Design and Development of Floodgate: A practical approach towards urban flooding protection

A report submitted in the partial fulfillment of the requirements for the degree of Bachelors in Civil Engineering

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Dedication

We dedicate our work to our Parents. Without the support of them, we wouldn’t have been able to meet our academic goals in a consistent fashion

Certificate of Originality

It is hereby declared that the research worked titled **"Design and Development of a Floodgate: A practical approach towards Urban Flood Protection"** is our own work and to the best to our knowledge. Any contribution made to the project by others, with whom we have worked, is explicitly acknowledged in the report.

It is also declared that the intellectual content of this report is the product of our own work, except to the extent that the assistance from others in the project's design and conception or in style, presentation and linguistic.

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List of Figures

HYDRO GUARDIAN

Abstract

Due to climate change, rising urbanization, and insufficient stormwater management systems, urban flooding has become a serious problem in many cities across the world. In order to protect metropolitan areas from floods, floodgates are frequently utilized as a viable option. This study describes a design and development strategy for a floodgate that is intended to offer efficient flood protection in urban settings.

The design process begins with a thorough investigation of the flood characteristics present in the target location, such as water levels, flow rates, and velocity. The size, materials, and structural toughness of the floodgate are determined using this information in order to survive the expected flood conditions. In order to cause as little interruption as possible during installation and operation, the floodgate is made to be compatible with the city's existing infrastructure, including roads, structures, and utilities.

A multidisciplinary method, involving civil engineering, hydrology, and materials science, was used to create the floodgate. To confirm prototypes' efficacy in avoiding floodwater infiltration, tests are conducted under simulated flood circumstances.

The floodgate's functionality is complemented by its user-friendliness, economy, and environmental sustainability. The use of eco-friendly materials and technology is taken into account, as well as the simplicity of installation, operation, and maintenance. In addition to include elements for public safety and aesthetics, the proposed floodgate design also contains options for emergency entrance and escape.

This thesis's use of a practical strategy gives an effective and long-lasting defence against urban floods. The design and development process considers the particular difficulties of urban settings and tries to lessen the detrimental effects of floods on populations. In their attempts to reduce the dangers of urban floods and improve urban resilience, urban planners, engineers, and politicians can benefit from the findings of this study.

CHAPTER 1: INTRODUCTION

1.1 GENERAL

A flood protection barrier is a specific type of floodgate that is designed to prevent water from entering a particular area. Also known as surge barriers or storm surge barriers, there are a number of different barrier materials used today. From glass to metal, flood barriers can be permanently installed along the edge of water banks to create a flood wall. For added protection, business owners and residents install temporary to further protect a certain area.

The flood barriers are robust and reliable flood mitigation product that helps in preventing your business or your home or both from flooding. In general, these are the barriers that restricts flood water to enter your property. These barriers are available in both the forms i.e. fixed and flexible. Though most of the people use the ones that are flexible and can use them only during the heavy rainfall or during flood.

1.2 PROBLEM STATEMENT

Every year Pakistan face flooding due to torrential monsoon rains in summer. It has caused loss of lives and billions in economy. One of the major issues is urban flooding. While urban flooding ensues several catastrophes, one of the major problem is flood water entering houses, shops and other buildings. Many houses and buildings are located in places which regularly get inundated during torrential rains for several reasons including unfortunate location, poor city drainage etc. This causes unnecessary economic losses and inconvenience.

Currently Pakistan has no standard available solution. Therefore, people try to prevent the water from entering their buildings with their own solutions primarily by putting sandbags in front of the entry.

While the sandbags are effective at the job it has several issues. For instance, they are too heavy and cumbersome to relocate, they require a lot of storage space etc. And they do not completely block water especially after they are sufficiently wet.

In short, there need to be a well-designed and effective solution to flooding of buildings to prevent damages.

1.3 PROJECT OBJECTIVES:

The objective of our project is to design a flood gate that protects buildings from urban flooding by preventing the entry of water.

The flood gate will be designed such that:

1. It is completely waterproof and completely prevents water entry from outside.
2. It withstands water pressure it will be subjected to.
3. It is easy to use and install.
4. It can be used for most doors, gates, or any other inlets.
5. It is inexpensive and easy to source.
6. It is easy to carry or store.
7. It is aesthetic.

By our flood gates, we can prevent a lot of damages and economical losses that people in Pakistan face simply due to water inundating the buildings during rainy seasons.

1.4 SCOPE AND LIMITATIONS:

The scope of floodgates can include a range of topics related to their design, function, and application in flood control and management. Here are some examples of what the scope of floodgates can include:

1. Introduction to floodgates - The basic principles of operation and function of floodgates, including their role in controlling water levels and managing flood risk.
2. Types of floodgates - The different types of floodgates available, including flap gates, slide gates, radial gates, sector gates, and others, and the advantages and disadvantages of each type.
3. Design of floodgates - The key considerations in designing floodgates, including the size and shape of the gate, the materials used, and the structural and hydraulic requirements.
4. Installation and maintenance of floodgates - The challenges and issues related to the installation and maintenance of floodgates, including issues such as access, safety, and cost.
5. Applications of floodgates - The different applications of floodgates in flood control and management, including their use in dams, levees, canals, and coastal protection.
6. Performance of floodgates - The performance of floodgates in different situations, including their ability to withstand extreme events such as floods and storms.
7. Future research directions - The current state of research and development in floodgates and potential areas for further investigation, including the use of new materials, the development of new designs, and the incorporation of new technologies such as sensors and monitoring systems.

1.5 INTRODUCTION TO FLOODGATES:

A floodgate is a device designed to control water flow by blocking, diverting, or regulating the amount of water that passes through a particular channel, such as a river or canal. The basic principle of a floodgate is to use a barrier or gate to restrict or allow the flow of water.

Floodgates are typically used in areas that are prone to flooding, where it is important to control the flow of water to prevent damage to buildings, infrastructure, and agriculture. Floodgates can also be used to divert water to irrigation systems, hydroelectric power plants, or other facilities that require a steady flow of water.

The operation of a floodgate typically involves opening or closing the gate or barrier to control the flow of water. This can be done manually or automatically, depending on the type of floodgate and the requirements of the situation. Some floodgates are operated by hydraulic or electric systems that can be controlled remotely.

In addition to gates and barriers, floodgates may also include other features such as spillways, sluice gates, and bypass channels, to help manage water flow and prevent flooding. Proper maintenance and monitoring of floodgates is essential to ensure they are functioning effectively and to prevent failure or damage during periods of high water flow.

1.6 INSTALLATION AND MAINTENANCE OF FLOODGATES

The installation and maintenance of floodgates can be challenging and involve a number of issues that need to be addressed to ensure their proper functioning. Some of the main challenges and issues related to the installation and maintenance of floodgates are:

1. Design and engineering challenges: Designing and engineering floodgates that are effective in controlling water flow and preventing flooding can be a complex task, especially in areas with highly variable water levels or with specific requirements for water management.
2. Installation and construction challenges: Installing floodgates can be difficult and may require significant construction work, such as excavation, reinforcement of embankments, and building foundations. This can be complicated by factors such as difficult terrain, accessibility issues, and environmental constraints.
3. Maintenance and repair challenges: Floodgates require regular maintenance and repair to ensure that they continue to function properly over time. This can involve inspections, cleaning, lubrication, and repair or replacement of mechanical components. Maintaining floodgates can be difficult due to their location in often challenging environments, as well as the need for specialized equipment and expertise.
4. Environmental and social impact: Floodgates can have significant environmental and social impacts, especially if they are installed in or near sensitive ecosystems or in areas with high levels of human activity. This can include changes to water flow and quality, habitat destruction, and impacts on local communities and livelihoods.

5. Funding and resource constraints: Installing and maintaining floodgates can be expensive, and many communities and governments may face funding and resource constraints that limit their ability to undertake these activities. This can lead to a lack of investment in floodgate infrastructure, which can exacerbate the impacts of flooding and other water-related disasters.

Overall, the challenges and issues related to the installation and maintenance of floodgates require careful planning, coordination, and management to ensure that they are effective in controlling water flow and preventing flooding, while also minimizing their environmental and social impacts.

Besides a lot of advantages, there are some limitations of floodgates as well which are as follows:

1. May fail or be overtopped by large floods or floods of long duration.
2. May be expensive depending on height, length, availability of materials, and other factors.
3. Requires periodic maintenance.
4. Requires interior drainage.
5. May affect local drainage, possible resulting in water problems for others.
6. Does not reduce flood insurance premiums.
7. May restrict access to structure.
8. Requires considerable land (levees only).
9. Does not eliminate the need to evacuate during floods.
10. May require warning and human intervention for closures.
11. May violate applicable codes or regulations.

CHAPTER 2: LITERATURE REVIEW

2.1 Urban Flooding

Flooding that happens in urban areas as a result of excessive water runoff is known as urban flooding. Urban flooding, as opposed to floods brought on by natural disasters like overflowing rivers or storm surges from hurricanes, results from established or underdeveloped areas' failure to efficiently handle and drain surplus water. This form of flooding can occur during ordinary weather events as well as catastrophic ones like Hurricane Harvey, which can cause problems like damp basements and sewage backups. Due to outdated or insufficient infrastructure, even minor amounts of rainfall can make the situation worse, especially in urban areas where underprivileged, excluded, and isolated communities are frequently disregarded by municipal authorities.

2.1.1 Definition

According to Federal Emergency Management Agency (FEMA), Urban Flooding is defined as:

"The inundation of property in a built environment, particularly in more densely populated areas, caused by rain falling on increased amounts of impervious surfaces and overwhelming the capacity of drainage systems."

2.1.2 Components

Urban flooding is caused by rain that:

1. Falls on impervious surfaces
2. Overwhelms local stormwater drainage capacity.

Three unique components make up the definition of urban flooding. It is first brought on by precipitation that strikes impervious surfaces. Second, the capacity of nearby stormwater drainage systems is exceeded by heavy rainfall. Heavy precipitation, which is expected to rise owing to climate change, as well as the spread of metropolitan areas worsen both of these factors. The issue is further made worse by obsolete or insufficient stormwater infrastructure.

No matter an area's economic or social standing, all levels of government must prioritise measures that target regions with the highest risk of flooding in order to solve the problem of urban flooding. Additionally, it is essential to motivate private property owners to take steps to lessen the effects of urban flooding.

Fig 2.1: Urban Flooding in Hoboken, NJ in April 2007

2.2 CAUSES OF URBAN FLOODING

The global issue of urban flooding has been a growing concern over the past decade, with Pakistan also experiencing an increase in urban flooding incidents. This trend is not limited to a specific region or country, but is a widespread problem that poses a significant challenge for urban planners worldwide. Urban floods can range from localized incidents to major events that result in cities being submerged for hours or even days, depending on the intensity and duration of the rainfall. Consequently, the impact of urban flooding can be far-reaching, including temporary displacement of people, damage to essential infrastructure, contamination of water sources, and increased risk of disease outbreaks [1].

Urban flooding has both natural and human-induced causes. Global warming, leading to rising sea levels, exacerbates the issue. It was once believed that only areas located in floodplains were at risk of flooding, but urban floods have challenged this notion [1].

2.2.1 Natural Causes:

Some natural causes of urban flooding are:

1. Higher rainfall
2. Storm surges and frequent depressions in open waters
3. Depleting groundwater tables
4. Heavy melting of snow causes flash floods in lower catchment areas [1]

2.2.2 Anthropogenic Causes:

Urban flooding is a complex problem that arises from a combination of natural and human factors. Among the human factors, some of the anthropogenic causes of urban flooding include:

1. Encroachments on drainage areas:

Natural drainage regions including lakes, marshes, and riverbeds are being encroached upon by habitations, businesses, and infrastructure development in many metropolitan areas. Floods result from this obstruction of the extra water's flow during periods of high precipitation. The ecosystem's capacity to absorb and store water is also diminished by the disappearance of these natural drainage regions, which makes floods a bigger issue.

2. Climate change and urban heat island effect:

In many locations, the consequences of climate change have changed the pattern of rainfall, increasing the frequency and intensity of downpour events. The urban heat island effect has also raised the temperature of urban regions, which may result in more rain falling over urban areas because of the concentration of heat-retardant materials there. Flooding may result from this confluence of causes, especially in places that are not well-prepared to handle excess water.

3. Pollution of water bodies:

In many metropolitan locations, water features like rivers and lakes are important parts of the natural drainage systems. The paths for extra water to flow, however, can become blocked if these water bodies are polluted with non-biodegradable garbage, sewage, and other contaminants. In addition to causing flooding, this puts the communities' health at considerable danger who live in the impacted areas. This issue is made worse by the inadequate application of waste management techniques.

4. Illegal mining activities:

Mining operations in rivers can lead to soil erosion, which depletes the river's natural bed and lowers its ability to retain water. Due to this, the river may overflow during periods of severe precipitation, resulting in floods in the neighbouring areas.

5. Unplanned and uninformed release of water from dams:

In some instances, water is released from dams without adequate preparation or communication with the populations below. The population might not have enough time to react to the abrupt release of water, which can result in deadly floods. The prevention of such tragedies depends heavily on effective flood warning systems and community involvement.

6. Poor flood governance:

It takes a concerted effort from numerous government agencies, communities, and stakeholders to manage floods effectively. However, administrators frequently don't take flood governance seriously, which can result in poor planning, subpar infrastructure, and a lack of community involvement. Urban floods may become more problematic as a result, and management may become more difficult.

In conclusion, urban flooding is a complex issue that calls for a diversified solution. Urban flooding has anthropogenic causes, which need to be acknowledged and handled through good governance, sustainable development methods, and community involvement [1].

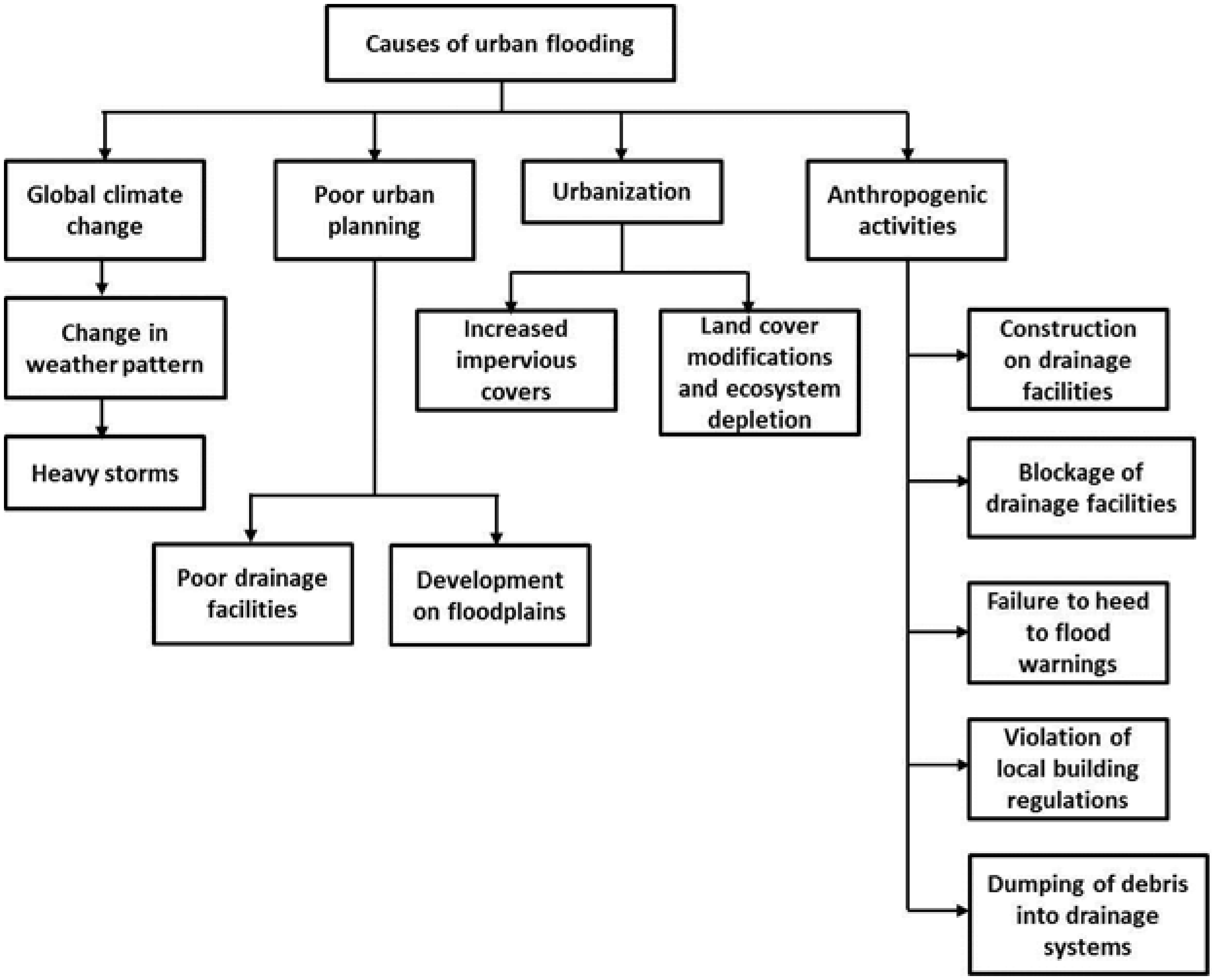


Fig. 2.2 Main causes of urban flooding showing global climate change, poor urban planning, urbanization and anthropogenic activities [2]. Source: Nkwunonwo et al. (2016)

2.3 IMPACTS OF URBAN FLOODING:

Flood effects are frequently categorised based on two factors. A distinction between tangible and intangible impacts is made in the first criterion. The term "tangible impacts" refers to effects that are easily defined in monetary terms, including property damage or lost revenues as a result of company interruption. Finding out if the impacted asset has a market worth is a different way to say this. In contrast, intangible effects are those that are difficult to measure financially, such as a loss of life, a detrimental effect on mental health, and environmental harm, such as the destruction of recreational places and contamination.

The distinction between direct and indirect damage is the second typical one. Floodwater that comes into direct physical contact with people, property, and the environment will cause damage. However, indirect damages can happen outside of the immediate scope of the flood event in terms of time or space because they are brought on by direct impacts. According to one study, direct losses take place inside the flooded area, whereas indirect harm happens outside of it. According to another study, although indirect damage refers to disruptions of flows and linkages, such as the loss of flow values, direct damage is typically measured as a damage to stock prices [4].

This review describes that there are following categories:

- Direct tangible impacts
- Business interruption and indirect tangible impacts
- Impacts on infrastructure
- Intangible impact

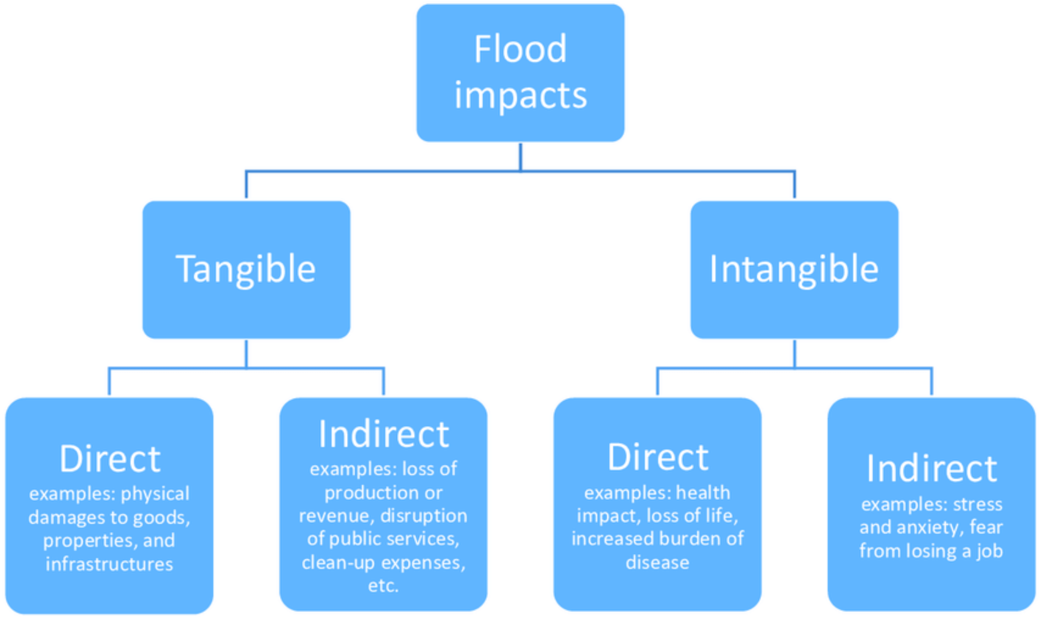


Fig 2.3: An overview of tangible and intangible types of damage caused by flood events [6]

2.3.1 Direct Tangible Impacts:

Direct tangible damage is any physical harm brought on by direct contact with floodwaters to infrastructure, property, and contents in both the residential and non-residential sectors. It is the class of flood consequences that is both most frequently investigated and best understood. Many flood impact estimates solely take into account direct tangible effects, ignoring additional categories like intangible effects. The main method used in estimating direct tangible damage is to create and use damage or susceptibility functions that link anticipated damage to flood features, such as depth and flow rate, for specific asset types [5].

Fig 2.4: Some of the destructions caused by Urban Flooding

2.3.1.1 Business interruption and indirect tangible impacts:

While some researchers distinguish between business interruption and indirect tangible impacts, the literature frequently lacks clarity regarding which costs are being assessed using a particular methodology. Both of these categories are taken into account in this review as a single unit. Costs associated with business interruption are calculated using two main methods. Applying a fixed percentage of the direct expenses is the easier approach. In their investigation of flood losses in the UK, Penning-Rowsell and Parker in 1987 found that the ratio of indirect losses to direct losses varied from 21% for a Bristol sample to 93% for a Chesil study. The simplicity of this approach is its main virtue, but it has the drawback that the right proportion differs widely not only between different places but also between different events at the same venue. Additionally, this approach disregards the duration of the disruption, which is crucial in determining the overall impact [5].

Utilizing a sector-specific unit loss value, which represents the losses from added value or wage losses, is the second approach. In a case study involving a South African country, Booysen evaluated business interruption costs on a firm level in 1999 by calculating the daily gross margin of each company and multiplying it by the number of days of disruption. This approach could help you comprehend business interruption losses even if it was location-specific and needed reliable historical data [5].

2.3.1.2 Impacts on infrastructure:

The infrastructure that supports modern life's necessities, including telecommunications, transportation, power, emergency services, water supply, agriculture and food production, and healthcare, is primarily reliant on urban areas. However, if these infrastructures are damaged as a result of a natural disaster like flooding, it could be very expensive and have negative effects. It can be particularly difficult to estimate how flooding will affect infrastructure, and little research has been done in this area. Because many infrastructure components are specialized, floodwaters can cause a wide range of direct damage. In addition, flooding can have indirect consequences that are geographically far from the original flooding since they are a part of a wider network of interrelated elements, such as electrical or water supply networks. Infrastructures are also interconnected, so problems in one network, like the water supply or telecommunications, can affect other networks as well.

There is still much to be done in the area of researching the effects of floods on infrastructures that go beyond the direct harm to particular assets. Lack of data is one of the key challenges, either because of inadequate understanding or because researchers are not given access to sensitive material. Therefore, additional research is required to better understand the effects of flooding on infrastructure and to create practical mitigation strategies [5].

2.3.2 Intangible impacts

Intangible effects of flooding include harm to the ecosystem and human health. Human health-related effects, which can be broadly classified into two categories, are the most significant of these effects. The first group covers physical health consequences that happen as a result of the flooding event, the cleanup procedure, or as a result of substantial infrastructure damage that causes population displacement. Injuries, fatalities, and infections brought on by flooding, such as watery illnesses (such as diarrhea), vector-borne illnesses (such as malaria and dengue fever), and rodent-borne illnesses (such as leptospirosis), are all physical health repercussions [6].

The second category of health effects has to do with mental health and can have an effect on people directly during the flooding event, indirectly throughout the restoration process, or among those who live nearby. Disease outbreaks, including bacterial epidemics like leptospirosis and diarrhea as well as vector-borne illnesses like malaria, are known to be associated with flooding. Numerous studies have emphasized the growing global awareness of the health risks associated with water, particularly in developing nations where patients with water-related illnesses occupy more than half of all hospital beds worldwide. The risk factors related to particular diseases and flooding have been the subject of several research [6].

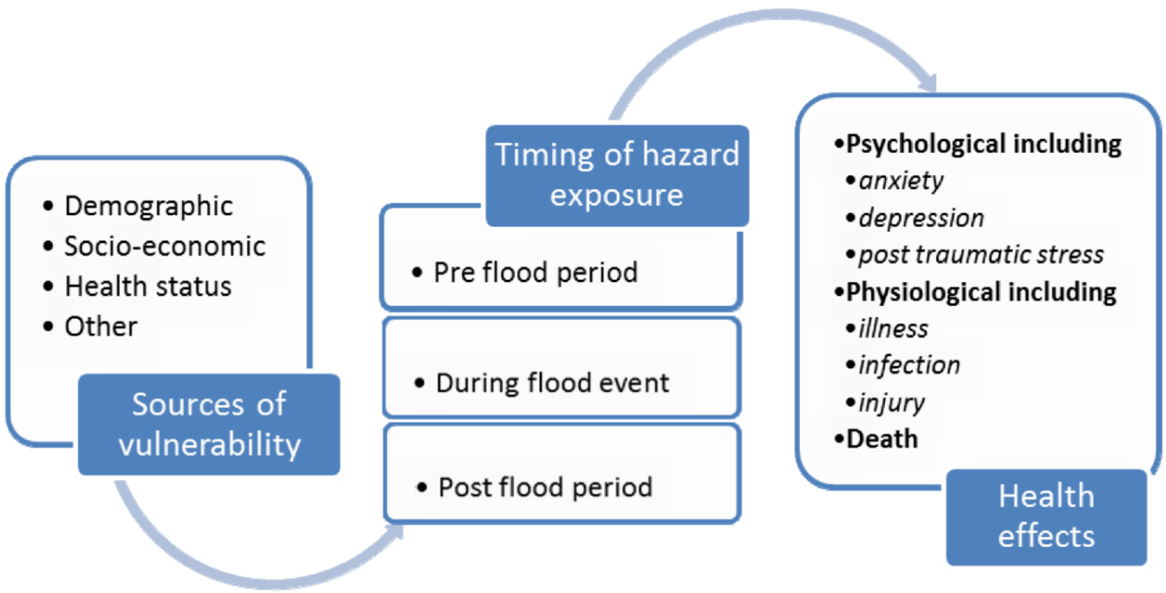


Fig 2.5: A flowchart representing impacts of Urban Flooding

2.4 VULNERABILITY ASPECT OF URBAN FLOODING

Some vulnerability aspects of urban flooding are as follows:

2.4.1 Concepts and Elements

Vulnerability is a term that has to do with how dangerous a natural disaster can be. It alludes to the possible harm or loss that any natural hazard could cause. It is significant to remember that these risks have varying effects on various population groups. For instance, different types of risks and degrees of risk are present in impoverished and wealthy metropolitan neighborhoods. The vulnerability of an individual, society, or area is established by their exposure and coping capabilities, which together make up their vulnerability. All living and non-living things that are impacted by a natural hazard are considered exposed, including people, plants, animals, buildings, and other structures. On the other side, coping capacity describes a person's or a society's capacity to deal with the effects of natural disasters. In various studies, vulnerability is defined using a variety of functional forms and formulas [7].

$$Vulnerability = \frac{Risk}{Hazard}$$

$$Vulnerability = f\ (D, T, S)$$

$$Vulnerability = E + R + Re$$

Where,

D = Dependence	E = Exposure
T = Transferability	R = Resistance
S = Susceptibility	Re = Resilience

Physical and social vulnerability can be separated into two categories. According to natural scientists, vulnerability is defined in terms of the material or physical harm brought on by exposure to natural hazards. This includes the dangers that come with being around natural disasters. Social scientists, on the other hand, define vulnerability as a collection of socioeconomic characteristics that affect how well a society can withstand the effects of a hazard. As a result, an integrated vulnerability assessment strategy that takes into account both the physical and social components is needed. To better comprehend the risks posed by natural hazards and how society might better plan for and adapt to them, it is necessary to take into account both dimensions of vulnerability [8].

Table 1. Types of flood vulnerability

Types	Physical vulnerability	Social vulnerability	Implications
I	High	Low	High degree of coping capacity of the society, adverse impacts upon property and infrastructure.
II	High	High	Less coping capacity, more off-putting shocks, multi-hazard environment.
III	Low	Low	High coping capacity, fast recovery, resilient society.
IV	Low	High	Deficiencies in a local network system, inadequate demographic composition, less coping.

Source: Karagiorgos, Thaler, Heiser, Hube & Fuchs, 2016.

Fig 2.6: Flood vulnerability and their implications

2.4.2 Social Vulnerability of Urban Flooding: Various Aspects

Urban areas are more prone to social sensitivity to risks. The high population density and unequal distribution of resources and opportunity are to blame for this. In order to examine social inequality in post-hazard scenarios, the measurement of social vulnerability is crucial. Numerous socioeconomic and demographic factors, including social networks, security, and post-incident outcomes, must be taken into account in order to assess social vulnerability. Inadequate social networks and security measures can make people more susceptible to incident-related effects. In hazard studies, it is crucial to pay attention to social vulnerability in order to reduce natural hazards like floods. The creation of a social vulnerability-based monitoring system can increase community awareness and resilience. The establishment of social vulnerability indices, which aid in pinpointing the most vulnerable regions and major causes of social vulnerability, is a necessary step in including and quantifying human factors in hazard research. Critical markers that affect societal susceptibility to flooding include coping skills, demographics, health, land tenure, neighborhood characteristics, risk perceptions, and socioeconomic level, including income, wealth, education, and occupation [9].

2.4.2.1 Data Source and Methods:

Numerous academic fields, including engineering, geography, hydrology, and social sciences, can be used to approach hazard studies. Engineering, geographic, or hydrological methodologies are frequently used to evaluate a hazard's physical vulnerability, while the social sciences approach focuses on including the human factor in vulnerability analyses. The spatio-temporal changes in flood susceptibility are analyzed using geographical methods like remote sensing and GIS. One such method that makes use of Arc GIS is the Inverse Distance Weighted Method [10]. Additionally, the National Bridge Inventory's secondary data has been used to address the vulnerability of coastal bridges to coastal floods [11].

2.5 URBAN FLOODING MITIGATION TECHNIQUES:

Urban flooding mitigation techniques are explained below:

2.5.1 Introduction

Natural permeable surfaces have been replaced by impermeable surfaces like roads, pavements, and roofs as a result of urbanization. Rainfall has been transformed into runoff as a result, which the local sewage system then removes. Urban flooding can happen after heavy downpours when the city's sewer system is unable to handle the extra runoff. It has been suggested to manage rainfall on-site by holding, detaining, infiltrating, harvesting, evaporating, transpiring, or reusing it in low-impact construction and water-sensitive urban design initiatives to lessen this issue.

Urban flooding still continues to be a big unsolved issue despite these suggestions. This has prompted a study of methods for reducing runoff by going through infrastructure built above ground, at ground level, then underground in that order. Green roofs, non-vegetated roofs, permeable pavements, water-retaining pavements, infiltration trenches, trees, rainwater harvesting, rain gardens, vegetated filter strips, and swales are some of these widely used approaches. Despite the fact that these methods work in different ways, they all efficiently reduce runoff during light rains but cause overflow during heavy rains. Furthermore, the majority of these methods necessitate sizable land areas for construction.

The evaluation ends by emphasizing the need for the creation of innovative discharge-controllable facilities that can reduce the peak flow of urban runoff by lengthening the time that the runoff discharge occurs. The issue of urban floods brought on by the substitution of naturally permeable areas with impervious ones can be addressed in part by doing this. Creating sustainable solutions that strike a balance between the demands of urban expansion and the desire to lessen the adverse effects of urbanization on the environment is crucial overall.

The review concludes by highlighting the requirement for the development of novel discharge-controllable facilities that can lower the peak flow of urban runoff by extending the period during which the discharge occurs. This can somewhat alleviate the problem of urban flooding caused by the replacement of naturally permeable zones with impermeable ones. It is essential overall to develop sustainable solutions that strike a balance between the need for urban growth and the aim to decrease the negative environmental consequences of urbanization.

Even open soils are vulnerable to runoff in metropolitan settings because building operations compress the soil, which causes it to function like an impervious surface. Conventional designed facilities like as gutters, channels, and pipelines are constructed to efficiently transfer rainwater from sealed surfaces to centralised detention ponds, retention structures, or local waterways in order to alleviate the runoff problem. The huge quantities of runoff from various sealed surfaces, however, are frequently too much for these facilities to handle during severe rainstorm events, resulting in overflow and floods [14,15].

Overall, the natural water cycle has been considerably impacted by urbanisation, increasing runoff, a key contributor to urban flooding. Alternative strategies, like low-impact development and water-sensitive urban design, have been suggested to retain, detain, infiltrate, harvest, evaporate, transpire, or reuse rainwater on-site because conventional engineered facilities are insufficient to manage the problem effectively. To successfully minimise peak flows of urban runoff by prolonging the runoff discharge period, unique, discharge-controllable infrastructure must be created [16].

Runoff can be controlled above, on and below the ground.

Table 1. Runoff can be controlled above, on and below the ground.

Runoff-Control Sites	Facilities
Above the ground	green roofs, non-vegetated roof
On the ground	trees, pervious pavements, water-retaining pavements, infiltration trenches, rain barrels, rainwater tanks, bioretentions
Below the ground	soakaways, and underground cisterns

Fig 2.7: Runoff Control Techniques

2.5.2 Above Ground Techniques

Some of the above ground techniques for mitigation of urban flooding are as follows:

2.5.2.1 Green Roofs

Vegetation and a growth media are added to conventional roof structures to create green roofs, often referred to as vegetated roofs, natural roofs, or eco roofs. The plants, a growth medium, a filter layer, a drainage layer, a root barrier, and a waterproof covering are the six layers that commonly make up a green roof. Together, these layers offer a green and lasting alternative to conventional roofing techniques. They are the most prevalent kind of green roof and have many advantages, including lowering the impact of the urban heat island, enhancing air quality, and supplying a habitat for insects and birds. They are the most prevalent kind of green roof and have many advantages, including lowering the impact of the urban heat island, enhancing air quality, and supplying a habitat for insects and birds.

Extensive and intense green roofs are the two primary varieties. Extensive green roofs have a substrate depth of 10 cm or less and are designed for light-weight, low-maintenance plants like sedums, grasses, and herbs.

A thicker substrate layer and a wider range of plants, such as trees, bushes, and even little gardens, are supported by intensive green roofs. They are less popular and need more upkeep than vast green roofs, but they can provide further advantages including better stormwater management and increased biodiversity. Additionally, by retaining rainwater on the roof surface and releasing it gradually, green roofs can decrease stormwater runoff, provide habitat for wildlife, and improve the aesthetic appeal of urban landscapes.

Numerous environmental advantages are provided by green roofs. Buildings receive thermal insulation from them, which lowers energy expenditures and boosts energy effectiveness. Additionally, they enhance air quality by removing carbon dioxide and other pollutants like dust.

Urban regions are using green roofs more frequently as a means of developing environmentally friendly infrastructure. They provide a special remedy for the problems caused by urbanisation and climate change and may contribute to the development of more resilient and sustainable cities [17,18].

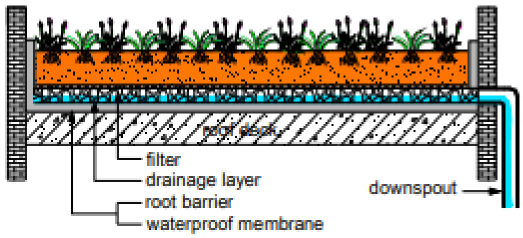


Fig 2.8: Rainwater falling on a green roof is retained and detained by plants and soils; additional rainfall leads to overflow.

2.5.2.2 Intensive Green Roofs

A more extensive substrate layer on an intense green roof enables the development of taller plants, trees, and shrubs, which can result in a more varied and aesthetically pleasing landscape. An intense green roof is less frequently utilized in metropolitan settings than an extended green roof because it costs more to build and requires more periodic care than an extensive green roof, which generally has a shallower substrate layer and is covered in low-growing plants.

Intensive green roofs have been found in studies to be an efficient way to lessen runoff during rainy events. A Manchester, UK research that tracked the runoff from an old, dense green roof over the course of 69 rainfall events discovered that the roof retained an average of 67.5% of the runoff. Kolb also investigated the evaporation and runoff coefficients of intense and comprehensive green roofs and discovered that the intensive green roof evaporated at a faster rate but discharged less runoff.

In a second research, conducted by Razzaghmanesh and Beecham, the hydrologic performance of extended and intense green roofs was tracked for two years. It was discovered that the effectiveness of both types of green roofs in lowering runoff was comparable. However, they also discovered that compared to the extensive green roof, the intensive green roof was able to Amore effectively and for a longer period of time attenuate the peak flow of runoff.

Intensive green roofs have several restrictions while being excellent at lowering runoff. They can be more expensive to install and maintain because they need a deeper substrate layer and more regular maintenance than extensive green roofs. An intense green roof may also need additional structural support due to the weight of the soil and vegetation, which would raise the cost of construction [19,20].

2.5.3 Ground Surface Techniques

Some ground surface techniques for urban flood mitigation are mentioned below

2.5.3.1 Permeable Pavements

The creative use of permeable pavement techniques to control stormwater runoff in urban settings. They are made to let water seep into the earth below as opposed to having it be transported away by traditional drainage systems. These systems comprise of an open-graded gravel or stone base layer, followed by a permeable surface course. In order to keep water-carrying tiny particles from getting into the base reservoir, a filter cloth is often installed at the bottom of the surface course.

Compared to conventional pavement systems, permeable pavement systems provide a number of advantages. They can lessen the quantity of stormwater runoff that enters the sewage system, which is one of their key advantages. This lessens the possibility of floods and prevents sewer overflows. Pavements that are permeable are also beneficial. By enabling water to seep into the earth and rehydrate groundwater sources, permeable pavements also aid in the restoration of natural hydrology.

The ability of permeable pavement solutions to reduce the impact of urban heat islands is another advantage. Traditional pavement surfaces have a tendency to absorb and hold heat, raising the temperature in metropolitan areas. On the other hand, permeable pavements permit water to evaporate from the surface, which can aid in cooling the surrounding air.

Tire-pavement noise can be reduced with the use of permeable pavement solutions. High amounts of noise from vehicle traffic can be produced by conventional pavement surfaces. But a portion of the noise generated by car tyres is absorbed by permeable pavements, which can aid in lowering total noise levels in metropolitan areas.

Finally, water purification is an additional advantage of permeable pavements. The soil and plants may naturally filter water as it seeps into the ground, which can assist to eliminate contaminants and enhance the quality of the water.

Overall, stormwater runoff in urban areas may be managed sustainably with permeable pavement solutions. They provide a number of advantages that can help to better the environment's quality of life as well as the health and wellness of city dwellers.

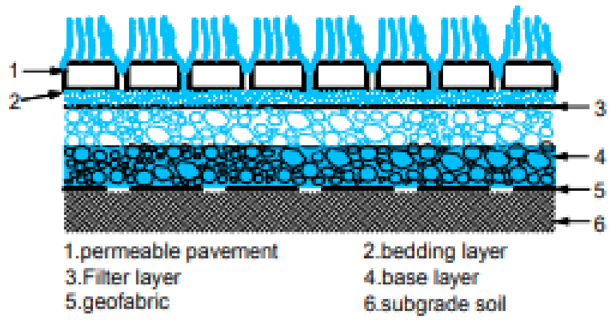


Fig 2.9: Rainwater falling on a permeable pavement is infiltrated to the base, which serves as a reservoir to store water

2.6 URBAN FLOODING IN PAKISTAN AND SOUTH ASIAN REGION:

In many Pakistani cities, urban flooding is a recurring problem, especially during the monsoon season, which lasts from July to September. Due to urban floods, Karachi, Lahore, and Peshawar are among of Pakistan's worst-hit cities. Numerous causes, such as insufficient drainage infrastructure, encroachment on natural drainage channels, deforestation, and unchecked urbanization, aggravate the situation.

The lack of sufficient drainage infrastructure in Pakistan is one of the main reasons of urban floods. In many metropolitan areas, drainage systems are frequently clogged by solid waste and debris, which causes waterlogging and floods after heavy rainfall. Additionally, the drainage systems are not built to handle the increasing water volumes brought on by unchecked urbanization, which is a factor in the regular occurrence of urban flooding.

The encroachment of wetlands and natural drainage routes is a key contributor to urban floods. Wetlands and natural drainage channels are crucial components of a city's natural drainage system because they significantly influence how much water flows. Urban flooding has resulted from the severe reduction in these places' ability to handle surplus water brought on by encroachment and filling for urban growth.

In Pakistan, urban flooding is also a result of deforestation. Deforestation has decreased the soil's ability to absorb water, increasing surface runoff and urban floods. Trees and vegetation are crucial for preserving soil structure and holding precipitation.

Uncontrolled urbanization has resulted in the construction of houses and structures on low-lying regions and natural drainage systems in Pakistan. This has drastically decreased these places' ability to absorb extra water and increased the likelihood of urban floods.

In Pakistan, the effects of urban floods are significant. Floodwaters invade homes, resulting in property damage and, occasionally, fatalities. Road and transport network flooding disrupts daily life and reduces production and income. Urban flooding has negative effects on the environment and public health as well.

The Pakistani government has taken a number of actions to address the problem of urban flooding, including investments in infrastructure and the establishment of new rules and regulations. To address the underlying roots of the issue and provide viable, long-term solutions, however, significant work still has to be done. The creation of suitable drainage systems, afforestation, control of urbanization, and preservation of wetlands and natural drainage channels are some solutions to the issue of urban floods in Pakistan.

2.6.1 Increased vulnerability to future flooding

Urban flooding may significantly affect a community, disrupt everyday life, destroy property and infrastructure, and even result in fatalities. As a result of possible damage to or destruction of the natural drainage system after a flood, the affected region may be much more susceptible to further floods. Urban flooding threats may be mitigated, but failing to do so can have serious, long-lasting effects that affect not just the immediate region but also the larger community and economy.

South Asia, an area now dealing with some of the most severe and obvious consequences of global warming, is likely to see an increase in the problem of urban floods as a result of climate change. The current urban infrastructure will be under additional stress and become even more susceptible to flooding as a result of an increase in the frequency and severity of rainfall events, sea level rise, and other climate-related phenomena. Therefore, creating long-term, sustainable solutions to the problem of urban floods is crucial.

Investing in better drainage systems, restoring natural drainage systems like wetlands and streams, reducing impervious surfaces with green infrastructure like permeable pavements and green roofs, and putting in place floodplain management policies and regulations are all effective ways to reduce the risks of urban flooding. Additionally, educating the public and encouraging modifications to decrease solid waste and litter can also aid in lowering the danger of floods.

In conclusion, urban flooding is an increasing concern in South Asia, and it is predicted that climate change will make it worse in the future. It is essential to put into place practical measures to reduce the dangers of urban floods and to provide viable, long-term solutions to this problem.

Here are some potential climatic changes that could occur in South Asia:

1. **Increased temperatures**:

Climate change is predicted to have a big influence on South Asia, which includes nations like India, Pakistan, Bangladesh, Sri Lanka, Nepal, Bhutan, and the Maldives. One of these repercussions will be a rise in temperature. Climate forecasts show that by the end of the century, temperatures in the area might climb by 2 to 5°C, with more frequent and severe heatwaves.

The economics, agriculture, and public health of the area are all predicted to be impacted in different ways by the temperature increase. A large majority of the population works in the agricultural industry, which makes it particularly susceptible to the effects of rising temperatures.

Increased soil temperature, decreasing soil moisture, and a rise in pests and diseases can all result in lower agricultural production and increased food insecurity.

Increased temperatures can seriously harm the public's health in addition to their effects on agriculture. Dehydration, heat exhaustion, and heatstroke can all be brought on by heatwaves, especially in the old and young. Since disease-carrying mosquitoes and other insects flourish in warmer temperatures, the frequency of vector-borne illnesses like dengue and malaria is predicted to grow as temperatures rise.

South Asian nations must take action to cut their greenhouse gas emissions and create plans for climate adaptation in order to deal with the effects of rising temperatures. In order to prepare for heatwaves and other climate-related health concerns, this might entail putting policies into place that increase the use of renewable energy sources, increase energy efficiency, encourage sustainable agricultural practices, and improve public health systems. South Asian nations may lessen the risks and effects of climate change and create communities that are more resilient and sustainable by implementing these actions.

2. **Changes in monsoon patterns**:

From June through September, South Asia, encompassing India, Pakistan, Bangladesh, Nepal, and Bhutan, experiences the monsoon, a seasonal weather pattern that provides rain. For the region's agricultural output and access to freshwater, the monsoon rains are essential. However, the monsoon pattern is anticipated to be impacted by climate change, resulting in more frequent and severe floods and droughts.

The timing and intensity of the monsoons are anticipated to shift in the South Asian area as a result of global warming, according to the Intergovernmental Panel on Climate shift (IPCC). A rise in the frequency and severity of extreme rainfall events, which will result in more frequent and severe floods, is one of the projected effects. Additionally, the IPCC forecasts lengthier droughts in some areas, which might have detrimental effects on agricultural and freshwater supply.

The economy and general health of South Asia may be significantly impacted by changes in the monsoon pattern. Flooding may harm crops and infrastructure, resulting in financial losses and food poverty. Communities may be uprooted by floods, which might cause social and medical problems. Contrarily, droughts can cause a shortage of water and lower agricultural output, which exacerbates food poverty and economic instability.

South Asian nations must create and put into practice efficient water management plans, including water harvesting and storage, flood control measures, and drought-resistant crops, in order to adapt to the shifting monsoon pattern. Additionally, by enabling communities to plan and react appropriately, early warning systems can lessen the effects of catastrophic weather disasters like floods and droughts.

Effective adaptation strategies are essential to reducing the effects on public health, agriculture, and the economy of the shifting monsoon pattern brought on by climate change in South Asia.

3. **Rising sea levels**:

The polar ice caps and glaciers are melting due to the continued increase in global temperatures, which is raising sea levels. Many coastal locations in South Asia, as well as other continents, might be severely impacted by this rise in sea level. India, Pakistan, and Bangladesh's coastal cities are particularly at risk from rising sea levels and the ensuing flooding.

Mumbai is one of the most dangerous cities in India. According to a World Bank research, Mumbai alone might sustain damages of up to $6.4 billion by 2050 as a result of a 100-year flood. According to a 2019 Climate Central assessment, nearly 5 million people in Kolkata may be at danger of yearly floods as a result of sea level rise by 2050

Karachi, Pakistan, is particularly at risk from coastal floods and sea level rise. According to a 2016 report by the International Union for Conservation of Nature (IUCN), Karachi is among the cities in the world most susceptible to coastal flooding as a result of sea level rise.

The threat posed by sea level rise is particularly worrisome in Bangladesh. Because so much of the nation is comprised of low-lying delta plains, even a slight rise in sea level might have disastrous effects. Due to the country's predisposition to floods brought on by the monsoon season's significant precipitation, sea level rise might make the situation worse and force millions of people to relocate.

In general, sea level rise poses a serious danger to South Asian coastal regions, and immediate action is required to lessen its effects. Coastal cities must take action to adapt to sea level rise, including enforcing construction standards that demand homes and other structures be built at higher altitudes and adopting coastal protection measures like sea walls. Sea level rise can also be slowed down by lowering greenhouse gas emissions through sustainable development and the use of clean energy sources.

4. **Increased frequency of extreme weather events**:

Extreme weather occurrences in South Asia are predicted to be significantly impacted by climate change. Due to its high population density, poor infrastructure, and pervasive poverty, this region is especially susceptible to the effects of harsh weather. South Asia has recently witnessed a number of disastrous extreme weather disasters, like Cyclone Amphan in India and Bangladesh in 2020, which seriously damaged infrastructure and claimed lives.

Extreme weather events are predicted to occur in South Asia more frequently and more severely as a result of climate change. The frequency and intensity of severe precipitation events in the area are expected to rise, according to the Intergovernmental Panel on Climate Change (IPCC). This may result in more frequent and severe floods, landslides, and mudslides, which can seriously harm property and infrastructure and cause fatalities.

In addition, climate change is predicted to result in an increase in the frequency and power of tropical cyclones in the Arabian Sea and Bay of Bengal. Infrastructure and towns along the shore might suffer severe harm as a result. Additionally, according to the IPCC, heatwaves and droughts would probably increase in frequency and severity in South Asia, which could have a substantial effect on agriculture and public health.

Governments and communities in South Asia must act to create more resilient infrastructure and create early warning systems to inform people of possible risks in order to lessen the effects of extreme weather occurrences. To lessen the effects of climate change and stop future extreme weather events from becoming even worse, efforts should also be done to limit greenhouse gas emissions.

5. **Glacial melt**:

South Asia has a big population, a high rate of poverty, and a reliance on natural resources for subsistence, making it one of the world's areas most vulnerable to the effects of climate change. The melting of the glaciers in the area, especially in the Himalayas, is one of the most severe effects of climate change on South Asia. Millions of people depend on the Himalayan glaciers for their water, and their melting is increasing the danger of flooding and, over time, reducing the amount of water available.

Because of the increased temperatures brought on by climate change, glaciers in the area are melting more quickly. Glacial lake outburst floods, which happen when meltwater accumulates in glacier-fed lakes and forces the lake to breach its natural barrier, can result from glacier melting. These floods may be deadly and unexpected, resulting in human casualties and property destruction. Additionally, because many of the major rivers in the area are supplied by glacial meltwater, the melting of glaciers may eventually result in less water being available.

South Asia is not the only place where the effects of melting glaciers are felt. Major rivers in the area, like the Ganges, Indus, and Brahmaputra, also flow into nearby nations including Pakistan, India, Bangladesh, and China. Food security, energy production, and regional economic growth may all be significantly impacted by anticipated changes in water supply and flooding patterns in the area.

Countries in South Asia need to take steps to cut greenhouse gas emissions, build climate-resilient infrastructure, and implement efficient disaster management techniques in order to lessen the consequences of melting glaciers and other climate change effects. This might entail making investments in alternative energy sources, putting into practiced water management plans that allow for future changes in water supply, and creating early warning systems and emergency response plans to lower the likelihood of flooding catastrophes. The problems brought on by climate change in South Asia will require cooperative efforts and international assistance.

2.6.2 Monetary loss in Pakistan due to urban flooding

Urban flooding is a persistent issue in Pakistan that has cost the country a lot of money over the years. According to research done by the Asian Development Bank (ADB) in 2018, urban flooding costs Pakistan's economy over USD 1.2 billion every year.

As we've already established, urban flooding is a persistent issue in Pakistan, especially in the country's largest cities, and it has cost the country a sizable sum of money over the years. Direct and indirect expenses can both be categorized as costs associated with urban floods in Pakistan. The direct costs include the damage to infrastructure, such as roads, bridges, buildings, and other public facilities, while the indirect costs include the loss of income, damage to agriculture, and other economic activities.

According to research done by the Asian Development Bank (ADB) in 2018, urban flooding costs Pakistan's economy over USD 1.2 billion every year. For a developing nation like Pakistan, where resources are few and expenditure on infrastructure, healthcare, and other priorities must take first, this is a significant expense.

Urban flooding may cost significantly in direct expenses to infrastructure and property. For instance, Karachi, Pakistan's largest metropolis, suffered estimated damages of USD 16.2 million in 2014 from urban flooding to its buildings and infrastructure. In 2017, urban flooding in Lahore is thought to have cost the city USD 53 million in damages. Such harm impacts not just private property but also small companies and public infrastructure.

Urban flooding also has considerable secondary consequences. For instance, floods can impede trade, tourism, and other economic operations. It may harm animals and crops, costing farmers and other rural populations their livelihoods. Urban floods can also result in health issues including the spread of waterborne illnesses, which can add to the economic expenses. Public utilities and services like the provision of power and water might also be disrupted, which can have a big impact on the economy.

It is also important to think about how urban flooding affects the ecosystem. Flooding can cause environmental damage, loss of plants, and soil erosion. Long-term environmental deterioration and increased expenses for ecosystem maintenance and restoration may arise from this.

The expense of urban flooding in Pakistan highlights the need for better urban infrastructure and planning to reduce the hazards of flooding. The economic consequences of urban flooding in Pakistan might be decreased with the deployment of efficient flood control measures, such as better drainage systems, early warning systems, and flood-resistant architecture. These actions might help lessen the negative social and environmental effects of floods, such as population displacement, biodiversity loss, and harm to places of cultural significance

Pakistan must move right away to lessen the dangers of urban floods and provide viable, long-term solutions to this expanding issue. Pakistan can lower the financial consequences of urban floods by investing in flood control measures and enhancing urban infrastructure, as well as increase the country's overall climate change resilience.

In conclusion, urban flooding is a big problem for Pakistan and has negative effects on the economy, society, and environment. Government, business, and civic society must work together to find a solution to this problem. Effective urban planning, infrastructure development, and catastrophe risk reduction measures are just a few techniques that may help lessen the effects of urban floods and increase community resilience.

2.7 DIFFERENT DESIGNS OF FLOODGATES

There have been several flood barrier solutions. Some of them are used only for small door and others that may protect entire neighborhoods. We have studied every design method before we designed our solution. The following are different designs which are available.

III. PROPOSED SYSTEM

- **BLOCK DIAGRAM**

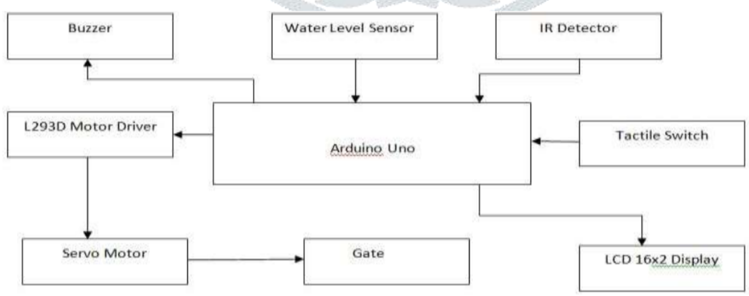


Figure 1: Block Diagram of Proposed System

Fig 2.10

Proposed system consists of water level sensor, tactile switch, L293D motor driver, servo motor, IR sensor.

1. Water Level Sensor

The sensor has a series of ten exposed copper traces, five of which are power traces and five are sense traces. These traces are interlaced so that there is one sense trace between every two power traces. Usually, these traces are not connected but are bridged by water when submerged.

2. Tactile Switch

Tactile switch is a switch whose operation is perceptible by touch. Tactile Switch Functions. Click Response. The click response of the button lets the user feel the response of the operation from the switch.

3. IR Sensor

An electrical gadget known as an IR sensor emits light in order to detect nearby objects. An IR sensor can monitor an object's heat while also spotting movement. Typically, all items emit some kind of heat radiation in the infrared range.

This block diagram uses an Arduino Uno as the processor. Arduino receives a 9V AC source for power.

The method to open or close gates uses a gear rack system, a DC motor, and a water level sensor to determine the water level. For switching operation, push switches and micro switches are also employed. A level sensor that uses a GSM modem to provide information to the appropriate authorities about the level of water in a dam. The fundamental function of the control unit is to code an Arduino to regulate a water pump. Water pumps are linked to an Arduino output pin using a relay circuit that is linked to a transistor. The level of the liquid will be monitored using a water level sensor. It may be set up to carry out a number of different tasks for various scenarios, depending on the requirements.

2.7.1 FLOW CHART:

The flowchart of the proposed system is given below. The starting conditions all the values are reset. The water level sensor to sense the water level in the dam. If the dam is not to be fill, then the alarm in off condition and the gate valve in closed position. Otherwise, the dam water level increases beyond the limit, the buzzer starts to give an alarm indicating the rise in water level. The message was sent to the person and valve are open automatically after the completion process was stopped.

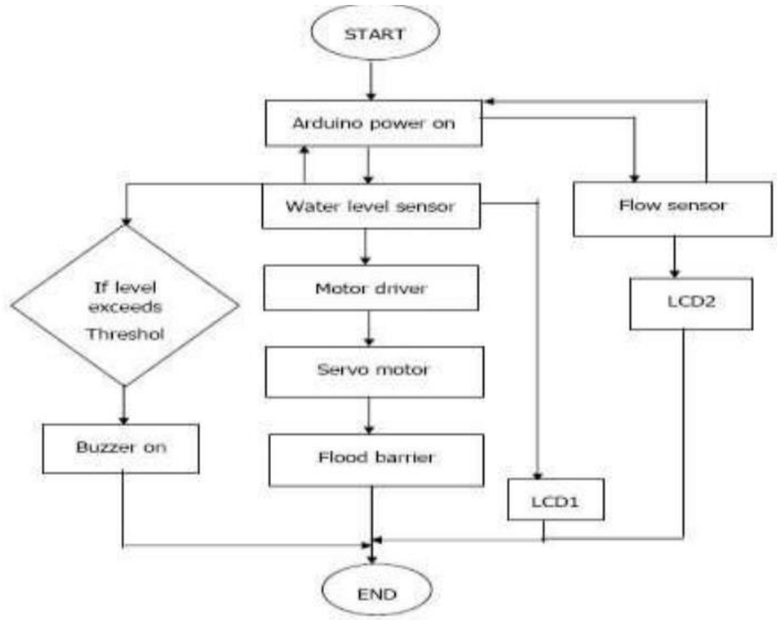


Fig 2.11: Flowchart of Automatic Floodgate [21]

2.7.2 Removable Flood Barrier

Our demountable flood barriers are designed to offer protection levels comparable to those of permanent flood defenses, but have the benefit of being completely demountable when not needed. Almost any form, including arcs, closed rectangles or circles, and straight lines of any length, can have them supplied. The portable flood barrier design may be stepped for steeper grades and utilized on slopes up to 20°. Because of this, our movable flood barriers work great as a continuous flood wall or around building openings. Each system may be designed for flood protection heights up to 4m and is load calculated depending on application and the current flood conditions. Up to 3m single spans are feasible.

For apertures that could completely submerge, a four-sided detail is offered. We may provide pre-formed ground plates with built-in anchors for the demountable supports to simplify installation in new construction. Drill and fix anchor sockets can also be offered as an alternative for inconspicuous fixing through completed paving [22].

2.7.2.1 Glass Floodwalls

The most effective flood defences for glass walls have been created by Flood Control International, and they can survive almost any flood situation. The latest Hard Body Drop Test video is included below. Where flood protection is needed, glass barriers may be installed without any operational input and with little visual intrusion. Each glass barrier makes use of a mix of engineering frameworks made to handle the static and impact stresses of the given site, carefully developed waterproof sealing technology, high strength structural glass, and structural anchoring systems. conventional flood protection heights of up to 1.8 metres. As a consequence, there is a nearly transparent glass barrier that doesn't reduce visual amenity and may be utilised as a first line of direct flood defence without the requirement for external buffers, sacrificial panels, or other deflection mechanisms [22].

2.7.2.2 Flip- Up Flood Barriers

The automated barrier is completely sunk into the ground when not in operation to provide unfettered access to pedestrian and vehicular entries. This flood barrier may be manually raised to flood defence heights of 2 metres and up to lengths of 12 metres when activated by a push button, automatically by sensors, or both [22].

2.7.2.3 Drop-Down Flood Barriers

The drop-down flood barrier is discretely positioned above the head of the aperture when not in use and is prepared to be lowered at a moment's notice. This effective, trustworthy flood defence system may be activated by automatic sensors in the event of increasing floodwaters, push button operation to keep you in control, or manual override [22].

2.7.2.4 Self-Closing Flood Barriers For Buildings

These cutting-edge flood barriers operate and are raised into position by the hydrostatic pressure of the increasing floodwater. They are perfect for unmanned sites, particularly those near rivers because they don't require external power or assistance.

The automated flood control techniques are a novel and efficient way to reduce the risk of major flooding. Without the need of any human or other energy, the automated flood control is operating.

The automated flood control device is thoughtfully constructed as a self-rising flood gate in response to an increase in flood water levels. The design raises the barrier automatically as floodwaters approach. This type of defence is perfect for unmanned sites where aesthetic concerns make a permanent barrier unacceptable or where there would not be enough time or manpower to manually install barriers because of its automatic operation and minimal footprint without the need for steps or ramps.

It operates without the use of electricity, requires no human input, and offers complete protection around-the-clock. The barrier will only rise in a flood event because to the short closure time. No need for pointless autumn deployments. As a result, access is still possible in the region [22, 23].

1. When a storm or heavy flood occurs the water level increase
2. If water level increases, the water enter into efficient water storage space through the inlet valve.
3. The increasing water level in the outer area and pressure in the inlet valve also increases
4. This causes the height of water in the efficient storage space to increase.

5. When the water level touches at peak of storage space water enters into flood gate inlet.
6. Water in the flood gate inlet make a pressure on the bottom of flood gate .That pressure raises flood gate up to
7. the desired level.
8. The floodgate limit stopper locks base of the floodgate without leaking water
9. When water level decreases in the outer area, pressure in the inlet valve decreases. Then flood gate will descent downwards.
10. Water then passes through the inlet and results in the opening of one way valve
11. The barrier usually resides below ground in a vertical position within a steel or concrete trough the barrier consists of a rigid foam core and a GRP outer layer.

2.7.2.5 Sand Master

The very ancient system is an extraordinary mechanism that US Company uses to supply massive numbers of sand bag bins. The sand master gives sand bag bins a far higher chance of finishing the preparations before the onset of a flood because to its high output rate. This amazing machine can produce 4800 sandbags in only eight hours. The sand master is first secured to empty bags using a speed lock. The sand master is prepared to continue once the trigger-activated tension rings have snugly secured the bags in position. The sand master fills empty bags that are already tightly secured to the machine by ploughing directly into the sand. This type of defence is perfect for unmanned sites where aesthetic concerns make a permanent barrier unacceptable or where there would not be enough time or manpower to manually install barriers because of its automatic operation and minimal footprint without the need for steps or ramps.

Fig 2.12: Illustrates the mechanism of sand master

2.7.2.6 Dam Easy

Due to the unpredictability of the weather, a flash warning effect might happen suddenly. This quick and simple barrier employs a special compaction seal to totally cover at a potential of water leaks in valuable home environment and can be installed in a matter of minutes without the need of an excessive number of brackets. Installing the dam easy barrier only requires three straightforward actions. The first step is to place the barrier in the gap just next our entrance. The wren side panels must then be used to secure the structure. This offers coverage for all door reveal spaces at a distance of 1.1 metres. The barrier installation is completed by inflating the seal using the compaction handle. For broader spaces that call for the use of various barriers, we can add extension poles and perform some concrete work for the area. To avoid dampening, a security cover is furthermore offered [22,23].

Fig. 2.13 and 2.14 illustrate the arrangement of dam easy barrier

2.7.2.7 Water Bloc

It is a really basic flood barrier, yet it works wonderfully well. Any water that is headed in that direction is essentially stopped by the water bloc. Protecting houses and even entire neighborhoods is done with the help of this incredibly effective flood barrier. The water bloc behaves precisely as its name suggests when water is present. It is blocked. It is constructed with high-strength PVC textiles that are intended to maximize tensile strength, punch resistance, etc. The water bloc is a tube-shaped building that includes [22,23].

Fig 2.15: Illustrates the arrangement of water bloc barrier

2.7.2.8 Flood Break

The complete set of flood gates automatically close, protecting pedestrians from floods at street level. These gates self-deploy without any type of oversight or human activation. These gates open normally without supervision or any other type of human activity. The gate maintains its architectural integration with the local infrastructure under typical circumstances. When a flood occurs, the rising water produces the hydrostatic pressure necessary for the gate to open and elevate solidly into place. Additionally, the rising water activates the surrounding infrastructure's self-integrated architecture. When a flood occurs, the rising water generates the hydrostatic pressure necessary to open and raise the gate securely in its position. Self-ceiling rubber caskets are also activated by increasing water [22,23].

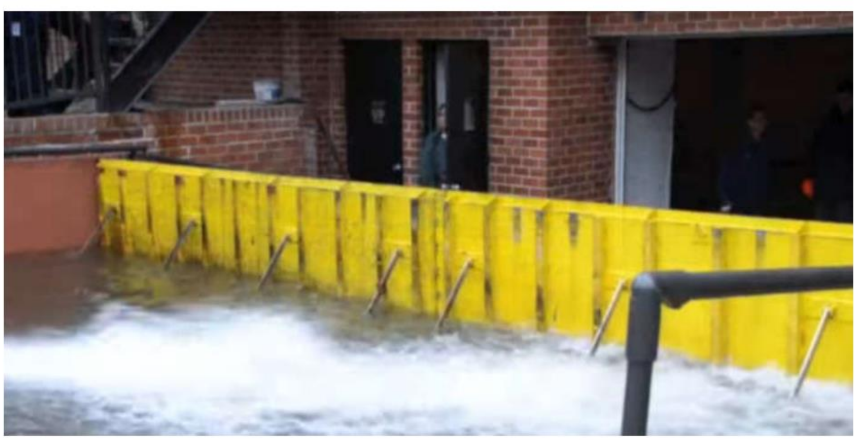


Fig 2.16: Illustrates the mechanism of flood break barrier

The flow defense system employs a tiny grate to place it with the surface directly in front of the concealed barrier assembly in order to generate the water pressure necessary to raise the barrier.

Flood waters fill the barrier with enough water as they enter the grate to float it upward into the proper position. In addition to providing four times the flood protection at a significant reduction in labour, maintenance, etc., the flow defence barrier also automatically lowers when the flood water recedes [22,23].

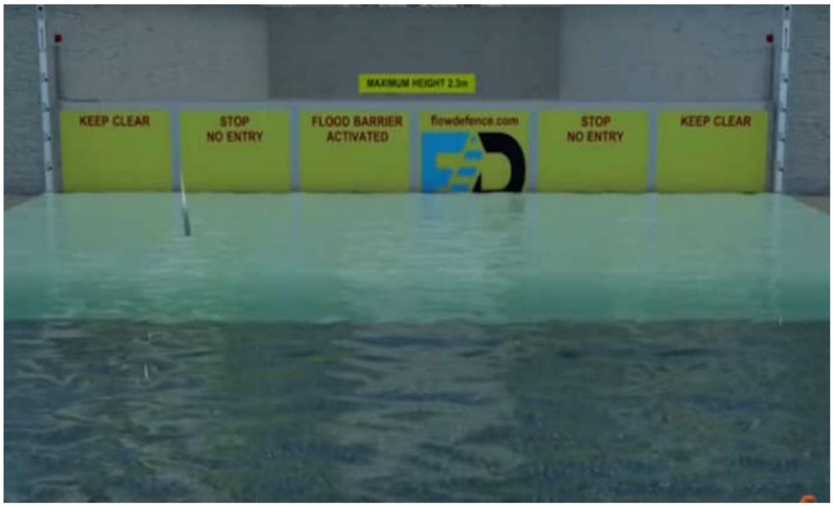


Fig 2.17: Illustrates the mechanism of flow defense flood barrier

2.7.2.9 NAOQ Flood Barrier

Two separate barriers are part of the NAOQ flood fighting system, which allows for significantly speedier defence while requiring less labour. The NAOQ box-wall BW 50 is a free-standing flood barrier that is kept in place by the weight of the floodwater. The BW 50 can be assembled by one person and is made of lightweight, portable block parts. Figure 7 depicts the BW 50 box, which is incredibly effective. It may be joined by simply two persons because it is broad enough. The NAOQ tube wall is made up of air-filled tube-shaped pieces that are placed in a chain-like integration with a skirt that is also fastened to the ground by floodwater. The tube walls function the best. Nowadays, it is used worldwide [22,23].

Fig. 2.18: Illustrates the mechanism of NOAQ flood barrier

2.7.2.10 Rapidam

It is a flood prevention strategy that may be used fast. Flooding situations provide residents with a greater opportunity to safeguard their residences, places of business, and reliable infrastructure. It is constructed from a unique PVC fabric that can only be rolled up properly by two or three persons. The free-standing models come in separate 10m parts that may be joined to create a 20m section, which can be set up in approximately 15 minutes [22,23].

Fig. 2.19: Illustrates the mechanism of Rapidam flood barrier

This arrangement's height may be in the 180–1800 m range [22]. After raising the upper barrier piece, specialized screw anchors are used to fasten the weeding edge. The flood maintains the barrier in place because of the weight of the water. The rapidam version, which is fastened to the grant by stainless steel bolts, needs a concrete beam to be set up. When the rapidam is rolled up, the bolts that were previously screwed into the concrete are removed. Per metre, it can keep back a tonne of water [23].

2.7.2.11 Flood Block

One person can easily deploy this strong, adaptable flood barrier. The flood block may be calculated in any desired length and direction. Its amazing ability to produce closed corners makes it ideal for forming a variety of forms. This makes it possible for a home or company to employ the flood block throughout. Flood block units have the ability to automatically fill as flood levels rise. Flood bricks are incredibly quick to install, lightweight, and stackable. The flood block is prepared to stop the water whenever the level of the water increases thanks to its practical mobility and conformable design [22,23].

Fig 2.20: Illustrates the mechanism of Flood Block flood barrier

2.7.2.12 Self Activating Flood Barrier (SAFB)

The Self Activating Flood Barrier (SAFB), a device made by UK Flood Barriers, is described as a floating entrenched wall that stays recessed under normal circumstances. The basin in front of the flood barrier fills up as flood waters start to climb, raising the wall. The barrier locks into a watertight state after the basin is filled. The manufacturer estimates the SAFBs' lifespan to be between 50 and 100 years, and they come with telemetry systems that will alert users when they are triggered. One barrier can be as long as 50 metres (164 feet) [23]. Depending on the location, expenses might vary, but the average, including installation fees, is $10,200 per square metre. Prior to installation, the business undertakes thorough evaluations of the locations [23].

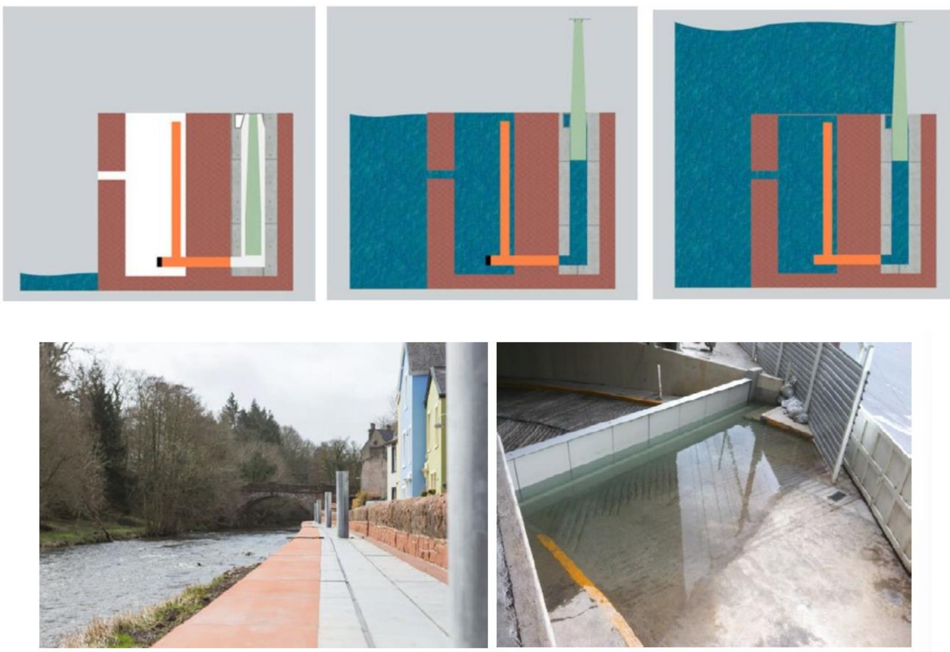


Fig 2.21: Self Activating Flood Barriers

2.7.2.13 Aquafragma

Aquafragma is a self-operating barrier that, like FloodBreak, is triggered by hydrostatic pressure and pushes a gate upright using a buoyant hinge mechanism. Aquafragma, in contrast to Floodbreak, is completely attached to its ground plate and does not require permanent sidewalls, allowing for a more flexible deployment. Aquafragma can be utilised along waterways, such as rivers, canals, or seaside promenades, or in front of building doors. Upon activation, the barrier sends warnings. Depending on the area it is intended to secure, the barrier may be constructed to any width and can be utilised with or without sides (for instance, it might secure subway, basement or road entrances). One continuous barrier plate and several series of "operating bodies" would be used in a longer deployment to push the gate higher [23].

CHAPTER 3: METHODOLOGY

This chapter represents the methodologies that have been employed for the design of different components of floodgates.

All techniques used to lessen or stop the destructive impacts of flood waters are referred to as flood control. Installing rock beams, rock rip-raps, sand bags, maintaining normal slopes with vegetation or using soil cements on steeper slopes are a few of the basic flood control strategies. Other methods include building or expanding drainage systems. Dyes, dams, retention basins, and detention are further techniques.

Some flood control techniques have been used since ancient times. These strategies include creating alluviums (man-made channels to divert water from floods), growing plants to retain surplus water, creating terrace slopes to minimize slope flow, and erecting dykes, dams, reservoirs, or holding tanks to store additional water during flood events.

Flood-prone rivers are frequently carefully maintained in various nations. Dams, reservoirs, and dykes are used as defences to prevent rivers from overflowing. A dam is one of the flood protection techniques that, in comparison to other techniques, lowers the danger of flooding by aiding in damage prevention. To lower the danger of an embankment collapsing, it is advisable to combine dykes with other flood control measures. Emergency defense systems like sandbags or transportable inflatable tubes are employed in case these defense systems fail.

The engineering works that can prevent and mitigate the effects of floods are as follows:

1) Steel pipes should be installed on highways to direct water from catchment basins away from the road.
2) The development of enormous swimming pools, which are massive subterranean water tanks to store the waters, would go a long way towards easing the severe flooding problems in a city where most of the land has been paved.
3) Requiring the installation of permeable drainage flooring in large parking lots in malls, supermarkets, and movie theatres in order to let water penetration in some areas of the ground, the same as is required for monuments and areas surrounding structures.
4) Using gutters and drains to direct rainfall away from all dwellings and towards a storage or disposal location.
5) When feasible, maintaining some green spaces to ensure that the soil can absorb the water again.
6) River and stream rectification, as well as the enlargement of great rivers' containment basins by the building of dams and canals.

Caring to avoid flooding in urban areas is, as follows:

1) Keeping streets and sidewalks always clean.
2) Cleaning and unclogging manhole and storm drain.
3) Keeping in the houses the channels and other channels of rainfall free of branches and leaves of trees to avoid clogging and, consequently, return of water.
4) Putting garbage bags on the sidewalks only near the time the garbage collection truck will come, preventing them from being drawn into the manhole when it rain.
5) Having a drain pump on hand if flooding cannot be avoided
6) Using Dutch and British flood proof technology as a floating amphibian house that allows buildings to float in the same way as a boat.

Hydrological experts recommend that, in order to avoid flooding in urban areas, the following measures should be adopted:

1) Reducing sedimentation of natural drainage and built-up by rigorously and extensively controlling soil erosion, irregularly disposing of urban waste and building debris, and enlarging river gutters.

2) Fighting waterproofing by constructing residential and commercial reservoirs and expanding green spaces.

3) Disallowing travel on busy streets when surrounding rivers are overflowing.

4) The planting of avenues lined with vegetation so that water that overflowed rivers or streams would be absorbed by the soil without pavement.

5) Building large rainwater-collecting swimming pools as well as little pools within homes and other structures.

6) Investing in the city's small and major streams to sustain the increased water demand and serve as containment barriers.

7) Examining inhabited regions and planning for future land usage.

8) Action and planning: creating a strategy to deal with floods and other catastrophic climatic changes, building reservoirs that can hold billions of cubic metres of water, and using that water for non-potable uses.

3.1 INTRODUCTION:

In many cities throughout the world, including Lahore and Rawalpindi in Pakistan, urban flooding has become a serious problem. Devastating floods have disrupted inhabitants' everyday life and seriously damaged property and infrastructure due to the increased frequency and severity of rainfall events mixed with poor urban design and infrastructure. A thorough assessment was carried out to determine the extent of the issue, pinpoint the impacted regions, and compile information on the socioeconomic and environmental effects of flooding in Lahore and Rawalpindi in order to better understand the effects of urban floods.

3.2 SURVEY PROCEDURE:

Survey Procedure for assessing the Impacts of Urban Flooding in Lahore and Rawalpindi is as follows:

3.2.1 Define the Study Area:

Define the boundaries of the study area to be surveyed. For this study, Lahore and Rawalpindi were selected as study areas.

3.3.2 Identify the Stakeholders:

Identify the stakeholders who are directly or indirectly affected by urban flooding. This may include residents, business owners, emergency responders, city officials, and other relevant groups.

3.3.3 Develop a Survey Instrument:

Develop a survey instrument that captures the key information needed to assess the impacts of urban flooding. This may include questions on the extent of flooding, duration of flooding, property damage, health impacts, economic impacts, and recovery efforts.

3.3.4 Pre-Test the Survey Instrument:

Pre-test the survey instrument with a small group of individuals from the study area to ensure that the questions are clear, understandable, and relevant to the local context.

3.3.5 Identify and Train Surveyors:

Decide who will administer the survey instrument to respondents, and train them. The research region should be familiar to surveyors, and they should be able to interact with respondents efficiently.

3.3.6 Conduct the Survey:

Conduct the survey by distributing the survey instrument to a sample of people who are reasonably representative of the research region. These might be conducted over the phone, online, or even door to door.

3.3.7 Analyze Survey Results:

Use the right statistical methods to analyze the survey findings and find patterns and trends in the effects of urban floods in the research region. Calculating averages, frequencies, and percentages may be required.

3.3.8 Interpret Survey Results:

To determine the effects of urban floods in the study region, interpret the survey data. This might entail determining the most impacted regions, impacts, and appropriate countermeasures.

3.3.9 Communicate Findings:

Inform stakeholders, decision-makers, and the general public about the survey's findings to increase awareness of the effects of urban floods and the need for action to solve this problem. This could entail writing reports, delivering research at conferences, and interacting with the neighborhood press.

3.3 CONDUCTING THE SURVEY:

The survey was conducted in two major cities of Pakistan, Lahore and Rawalpindi. The following steps were undertaken to carry out the survey:

Study Design:

A systematic questionnaire was used in the survey to gather primary data from the impacted areas. The questionnaire was created after doing a study of the literature on pertinent research on urban flooding and was intended to gather data on a number of different topics, such as the severity and frequency of floods, effects on homes, infrastructure, and the environment, and coping mechanisms.

Sampling:

The places to be surveyed were chosen using a purposive selection approach. The decision was made based on the frequency and seriousness of floods in the cities. To provide a complete picture of the effects of floods, both residential and business sectors were surveyed. In all, 30 families in Lahore and 80 in Rawalpindi were surveyed.

Data Collection:

The standardized questionnaire was given to the chosen homes by trained enumerators. The inhabitants of the chosen houses were interviewed in-person to conduct the questionnaire. The poll covers a number of topics, such as demographics, past floods, effects on homes and infrastructure, coping mechanisms, and suggestions for reducing the effects of urban flooding.

Data Analysis:

Descriptive statistics were used to analyse the survey data and produce quantitative and qualitative conclusions. While content analysis methods were used to analyse the qualitative data, statistical software was used to analyse the quantitative data. To give a thorough knowledge of the effects of urban floods in Lahore and Rawalpindi, the data were then presented in tables, infographics, and narratives.

The survey was carried out close to Muslim Town Flyover in Lahore and Nulla Leh Rawalpindi in regions impacted by urban floods.

The stratified random sampling technique was employed to guarantee that the sample was representative of the population. Based on factors including geography, age, gender, and socioeconomic position, the target population was separated into strata, and within each stratum, random sampling was carried out.

A structured questionnaire containing both closed-ended and open-ended questions was the survey tool that was employed. The purpose of the survey was to learn about respondents' experiences with urban floods, how it affected their lives, and how they saw its causes and potential remedies.

To detect and fix any possible problems with the questions, language, or structure, a pretest of the survey instrument was carried out. The survey was given personally to the chosen sample, and the replies were gathered and recorded in a way that could be simply analyzed.

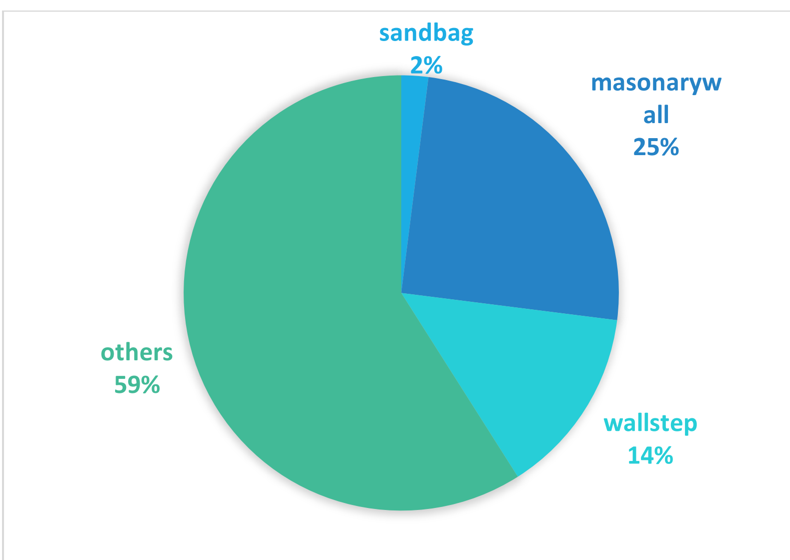
For statistical analysis to find patterns, trends, and correlations between the variables, the data was put into a database.

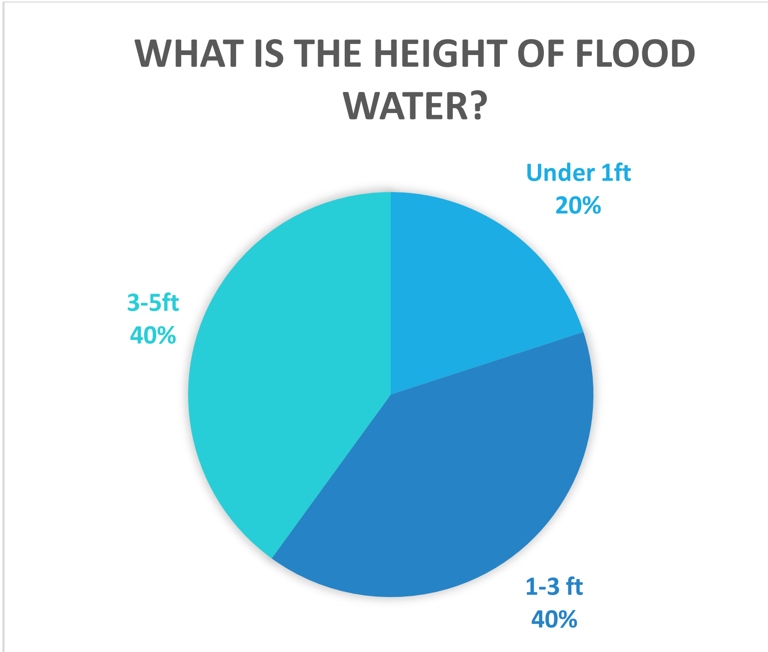
The survey's results were then summarized in a report that also covered the study question, survey design, sampling strategy, survey instrument, data collection techniques, and analytic methodologies. Charts were provided in the report to help visualize the conclusions and suggestions for resolving the problems raised by the survey.

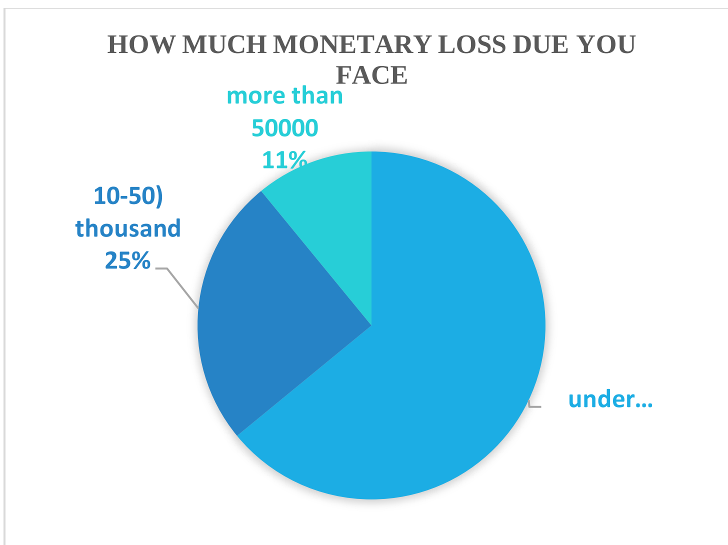
We gathered a total of 110 responses.

Here are some of the questions which we asked in our survey.

Do you follow any of the measures to prevent flood water from entering?







3.4 RESULTS:

The survey revealed significant findings on the impacts of urban flooding in Lahore and Rawalpindi. The key findings include:

3.4.1 Frequency and Severity of Flooding:

The survey found that both Lahore and Rawalpindi experienced frequent and severe flooding events, with the majority of respondents reporting that their areas were flooded at least once a year, and some areas experiencing flooding multiple times a year.

3.4.2 Impacts on Households:

According to the poll, urban flooding has a number of effects on households, including financial losses, property damage, loss of possessions, disruption of daily life, and health risks. Numerous households stated that floods had disrupted their everyday lives, caused damage to their houses, and caused the loss of important goods.

3.4.3 Impacts on Infrastructure:

The report also brought attention to the harm that urban floods can do to infrastructure, such as street roadways, drainage systems, and public utilities. Numerous respondents stated that because to flooding, their communities experienced substantial interruptions in communication, transportation, and access to essential services.

3.4.4 Coping Strategies:

According to the survey, households in Lahore and Rawalpindi used a variety of coping mechanisms to deal with the effects of urban flooding. These included moving to safer areas during floods, keeping valuables in higher places, and asking for assistance from friends, neighbours, and governmental organizations. These coping mechanisms, meanwhile, were frequently ineffective and short-lived.

3.4.5 Recommendations:

Based on the results, the survey suggested a number of actions to lessen the effects of urban floods, including increasing early warning systems, urban planning, and infrastructure, and encouraging community-based disaster risk reduction. This is why we started working on a floodgate design that would enable people to protect themselves from the consequences of urban floods.

CHAPTER 4: DESIGN

The flood barrier is made of iron pipes, sheets, rods and bearings. It is rectangular shaped and works by expanding its 3 wings to completely fit against the walls and floor.

The whole assembly is covered by a neoprene sheet on the front and back. It serves the purpose of sealing the sides as the wings press on uneven surface of wall and floor, waterproofing internals and to move flexibly as the wings expand and move.

Pneumatics are used to move and apply forces.

These are powered by electric water pump and controlled by electric solenoid valves.

The sequence is controlled by a micro controller chip that is pre-programmed.

We will breakdown the HydroGuardian into components to explain detailed working.

4.1 Structure:

Iron pipe running 20cm x 40cm to form a rectangle as shown.

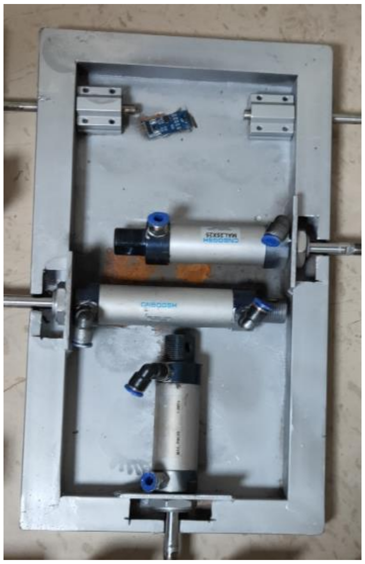


Figure 1 Rear with cylinders

Circular cutouts are made to install pneumatic cylinders.

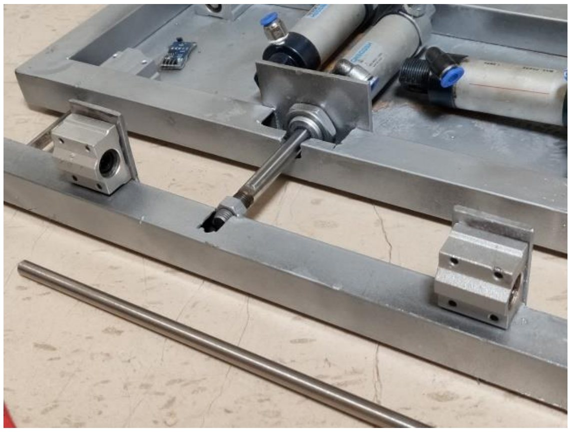


Figure 2 Cutouts for cylinders

A rectangular sheet of 20cm x 40cm is also welded on what is the front side of assembly.

Figure 3 Front with metal sheet

Furthermore, three rods are attached on the three sides sans top side to the pneumatic cylinder. The left and right rods that measure 42cm each also have rods attached on upper parts that goes into a bearing. This helps restrict the degree of movement.

Finally, L shaped pipes are needed to fill in the bottom corners when the wings move out.

Figure 4 L-shaped pipes

The L pipes are installed on a plane above the wings, but the entire perimeter is completely covered.

Figure 5 Side view of L shaped pipe

To help with x axis and y axis movement of L shaped pipes which is necessary, cnc rods and bearings are installed as shown. The rods ensure the L shaped pipe moves in two directions and is always levelled with wings' pipes to create a continuous surface.

4.2 PNEUMATICS

The flood barrier uses pneumatics equipment to apply large forces to make sure that flood barrier is pressed and held firmly. However, instead of compressed air, we will be using water as fluid because of ease of use and simplicity. The pump we use is a 100 psi which is same pressure compressed air is.

Figure 6 100 psi 12v DC pump

To move the cylinder in both directions i.e expand and retract, we used 5-way 2-position pneumatic solenoid valve. Although we only need 4-way 2-position valve, it is not readily available. 5-way valve can also do the job by joining the two exhausts together with T joint.

Figure 7 5/2 way 24v DC solenoid valve

To lock cylinders in their positions, a solenoid valve is installed between cylinder and 5/2 valve. After the wings have expanded, the valve shuts off. Since it is a normally closed valve, it will close when power is cut off, which help ensure that the barrier stays locked even without power.

Figure 8 Unidirectional 12v solenoid valve

A water reservoir is also used to store enough water for all the cylinders' requirements. About 50 ml bottle provides more than enough reserve of water.

Two side cylinders which are 25x50mm are installed in series to synchronize movements. The side cylinders and bottom cylinder which is 25x25mm are installed in parallel. The bottom cylinder has a solenoid valve before it. This helps control the sequence of opening of wings. Bottom cylinder cannot open until the valves open.

Figure 9 Pneumatic cylinder

The schematic of connections is shown below.

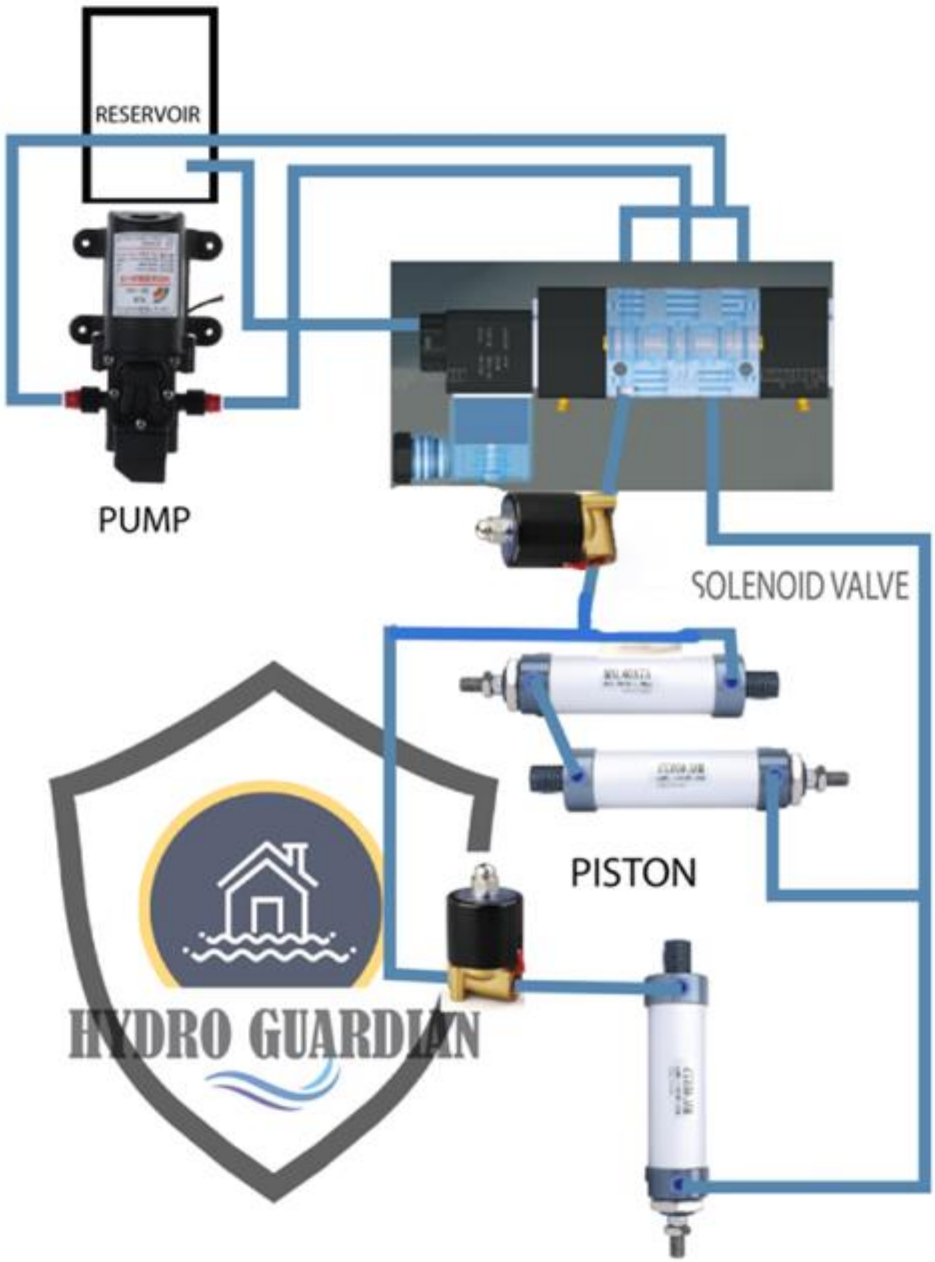


Figure 10 Hydraulics schematics

When installing flood barrier in door, wings are supposed to expand. To accomplish this, 5/2 valve stays in its default position and lock valve opens. Water is pumped from reservoir into 5/2 valve and moves out from outlet 1 from where it feeds into side cylinders 1 and 2. Water coming out from outlet of cylinder 2 moves into outlet 2 of 5/2 valve from where it moves from one of exhaust pipes and finally into reservoir.

After the cylinders have moved to their maximum positions, bottom cylinder's solenoid valve is opened and thus water flows into bottom cylinder, expanding it. The water coming from this cylinder moves into reservoir just like side cylinders.

The sequence of opening if valves is programmed and controlled as illustrated in next section.

Similarly, to close the flood barrier, 5/2 way is switched on so that water from pump now comes out from outlet 2 on 5/2 valve and moves through pipes that were used for exhaust in previous case. Therefore, the cylinders now move in opposite direction. Likewise, the exhaust water now feeds into outlet 1. All the valves are opened from closing flood barrier as sequence is not important.

At 100psi of pressure, each cylinder produces a theoretical force of:

$F=P*A= 100*pi*0.5^2$

$= 78.54$ pounds

4.3 ELECTRONICS

The electronics help control and operate the HydroGuardian in a preprogrammed manner. The main components are water pressure pump, esp8266, relays, battery, switch and a hall effect sensor.

The ESP8266 is a microcontroller that is used to program the circuit. We have used yaml for programming with nodemcu flashed with esphome.

The battery supplies 12v 4.4amps. It can be charged with any USB Type C charger that supplies 12v.

The esp8266 operates on 5v so a step-down dc to dc converter is used to convert 12v to 5v. The pump and solenoid valves operate on 12v; therefore, relays are used to let esp8266 control all the 12v components. The solenoid valves and pump may also commonly operate at 24v which was the case for us. Therefore, we have used a DC Step Up converter xl6009 to boost voltage to 24v from 12v.The pressure pump uses up to 3 amps and solenoid valves use about 1.6 amps each. Ideally more efficient and smaller solenoid valves should be used which draw less power. Pilot valves use a lot less power than direct acting ones and should be preferred.

One hallmark of the design is its simplicity to operate. The user only needs to press a button and the Flood Shield will automatically expand and the completely shut off itself, locked in position.

And later, when it needs to be removed, the user will again just have to push the same button and it will automatically know that it needs to retract, so, it will retract and then again completely shut down. It is a one button operation.

Circuit schematics is as shown:

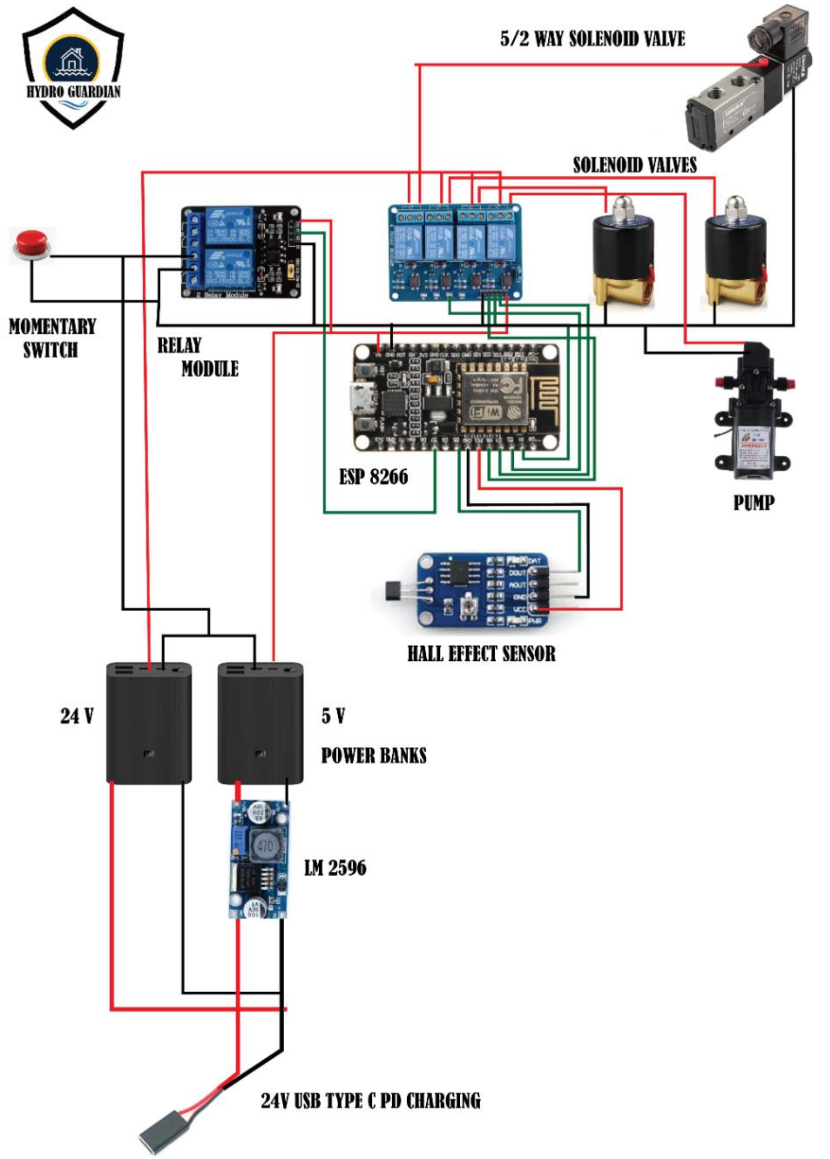


Figure 11 Electronics schematics

To know if Hydro-Guardian is retracted or expanded, a hall effect sensor is used. A small magnet is attached to one of the top rods. When expanded, magnet is out of range of sensor and signal output is low. And vice versa.

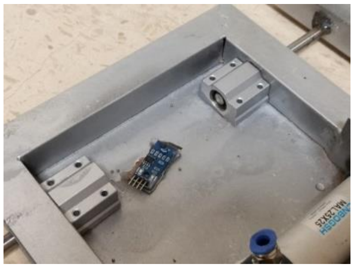


Figure 12 Hall effect sensor

To create a mechanism in which Hydro-Guardian completely shuts off after operation to save battery, a relay is connected in series right after power supply. The switch is connected parallel to the relay as shown. When the switch is pressed the circuit is closed and it also turns on the relay. Since the relay is connected parallel to the switch, it keeps circuit closed even when the momentary switch is released. Therefore, the circuit stays closed. After all the operations are completed, the micro-controller signals the power relay to turn off which effectively opens the circuit so that no power is being used at all when the HydroGuardian is dormant.

Rest of circuit is simple and self-explanatory. A controller esp8266 controls the opening and closing of valves and pump using relays. Esp8266, relays and sensor have separate 5v power supply from 12v power supply for pump and valves because of in-rush current. Inrush current shuts off and restarts esp8266 which is why its power is kept separate.

4.5 Rubber Sheet

Rubber sheet used is Luna Para. It is durable, flexible, and waterproof fabric which is perfect for our requirements. A rectangular pouch of matching dimensions of 28cm x 40cm x 8cm is prepared. The sheet used is 3mm thick. Then the HydroGuardian Assembly is bagged inside and completely covered. The flexible sheet expands as the wings expand outwards and contracts as the wings retract. The rubber nature is also crucial as it also firmer grip on walls when HydrGuardian is pressed against wall. Alternatively, neoprene sheet may also be used.

Figure 13 Luna para rubber sheet

4.6 Manual Model

The manually operated variant will require the user to physically expand or retract it. This will be done with help of jack and screws. To move side wings, the user will wrench a jack fixed in between as shown. And then to move the bottom wing, two screws shown in diagram will be needed to be driven. It can then be retracted in a similar manner.

The whole manual will be very similar to automatic in construction sans pneumatics and electronics.

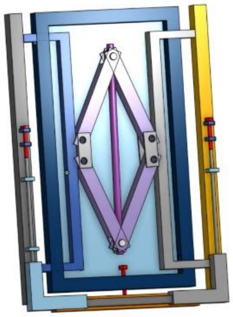


Figure 14 Manual model

4.7 Assembly

The following pictures show the final assembly of HydroGuardian sans rubber sheet.

Figure 15 Rear view with complete assembly except rubber sheet

Figure 16 Rear view when extended

Figure 17 Front oblique view

CHAPTER 5 : DRAWINGS

5.1 MANUAL MODEL:

A manual floodgate is a particular kind of gate used to manage water flow in flood-prone locations. Here is a basic explanation of what a manual floodgate may look like from the front, rear, and side:

5.1.1 Front View:

A manual floodgate's front aspect often reveals a rectangular or square gate constructed of a durable material like metal. Typically, a frame that is fastened to the ground or another support structure is where the gate is attached. The locking mechanism that keeps the gate in place when closed is also visible from the front.

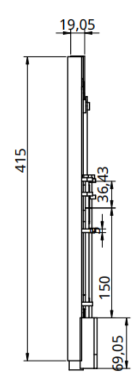
5.1.2 Back view:

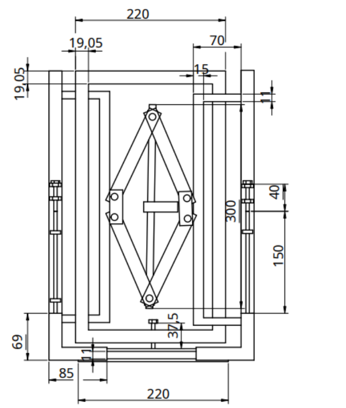
A manual floodgate's underbelly, which may contain bracing or other support structures to boost its strength, is normally visible from the rear. The mechanism that raises and lowers the gate—typically activated by a handle or crank—is likewise visible from the back.

5.1.3 Side view:

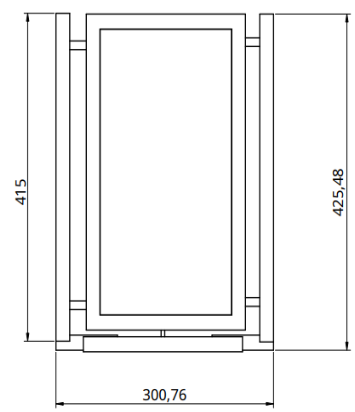
A manual floodgate's profile and frame are visible from the side. Depending on the requirements of the area, the gate may be built to swing open horizontally or glide up and down vertically. The depth of the gate is also visible from the side, which is crucial for confirming that it can resist the force of the water it is intended to endure.

Overall, the manual floodgate's design will be determined by its position and by the requirements of the region it is intended to safeguard. These fundamental concepts, however, provide a rough picture of what a manual floodgate would be like. The side view is given as:

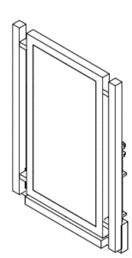




Back View



Front View



Side View (Closed

5.2 AUTOMATIC MODEL:

An automatic floodgate is a type of gate that is designed to automatically control the flow of water in flood-prone areas. Here is a brief description of what the front view, back view, and side view of an automatic floodgate might look like:

5.2.1 Front view:

A rectangular or square gate composed of a durable material, such metal, is often visible from the front of an independent floodgate. The gate is often fastened to a ground-anchored support structure. The front view reveals a decorative neoprene layer that contributes to the floodgate's attractive appearance.

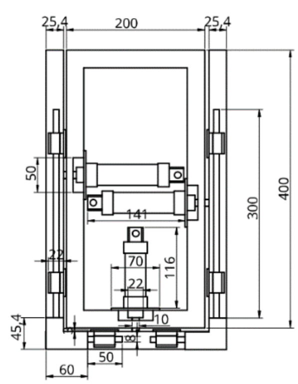
5.2.2 Back view:

The underside of an independent floodgate, which may contain bracing or extra support structures to boost its strength, is normally visible from the rear. The motor or hydraulic system that raises and lowers the gate—typically managed by an electronic system—is also visible in the back perspective.

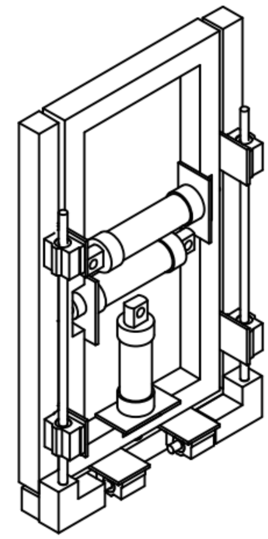
5.2.3 Side view:

An independent floodgate's profile and support system are visible from the side. The gate is made to move vertically up and down. The depth of the gate is also visible from the side, which is crucial for confirming that it can resist the force of the water it is intended to endure.

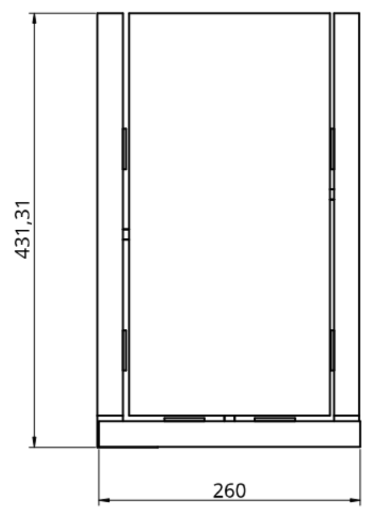
Overall, the demands of the region that the automatic floodgate is intended to protect will determine the design of the floodgate. These fundamental concepts, however, provide a rough picture of what an independent floodgate would seem. The automatic floodgate is a cutting-edge piece of equipment that aids in reducing flood damage. Its automated characteristics increase its effectiveness and dependability.



BACK



Back View



FRONT

CHAPTER 6 : CONCLUSION

In order to lessen the consequences of floods in low-lying locations, this thesis has discussed the creation of a floodgate that we name HydroGuardian. The floodgate was created and constructed with the goal of offering a practical and effective solution to this issue.

Our team successfully tested the floodgate, and the outcomes were quite encouraging. The floodgate was subjected to water at 35cm head. It was able to resist the force of the water and keep the specified region from flooding.

It was able to press flush against the wall of flume. The L-shape pipes were able to fill the corners. The rubber sheet successfully filled gaps and irregularities. Therefore, the water was completely blocked behind the HydroGuardian and no water leaked through.

The floodgate's design featured a number of qualities, such as a sturdy construction, simple installation, and the capacity to adjust to varying flood situations. Furthermore, it was a cost-effective option for communities in flood-prone locations due to the utilization of materials that were readily available locally.

The results of the tests demonstrated that the floodgate was successful in keeping floods from occurring in the defined region. The floodgate was a dependable flood control method since it could endure tremendous water pressure.

To determine the force the HydroGuardian can sustain, we find out how the forces act. The HydroGuardian resists the pressure by pressing against the walls and floor of doorway. This force generates friction between the walls and rubber. HydroGuardian can sustain enough pressure so that force acting on it is smaller than force required to overcome friction and make the HydroGuardian just move or slip. This is determined by formula:

$$Fr = (fr)(N)$$

Where Fr is resistive force, fr is coefficient of friction and N is normal force pushing the two objects together. For HydroGuardian, normal force is applied by the hydraulic cylinders or the jack and screws in case of manual model. Fr will be the force that HydroGuardian can sustain before slipping. And fr is coefficient of friction between rubber sheet and the walls and floor of doorway.

The fr for rubber on concrete varies from 0.78 to 1.72 depending on different conditions like dry, wet and different temperatures. [24]

For wooden doorways, the fr for rubber and wood varies from 0.7 to 0.95. [25]

For glass fr varies from upto 0.6 to 2.4. [26]

Rubber generally has a high coefficient of friction and forms firm grip on most surfaces.

Since fr is constant, Fr is dependent on N entirely. That is the amount of pressure the HydroGuardian can sustain is direct function of amount of force the hydraulic cylinders provide.

For the prototype, the forces applied by each cylinder is roughly 78 pounds or 340 N. So, the three cylinders provide a total normal force of 1020 N.

Wetted area = 0.4 x 0.3 = 0.12m^2

Assuming an average fr of 2.0 for dry glass since flume has glass surface:

Fr = 1020 x 2 = 2040N

P = 2040/0.12 = 17,000 Pa

Average hydrostatic pressure = $\boldsymbol{P = \frac{1}{2}\rho gh}$

= 0.5 x 1000 x 9.81 x 0.4 = 1962 Pa

Therefore, HydroGuardian can easily sustain its hydrostatic pressure.

Now we can also determine the maximum velocity of flow the HydroGuardian can sustain.

Average dynamic pressure = $\boldsymbol{P = \frac{1}{2}\rho v^2}$

$$= 17{,}000 \text{ Pa}$$

Solving for v,

$$v = 8.24 \text{ m/s or } 29.69 \text{ km/h}$$

However, it must be noted that fr varies for different materials in contact, temperatures, and dry or wet conditions. The referenced fr may not be accurate for rubber we have used. Significant allowance should be made especially for wet conditions. For maximum performance, the surface of doorway should be cleaned and dry.

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ANNEX A

Programming

Esp8266 is flashed with esphome and configuration file is created. Therefore yaml is used for programming. The program is as follows:

```
esphome:
  name: "HydroGuardian"
  friendly_name: HydroGuardian

  on_boot:
    priority: 600 #executes after all switch and sensors are initialized
    # ...
    then: # executes the pre-programmed script
       - script.execute: mainn

esp8266:
  board: esp01_1m


logger:


api:

ota:


wifi:
  networks:
  - ssid:
    password:
  - ssid:
    password:


  ap:
```

```yaml
    ssid: HydroGuardianap
    password: floodpio

captive_portal:


binary_sensor: # hall effect sensor to check if it is open or closed
  - platform: gpio
    pin:
      number: GPIO14
      inverted: false
    name: statuss
    id: status


switch:

  - platform: gpio
    pin:
      number: GPIO5
    name: "5 way"
    id: five
    inverted: true

  - platform: gpio
    pin:
      number: GPIO4
    name: "Lock valve"
    id: lock
    inverted: true
  - platform: gpio
    pin:
      number: GPIO0
    name: "Bottom cylinder valve"
    id: bottom
    inverted: true

  - platform: gpio
    pin:
      number: GPIO2
    name: "Power relay"
    id: power

   - platform: gpio
    pin:
```

```
      number: GPIO2
    name: "Pump"
    id: pump

script:
  id: mainn
  then:
    - if:
       condition:
        and:
          binary_sensor.is_off: status
       then:
          - switch.turn_on: lock
          - delay: 1s
          - light.turn_on:
             id: pump
             brightness: 80%
          - delay: 4s
          - switch.turn_on: bottom
          - delay: 4s
          - switch.turn_off: lock
          - delay: 500ms
          - switch.turn_off: bottom
          - delay: 500ms
          - light.turn_off: pump
          - delay: 2s
          - switch.turn_on: power

       else:
          - switch.turn_on: five #five way
          - delay: 1s
          - switch.turn_on: lock
          - switch.turn_on: bottom
          - delay: 1s
          - light.turn_on: pump
          - delay: 5s
          - switch.turn_off: bottom
          - delay: 500ms
          - switch.turn_off: lock
          - delay: 500ms
          - light.turn_off: pump
          - delay: 2s
          - switch.turn_on: power
```

ANNEX B

Final Year Project

Hydraulic Engineering Survey

Area **Name of Respondent** **Phone Number**

1. Does flood water enters your house when it rains heavily?

Yes ☐ NO ☐

2. Do you follow any of the measures to prevent flood water from entering?

Sandbag ☐ Masonry Wall ☐ Wall step others ☐

3. If not then are there any solutions in mind that you think you might be able to produce, please specify.

Comments

4. What is the height of flood water?

Under 1 ft ☐ 1-3ft ☐ 3- 5ft ☐ 5 ft ☐

5. How often does a flood comes?

Every Monsoon☐ twice a year☐

More than 3 times ☐

6. How long does flood water stays?

8. What kind of losses have you experienced?

Households☐ Structure☐ Inventory☐ Mental Distress ☐

9. How much monetary loss you have faced due to flooding?

under 10 thousand ☐

(10-50) thousand ☐

more than 50 thousand ☐

10. Do you want an appropriate solution to the flooding problem?

Yes ☐ No ☐

11. How much do you believe you can spend for an appropriate solution of this problem?

5000-15000 ☐ 15000-35000 ☐ 35000-60000 ☐ 60000+ ☐

11. Width of the gate

12. Type of entrance

Elevated Entrance ☐

Under 1hr☐ 1hr-3hr ☐ more than 3 hours

Regular Entrance☐

7. What are the points from where water entershe unit (house, shop etc.)

Ventilator ☐ Door ☐ Window ☐

13. Height of gate from street level

Under 1 feet ☐ 2-4 feet ☐ more than 4 feet ☐

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Comments