data tracking, while ensuring cost-effectiveness within project budget constraints. This phase carefully coordinates a combination of detailed design work and coding tasks to align hardware selections with our specific project requirements.

Phase 5

The final phase of product development involves assembling, testing, and refining the prototype, with a focus on integrating coding, hardware, and IoT elements. The creation of prototypes requires careful debugging and tuning to obtain optimal device performance. The coding and debugging phases are critical, shaping the operational code base critical to system functionality. The code base contains important elements such as enhanced functional libraries, complex data processing algorithms, defined task-specific functions and indispensable components. Seamless integration of these aspects ensures the system operates as expected. Before that, the selecting and building the final prototype model, the prototyping phase requires meticulous material preparation and strict adherence to specified standards. Precision in component placement and wiring connections during assembly establishes operational integrity and consistency, which is critical to optimizing system functionality. The study concludes with a results and discussion section, illustrating the significance of the findings within the wider research context. Overall, the final phase is a critical step in ensuring that the final product meets the intended goals and functionality.

Then, testing primarily evaluates system functionality through observation techniques against predefined criteria. Physical testing is a critical stage in verifying the functional reliability of a product. Real-world testing solidifies ideas and reveals challenging aspects and overlooked issues, while the refinement process addresses and enhances problematic areas.

3.2 Summary

In short, this research followed a clear path, starting with comprehensive planning and research, through concept generation, system-level design, detailed schematics, coding and prototype development. Each stage plays a vital role in the process, planning lays the foundation, concept generation refines the idea, design ensures functionality, coding turns the idea into reality, and prototypes test and refine the concept. The methodology employed in this process spans techniques such as survey, concept mapping, IoT integration, sensor selection, meticulous schematic design, coding and system prototyping to ensure product robustness. The real-world testing phase plays a key role in identifying issues, allowing for improvements, and thus facilitating the evolution of the project from mere concept to functional reality.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This is the preliminary result from the questionnaire survey that was conducted from 10 June 30, 2023, to 28 June 30, 2023, by using google form among the community. From the survey provided 41 respondent and the detail result shown below:

4.2 Result

4.2.1 Survey results

Section a is data collection in background of the respondents, that contain the gender, age, occupation, and education background.

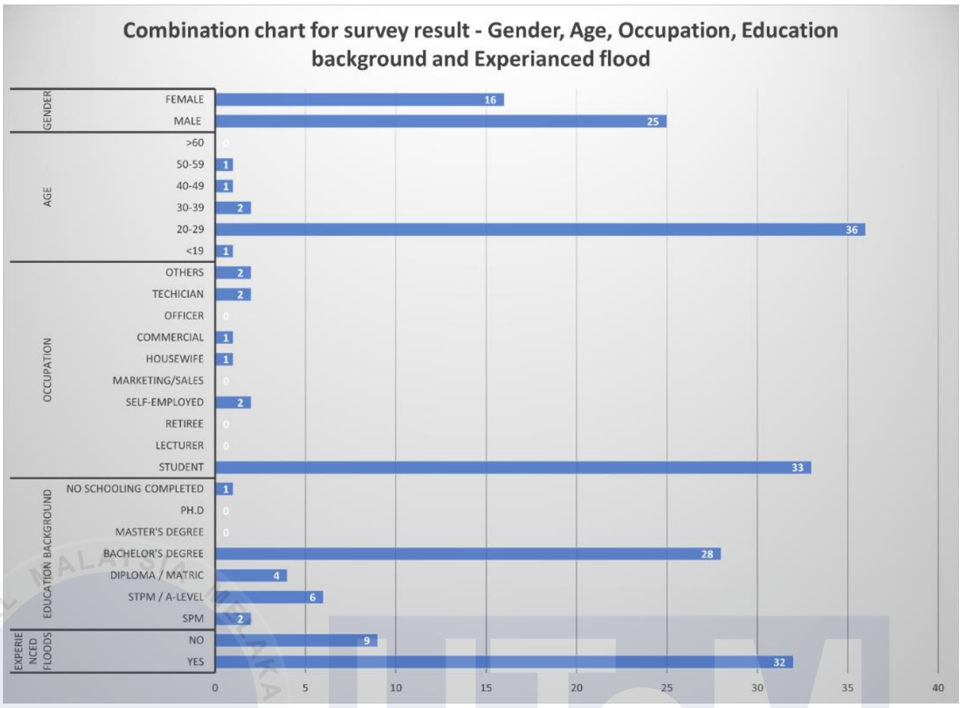


Figure 4.1 Combination chart for survey result - Gender, Age, Occupation, Education background and Experianced flood

In the survey data collected, there were 41 respondents, with 61% identifying as male (25 respondents) and 39% as female (16 respondents). Age distribution showed one respondent below nineteen, alongside respondents in the ranges of forty to forty-nine and fifty to fifty-nine. Notably, 87.8% fell within the twenty to twenty-nine bracket (36 respondents), while only 4.9% were in the thirty to thirty-nine range (2 respondents). The majority of occupations were students, comprising 80.5% of respondents (33 individuals), with a minority in roles like retirees, commercial workers, technicians, and others. Regarding education, 68.3% held bachelor's degrees (28 respondents). Flood experiences were prevalent, with 78% having witnessed or experienced floods in their area, while 22% did not (9 respondents).

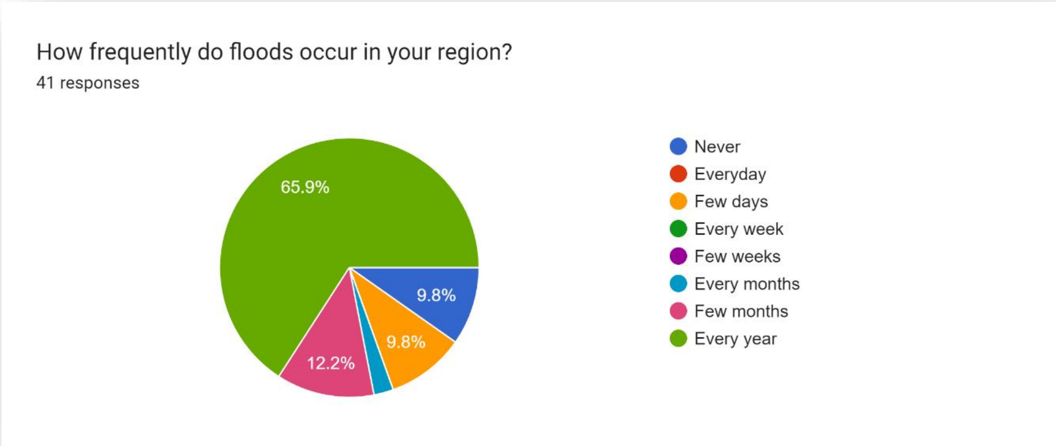


Figure 4.2 Chart frequence of floods occur

The survey results Figure 4.2 shows a significant trend, with 65.9% of respondents (i.e. 27 respondents) stating that flooding is an almost annual event in their area. The data highlights the alarming frequency of flooding, thereby indicating an ongoing and recurring problem within the survey area. The high proportion of respondents who experience annual flooding may indicate an urgent need for effective mitigation strategies, increased preparedness, and possibly improved infrastructure to deal with this recurring natural phenomenon.

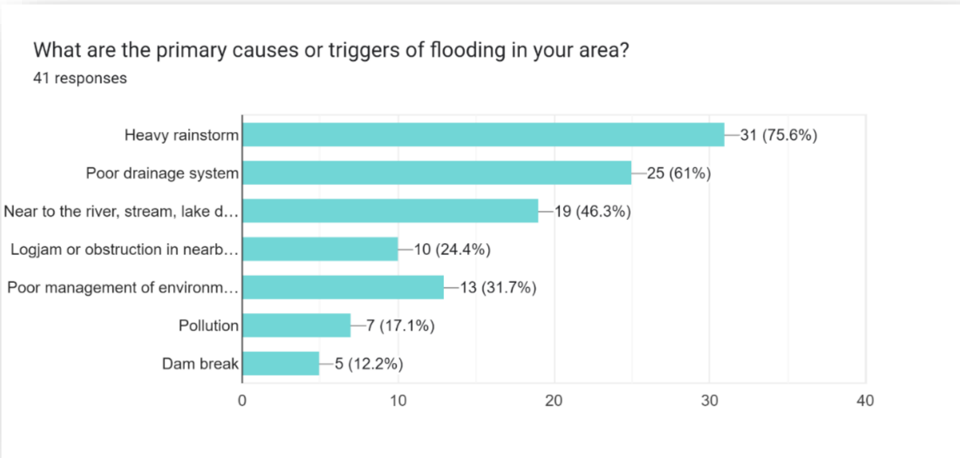


Figure 4.3 Chart primary causes of flooding

The survey result Figure 4.3 reveals the main causes of flooding. 75.6% of the respondents (31 people) overwhelmingly believed that heavy rain was the main cause of floods. Subsequently, 61% of respondents pointed to poor drainage systems, indicating that drainage systems play an important role in exacerbating flood events. Additionally, 46.3% (25 respondents) highlighted the proximity of their area to water bodies as an influencing factor. Other factors of note include blockage (24.4% (10 respondents)), poor management (31.7% (13 respondents)), pollution (17.1% (7 respondents)) and dam failure (12.2% (5 respondents)). Taken together, these percentages indicate that respondents have a multifaceted understanding of the various factors that contribute to flooding in their area, emphasizing the complexity of the issue. Addressing these different factors may require a comprehensive approach including improved infrastructure, better management strategies and environmental considerations to effectively mitigate future flood events.

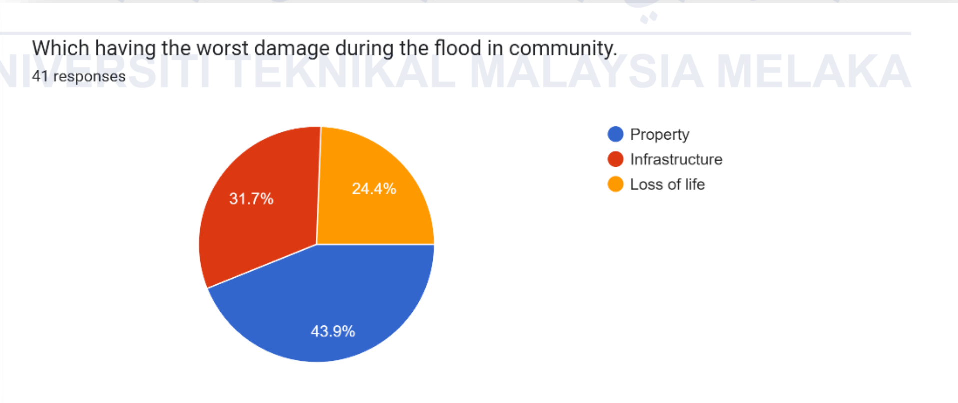


Figure 4.4 Chart worst damage

The survey results Figure 4.4 reflect respondents' priorities for flood impacts. Interestingly, 43.9% (18 respondents) highlighted property damage as their top concern, indicating that floods have had a significant financial and physical impact on their assets. 31.7% of respondents (13 people) were also very concerned about infrastructure, highlighting the fragility and potential damage to important community structures. Additionally, 24.4% (10 respondents) highlighted the issue of severe loss of life, emphasizing the casualties and safety risks associated with flood events. These varying concerns highlight the multifaceted nature of flood impacts, from economic losses to risks to human life, and underscore the importance of addressing them.

Figure 4.5 Chart effectiveness of the existing flood control approach

This chart Figure 4.5 depicts the effectiveness of existing flood protection methods, providing insight into the views of 41 respondents. Notably, three specific measures were deemed the most effective, each receiving 12 votes from respondents. These include urban planning and land use regulations, floodplain mapping and risk assessment, and stormwater management systems. Effectiveness ratings for all three methods were consistent, indicating a consensus among respondents about their efficacy in mitigating and managing flood-related risks. The prominence of these measures highlights their importance and effectiveness within existing flood protection strategies and may indicate areas where further emphasis or improvement could have significant benefits in reducing and managing flood risk.

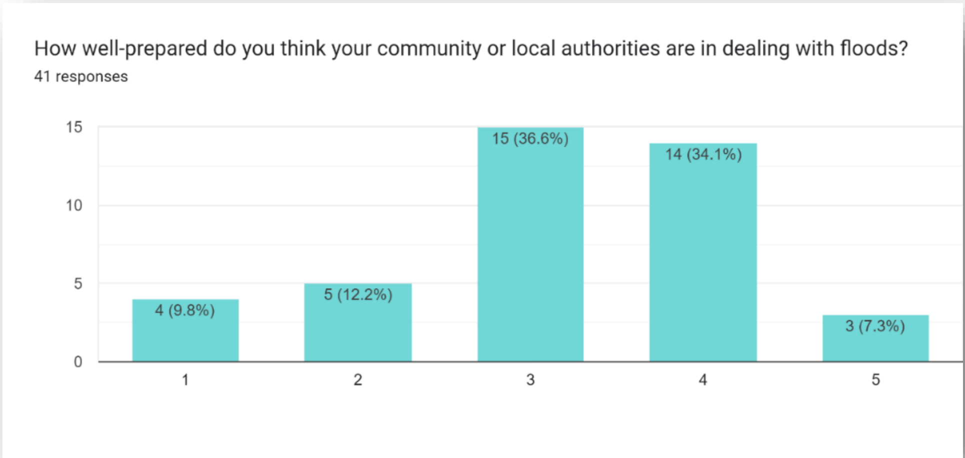


Figure 4.6 Chart of local authorities prepared

Survey data Figure 4.6 shows that the majority (36.6%) of the respondents (15 people) considered their level of flood prevention preparedness to be "medium". This was followed by 34.1% (14 respondents) who considered themselves "fairly well prepared." This distribution indicates a moderate level of preparedness among respondents, with a large proportion acknowledging a reasonable level of preparedness but not necessarily considering themselves to be well prepared for a potential flood event. This information highlights a range of preparedness perceptions among respondents, indicating the need to improve overall preparedness and resilience to cope with future flood events.

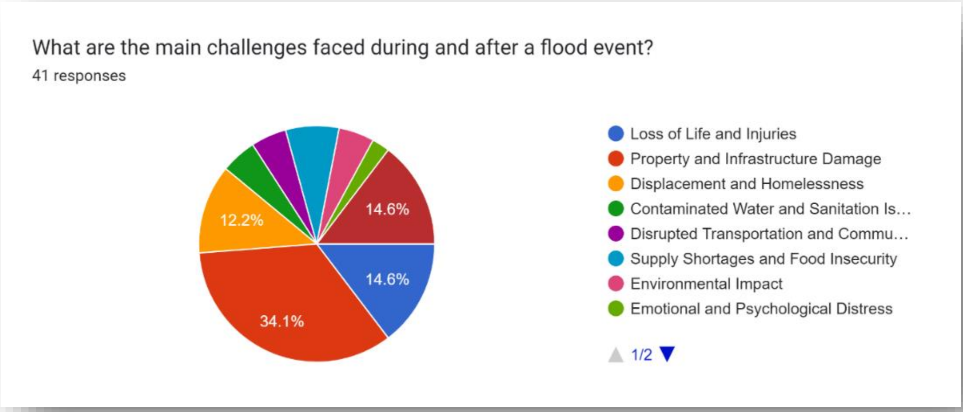


Figure 4.7 Chart main challenges during flood event

The Figure 4.7 illustrates key challenges during flood events, revealing significant concerns among respondents. Property and infrastructure damage emerged as the most common challenge, with 34.1% of respondents (14 people) choosing it as their top concern. In addition, 14.6% of the respondents (6 people) pointed to recovery and rebuilding work and casualty risks respectively. Floods pose major challenges, causing severe damage to buildings and infrastructure, disrupting normal life and impacting businesses. Post-flood recovery efforts are complex and involve infrastructure restoration, financial management, and efforts to quickly restore communities. Additionally, the risk of loss of life during flooding highlights the critical need for effective evacuation plans, responsive emergency response measures, and enhanced public safety protocols.

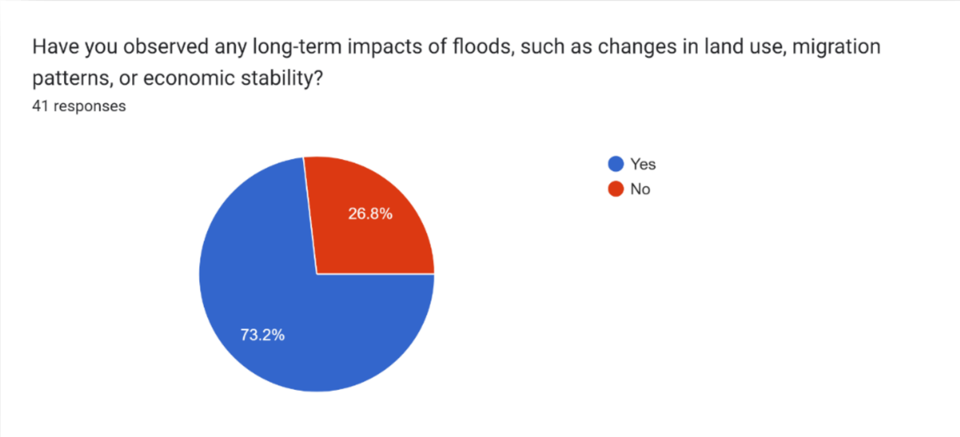


Figure 4.8 Chart of long term impacts

Survey data Figure 4.8 shows that respondents' awareness of the lasting impacts of flooding is noteworthy. The majority of respondents (73.2%) agreed with the idea that flooding does have long-term impact. These impact may include changes in land use patterns, changes in immigration trends, and changes in the economic stability of affected areas. This recognition underscores the persistence of flood impacts, likely to trigger changes in land use patterns, population movements, and community economic status over longer periods of time.

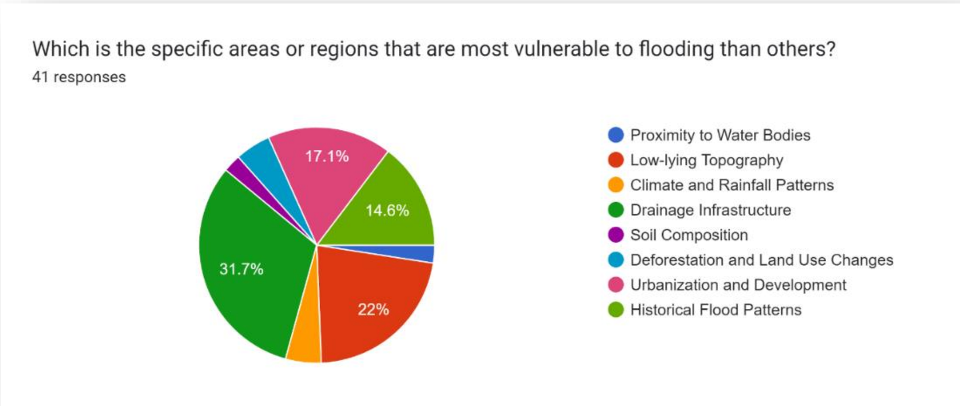


Figure 4.9 Chart specific areas of most vulnerable to flooding

After examining the Figure 4.9 chart of areas most vulnerable to flooding, respondents identified several significant issues. The majority of respondents (31.7%) considered drainage infrastructure to be the aspect most vulnerable to flooding. Additionally, 22% of respondents (9 respondents) considered low-lying terrain to be a major issue, while urbanization and historical flood patterns were cited by 17.1% (7 respondents) and 14.6% (6 respondents) respectively. The data mentioned key vulnerabilities, such as inadequate drainage infrastructure and low-lying areas prone to flooding, as well as the impact of urbanization and historical flooding patterns on the susceptibility of specific areas to flooding events. Addressing these vulnerabilities can play a crucial role in improving flood resilience and mitigating risks in these areas.

Section C:

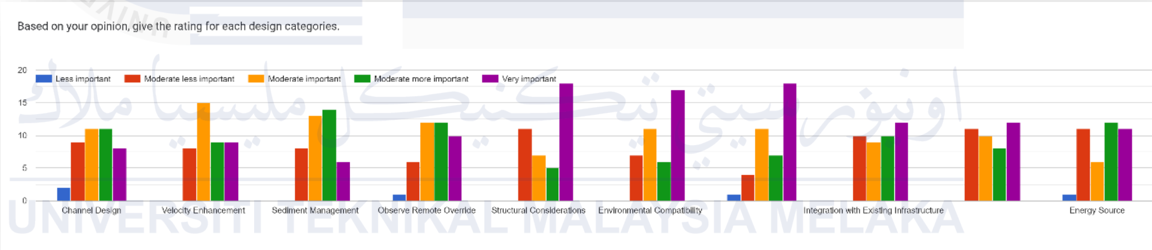


Figure 4.10 Chart rating of each design categories

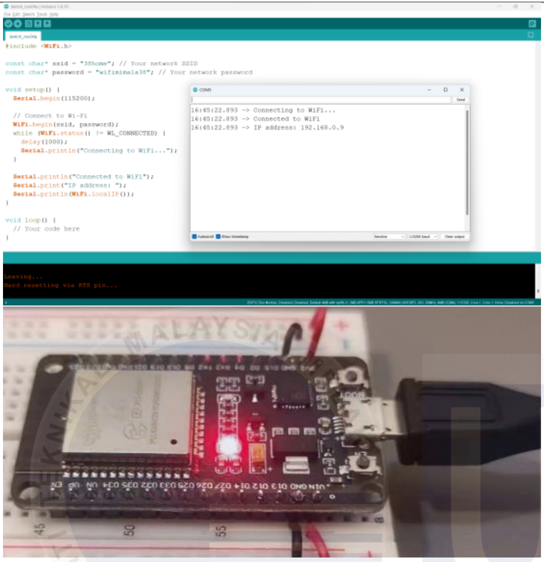
The data presented in Figure 4.10 reveal clear preferences among respondents for three specific design categories. Structural considerations, environmental compatibility, and maintenance and accessibility were the most popular categories, each receiving responses from 18 respondents. This important choice emphasizes the collective value of structural integrity, environmental sustainability, and ease of maintenance and accessibility in design considerations. This preference suggests that these factors play a key role in decision-making processes related to infrastructure and development planning.

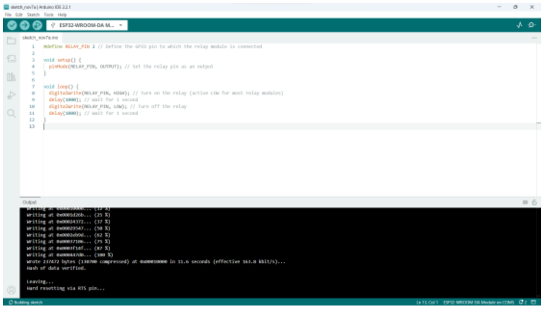
Summary

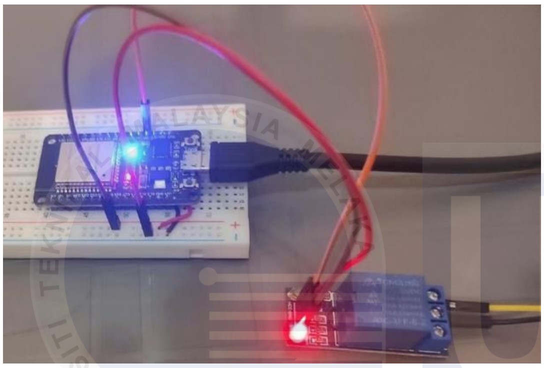
In summary, this survey of 41 respondents provides an inclusive view of community stances on flooding. The findings reveal a recurring dilemma, with the vast majority of countries experiencing annual flooding, primarily due to heavy rainfall and inadequate infrastructure. The impacts of flooding are multifaceted, including property damage, fragile infrastructure and compromised security, highlighting the complexity and urgency of addressing these challenges. Respondents highlighted the effectiveness of flood protection measures such as urban planning and stormwater management systems, while also acknowledging weaknesses in measures such as drainage infrastructure and low-lying areas. Notably, they prioritized design considerations that emphasized structural soundnessi ntegrity, environmental compatibility, and accessibility. This collective awareness underscores the need for a comprehensive approach, enhanced infrastructure, and proactive strategies to address flood hazards and build community resilience.

4.2.2 Testing result of each component

Table 4.1 Table of each component testing

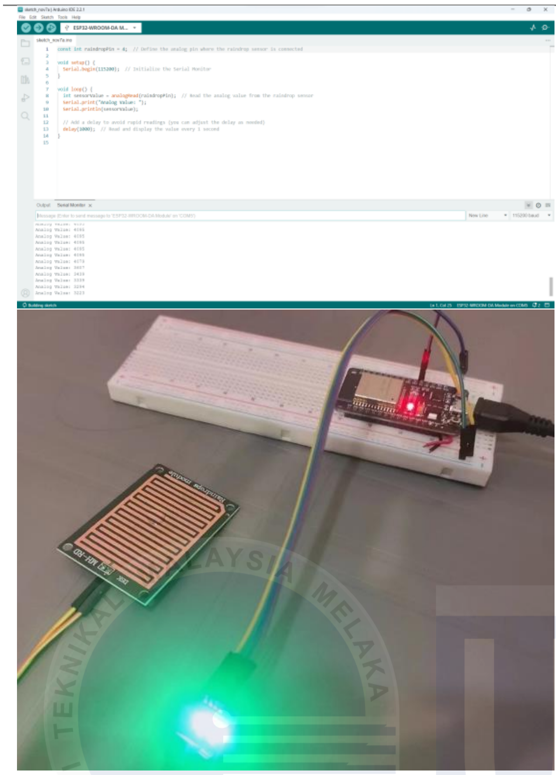
Picture	Explaination
 **ESP32 Wifi testing**	Verifying the operational integrity of the ESP32 involves first establishing a connection via USB and then integrating appropriate code to facilitate the Wi-Fi connection. Subsequently, you must access the serial monitor to determine the success or failure of the established connection.
 **LCD I2C testing**	Begin the setup by making a connection between the VCC pin and the VIN pin on the ESP32, while connecting the GND pin to ground. Proceed to identify and assign the necessary pins designated for I2C communication, utilizing the default I2C configuration on the ESP32, specifically GPIO#21 and GPIO#22. Then, compile the relevant code to the ESP32 microcontroller, and finally observe and analyse the result output.





Relay module testing

Modify the code so that the relay automatically alternates between activation and deactivation according to predefined intervals. Specifically, configure the timing parameters to require a continuous activation time of 1 second and a deactivation time of 1 second. After successfully uploading the modified code, conduct an evaluation to verify the proper functionality of the relay.



Raindrop sensor testing

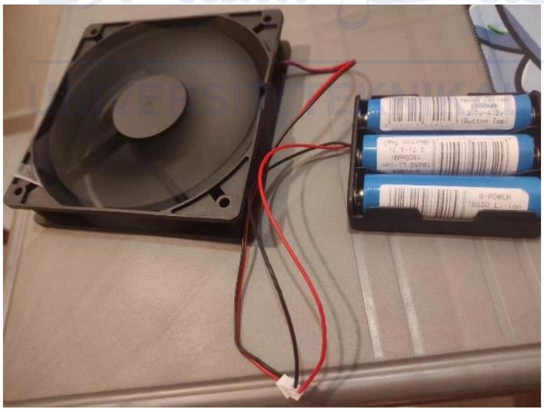
The test procedure uses the analogRead function to collect data from the raindrop sensor designed to detect the presence of water. Once water is detected, the sensor triggers a data transmission, which is then displayed on a serial monitor within the Arduino IDE interface.

Water level sensor testing

Make a connection between the water level sensor and the ESP32 and configure the code to read data in the range 0 to 4095. After successfully completing the upload process, immerse the sensor in water to trigger a reading. The serial interface is then monitored to determine the accuracy and reliability of the read data.

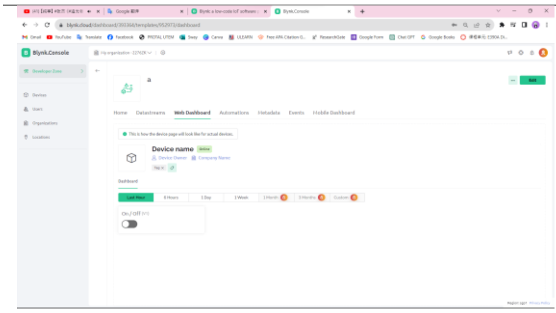
Water flow sensor testing

Configure the code to interpret the simulated values and convert them to corresponding flow rates in Liters per minute (L/min). After completing the code upload process, the water in the pipe is used to drive a turbine inside the sensor. Subsequently, watch the serial monitor to access the calculated data, displaying the resulting flow measurements.



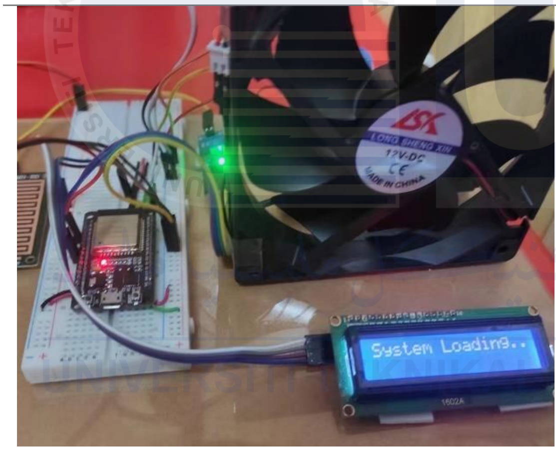
Fan and battery testing

There is a direct wire connection between the fan and battery and the colours are followed for accurate testing procedures, usually red represents the positive terminal and black represents the negative terminal. After successful connection, the fan starts running, confirming the optimal function of the fan and battery.



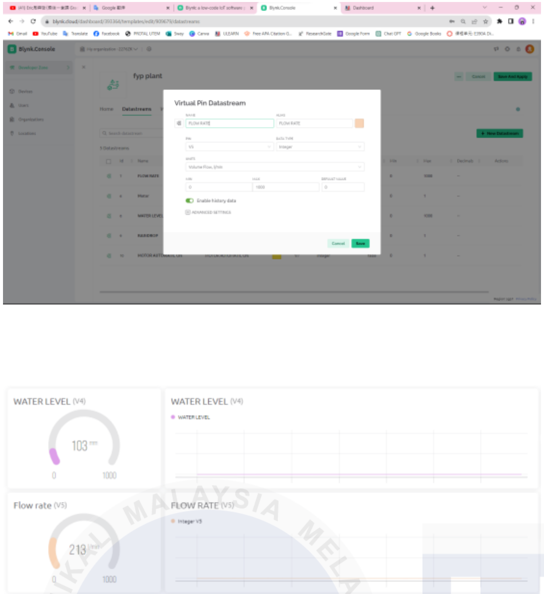
Blynk connect to ESP32 and relay module

First generate a new template to get the ID, name, and authentication token in Blynk. Integrate these credentials into your code and configure it to enable the relay trigger, setting it high to activate and low to deactivate. After completing these configurations and uploading successfully, confirm that the relay module is functioning as expected.



Picture of adding LCD

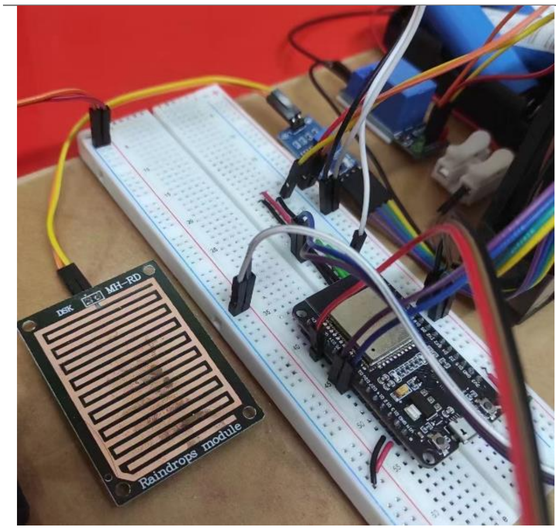
The LCD I2C interface is set up by connecting its power supply to VIN and GND, while the communication pins are connected to GPIO 21 and 22. This configuration can display relay on/off status for testing purposes. After modifying and uploading the code, use Blynk to control the relay and monitor the on-off status of the synchronization relay displayed on the LCD.



Picture of water level and flow rate in Blynk

A new data stream is incorporated into Blynk, and a virtual pin is assigned for data reception to establish a connection to the ESP32. Formula calculations are integrated into the code to display flow values. Data is uploaded to Blynk and stored for a specified time for comprehensive data tracking. After adding these, the test results were successful, consistent with the expected conditions.

Likewise, repeat the process for the water level sensor using a different pin assignment. Data from this sensor is similarly processed and integrated into Blynk for recording and analysis. Subsequent testing confirmed the intended functionality, reflecting the positive results observed.



Picture of adding raindrop sensor

The implementation of the raindrop sensor involves enhancing the dashboard with integrated LED bulbs to act as rain detection indicators. Then, different virtual pins need to be assigned and the corresponding code integrated in the ESP32 to manage and synchronize the system. After making these adjustments, place a few drops of water on the sensor and watch the results reflected on the LCD display and Blynk interface. This action will allow real-time monitoring and confirmation of the system's response to rainfall detection.

Summary

Testing each component individually and subsequently in combination with other components can serve a variety of purposes. First, it independently ensures the proper functioning of each component, reducing the use of defective parts within the system. Second, this approach fully tests the assembled system by confirming all final functionality in advance, thereby minimizing time waste, and ensuring system coherence and efficiency without the need for individual component inspections after assembly.

4.2.2.1 Finalization

<u>Finalize includes design finalization, coding refinement, and schematic phases:</u>

The careful evaluation of individual components through a testing program marks the beginning of a critical phase of system transformation. This transformation stage requires serious reorganization and reconstruction to bring the system to a unified and integrated state. Noteworthy advancements are introduced, particularly the integration of automation features demonstrating greater responsiveness. For example, the system is now able to automatically start the motor once the water level exceeds a preset threshold. Additionally, LED indicators are seamlessly integrated into the Blynk interface, providing visual feedback synchronized with motor activation.

A detailed schematic diagram complements this comprehensive coding framework. This visual representation provides a meticulous overview of the complex network of connections, wiring configurations, and terminology that make up each component of the system. This visual aid provides a holistic perspective that facilitates a deeper understanding of the complex interactions and spatial relationships between various system components. The detailed schematic diagram below complements this comprehensive coding framework. This visual representation provides a meticulous overview of the complex network of connections, wiring configurations, and terminology that make up each component of the system. This visual aid provides a holistic perspective that facilitates a deeper understanding of the complex interactions and spatial relationships between various system components.

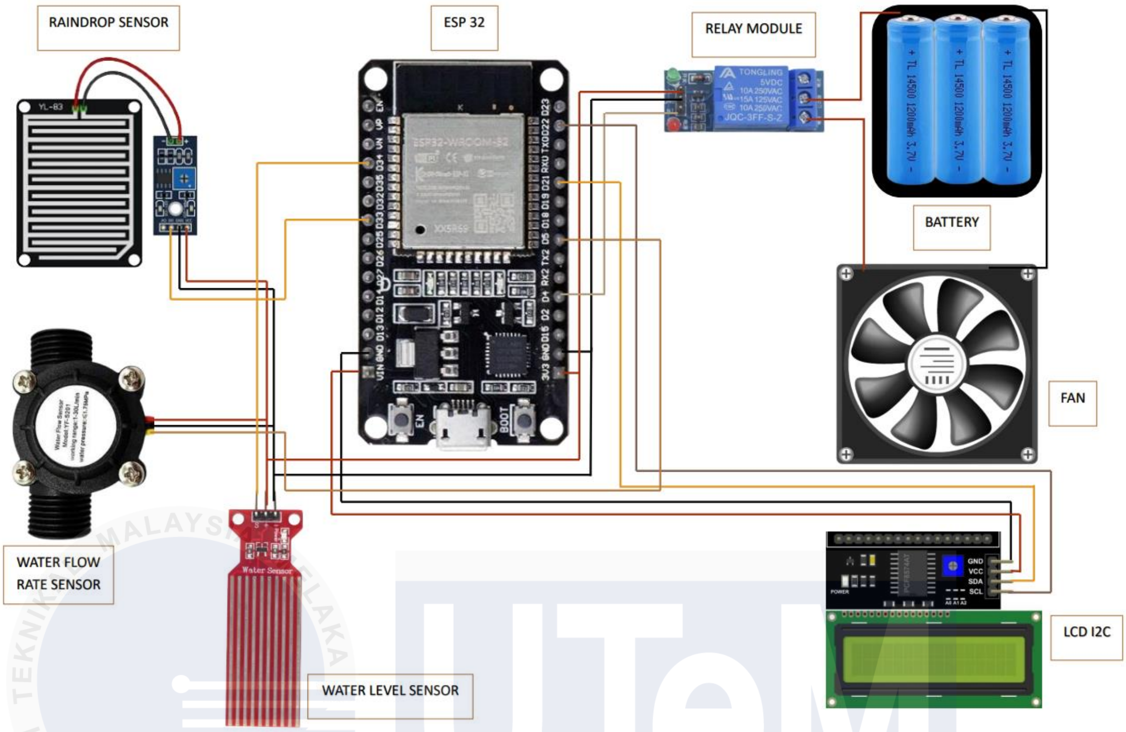


Figure 4.11 Schematic diagram

The following section contains the pinnacle of this trajectory: well-designed and refined code structure. The code is followed by detailed comments after the "//" mark, clarifying the complexity and functionality of the coding within it. These comments serve as a comprehensive guide, clarifying the purpose and complexity of the operations of different code segments.

```
#define BLYNK_PRINT Serial
#define BLYNK_TEMPLATE_ID "TMPL6Utn0L4J4"
#define BLYNK_TEMPLATE_NAME "fyp plant"
#define BLYNK_AUTH_TOKEN "8VKau_HMQ5-HmgIWwhOMF5p5jZuCYN6E"

#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

BlynkTimer timer;

char ssid[] = "Redmi Note 9 Pro";  //Wifi name
char pass[] = "12345678";          //Wifi password
char auth[] = BLYNK_AUTH_TOKEN;    //Blynk Auth Token

#define PIN_RELAY_MODULE 4      //Define relay module using pin 4
#define PIN_WATER_FLOW_RATE 5   //Define water flow rate sensor using pin 5
#define PIN_WATER_LEVEL 34      //Define water level sensor using pin 34
#define PIN_RAINDROP 33         //Define raindrop sensor using pin 33
#define I2C_ADDRESS 0x27        //Define LCD address to 0x27

volatile int pulseCount = 0;
unsigned int flowMilliLitres;
unsigned long totalMilliLitres;
unsigned long lastMillis = 0;
unsigned long myMillis = 0;
float FLOW_RATE;
float WATER_LEVEL;
int RAIN_STATUS;
```

Figure 4.12 Coding of the smart flood control system

4.2.3 Result of prototype testing

The prototype was evaluated through manual observation, providing valuable insights into its functionality, usability, and potential problems.

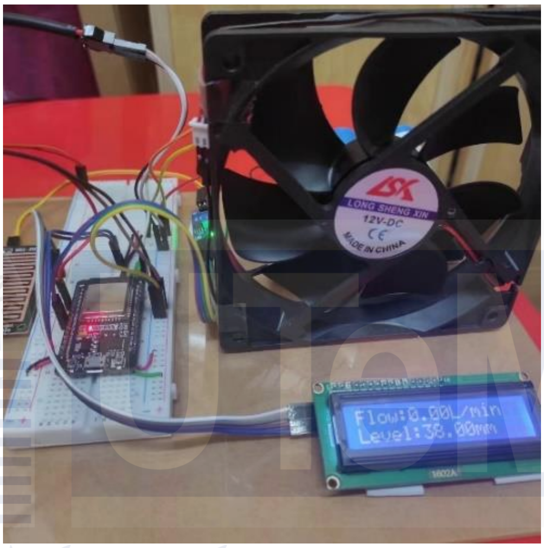
Table 4.2 Table of result prototype testing

Picture of entire system test run

The prototype efficiently displays the results on an LCD screen, ensuring visibility and accessibility of relevant information.

Picture of testing automatically activates

Regarding motor activation, the system can successfully activate and deactivate motors as needed. Additionally, it automatically activates when the water level exceeds a preset threshold of 30. When triggered, the system issues a high water level alarm on the LCD and lights up the LED on the Blynk platform.



Picture of data receiving

The device demonstrates the ability to receive data from external sources or sensors, demonstrating its interactive nature and ability to gather environmental information.

Picture of data showing in Blynk software

The device's functionality extends to logging data and displaying historical information on the Blynk platform, showcasing its connectivity and remote data visualization capabilities within an IoT framework.

4.3 Result and Discussion

Findings indicate that flooding has a significant impact on communities, often causing loss of life and remains a focus of concern. Despite the recurrence of these incidents, solving the problem remains a challenge, indicating its persistence and the likelihood of recurrence in the future. Stakeholder awareness of the main causes of flooding, such as heavy rainfall and inadequate drainage systems, has led to a collective desire for strong flood management and enhancement strategies. Among the various proposed systems, namely stormwater management systems, urban planning and land use regulations, and floodplain mapping and risk assessment, those that received greater recognition in the surveys were considered key avenues for intervention. The survey therefore highlights the need to increase the resilience and stability of the nation's infrastructure by leveraging technology as a tool to mitigate the economic, environmental and development impacts of flooding.

A recurring problem discovered during the prototyping phase is read issues or dysfunctional components. Often, these problems are caused by incorrect pin connections. However, given that each component is tested individually, there is a high degree of certainty about their individual functionality. This approach significantly reduces the potential for time wastage as it ensures components are individually verified before integration, thus minimizing the possibility of failures during assembly.

The entire system relies on three key input data streams, namely water level, water flow and raindrop measurements, each of which is very important. Lower flows can accelerate water level rises, ultimately leading to potential flooding, thus emphasizing the need for reliable and accurate data flows. The purpose of adding a raindrop sensor is to detect precipitation in real time so that relevant departments can understand the current weather conditions in a timely manner. While human intervention and identification are still critical, machines offer greater reliability in specific scenarios. When such a machine operates seamlessly without the need for constant human attention, its efficacy becomes apparent and evolves into a reliable system. In addition, the device not only facilitates real-time mobile observation, but also has the ability to automatically activate when predefined conditions are met. When it comes to software choice, Blynk is the top choice for its accessibility and convenience of data monitoring and motor control features.

An overall evaluate of the entire system indicates that its performance is average, so further in-depth investigation of the drainage system, environmental considerations and technical capabilities is required before actual implementation. To effectively address potential usage issues, particularly those related to river congestion, solutions must be strengthened. The system was therefore considered a conceptual prototype designed to clarify its functionality and demonstrate the potential advantages it offers in mitigating damage to communities during flood events. This status emphasizes the need for continuous improvement to ensure its readiness for real-world deployment.

4.4 Summary

In short, the findings highlight the significant impact of flooding caused by heavy rainfall and insufficient drainage. The prototyping phase effectively addressed recurring component failures, highlighting the critical role of accurate data input in avoiding flooding. Given the moderate performance of the system, pre-implementation surveys are imperative to reveal the promise of the prototype and areas for continued improvement. Additionally, the multifaceted prototype demonstrates the ability to manage data, control motors, dual data visualization via LCD and Blynk, and integrate with Internet of Things (IoT) frameworks. Thorough documentation of these observations remains critical to fully assess strengths, weaknesses, and paths for improvement before moving onto further development phases or iterations.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, this project study is chosen because of the flooding issues always an obstacle that humans cannot yet control and prove difficult to resolve. The cumulative variety of fatalities, especially economic losses, seems incalculable, but these will continue endlessly. The project is carryout by design and develop a smart flood control device that combined with a monitoring function for the situation river and motor. The different between the flood control pump and station is the flood control device is designed with the idea of turbine that drive the waterflow rate and the technologies IoT and mircocontroler sensor is used for the purpose of tracking river situation. The design and development process is used some method which is the new product development (NPD) process, survey and engineering design. Both objectives are achieved with the successful operation of the system in terms of degree tracking, control and automation. Going forward, the goal is to further develop such systems, moving from manual pump control and on-site observation to leveraging IoT technology to help. This research is simply a starting point. Extensive research on topography, pumps, technology, etc. is essential. Cooperation and assistance from all parties are important to successfully respond to flood disasters.

5.2 Recommendations

- Combine data from various sources (weather forecasts, sensors, satellite imagery) to conduct a comprehensive flood risk assessment.
- Regularly test the effectiveness of the system through simulations.
- Leverage artificial intelligence for monitoring, analysis and decision-making processes.
- Flood notices are issued to notify nearby communities.

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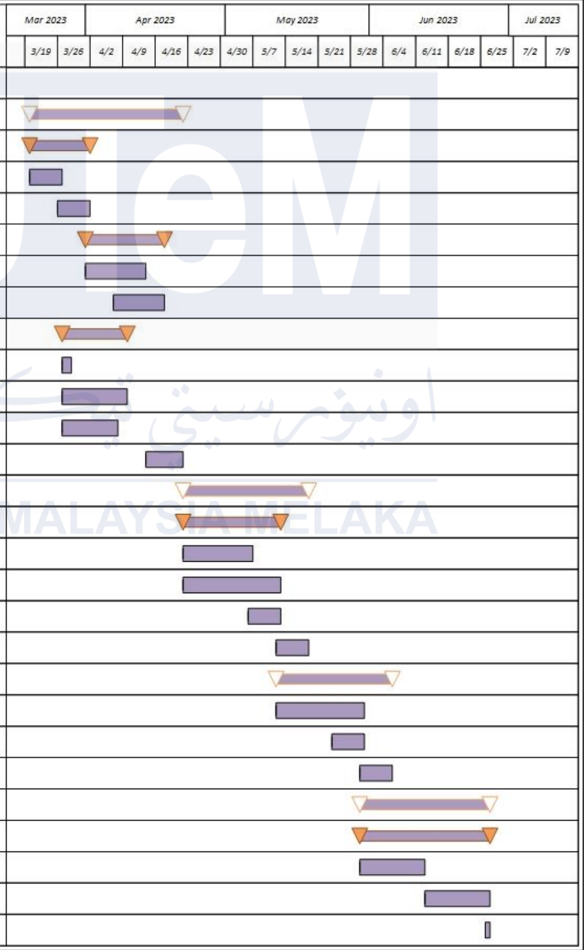
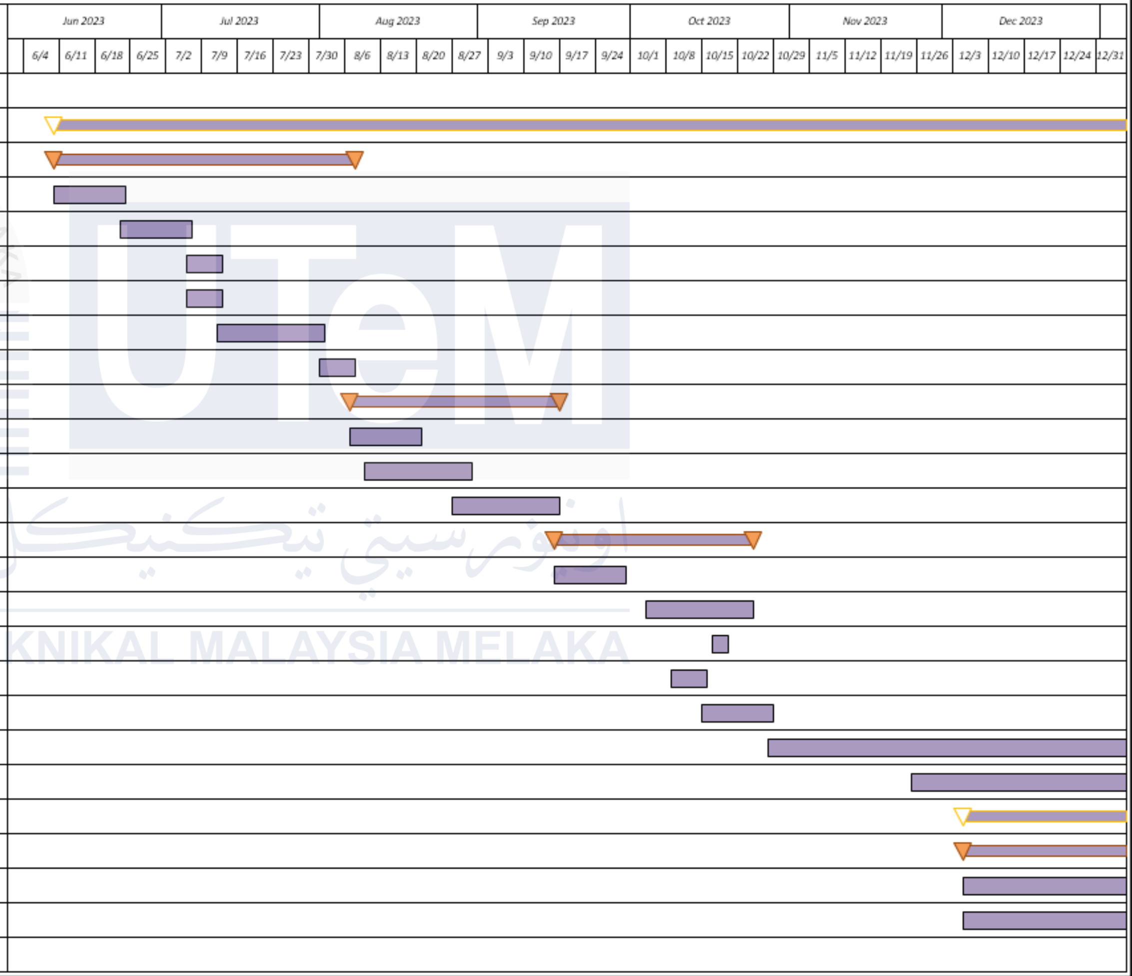
APPENDICES

APPENDIX A Gantt Chart PSM 1 and 2

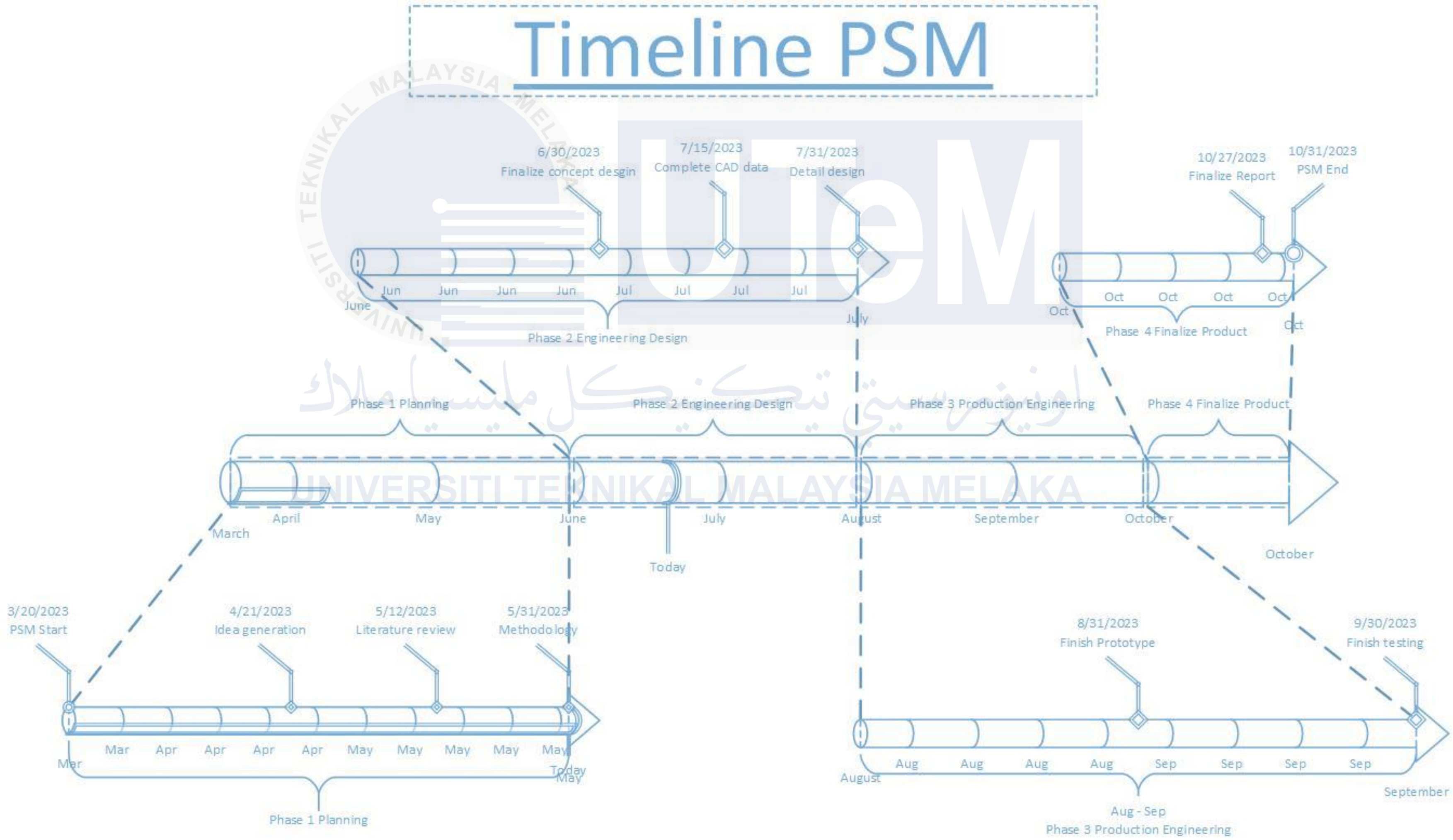
ID	Task Name	Start	Finish	Duration
1	**PSM 1**			
2	**Chapter 1 Idea generation writing**	**3/20/2023**	**4/21/2023**	**33d**
3	**Topic Selection**	**3/20/2023**	**4/1/2023**	**13d**
4	Research for the title	3/20/2023	3/26/2023	7d
5	Discussion with supervisor	3/26/2023	4/1/2023	7d
6	**Information collection**	**4/1/2023**	**4/17/2023**	**17d**
7	Research of flood	4/1/2023	4/13/2023	13d
8	Define the problem statement	4/7/2023	4/17/2023	11d
9	**PSM planning**	**3/27/2023**	**4/9/2023**	**14d**
10	Timetable	3/27/2023	3/28/2023	2d
11	Flow Chart	3/27/2023	4/9/2023	14d
12	Gantt Chart	3/27/2023	4/7/2023	12d
13	**Writing checking**	4/14/2023	4/21/2023	8d
14	**Chapter 2 Literature review writing**	**4/22/2023**	**5/18/2023**	**27d**
15	**Research**	**4/22/2023**	**5/12/2023**	**21d**
16	Study others research	4/22/2023	5/6/2023	15d
17	Information Analysis	4/22/2023	5/12/2023	21d
18	**Writing report**	5/6/2023	5/12/2023	7d
19	**Writing checking**	5/12/2023	5/18/2023	7d
20	**Chapter 3 Methodology writing**	**5/12/2023**	**6/5/2023**	**25d**
21	**Research method**	5/12/2023	5/30/2023	19d
22	**Writing report**	5/24/2023	5/30/2023	7d
23	**Writing checking**	5/30/2023	6/5/2023	7d
24	**Presentation preparation PSM 1**	**5/30/2023**	**6/26/2023**	**28d**
25	**Presentation**	**5/30/2023**	**6/26/2023**	**28d**
26	Slide presentation	5/30/2023	6/12/2023	14d
27	Pre-test presentation	6/13/2023	6/26/2023	14d
28	Presentation	6/26/2023	6/26/2023	1d



ID	Task Name	Start	Finish	Duration
1	**PSM 2**			
2	**Chapter 4 Result and discussion**	**6/10/2023**	**1/10/2024**	**215d**
3	**Concept development**	**6/10/2023**	**8/7/2023**	**59d**
4	Questionnaire design	6/10/2023	6/23/2023	14d
5	Data collection	6/23/2023	7/6/2023	14d
6	Data convert	7/6/2023	7/12/2023	7d
7	Data analysis	7/6/2023	7/12/2023	7d
8	System level design	7/12/2023	8/1/2023	21d
9	Preliminary survey	8/1/2023	8/7/2023	7d
10	**Product development**	**8/7/2023**	**9/16/2023**	**41d**
11	Select final design	8/7/2023	8/20/2023	14d
12	Schematic Diagram Drawing	8/10/2023	8/30/2023	21d
13	Coding Generate	8/27/2023	9/16/2023	21d
14	**Prototype and testing**	**9/16/2023**	**10/24/2023**	**39d**
15	Purchase component	9/16/2023	9/29/2023	14d
16	Prototype making	10/4/2023	10/24/2023	21d
17	Prototype testing	10/17/2023	10/19/2023	3d
18	Design verification and validation	10/9/2023	10/15/2023	7d
19	**Refinement**	10/15/2023	10/28/2023	14d
20	**Writing report**	10/28/2023	1/10/2024	75d
21	**Writing checking**	11/25/2023	1/10/2024	47d
22	**Presentation preparation PSM 2**	**12/5/2023**	**1/17/2024**	**44d**
23	**Presentation**	**12/5/2023**	**1/17/2024**	**44d**
24	Poster design	12/5/2023	1/5/2024	32d
25	Pre-test presentation	12/5/2023	1/17/2024	44d
26	Presentation	1/17/2024	1/17/2024	1d



APPENDIX B Timeline PSM with milestone



APPENDIX C Questionnarie survey form

Questionnaire Survey For Investigating Design And Develop of Smart Flood Control Device

Hi everyone!

I am the student from **Bachelor of Manufacturing Engineering Technology (Product Design) UTeM (Universiti Teknikal Malaysia Melaka)**. The survey objectives are collecting information and opinions about my Final Year Project (FYP) which is design and develop a **Smart Flood Control Device**. Malaysia, like many other parts of the world, is not immune to the catastrophic impact of floods, which have become a global epidemic. Floods bring about a multitude of detrimental consequences, such as loss of human lives, destruction of property and infrastructure, transportation disruptions, erosion and sedimentation, agricultural devastation, water contamination, and significant economic setbacks. The primary purpose of this smart flood control device is to **effectively monitor** and **regulate the flow rate of water** during periods of high water levels. The device has been meticulously designed and developed to assist communities in **mitigating flood risks** and **safeguarding both lives and valuable assets**.

It is appreciate having your precious suggestions and thank you for spending your time to help me fill up this survey question.

Student
YON CHOW JYE
FTKMP, BMMD

Supervisor
TS. DR. HAMBALI BIN BOEJANG

* Indicates required question

Section A : Background

This section helps to categorize your answers based on your background.
Please check ◉ to answer only one of the following questions.

4. Education background *

Mark only one oval.

- SPM
- STPM / A-Level
- Diploma / Matric
- Bachelor's degree
- Master's degree
- Ph.D
- No schooling completed

Section B : Personal Experiance

This section is to know able your oersonal experiance or opinion about the flood in your area.

5. Have you personally experienced or witnessed any floods in your area? *

Mark only one oval.

- Yes
- No

6. How frequently do floods occur in your region? *

Mark only one oval.

- Never
- Everyday
- Few days
- Every week
- Few weeks
- Every months
- Few months
- Every year

7. What are the primary causes or triggers of flooding in your area? *

Tick all that apply.

- Heavy rainstorm
- Poor drainage system
- Near to the river, stream, lake ditch or pond
- Logjam or obstruction in nearby watercourse
- Poor management of environment
- Pollution
- Dam break

8. Which having the worst damage during the flood in community. *

Mark only one oval.

- Property
- Infrastructure
- Loss of life

9. Below showing the existing flood control measures or infrastructures . In your opinion, how effective have they been? *

Mark only one oval per row.

	Less effective	Moderate less effective	Moderate effective	Moderate more effective	Most effective
Dams and Reservoirs	⬭	⬭	⬭	⬭	⬭
Flood Walls and Levees	⬭	⬭	⬭	⬭	⬭
Flood Channels and Canals	⬭	⬭	⬭	⬭	⬭
Flood Barriers	⬭	⬭	⬭	⬭	⬭
Stormwater Management Systems	⬭	⬭	⬭	⬭	⬭
Flood Warning Systems	⬭	⬭	⬭	⬭	⬭
Urban Planning and Land Use Regulations	⬭	⬭	⬭	⬭	⬭
Floodplain Mapping and Risk Assessment	⬭	⬭	⬭	⬭	⬭
Emergency Response and Evacuation Plans	⬭	⬭	⬭	⬭	⬭

10. How well-prepared do you think your community or local authorities are in dealing with floods? *

Mark only one oval.

Poor prepared

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Well prepared

11. What are the main challenges faced during and after a flood event? *

Mark only one oval.

- Loss of Life and Injuries
- Property and Infrastructure Damage
- Displacement and Homelessness
- Contaminated Water and Sanitation Issues
- Disrupted Transportation and Communication
- Supply Shortages and Food Insecurity
- Environmental Impact
- Emotional and Psychological Distress
- Recovery and Rebuilding
- Community Resilience and Preparedness

12. Have you observed any long-term impacts of floods, such as changes in land use, migration patterns, or economic stability? *

Mark only one oval.

- Yes
- No

13. Which is the specific areas or regions that are most vulnerable to flooding than others? *

Mark only one oval.

- Proximity to Water Bodies
- Low-lying Topography
- Climate and Rainfall Patterns
- Drainage Infrastructure
- Soil Composition
- Deforestation and Land Use Changes
- Urbanization and Development
- Historical Flood Patterns

14. What are the key recommendations or improvements you would suggest to enhance flood management and preparedness in your area?

Section C: Expected product

This section trying to know your opinion and suggestion about the specification of designing the smart flood control device to have a comprehensive improvement. Please indicate the level of importance following specification that attach you in smart flood control device.

1. Gender *

Mark only one oval.

- Male
- Female

2. Age *

Mark only one oval.

- < 19
- 20~29
- 30~39
- 40~49
- 50~59
- >60

3. Occupation *

Mark only one oval.

- Student
- Lecturer
- Retiree
- Self-employed
- Marketing/Sales
- Housewife
- Commercial
- Officer
- Technician
- Others

15. Based on your opinion, give the rating for each design categories. *

Mark only one oval per row.

	Less important	Moderate less important	Moderate important	Moderate more important	Very important
Channel Design	◯	◯	◯	◯	◯
Velocity Enhancement	◯	◯	◯	◯	◯
Sediment Management	◯	◯	◯	◯	◯
Observe Remote Override	◯	◯	◯	◯	◯
Structural Considerations	◯	◯	◯	◯	◯
Environmental Compatibility	◯	◯	◯	◯	◯
Maintenance and Accessibility	◯	◯	◯	◯	◯
Integration with Existing Infrastructure	◯	◯	◯	◯	◯
Comprehensive System Approach	◯	◯	◯	◯	◯
Energy Source	◯	◯	◯	◯	◯

Appendix D Coding of smart flood control device

```
#define BLYNK_PRINT Serial
#define BLYNK_TEMPLATE_ID "TMPL6Utn0L4J4"
#define BLYNK_TEMPLATE_NAME "fyp plant"
#define BLYNK_AUTH_TOKEN "8VKau_HMQ5-HmgIWwhOMF5p5jZuCYN6E"

#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

BlynkTimer timer;

char ssid[] = "Redmi Note 9 Pro";  //Wifi name
char pass[] = "12345678";          //Wifi password
char auth[] = BLYNK_AUTH_TOKEN;    //Blynk Auth Token

#define PIN_RELAY_MODULE 4     //Define relay module using pin 4
#define PIN_WATER_FLOW_RATE 5  //Define water flow rate sensor using pin 5
#define PIN_WATER_LEVEL 34     //Define water level sensor using pin 34
#define PIN_RAINDROP 33        //Define raindrop sensor using pin 33
#define I2C_ADDRESS 0x27       //Define LCD address to 0x27

volatile int pulseCount = 0;
unsigned int flowMilliLitres;
unsigned long totalMilliLitres;
unsigned long lastMillis = 0;
unsigned long myMillis = 0;
float FLOW_RATE;
float WATER_LEVEL;
int RAIN_STATUS;
int MOTOR_STATUS;

LiquidCrystal_I2C lcd(I2C_ADDRESS, 16, 2);

#define MAX_WATER_LEVEL 100  //Define maximun water level value to 100

void setup() {
  Serial.begin(115200);
  Blynk.begin(auth, ssid, pass);  // Use to connect WIFI

  pinMode(PIN_RELAY_MODULE, OUTPUT);     // Define the pin mode
  digitalWrite(PIN_RELAY_MODULE, LOW);  // Define the pin in off

  pinMode(PIN_WATER_FLOW_RATE, INPUT);
```

```
  attachInterrupt(digitalPinToInterrupt(PIN_WATER_FLOW_RATE),
pulseCounter, FALLING);

  pinMode(PIN_WATER_LEVEL, INPUT);  // Define the pin mode

  pinMode(PIN_RAINDROP, INPUT);  // Define the pin mode

  lcd.begin();
  lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.print("System Loading...");
  delay(2000);
  lcd.clear();
}

void loop() {
  Blynk.run();            //Call to run the Blynk
  UPDATE_FLOW_RATE();     //Call for function read the flow rate value
  UPDATE_WATER_LEVEL();   //Call for function read the water level value
  UPDATE_RAIN_STATUS();   //Call for function checking raining status
  UPDATE_VALUES();        //Call for function display values flow rate and
water level in LCD
  UPDATE_STATUS();        //Call for function display motor and raining
status
  AUTOMATIC();            //Call for function automatic on and off the
motor once the value is over

}

BLYNK_WRITE(V1) {
  int motorControl = param.asInt();

  if (motorControl == 1) {
    digitalWrite(PIN_RELAY_MODULE, HIGH);
    lcd.setCursor(0, 1);
    lcd.print("Motor: ON ");
  } else {
    digitalWrite(PIN_RELAY_MODULE, LOW);
    lcd.setCursor(0, 1);
    lcd.print("Motor: OFF");
  }
  Blynk.virtualWrite(V1, motorControl);
}

void pulseCounter() {
  pulseCount++;
}
```

```
void UPDATE_FLOW_RATE() {
  if ((millis() - myMillis) > 1000) {
    detachInterrupt(digitalPinToInterrupt(PIN_WATER_FLOW_RATE));
    FLOW_RATE = pulseCount / 7.5;                // YF-s201 sensor produces 
about 7.5 pulses per liter
    flowMilliLitres = (FLOW_RATE / 60) * 1000;  //Calculation formula
    totalMilliLitres += flowMilliLitres;
    pulseCount = 0;
    myMillis = millis();
    attachInterrupt(digitalPinToInterrupt(PIN_WATER_FLOW_RATE), 
pulseCounter, FALLING);
    Blynk.virtualWrite(V5, FLOW_RATE);  //Data send to Blynk via Virtual 
Pin
  }
}

void UPDATE_WATER_LEVEL() {                      //Function that used to read 
water level
  WATER_LEVEL = analogRead(PIN_WATER_LEVEL);  // Read the analog value 
from the water level sensor

  WATER_LEVEL = map(WATER_LEVEL, 0, 4095, 0, MAX_WATER_LEVEL);  // Map the 
analog reading to the expected water level range

  Blynk.virtualWrite(V4, WATER_LEVEL);  //Data send to Blynk via Virtual 
Pin
}

void UPDATE_RAIN_STATUS() {                       //Function that used to 
check raining status
  int sensorValue = analogRead(PIN_RAINDROP);  // Read the analog value 
from the raindrop sensor

  if (sensorValue < 4000) {
    // It's raining, turn on LED and display on LCD
    digitalWrite(LCD_BLINKON, HIGH);
    lcd.setCursor(0, 0);
    lcd.print("Raining ? : Yes");
    RAIN_STATUS = 1;
  } else {
    // It's not raining, turn off LED and display on LCD
    digitalWrite(LCD_BLINKON, LOW);
    lcd.setCursor(0, 0);
    lcd.print("Raining ? : No ");
    RAIN_STATUS = 0;
  }
  Blynk.virtualWrite(V6, RAIN_STATUS);  //Data send to Blynk via Virtual 
Pin
```

```
}

void UPDATE_VALUES() {  //Function that used to display value in LCD
  lcd.clear();          //Clear the LCD
  lcd.setCursor(0, 0);  //Location of the display text
  lcd.print("Flow:");
  lcd.print(FLOW_RATE);
  lcd.print("L/min  ");

  lcd.setCursor(0, 1);
  lcd.print("Level:");
  lcd.print(WATER_LEVEL);
  lcd.print("mm");
  delay(4000);
  lcd.clear();
}

void UPDATE_STATUS() {  //Function that update the raining and motor
status

  lcd.setCursor(0, 0);
  lcd.print("Raining ? : ");
  lcd.print((RAIN_STATUS == 1) ? "Yes" : "No");
  lcd.setCursor(0, 1);
  lcd.print("Motor: ");
  lcd.print((digitalRead(PIN_RELAY_MODULE) == HIGH) ? "ON " : "OFF");
  delay(4000);
  lcd.clear();
}

void AUTOMATIC() {  //If value over the certain value the motor will
automatic on and LED will light up in Blynk
  if (WATER_LEVEL >= 30) {
    digitalWrite(PIN_RELAY_MODULE, HIGH);
    lcd.setCursor(0, 1);
    lcd.print("Motor auto ON!!!");
    MOTOR_STATUS = 1;
    delay(4000);
    lcd.clear();
  } else {
    // It's not raining, turn off LED and display on LCD
    digitalWrite(PIN_RELAY_MODULE, LOW);
    MOTOR_STATUS = 0;
  }
  Blynk.virtualWrite(V7, MOTOR_STATUS);  //Data send to Blynk via Virtual
Pin
}
```