10102

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HYDRO-GUARD

Ibrahim Walid Ibrahim

Marwan Abdelaziz

Farouk Mohamed

Tarek Ahmed

Ahmed Yehia

Contents

Chapter 1:

Present and justify problem and solution requirements.

Introduction

Egypt faces many problems and challenges that affect it in various aspects and forms and prevent its progress in different fields, and they are 11 challenges, shown in Figure (1). These problems are becoming more serious for the Egyptian state and cause many problems that, if solved, Egypt will become a developed country.

Figure 1: Egypt's grand challenges

Increasing the effects of the climate change problem leads to the reduction of water sources because of the rise in the temperature, which evaporates the water, which results in urban congestion because of people migrating to big cities searching for clean water, which concludes the rise of the garbage percentage thrown in the street because of the high population in many places.

These problems that affect Egypt are linked to each other. An increase in a particular problem may increase the rest of the problems and solving one may open new solutions to the rest of the problems.

This is one of the biggest reasons that pushes Egypt to begin solving these difficult problems, aspiring to advance in the future.

EGYPT GRAND CHALLENGES

❖ Urban Congestion.

Urban congested places are places that are extremely crowded and blocked by traffic or people. Urban congestion is a worldwide phenomenon, particularly in high-density cities such as those found in Europe. It is a genuine problem in Egypt too, particularly in Cairo and Alexandria. According to CAPMAS, the population of Egypt is 105.5 million inhabitants in October 2023, The Greater Cairo Metropolitan Area (GCMA) is about 26 million inhabitants, which is more than a fifth of the population of Egypt. Traffic congestion is a fundamental problem in the GCMA which negatively affects the quality of life and the economy.

- **Causes:**

Rapid growth population.

Egypt's urban congestion is becoming more prevalent due to rapid population growth. The country's population has been increasing at an annual rate of around 2% in recent times, posing a challenge to make room for the growing populace. According to the Central Agency for Public Mobilization and Statistics (CAPMAS), the population of Egypt was close to 104 million in 2021, and it is anticipated to continue rising. Coping with this growing population is hard on infrastructure, such as public services, housing, and transportation. In major cities such as Cairo and Alexandria, overcrowding and burdensome public facilities have resulted from increased traffic congestion. To address these challenges, it is crucial to manage urban growth and enhance transportation and housing infrastructure given the rapid rise in Egypt's urban centers' population.

The progress of medicine.

The progress of medicine and the issue of urban congestion in Egypt are intrinsically connected. As medical advancements have improved healthcare access and quality in urban areas, the attraction of cities for medical facilities and services has grown. Urbanization has, in turn, led to population growth and congestion in major cities, exacerbating challenges related to healthcare provision, infrastructure, and public health. The increasing demand for healthcare services has strained resources and infrastructure, especially in densely populated areas. To address the healthcare needs of urban populations, governments and policymakers in Egypt face the challenge of expanding and modernizing healthcare facilities, improving transportation systems, and promoting urban planning that balances the benefits of urbanization with the need for accessible and efficient healthcare.

<u>Bad distribution of population.</u>

As shown in Figure (2.1), there is a huge disparity among the different governorates of Egypt in the population density for each square kilometer. The reason behind that is that some governorates have high-quality services (Health, Education, Infrastructure, Security, Means of transport, …etc.), like Cairo and Alexandria, whereas other governorates have low-quality services like North and South Sinai. This bad distribution of services leads to widespread of poverty, ignorance, crimes, and diseases in the poor-serviced areas.

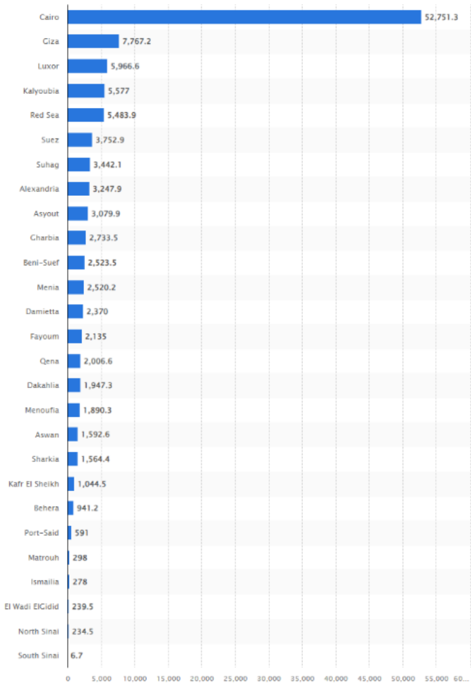


Figure 2. 1: population density in deffirent governoments.

- **Impacts:**

<u>Pollution.</u>

The enormous number of people in a specific place requires more job opportunities, and that is why the government tends to build more factories. Those factories release massive amounts of dangerous gases. According to USAID, Greater Cairo is the most polluted place in Egypt. It houses about 50% of the industrial activities and generation of electricity from thermal power stations and motor vehicles all over the country. Consequently, air pollution has become a severe problem in the area.

Table (1) indicates the enormous number of used means of transport in 1997, causing numerous harmful effects on the environment and, consequently pollution.

	Bus and minibus	Taxi	Metro	Private cars	Motocycles
Number of Vehicles	19498	77243	2 lines	925120	170313
Million person per day	7.5	1.5	1.3	1.7	0.3
% Person trip per day	61	12.2	10.6	13.8	2.4

Table 1: Number of vehicles and trip distribution by mode in greater Cairo, 1997

<u>Traffic crashes.</u>

According to CAPMAS in 2022, Cairo came in first with the largest number of licensed vehicles, which stood at 2.6 million. That vast number increases the rate of traffic accidents. According to WHO & AUC, every year about 12,000 Egyptians lose their lives because of a road traffic accident. Unless addressed urgently, road traffic collisions will continue to increase to become one of the top leading causes of death by 2030.

<u>Emergence of slums.</u>

Usually in urban congested areas, the phenomenon of the appearance of slums increases rapidly. Slums appear because of the migration of residents from rural to urban areas. Whatever the reason is looking for job opportunities or a better chance at education. Figure (2.3) shows the spread of slum areas along the GCMA. Which has negative effects on the services in these places because they are illegal constructions.

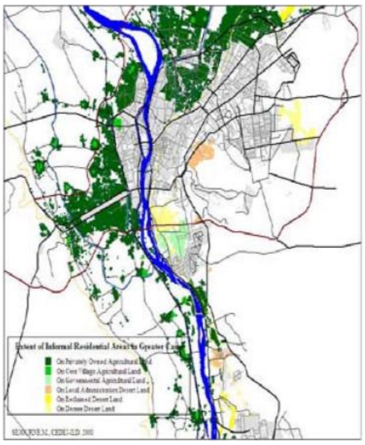


Figure 2.2: Spread of slums areas along GCMA

❖ Increase the source of clean water.

Egypt is facing a water shortage due to limited water resources. The country's water resources are estimated at only 60 billion cubic meters per year, with the majority coming from the Nile River. Rainwater and deep groundwater in the deserts are the only other sources of water, but they are scarce. In contrast, the total water needs in Egypt reach about 114 billion cubic meters of water annually (according to the Minister of Water Resources statement on March 28, 2021), Egypt suffers from a water shortage. In contrast, the total water needs in Egypt reach about 114 billion cubic meters of water annually (according to the Minister of Water Resources statement on March 28, 2021) Figure (3.1) shows sources of clean water.

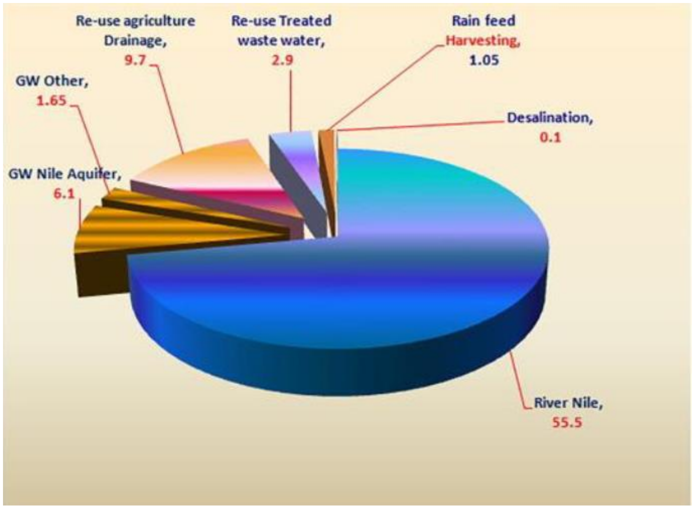


Figure 3. 1: sources of clean water

As Egypt’s share of Its water amounts to 55.5 billion cubic meters, representing 79.3% of water resources and covering 95% of current water needs.

The amount of groundwater used In Egypt is estimated at 6.1 billion cubic meters/year in the valley and delta and this amount can be increased in the future to reach 7.5 billion cubic meters/year without endangering the groundwater reserve.

Rain is not a major source of water in Egypt due to the small amounts that fall in winter, as about 1.3 billion cubic meters of rainwater falls in Egypt every year.

Agricultural drainage water Is a significant water resource, as the annual average of agricultural drainage water is about 12 billion cubic meters/year. About 5.7 billion cubic meters are currently reused.

Treated wastewater can be used for irrigation purposes if it meets internationally accepted health conditions, as its quantity amounts to about 2.5 billion cubic meters annually.

- **Causes:**

<u>Population growth.</u>

According to the United Nations, the population increase, as shown in Figure (3.2), means an Increase in the amount of water that the country needs to provide, as an adult man needs 3.7 liters, while an adult woman needs 2.7 liters. Unfortunately, the amount of water in Egypt has not increased. on the contrary, it has decreased over time, which makes access to water in some areas almost impossible.

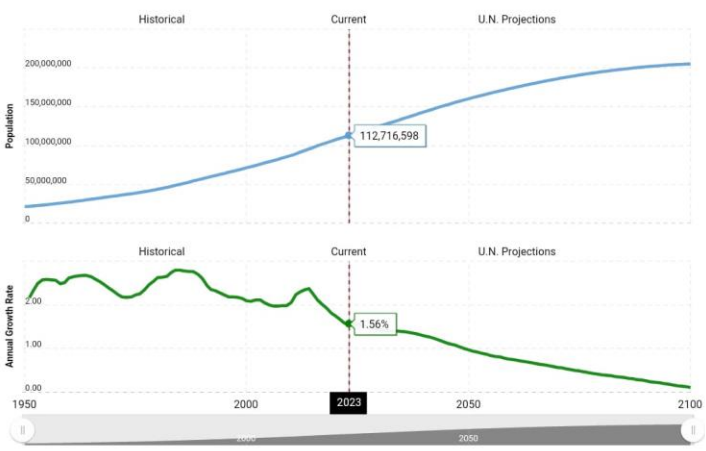


Figure 3. 2: increase in the number of population

<u>Pollution of the Nile River.</u>

Barrage receives wastewater from 67 agricultural drains, including 43 major drains. However, only 10 drains meet Egyptian regulations governing the acceptable caliber of wastewater released into the Nile River. The biggest pollutant in the Nile River is heavy metals. Nile water pollution comes from multiple human sources including Industrial, agricultural, and domestic effluent.

<u>Excessive water wastage in economic activities.</u>

A lot of water consumption in agriculture, as about 85% of Egypt's water resources are used for agricultural Irrigation systems, which are characterized by high levels of water loss and low efficiency. The amount of wastewater produced in Egypt is about 16.4 billion cubic meters, of which 4.4 billion cubic meters is sewage and 12 billion cubic meters is agricultural wastewater.

- **Impacts:**

<u>Lack of water and spread of diseases.</u>

While access to water Is almost universal and reliable in urban areas, a large number of households remain disconnected from the water network in rural areas and urban slums. 7.3 million people are deprived of access to safe water, of whom 5.8 million live in rural areas and 1.5 million in urban areas. Lack of access to safe drinking water and proper sanitation facilities, as well as poor hygiene, contribute to the spread of diseases, which has a significant and negative impact on children's health and nutrition. In Egypt, diarrhea is the second leading cause of death among children under the age of five. Most deaths associated with diarrhea in children are due to dehydration caused by the loss of large amounts of water and electrolytes. Statistics indicate that between 3,500 and 4,000 children under the age of five die from diarrhea every year.

<u>Egypt falls below the water poverty line.</u>

Egypt is one of the countries suffering from water poverty, as Cabinet figures show that Egypt's annual water share Is 560 cubic meters per capita, which places the country below the international threshold for water scarcity. The United Nations specified 1,000 cubic meters of water per capita.

<u>Weakness of economy.</u>

The lack of sufficient water to meet the need for agricultural land will lead to the weakness of the Egyptian economy, as it contributes 11.3 percent of the country's gross domestic product. The agricultural sector represents 28% of all jobs, and more than 55% of jobs in Upper Egypt are related to agriculture.

❖ Address and reduce pollution fouling our air, water, and soil.

Pollution has become a serious, bad, and widespread problem in all parts of the world at present. Pollution is a complex and pervasive issue that poses significant challenges to our environment and well-being. It refers to the introduction of harmful substances or contaminants into the natural environment, resulting in adverse effects on living organisms and ecosystems. There are various forms of pollution, including air pollution, water pollution, soil pollution, and noise pollution. Each type has its own set of causes and impacts. It is a serious problem that must be dealt with as soon as possible due to the increasing number of deaths resulting from the increased rate of pollution in the world, especially among the elderly, as shown in Figure (4.1). This problem leads to the death of 9 million people annually around the world due to diseases and toxins that result from them. This also leads to the state spending huge sums of money because of it. Air pollution costs Egypt around 47 billion pounds annually.

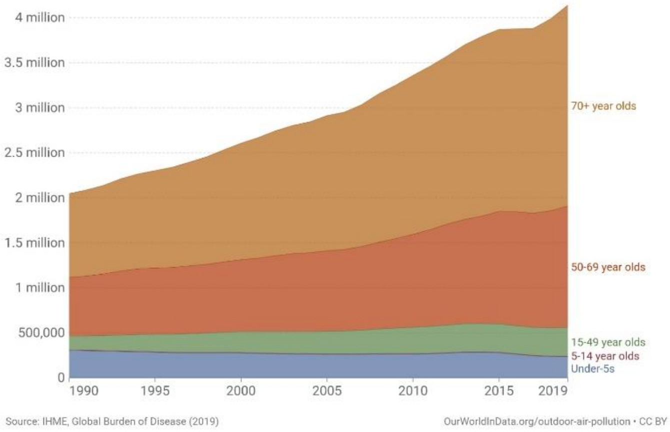


Figure 4. 1: Deaths from outdoor particular matter air pollution.

- **Causes:**

<u>Agricultural Practices</u>

Agricultural operations, including the use of chemical fertilizers and pesticides, act a risk not only to human health, but also to water and soil quality and usage. In addition, many agricultural practices are unsustainable, contributing to soil erosion, biodiversity loss, and natural resource degradation.

Egypt is one of the world's largest producers of cotton and relies heavily on extensive irrigation techniques that often require the use of large amounts of water and chemical fertilizers. Over time, this has led to increased soil and water salinity, which poses a threat to both crop yields and human health. Furthermore, uncontrolled burning practices of normal wheat brush after harvest season led to air pollution, which can cause harm to human respiratory systems.

<u>Industrial Activities.</u>

Heavy manufacturing, such as cement production, heavy machinery, and steel production, releases significant amounts of greenhouse gases, chemicals, and other pollutants into the air and water.

Egypt has a flourishing industrial sector with approximately 30,000 factories all over the country. However, these industries often work under weakened environmental systems and unenforced laws, leading to outspread environmental degradation and health consequences for the population.

Deforestation.

Deforestation presents a significant challenge to Egypt, leading to several environmental problems such as pollution and erosion. Deforestation reduces the number of trees responsible for filtering the air, improving soil health, controlling soil erosion, and shading landscapes. As a result, with fewer trees, there is an increased amount of carbon dioxide in the air, leading to rising temperatures and further pollution.

- **Impacts:**

Degradation.

The impacts of pollution in Egypt have been directed to the loss of countless living beings, including plants and animal species. Due to the disruption of ecosystems caused by air, water, and soil pollution, many species are endangered or critically endangered. The habitat elimination resulting from environmental degradation has farther make this problem worse, leading to significant declines in biodiversity.

The death of many living creatures.

The quality of air in Egypt has worsened significantly due to the growth of pollution levels. Motor vehicle emissions, construction sites, and industrial facilities are the main contributors that emit harmful pollutants, including sulfur dioxide, nitrogen oxides, and particulate matter, which pose a threat to the public's health. As these pollutants concentrate in large cities such as Cairo and Alexandria, respiratory illnesses and related health problems are on the rise.

Poor Atmosphere.

The quality of air in Egypt has worsened significantly due to the growth of pollution levels. Motor vehicle emissions, construction sites, and industrial facilities are the main contributors that emit harmful pollutants, including sulfur dioxide, nitrogen oxides, and particulate matter, which pose a threat to the public's health. As these pollutants concentrate in large cities such as Cairo and Alexandria, respiratory illnesses and related health problems are on the rise.

❖ Climate change.

Climate change is long-term shifts in temperatures and weather. These transitions can be natural or artificial, because of the changes in the sun's activity or large volcanic eruptions. But since the 19th century, humans have been the main reason for climate change, because of the burning of fossil fuels such as coal, oil, and gas.

Burning fossil fuels produces greenhouse gases that cause climate change including methane and carbon dioxide. These come from using diesel fuel to drive a car or coal in the factories, for example. Land clearing and cutting down trees can release carbon dioxide. burning gas and coal operations are major sources of methane emissions. Energy, industry, transportation, buildings, agriculture, and land use are among the major sectors causing greenhouse gases.

Earth's average temperature is now about 1.1°C warmer than it was in the late 19th century (before the Industrial Revolution) and warmer than at any time in the last 100,000 years. The past decade (2011-2020) was the warmest on record, and each of the past four decades has been warmer than any previous decade since 1850.

Egypt is going through a crisis of climate change, as shown in Figure (5.1) which increases in heat waves, dust storms, storms and the Mediterranean coast, and other weather events. Stronger warming has been documented over the past 30 years, with average temperatures increasing by 0.53 degrees Celsius per decade. The country's climate risks are and will impact the younger generations of today.

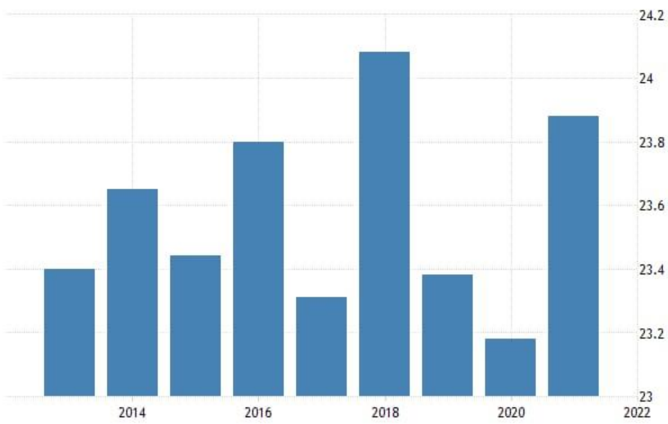


Figure 5. 1: Climate change in Egypt.

- **Causes:**

<u>Energy industry.</u>

Due to the factory wastes that arise in the air in Egypt. Between 1901 and 2013 temperatures in Egypt increased by an average of 0.1°C per decade due to industry. The rate accelerated between 2000 and 2020 with a temperature increase averaging 0.38°C per decade, which was higher than the world average (0.31°C per decade). As a result, the number of cooling degree days (CDDs) increased dramatically – by around 300 during 2000-2020 – while winter heating needs declined by over 50 heating degree days (HDDs) in the same period. UNEP's recent study shows that 50% of all electricity is already being consumed for air conditioning during the peak summer months in Cairo.

<u>Greenhouse Gas.</u>

The increase of greenhouse gases, happen from human activities, increase the temperature of the Earth's atmosphere, leading to climate change. In Egypt, the burning of fossil fuels for energy production, industrial activities, transportation, and agriculture are significant sources of greenhouse gas emissions.

According to the World Bank, in 2018, Egypt's total greenhouse gas emissions amounted to approximately 297 million metric tons of carbon dioxide equivalent (MtCO2e).

<u>Land Use Changes and Deforestation.</u>

Modification of land use through deforestation, urbanization, and conversion of natural habitats not only disrupts ecosystems but also affects the Earth's climate system. In Egypt, land use changes have led to the loss of forests and vegetation cover.

According to the Food and Agriculture Organization (FAO), Egypt experienced an average annual deforestation rate of 0.2% between 1990 and 2020.

- **Impacts:**

<u>High temperature.</u>

The increase in temperature has resulted in the Mediterranean Sea experiencing a rise in water levels, as shown in Figure (5.2), primarily due to the melting ice in the polar regions. This poses a significant threat to coastal areas in the northern region, including the governorates of Port Said,

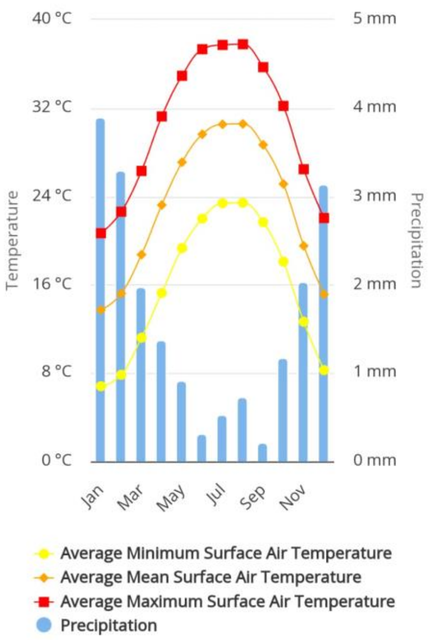


Figure 5. 2: Rise in water level in The Mediterranean Sea.

Kafr El-Sheikh, Damietta, Behera, and Dakahlia. If the water level exceeds 100cm, there is a possibility of extensive submergence of these inhabited areas. Additionally, this could lead to the intrusion of saline water into vast portions of the northern delta lands, resulting in soil salinity, deterioration of agricultural crops, reduced productivity, and food scarcity.

Drought.

The increasing severity of drought in Egypt is indeed a significant issue. With 86% of the country's land falling within the driest areas globally, there is a higher risk of desertification, drought, and inadequate water resources. This situation can lead to water scarcity, affecting agricultural productivity. Furthermore, if the global temperature rises by more than 1.5 degrees, it can hinder the germination of essential crops, particularly wheat.

The spread of disease.

Egypt does face vulnerability to the spread of diseases such as malaria, lymph nodes, dengue fever, and Rift Valley fever. Climate change can exacerbate the conditions that favor the spread of these diseases. prevalence of many parasitic diseases, physiological disorders, skin cancer, eye cataracts, respiratory ailments, heat strokes, and heat-related illnesses has increased due to it.

While Egypt's contribution to global warming may be limited compared to countries like India, China, the United States, or European countries, it still experiences the impacts of climate change. The effects can be more pronounced due to the country's geographical location and socio-economic factors.

❖ Recycle garbage and waste for economic and environmental purposes.

The problem of recycling is considered one of the most serious problems facing Egypt throughout the ages, and it is one of the problems that Egypt is striving to find a solution to, but to no avail, because every year the amount of wasted waste that is not recycled increases and is therefore thrown into landfills, and this It has many negative effects on the population, such as the spread of diseases and pollution of the surrounding environment.

The percentage of waste that is not recycled (thrown away) reaches 40%, while the percentage of waste that is partially recycled reaches only 6%, and this is a very small percentage.

A study was conducted in Egypt and determined that by March 2018, 80 million tons of garbage were collected in Egypt per year, and companies collected 55.2% of solid household waste, while 44.8% of families disposed of their waste in the streets in an unhygienic manner. It is harmful to the environment, and this statistic shows the extent of the importance of spreading awareness among the people and the full awareness of population in Egypt of the existence of the problem, as people who are aware of the existence of problem seek to solve it and facilitate the state's access to a solution to this problem.

- **Causes:**

Lack of awareness of the seriousness of the problem.

It seems that Egypt is facing a serious issue regarding recycling. One of the causes of this problem is the lack of awareness among the public people about the seriousness of not properly disposing of waste. Many people may not realize the impacts that their actions due on the environment and other people`s health. It is necessary to educate and teach the people of Egypt about the importance of recycling and how to manage their waste properly in order to make a positive difference.

The lack of quality.

It appears that another cause of poor recycling practices is the lack of quality in recycled products. Many individuals and organizations in Egypt choose not to recycle due to the belief that the process produces goods of lower quality compared to new materials. Unfortunately, this perception is all too often consistent with reality. Recycling facilities in Egypt may lack the proper equipment or financing to produce high-quality, reusable materials. This phenomenon discourages many people from recycling because they believe that it is merely a waste of time and resources. It is essential to enhance the recycling processes and support facilities to help produce high-quality recycled goods that meet local and international standards. By doing so, the reliance on new materials can be reduced, encouraging people to involve themselves more proactively in recycling efforts.

Capital.

Indeed, capital is one of the major causes of poor recycling efforts across Egypt. Recycling facilities are often expensive to build and maintain, and individual residents and businesses may not have the necessary capital to invest in them. In many cases, private investors are hesitant due to the obvious lack of profitability in recycling businesses. Furthermore, government financing for waste management services is not always prioritized in Egypt, which further worsens the problem. Without adequate funding, there is a deficiency of infrastructure, equipment, and personnel needed to manage waste processing resources and provide recycling services to communities.

- **Impacts**

Water pollution.

Water pollution is one of the most serious problems resulting from the recycling problem, as Egypt is the largest country polluted with marine plastic in the Middle East and North Africa, and the seventh largest country in the world. According to the 2010 data mentioned in the report, which is the most recent data available, Egypt alone is responsible for 3% of the discharge of plastic waste into the world's oceans and seas. It was also found that the water in Egypt (especially the Nile River) contains heavy metal pollutants, which are harmful to the population in Egypt. From diseases and other damages.

Lack of resources.

Recycling plays a crucial role in conserving natural resources. When materials are not recycled, there is a continued reliance on extracting and manufacturing raw materials, which can deplete valuable resources such as forests, minerals, and fossil fuels. The world is producing twice as much plastic waste as two decades ago, with the bulk of it ending up in landfills, incinerated, or leaking into the environment, only 9% successfully recycled, meanwhile, the rest of it is exhausted according to a new Organisation for Economic Co-operation and Development (OECD) report.

Diseases and Epidemics.

When items are not recycled and end up in landfills or incinerators, they contribute to the release of pollutants and toxins into the environment. This can result in air and water pollution, which can pose significant health risks. For instance, the burning of non-recycled waste releases harmful gases and particulate matter, which can lead to respiratory problems, cardiovascular issues, and even cancer.

Problem to be solved.

There are many problems facing Egypt, including the problem of increasing the sources of clean water. It can be solved by exploiting floodwaters that are abundant in Egypt. If the floods are exploited properly, the problem of increasing the sources of clean water in Egypt will be solved.

Floods are the most common type of natural disaster in the world and Egypt, as between 80% and 90% of all documented disasters arising from natural hazards during the last ten years arose from floods, tropical cyclones, and heat waves. Floods occur as a result of abnormal levels of rainfall, the collapse of dams, changes in water pressures beneath the oceans, or changes in valley courses. Floods cause widespread destruction and damage to public and private property, destroying the state's infrastructure, and also causing huge losses of life.

Widespread flooding occurred across Egypt due to heavy rain, strong winds, and thunderstorms. The floods caused the death of at least 40 people, with 10 people losing their lives and over 400 injured in Cairo, and three people dead and five injured in Qena Governorate (central Egypt). The remaining fatalities occurred in Giza, Ismailia, Sharkeia, New Valley, Menofia, and South Sinai Governorates, with 12 people still missing. Due to heavy rain, train services were suspended nationwide. A train collision in northern Giza injured 13 people.

❖ Positive consequences:

Reduced property damage.

By implementing proactive measures to manage and control the flow of floodwaters, the devastating impact on residential, commercial, and public properties can be successfully minimized.

However, according to the World Bank, every dollar invested in flood management can save up to $7 in damages. This effectively indicates that appropriate measures to control flood discharges, such as building dams, levees, underground tunnels, and other such infrastructures can help reduce property damage. A study performed by the University of East Anglia in the UK also found that investments in a range of upstream interventions can reduce downstream flood risk and associated economic losses by 40-70%.

Protecting the environment.

By addressing this pressing issue, the delicate balance of ecosystems and preserving vital natural resources can be proactively safeguarded.

Floods can wreak havoc on ecological systems, causing harm to biodiversity, water quality, and overall environmental health. By skillfully managing floodwater, we can curtail these detrimental effects and help maintain the integrity of our ecosystems. This, in turn, supports the preservation of diverse plant and animal species, sustains the quality of our water sources, and fosters a healthier natural environment for future generations.

One example of such a benefit is the improvement in water quality. A study published in the Journal of Environmental Management concluded that stored sediment from upstream storage could help to improve downstream water quality. Another study by the European Union found that the creation of wetland areas near rivers and other low-lying regions may help effectively reduce the negative impacts of floods and enhance biodiversity.

Improved safety.

Dealing effectively with flood discharges in Egypt has resulted in improved safety for communities and individuals in several ways. First and foremost, by implementing flood control measures such as dams and embankments, the risk of widespread flooding and its associated dangers has been significantly reduced. This ensures the safety of people living in flood-prone areas, protecting their lives and properties from the destructive forces of floodwaters. When flood-related damages are adequately managed and mitigated, the cost for property owners, insurance companies, and local governments significantly decreases. This allows property owners to arrange their resources towards other essential priorities, such as education or healthcare. In turn, local governments can allocate funding to other areas of need, including environmental preservation or infrastructure improvement projects.

❖ Negative consequences:

Destruction of crops.

The farmers of Egypt often bear crop damage due to sporadic heavy rains that flood their fields. An excess of water can have destructive effects on the growth of plants, hindering the chances of a fertile crop. Recently, in various parts of Egypt, there have been complaints of crops being hampered by the rainfall in 2021. This unfortunate eventuality can leave farmers stranded without a substantial yield. Thus, designing mechanisms to resist the excessive water inflow is essential for crop protection and farmer support.

In more northern coastal regions such as Alexandria and Matrouh, the impact of sudden rain and flash floods may differ due to variations in soil types and crop preferences. For instance, in Alexandria, where citrus fruits are a prominent crop, excess water can lead to soil erosion and damage to tree roots. while, in Matrouh, where olive farms are common, sudden floods can negatively affect the health of these drought-tolerant trees.

Deterioration of health conditions owing to waterborne diseases.

Rain floods can increase the risk of waterborne diseases, which can have a negative impact on human health. According to the National Institute of Environmental Health Sciences, flooding can overwhelm sewage treatment facilities, causing bacteria like Legionella and Escherichia coli (E. coli) to grow and develop in still water.

Egypt is a country that is particularly susceptible to the negative effects of rain floods on human health. According to the World Health Organization (WHO), Egypt has a high incidence of waterborne diseases such as typhoid fever, cholera, and leptospirosis. The risk of contracting these diseases increases during periods of heavy rainfall and flooding, as contaminated water sources become more widespread.

Loss of human life.

In 2010, heavy rainfall in Egypt caused flash floods that resulted in the loss of 12 lives and many more injuries and displacements. The floods affected various regions of the country, including the Sinai Peninsula, the Red Sea port of Hurghada, and the Aswan Governorate in the south. The floods caused extensive damage to homes in four regions of Egypt, which are: North Sinai, South Sinai, Red Sea, and Aswan. leading to the evacuation of 3,500 people (500 households).

Research

❖ Topics related to the problem:

Property damage.

Many areas in Cairo and Giza tested rainfall on Tuesday 24 April 2018, due to flooded roads, power outages, and structural damage to buildings.

The heavy rainwater caused several traffic congestions in various parts of Greater Cairo, including sections of the Ring Road and the Autostrad.

Some people expressed their fear on social media platforms, saying that the local emergency services didn't respond to their requests for help.

Additionally, some residents reported that vacuum trucks didn't come to their neighborhoods to alleviate the accumulation of rainwater on the streets.

Vulnerable Populations.

Such as those who live in low-lying areas, informal settlements, or other high-risk locations. Floods can cause displacement, and loss of homes, businesses, farms, and even lives. People who are already living in poverty or marginalized conditions may be particularly vulnerable since they lack the resources, skills, or information to cope with floods and the associated risks.

Moreover, the management of flood discharge often involves trade-offs between costs, environmental impacts, and social justice concerns. For example, building a new flood protection infrastructure may involve substantial costs and environmental impacts such as displacing habitats or flooding upstream communities.

Use of modern technology.

The integration of modern technology offers a potential avenue for effective mitigation of the impacts caused by flooding. According to recent statistics, the use of advanced technologies for flood monitoring, warning, and response systems can improve disaster resilience by about 40%. These technologies include the use of drones, remote sensing, IoT, and other artificial intelligence-enhanced options to create more effective planning, communication, and forecasting tools. Real-time data from these technologies assists in early detection and warning, enables predictive analysis closer to the onset of flooding along with enabling a rapid and proactive emergency response. The integration of these new technologies can help reduce the impact of flood disasters on communities around the world and decrease financial impacts related to flood damage.

❖ Topics related to the solution:

Geological study.

One of the most important topics related to solving the problem of floods in Egypt is the geological study of the place where the solution will be implemented because this greatly affects the solution that will be used to solve this problem. Each soil type has different properties and different layers, and therefore the solution that will be used will differ depending on the characteristics of the soil in the location of the solution. For example, the Red Sea Mountains region in the east of Egypt is one of the regions facing the problem of floods, so when we want to solve this problem, we must first know that the Red Sea Mountains were primarily formed by refractive movements, so the soil is solid, and this conclusion will greatly benefit in choosing the type of solution.

Study of the prevailing climate.

Studying the climate in Egypt (especially in the place where the solution will be applied) is considered one of the topics that greatly affects the solution and its location. The prevailing climate in the region facing the problem of floods in Egypt must be considered in order to know the seasons of heavy rainfall and the directions of wind movement throughout the year, As the direction of the wind can change the places where water collects and the valleys through which water flows from the mountain, this will greatly help in determining the location of implementing the solution. For example, the Mount Musa area (on the edge of Sinai Island in the far north-east of Egypt) is facing the problem of Floods, but the wind direction is to the east of the mountain, so the solution will be implemented in the eastern part of the mountain instead of in the middle of it.

Water pressure.

Whatever the solution that will be used to solve the problem of floods in Egypt and deal with it, it must be taken into account that the flood waters flowing from the mountains, such as (the Red Sea Mountains in Egypt), will be flowing at a high speed and flowing with a huge force, so the water pressure must be calculated physically from the equation ($P = F/A$ & pressure = force/area), for example, if a flood occurred due to torrents in the Red Sea Mountains area and the area in which the water must be collected was equal to 50 m^2 and the force with which the water was flowing was equal to 200 Newtons, then using the previous law, the pressure = 200 / 50 = 4 bar.

Other Solutions already been tried.

❖ Dworshak Dam.

Figure 6: Dworshak Dam

Dworshak Dam, shown in Figure (6), is located on the North Fork Clearwater River, in the United States of America. The dam is the third tallest dam in the United States and the highest straight-axis concrete dam in the Western Hemisphere. Construction of the dam began in 1966, and the project became functional for flood damage reduction in June 1972. The power was activated in March of 1973. Since 1972, $2,836,000 in potential flood damages have been prevented by the project, according to the United States Army Corps of Engineers (USACE). This project was authored by the congress, it includes Dworshak Dam, Dworshak Reservoir lands, powerhouse, recreation facilities, wildlife mitigation, and Dworshak National Fish Hatchery. The dam is a concrete gravity dam. Its drainage area is 2,440 square miles. The maximum structural height is 717 ft. Its Effective hydraulic height is 632 ft. The overall length at the crest is 3,287 ft at an elevation of 1,613 Mean Sea Level (MSL). The minimum record of streamflow is 250 cubic feet per second (cfs). The minimum tailwater elevation discharge is 968 – 1,000 cfs. While the maximum tailwater elevation discharge is 1,003.4 – 150,000 cfs. The total estimated cost of the project is about $302,000,000. The concrete volume is 6,500,000 cubic feet. The spillway is by a controlled gate with a stilling basin. The type of the gate is Tainter. There are two gates, the size of each is 50 (width) * 56.4 (height) ft. Their crest elevation is 1545 ft.

- **Mechanism:**

The total available storage capacity or active capacity of Dworshak Reservoir, including flood control, is 2,016,000 acre-feet (2.487 km^3). The inactive capacity (the portion of the reservoir's capacity below the power generating outlets and the lower river outlet works) is 682,000 acre-feet (0.841 km^3). The pool (below the river outlet works) corresponds to a storage of 770,000 acre-feet (0.95 km3). The reservoir has an additional capacity (above the spillway gates) of 92,000 acre-feet (0.113 km^3), bringing the maximum amount of water that can be preserved behind the dam to 3,560,000 acre-feet (4.39 km^3). Most of the active capacity not used for flood control is used to produce power. Water releases from Dworshak Dam are also controlled to improve power generation at four downstream dams on the Snake River and four more on the Columbia River.

Stages of Dworshak dam to store water:

1. The dam stores an extensive quantity of water in the reservoir by making a height difference or “head” between the water level in the reservoir and the turbine location.
2. Water is drawn from various depths in the reservoir to adjust the temperature, which exactly ranges from 46°–48°F.
3. Water is drawn from the reservoir through an intake structure and transmitted to the turbine using a supply channel, which is a large pipe or conduit.

- **Points of strength:**

<u>Hydropower generation.</u>

Dworshak Dam has one 220-megawatt turbine unit which is the largest hydroelectric generator in the USACE inventory. The other two units are 90-megawatt each, for a total project generating capacity of 400 megawatts which is enough to power approximately 300,000 homes. Water released from Dworshak Dam is also controlled to maximize power generation at four downstream dams on the Snake River and four more on the Columbia River.

<u>Flood control.</u>

Dworshak Reservoir is an artificial lake created by the Dworshak Dam. The reservoir has a total capacity of 3,468,000-acre feet (4,278 km^3) and an operating capacity of 2,016,000-acre feet (2,487 km^3). The reservoir extends upstream approximately 54 miles into the Clearwater National Forest in the Bitterroot Mountains. The dam has a spillway capacity of 150,000 cubic feet per second (4,200 m^3/s).

<u>Recreation.</u>

Dworshak Dam provides benefits, such as outdoor recreation, navigation, and fish and wildlife benefits.

At Dworshak Dam and Reservoir, visitors can enjoy popular recreational activities such as boating, swimming, fishing, hunting, camping, picnicking, geocaching, and hiking. These activities benefit the American economy by providing it with foreign currency.

Fish hatchery.

The Dworshak Dam's fish hatchery, managed by the U.S. Fish and Wildlife Service, supports salmon and steelhead recovery efforts in the Columbia River Basin. This benefits the public by maintaining healthy fish populations for various uses and aligns with the agency's mission. The hatchery also contributes to research and education in fish biology and conservation.

- **Points of weakness:**

Loss of wildlife.

The construction of the reservoir caused significant damage to the environment, resulting in the loss of approximately 15,000 acres of terrestrial habitat. The most significant loss of wildlife habitat occurred in the winter range used by Rocky Mountain elk and white-tailed deer. Additionally, the dam's construction led to the destruction of a significant portion of the anadromous steelhead trout population.

Environmental Impact.

The construction of dams can have significant environmental impacts, including changes to water temperature, flow, and quality; habitat fragmentation; and impacts on fish populations. The USACE works with other federal and state agencies to minimize these impacts and protect the environment.

Sedimentation.

Entrainment losses caused by sedimentation in Dworshak Dam have a disastrous impact on the fish population and decrease the reservoir's storage capacity. As a result, the dam's ability to produce hydroelectric power is affected. Additionally, aggregation of sediment in the reservoir can lead to adverse impacts.

❖ Wivenhoe Dam.

Figure 7: Wivenhoe Dam

Wivenhoe Dam, shown in Figure (7), is located in Southeast Queensland in Australia is a multipurpose dam built on the Brisbane River. It serves many important roles, like providing water supply and flood mitigation.

The dam was built in 1983 by the Thiess Brothers, it was built in response to the devastating floods that occurred in Brisbane in 1974. With a total storage capacity of 1.16 million megaliters, it's one of the largest dams in the region and plays an important role in reducing the impact of flooding in the Brisbane Valley.

Water Supply from dam's primarily functions as a water reservoir, providing a reliable and sustainable water source for the rapidly growing Southeast Queensland region, including Brisbane and its surrounding areas. It stores water from the Brisbane River for drinking water, irrigation, and industrial use.

Another critical role of Wivenhoe Dam is flood control. The dam was constructed following devastating floods, like the 1974 Brisbane flood. It's designed to capture and regulate floodwaters, reducing the risk of downstream flooding during periods of heavy rainfall.

And release this water in drought periods so residents in the region can plant and drink this water.

- **Mechanism:**

Wivenhoe Dam is an earth and rockfill dam constructed across the Brisbane River. It consists of a central impervious core made of clay and compacted earth, surrounded by layers of rockfill called the dam body. This design provides stability and prevents leakage.

It has a large storage capacity of 1.16 million megaliters. It collects water from the Brisbane River and its tributaries, including the Stanley River and the Upper

Brisbane River catchments. The dam's catchment area spans over 7,000 square kilometers, allowing it to capture significant amounts of rainfall.

The dam is equipped with a spillway structure that consists of multiple gates designed to release excess water during times of heavy rainfall or potential flooding. The spillway system helps prevent the dam from reaching its maximum capacity, reducing the risk of overtopping and downstream flooding.

When the dam's storage capacity reaches a certain level, known as the "full supply level," excessive inflows are held back to mitigate flooding downstream. The dam's storage compartment can store up to 1.45 million megaliters of floodwater, which is released gradually to manage downstream flows and minimize flood peaks.

Controlled water releases from Wivenhoe Dam are carefully managed by Seqwater, the responsible authority. The releases are made through the gates in the spillway or via the dam's outlet works, located at the base of the dam. The timing and volume of these releases are determined by weather conditions, forecasted rainfall, and downstream flood patterns.

The mechanism of Wivenhoe Dam exemplifies it's multifunctional design, combining water storage, flood mitigation, and hydroelectricity generation. Its various components and processes work together to protect downstream communities from flood risks, provide a reliable water supply, and support sustainable energy generation for the region.

- **Points of strength:**

Flood Mitigation.

Wivenhoe Dam's primary strength lies in its flood mitigation capabilities. By storing and releasing water in a controlled manner, it helps reduce downstream flood peaks and protect surrounding communities from severe flooding events.

Water Supply.

The dam plays a crucial role in ensuring a reliable water supply for domestic, agricultural, and industrial needs in the region. It captures and stores water during wet periods, allowing for controlled releases during dry spells.

Drought Management.

Wivenhoe Dam assists in managing drought conditions by storing water during wet times and providing a reserve for times of low rainfall. This strategic water management aids in maintaining water security during prolonged dry periods.

- **Points of weakness:**

Environmental Impact.

The construction and operation of the dam have altered the natural flow of the Brisbane River, impacting downstream ecosystems and aquatic habitats. Maintaining ecological balance and addressing potential long-term effects on biodiversity is a challenge.

Limited Flood Storage.

While Wivenhoe Dam is designed to mitigate flooding, its storage capacity is not unlimited. During extreme weather events or prolonged heavy rainfall, the dam can reach its storage limit, risking downstream flooding should it exceed its designed limits.

Infrastructure Risks.

As with any large-scale infrastructure, Wivenhoe Dam is vulnerable to potential structural failures, seepage, or mechanical malfunctions. Regular maintenance and monitoring are necessary to identify and address such risks.

❖ Urayama Dam.

Urayama Dam, shown in Figure (8), is a compacted concrete gravity dam located at 4041 Arakawa, Chichibu, Saitama 3691801, Japan. The dam has multiple usages including water supply for domestic purposes, power generation, and flood control. The capture area of the dam is 51.6 km2.

Figure 8: Urayama Dam

The dam captures about 120 hectares (ha) of land when full and can store 58 million cubic meters of water. The construction of the dam was started in 1972 and opened in 1998. It has a length equal to 372m and a height equal to 162m.

This gravitational concrete dam is said to be the second-highest dam in Japan.

- **Mechanism:**

The method RCD method was used in building the Urayama dam. RCD (Rapidly Constructed Dam) uses prefabricated blocks assembled quickly on-site to temporarily contain or divert floodwaters. It is designed for temporary use during natural disasters or requiring rapid action. Another method is the RCC method. The RCC (Roller Compacted Concrete) is a fast, low-cost method of construction using a dry mix of concrete, which is compacted with rollers. This dense and durable structure has been used in a variety of contexts, including spillways, retaining walls, and dam foundations. This was done to rationalize and streamline the construction process. It utilizes a concrete gravity design, which allows it to withstand the tremendous force exerted by water. This type of concrete is called RCD, which differs from RCC in design and construction philosophies for dams. This type of dam relies on its mass to resist the pressure and stabilize water flow. The dam incorporates intricate mechanisms for regulating water levels and control release. The main gate of Urayama Dam is a mighty structure made of robust materials, built to withstand the immense force of water pressure. It can be controlled remotely or manually, allowing for precise adjustments depending on the circumstances. The gate opens and closes smoothly, enabling the dam operators to regulate the water flow as needed.

As water rushes towards the dam, the gate acts as a barrier, preventing excessive flooding downstream. When the water level rises, the gate can be gradually lifted or fully opened, releasing the surplus water in a controlled manner.

- **Points of strength:**

<u>A Reliable Source of Hydroelectric Source.</u>

The Urayama Dam functions as a reliable source of hydroelectric power due to its ability to harness the energy of flowing water. As water is released from the reservoir through turbines, the force of the water turns the turbines, which then generate electricity. This process, known as hydroelectric power generation, is consistent and dependable if there is a steady supply of water in the reservoir. Unlike other forms of energy generation that rely on finite resources or are subject to fluctuations in weather conditions, hydroelectric power can provide a consistent and sustainable source of renewable energy over an extended period. By utilizing the Urayama Dam for hydropower, the surrounding communities can rely on a stable source of electricity for their needs.

A Remarkable Source of Water.

The dam collects and stores water from natural sources, such as rivers or precipitation, within its reservoir. This stored water can then be released gradually as needed, allowing for a controlled and regulated flow. This ensures a consistent supply of water for various purposes, including irrigation for agriculture. By providing a reliable water source, the dam helps support farming activities by enabling farmers to irrigate their fields and maintain crop productivity even during dry spells or periods of low rainfall. The steady water supply offered by the Urayama Dam is crucial for sustaining agricultural practices and ensuring food security in the surrounding areas.

Migrating The Risk of Floods.

When heavy rainfall occurs or water levels rise rapidly, the dam can regulate the release of water from its reservoir. By strategically controlling the water discharge, the dam helps to prevent excessive flooding downstream. This controlled water flow reduces the pressure on riverbanks and minimizes the risk of damage to surrounding communities and infrastructure.

By acting as a barrier, the dam intercepts and absorbs the excess water, gradually releasing it in a controlled manner to match the downstream capacity of rivers. This mitigation measure helps to prevent sudden surges in water volume and provides a buffer against potential flood-related disasters.

The Urayama Dam contributes to the protection and safety of downstream areas by effectively managing water flow and reducing the likelihood of floods, safeguarding properties, livelihoods, and lives of the communities.

- **Points of weakness:**

Environmental impact.

The dam construction has led to the flooding of land, resulting in the loss of habitats such as forests, wetlands, and coastal zones. This habitat loss can lead to the displacement or extinction of plant and animal species that rely on these ecosystems for survival. Additionally, the shifted flow patterns caused by the dam can disturb fish migration routes, hinder the movement of sediment, and change water temperature and oxygen levels in the river. These changes negatively affect fish populations and other aquatic organisms, potentially leading to a decline in biodiversity.

Displacement of communities.

The construction of the Urayama Dam may necessitate the relocation of communities living in the affected area. This process of displacement can have far-reaching social and economic impacts on these communities, as they are ripped from their homes, land, and often their established way of life. Families and individuals may be forced to leave behind generations of memories and community ties, leading to a sense of loss and upheaval. Relocated communities may face challenges in adapting to new environments and finding suitable livelihoods in unfamiliar surroundings. The disturbance caused by displacement can also strain social networks and community cohesion. Authorities need to address the concerns and needs of displaced communities throughout the planning and implementation of such projects.

The maintenance and operation costs

Firstly, the huge burden of construction preservation; and operation expenses can raise challenges for the responsible authorities. Devoting significant funds towards the dam may divert resources from other areas of social development or infrastructure projects that could benefit the community in different ways.

Additionally, the high costs may result in higher water tariffs or taxes charged to the residents in the region. This can place an economic burden on individuals and businesses relying on the dam for water supply or hydropower. The increased costs of water services can have a broader socio-economic impact, affecting industries, agriculture, and households.

Furthermore, excessive reliance on hydropower generated from the Urayama Dam may leave the region sensitive to variations in water availability or environmental changes.

❖ El Wahda Dam.

Al Wahda Dam, shown in Figure (9), anciently it was known as Majara Dam, is a dam near Majara in the Taounate Province, Morocco. It was constructed for flood control, irrigation, water supply, and hydroelectric power production. It is the second-largest dam in Africa and the largest in Morocco. It has been described by Land-Ocean Interactions

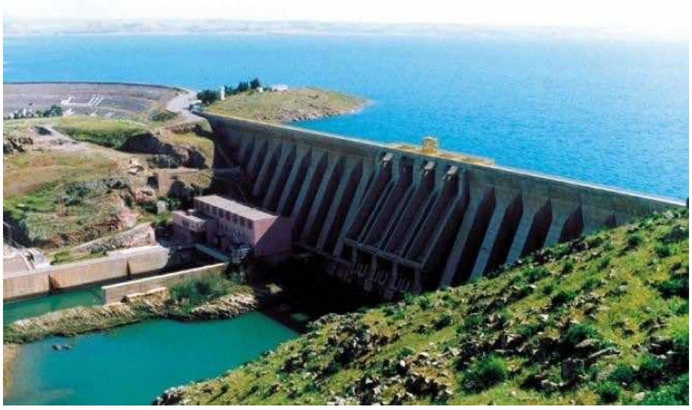


Figure 9: Al Wahda Dam.

in the Coastal Zone (LOICZ) as “the second most important dam in Africa after the Aswan High Dam.”

Al-Wahda Dam is located in the north of the State of Morocco at coordinates (34°35′54″N 5°11′51″W). In 1988, the Council considered Water and climate in the issue of building the dam. Indeed, the construction of the dam began in 1991, and the construction of its reservoir began in 1996. The construction of the dam was completed on March 20, 1997, and 14,000,000 cubic meters of building materials were excavated during construction, the state of Morocco decided to take advantage of the heavy rainwater that is wasted every year by building dams, and one of these dams, and even the largest of them, is the Wahda Dam. Therefore, the main purpose of building the Wahda Dam in the State of Morocco is to control the heavy rainwater. The dam has other benefits in addition, the dam controls rainwater, it plays an important role in protecting the lives of people residing in the area where rainwater flows and allows them to live a safe life.

- **Mechanism:**

The dam's height is 88 meters, the length of the dam is 2,600 meters, the volume of the dam is 28,000,000 cubic meters, and the capacity of the drainage channel is 13,000 m^3 / s. Over time, the dam formed a reservoir known as the Wahda Reservoir. The total capacity of the Wahda Reservoir is 3 billion and 800 million cubic meters. The area of the water catchment area is 6,200 square kilometers and the surface area is 123 square kilometers. The dam is also used to generate electrical power, as it contains 3 x 80 MW Francis turbines, with an installed capacity of 240 MW and an annual generation of 400 GWH.

The dam is an earthen dam made of 28,000,000 cubic meters of material and 720,000 cubic meters of concrete. Its height at the highest point is 88 meters, and the length of the main part is 1,600 meters. Near the water drainage canal, there is a saddle dam that is 1,000 meters long and 30 meters high. The water drainage stream is controlled through six gates and has a drainage capacity of more than 13,000 cubic meters per second.

- **Points of strength:**

<u>Electricity generation.</u>

One of the most important features of the Al Wahda Dam in Morocco is the generation of clean electrical energy from the flow and speed of water. The dam contains 3 x 80 MW Francis turbines, with an installed capacity of 240 MW and an annual generation of 400 GWH. The electricity generated from the dam has environmental benefits, as it is clean electricity that is not harmful to the environment, and it has material benefits, as electricity saves money for the state.

Water drainage gates.

Al-Wahda Dam has gates that drain excess water. In cases of high water levels, excess water is used to drain so as not to cause a threat to the lives of residents into the rainwater stream. This excess water causes excessive pressure on the dam and can cause the dam to collapse, so these gates also protect the dam from demolition.

Low construction costs.

One of the most important points of strength that impact characterize the Al Wahda Dam in Morocco is the cheap construction costs because Al Wahda Dam is a type of earthen dam that does not require large capital and does not require the construction of huge underground foundations.

- **Points of weakness:**

Influencing water deposits.

The sediments carried by water bodies are important to aquatic life and are important in perpetuating the carbon cycle. Building dams can block the path of these sediments, causing on water bodies to create alternative paths or login in one place. This will cause a geological imbalance.

Impact on the ecosystem.

Dams can affect the temperature, chemical composition, and physical conditions of their surroundings which may lead to biological changes that can make the habitat unsuitable for local organisms to live in. As a result, the extinction of many species occurs. Since this effect is irreversible over time, it is essential.

Impact on deportation.

Building a dam on a river or stream destabilizes the lives of people living near it. To prevent residents from catastrophic events such as landslides, floods, or earthquakes during construction, residents should be relocated. This affects the businesses, lands, and properties of a large number of people.

Chapter 2:

Generating and defending a solution.

Solution requirements.

Flexibility.

Flexibility is one of the most important requirements that must be in any dam, because flexibility significantly helps the dam bear any excess force, so the dam absorbs this excess force and bends very slightly, which reduces the overall danger and reduces potential damage.

Eco friendly.

That the dam be environmentally friendly is one of the most important requirements that must be met in any dam, because a dam that is environmentally friendly has less harm to the environment and less waste is dumped from it, and this reduces the general damage resulting from the dam.

Engineering quality

Engineering quality is a study that needs to be conducted to ensure that the dam can be safely constructed in a specific location. This study will take into account factors such as geology.

Legal and Regulatory Requirements.

Permits, licensing, and adherence to certain environmental and safety standards are only a few of the legal and regulatory requirements that apply to dams. Ensuring compliance with all legal duties is crucial throughout the duration of the dam's life.

Design requirements

Storage Capacity.

The proposed gravity dam prototype must exhibit a storage capacity ranging from a minimum of 50 liters to a maximum of 60 liters. This range ensures the dam's ability to handle varying water volumes efficiently.

Structural Load Bearing.

The cross-sectional design of the dam's crest must be engineered to withstand a load of at least 10 kg at its midpoint. This design criterion is crucial for maintaining the structural integrity of the dam, ensuring stability under applied loads.

Flexible Discharge Options.

The dam design should incorporate the capability to discharge water at both 25% and 50% of the targeted storage capacity. This feature enhances the dam's versatility, allowing controlled water releases as needed.

Automatic Overflow Mechanism.

An automated overflow mechanism must be integrated into the dam to manage any water surpassing the maximum storage capacity. This feature guarantees the dam's ability to handle excess water safely and efficiently.

Minimum Storage Water Height.

The dam is required to maintain a minimum water height of 25 cm, ensuring it can effectively store a substantial volume of water as intended.

Minimum Dam Height.

The dam structure should have a minimum height of 30 cm, providing the necessary elevation for achieving the desired water storage capacity and ensuring structural stability.

Bottom Thickness.

The thickness of the dam's bottom should not fall below 10 cm, emphasizing the importance of structural robustness in the lower part of the dam.

Top Thickness.

The top section of the dam must have a thickness of no less than 3 cm to guarantee durability and stability in the upper part of the structure.

By adhering to these design specifications, the gravity dam prototype will be well-equipped to fulfill its objectives in terms of storage, structural integrity, and operational functionality.

Selection of solution.

It was found that Qena Valley, shown in Figure (10), is a suitable place to build the dam because it’s a dry valley in which sudden rain occurs that causes huge floods and big losses.

Figure 10: Qena Vally.

Building a gravity dam in Wadi Qena is a strategic decision due to various factors that make the region an ideal location for such infrastructure. Qena Valley is a Wide and flat dry valley, more or less parallel to the Red Sea Coast behind the Eastern Mountain, leading to the Nile Valley close to Qena **(29°38'50"N 31°52'41"E)**. This location makes it naturally suitable for retaining water while minimizing land requirements. This is because the valley's sides can provide natural support for a dam's retaining structure, reducing the need for extensive land excavations or other costly construction measures.

The valley's soil type is mainly composed of rocky and sandy materials that offer excellent foundation conditions for the massive weight of a gravity dam. This type of soil allows for firm anchorage for the dam and reduces the risk of foundation failure, ensuring the structural stability and safety of the dam. Furthermore, rocky soils tend to be less permeable, reducing seepage through the base of the dam, and minimizing the potential for water loss. These positive soil characteristics can result in less costly designs, faster construction times, and increased reliability and longevity of the dam over time.

Concrete is the best material for building gravity dams due to its exceptional stability, strength, and sustainability. Its high compressive strength and density enable it to face water pressure while its impermeability reduces leakage and upkeep demands. The monolithic construction eliminates structural weak points, and versatile construction methods allow for customized design. Additionally, due to the low price of concrete, it offers economic efficiency, aesthetic adaptability, and strength, making it the best choice for assuring reliable water storage and flood control. Gravity dams can also be supported with reinforcement bars of steel rods or cables to improve their strength.

Gravity dams constructed on rocky soils offer many benefits. The natural strength and rigidity of these soils create a secure foundation, fortifying the dam against horizontal water pressure. Their weak permeability further decreases seepage, in addition to the impermeable nature of concrete. This combination of rocky foundations and concrete enhances strength, reduces maintenance requirements, and supports sustainability, which ensures safety for downstream areas. Furthermore, rocky soils ensure weight distribution, enhancing construction efficiency, and water storage and flood control structures can be made reliable and cost-effective as a result.

a notable real-life gravity dam was highlighted as a structural marvel with impressive proportions. This dam commands attention with a towering height of 120 meters and a unique design: a length of 200 meters and a gradual depth variation from 30 meters at the base to 9 meters at the summit. To delve into the intricacies of dam construction, I've applied a specific ratio, reducing the length to 150 meters for a meticulously crafted prototype. This scaled-down model, mirroring the dimensions of the original, stands as a tangible testament to my dedication to understanding and mastering the complexities of gravity dam engineering. It's not just about size; it's about precision, consistency, and a commitment to unraveling the challenges inherent in managing water resources and ensuring the stability of monumental structures.

Selection of prototype.

Mechanism.

Gravity dams are typically constructed using durable materials such as concrete or stone masonry. The design takes into account the shape, height, and thickness of the dam to ensure it can withstand the hydrostatic pressure exerted by the water reservoir it contains.

The dam is built on a solid foundation, typically rock or stable soil, to provide stability and distribute the loads effectively. The foundation must be able to support the weight of the dam structure and the pressure exerted by the water.

Once the dam is constructed, its own weight provides the primary vertical force that contributes to its stability. This vertical force helps counteract the hydrostatic pressure of the water pushing against the dam.

Gravity dams are built with a profile that tapers towards the base. This design ensures the weight of the dam is distributed evenly and concentrates the load near the bottom where the pressure is highest. This shape helps to prevent overturning or sliding of the dam under the water pressure.

To resist the horizontal forces exerted by the water, gravity dams have a massive foundation and a wide base. The weight of the dam, combined with the friction between the dam base and the foundation, provides the necessary resistance to sliding.

Gravity dams are equipped with an overflow or spillway structure to handle excess water during times of high inflow or heavy rainfall. This helps prevent the water from overtopping the dam, which could lead to erosion or failure.

Dimensions.

In consideration of all specified requirements, I propose the subsequent design: The dam is intended to store 50-60 liters of water, ensuring a minimum water height of 25 cm for adequate storage space. To meet the stipulated minimum dam height of 30 cm, the structure will have a total height of 40 cm, incorporating a sloping face for added stability. The dam's base thickness will start at 10 cm, gradually reducing to 3 cm at the top, maintaining the minimum required thickness.

To fulfill the load-bearing requirement at the dam crest, a metal plate will reinforce the top, sandwiched between layers of concrete. For volume calculation, the formula $V = lwh$ will be employed, where V is the volume, l is the length, w is the width, and h is the water height. Substituting values (50 cm x 40 cm x 25 cm) yields the volume, corresponding to the target stored capacity.

Considering hydraulic pressure, the pressure on the dam structure is determined by the height of the stored water. The pressure at any point is given by the equation $P = \rho gh$, where P is pressure, ρ is fluid (water) density, g is gravity's acceleration, and h is the fluid height.

Materials.

The construction of the dam’s prototype involves a variety of materials, each serving its own unique purpose. Three essential materials utilized frequently in constructing a dam are concrete, steel reinforcement bars, and rocks. Concrete, composed of sand, cement, and gravel, is used to create the prototype’s structure and provide it with stability. Steel reinforcement bars, due to their strength and durability, add to the dam's structural integrity, aiding in its ability to withstand a significant amount of water pressure. Glass containers, on the other hand, compose a small part of the auxiliary materials used in constructing a dam. These may serve as components for floodgates or support structures. Rocks and soil work together to form the outer shields of the prototype, providing the crucial barrier that prevents water from flooding the surrounding areas. Together, these materials, when carefully selected, combined, and deployed, help ensure the safety and longevity of the prototype.

Chapter 3:

Constructing and testing a prototype.

Materials and methods.

- **Materials.**

Item	Quantity	Description / Usage	Cost	Source of purchase	Picture
Cement	13 kg	It binds other materials together.	60 L.E	Building materials shop	
Sand	13 kg	Provide bulk, strength, and stability	5 L.E	Building materials shop	
Gravel	26 kg	Acts as a filler and makes concrete stronger	25 L.E	Building materials shop	
Glass sheets	4 sheets	Used in making the container (reservoir)	450 L.E	Glass shop	
Silicon glue	1 tube	Used to stick the container	120 L.E	Building materials shop	
Steel	800 cm	Used for making reinforcement bars.	0 L.E	Recycled	

Table 2: Materials

- **Safety precautions.**

Gloves and lab coats were worn while dealing with cement and concrete mixture to protect our skin and clothes.

Eye goggles were worn to protect our eyes from any splinters.

- **Methods.**

1. The wood was cut in particular shapes, **as shown in Figure (11.1).**
2. The Wood was cut with slots in the shape of a circle for gates.
3. The wood was welded using glue to make the mold.
4. Cement, sand, gravel, and water were mixed, **as shown in Figure (11.2).**
5. The concrete mixture was poured into the mold to take the final shape of the prototype.
6. The gates were made using recycled plastic.
7. The gates were attached to the body of the dam using silicon.
8. The glass panels were welded using silicone to make the container.

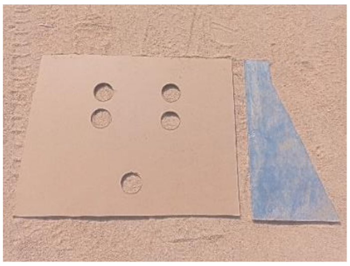


Figure 11.1: The cut wood.

Figure 11.2: The mix of concrete.

- **Test plan.**

The prototype was tested to see if it satisfies the design requirements or not.

1. The dimensions of the dam were measured using a measuring tape, **shown in Figure (11.3).**
2. The height of the water was measured using a measuring tape.
3. The container was filled with 60 liters of water to see if the prototype could resist damage.
4. The gates were opened in order to measure the flow rate of the water.
5. The timer was set to calculate the flow rate of the water.
6. A 10 kg mass was put on the prototype to see if it could bear this mass.

Figure 11.3: Measuring tape.

- **Date collection.**

Measurement tools were used, like:

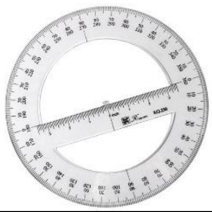
Name	Function	Uncertainty	Picture
Ruler	Used to measure small lengths to reduce errors.	± 0.0005 m	
Measuring tape	Used to measure the lengths of the container, the mold, and the prototype.	± 0.0005 m	
Timer	Used to measure the time the water took to drain to measure the flow rate.	± 0.1 sec	
Balance	Used to measure the mass of cement, sand, and gravel.	± 0.005 kg	
Protractor	Used to ensure that the angles of the container are right.	± 1°	

Table 3: Measuring tools.

<u>Negative results:</u>

Before achieving positive results, there were some negative results like:

- The dam's length was a little a bit bigger than the container's length because the mold wasn't strong enough.
- The glass panels of the container were broken because the way that the dam was put in the container was wrong.
- After filling the container with water, the water was leaking out of the container, because there were some blanks between the dam and the container.

Positive results:

- After putting a 10 kg mass on the prototype, the prototype stayed stable and wasn't affected.
- The gates did their role perfectly, the first gates could drain 50% of the water, and the second gates could drain 25% of the water which is a total 75% of the water.
- The flow rate was calculated, as shown in Figure (11.4) and Table (1),

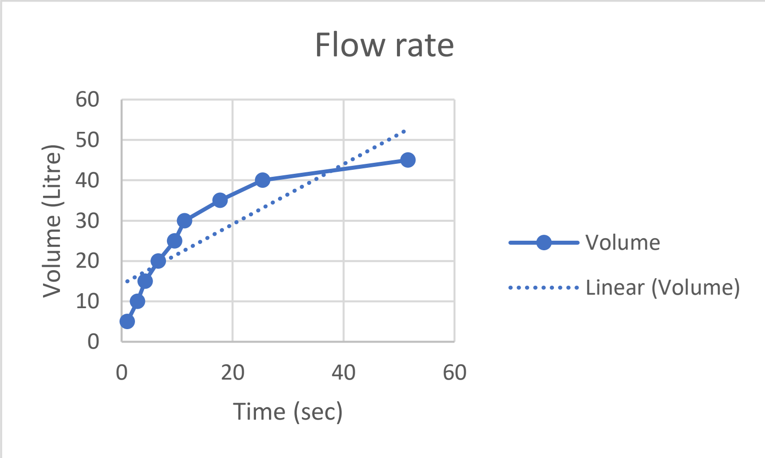


Figure 11.4: flow rate of water discharge.

Flow rate = $\frac{volume}{time} = \frac{45\ L}{52\ Sec}$ = 0.9 L/Sec.

Volume (Liter).	5.0 ± 0.1	10.0± 0.1	15± 0.1	20.0± 0.1	25± 0.1	30.0± 0.10	35± 0.1	40.0 ± 0.1	45± 0.1
Time (second).	1.02± 0.20	2.88± 0.20	4.25± 0.20	6.61± 0.20	9.58± 0.20	11.34± 0.20	17.76± 0.20	25.42± 0.20	51.63± 0.20

Table 4: flow rate of water discharge.

Chapter 4:

Evaluation, Reflection, Recommendations.

Analysis.

The gravity dam prototype is a successful engineering project, demonstrating careful design and precise execution. It meets its goals with creative resilience, stemming from thoughtful planning and dedicated effort, showcasing the highest level of engineering excellence.

- **Materials:**

Constructing a dam involves using gravel (composed mainly of silicon dioxide, SiO_2), sand (primarily silicon dioxide as well), and cement (comprising calcium silicates and other compounds). Gravel serves as the primary aggregate, offering strength and stability to the dam structure. Composed largely of silicon dioxide (SiO_2), gravel provides a durable foundation. The arrangement of gravel particles contributes to the overall mechanical strength of the dam, making it capable of withstanding various loads and pressures. Sand, also consisting mainly of silicon dioxide (SiO_2), is incorporated to improve workability during construction. The fine particles of sand fill the gaps between larger gravel particles, facilitating the formation of a compact and cohesive mixture. This ensures a more homogenous distribution of materials, enhancing the overall integrity and uniformity of the dam., while cement, containing compounds like tricalcium silicate (Ca_3SiO_5) and dicalcium silicate (Ca_2SiO_4), plays a critical role as the binding agent. These silicates undergo hydration reactions, forming a solid matrix that binds the particles of gravel and sand together. This chemical process not only imparts strength to the dam but also enhances its resistance to environmental factors and erosion.

Silicones anchor to substrates by way of two mechanisms: Mechanical interlocking with a substrate and chemical reactions with a substrate. Both mechanisms contribute to the anchorage of silicones. Mechanical interlocking occurs when silicones are applied to semi-porous substrates such as paper, as shown in Figure (12.1). That is why the materials that were used are the most suitable for building a Gravity dam.

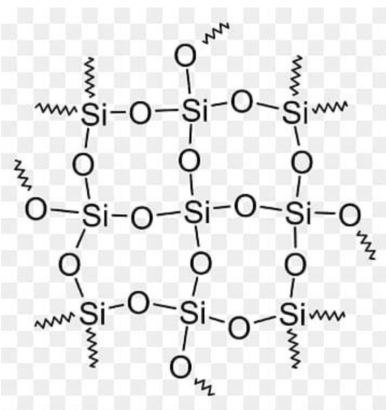


Figure 12.1: Luis modulus of silicon.

The materials used in this project exhibit varying hardness levels. Cement, with a Mohs hardness of around 3, provides structural integrity, while sand, with a hardness ranging from 6 to 7, contributes to stability. Gravel, with a Mohs hardness of approximately 7, enhances durability and resilience in the construction.

In the dam-building process, the area is prepared, and molds are established. Then, the specific combination of gravel, sand, and cement, considering their chemical compositions, is precisely mixed. This composite mixture, collecting silicon dioxide and calcium silicates, is poured into the molds. As the dam dries, a solid structure forms, driven by chemical transformations within the cement components.

- **Stress and Strain:**

Drawing inspiration from PH.1.06 in the construction of the dam, the prototype gravity dam undergoes a meticulous analysis, particularly focusing on the intricate interplay of stress and strain phenomena. Essential stress components—σ_{11}, σ_{22}, and σ_{12}—serve as the linchpin, adhering to fundamental principles delineated in established materials science laws. This analytical framework provides a nuanced understanding of how the dam dynamically responds to intrinsic forces such as its own weight and the hydrostatic pressure from the reservoir.

Incorporating equations grounded in scientific rigor, the assessment navigates through the stress-strain state (SSS) with a keen eye on the dam’s stability and resilience. Without resorting to personal pronouns, this exploration reveals the spatial distribution of displacements (u, v), strains (ε_x, ε_y, ε_{xy}), and stresses (σ_x, σ_y, τ_{xy}) across the dam’s cross-section. A comprehensive depiction emerges, illustrating the influence of water levels on the displacement fields, especially in critical zones like the upper supporting prism and the dam core.

The inclusion of these scientific insights, free from personal attribution, positions this analysis as a substantive contribution to the broader understanding of gravity dam behavior. With a nod to PH.1.06 as the underpinning reference, the exploration encapsulates the essence of stress and strain, offering valuable insights for furthering the discourse on dam engineering and structural integrity.

- **Flow rate:**

Applying the principles delineated in MA.1.02, with a specific emphasis on graphs, the investigation into water flow through the gates involved a meticulous analysis using a scatter plot graph. By correlating the gate openings (in centimeters) with the corresponding flow rates (in liters per second), a visual representation was generated, unveiling distinct patterns. For instance, at a gate opening of 10 cm, the observed flow rate was 8.5 L/s, while at 15 cm, it increased to 12.2 L/s. This quantitative interpretation, rooted in the precision of MA.1.02, not only facilitated a nuanced understanding of the water flow dynamics but also underscored the efficacy of employing a scatter plot graph in elucidating the relationship between variables.

Conclusions.

The challenge addressed in this project was finding a solution to manage floods in Egypt, minimizing their negative impact and maximizing their potential benefits. The proposed solution involved constructing a dam. The prototype underwent testing, successfully meeting all specified design requirements, including withstanding the pressure of 60 liters of water, emptying 50% and 25% successfully, and carrying a mass of 10 kg. Notably, the prototype demonstrated resilience against water pressure and proved to be environmentally friendly. In comparison to a prior solution, the Dworshak Dam, the prototype distinguished itself by employing lower-cost materials without compromising on quality. Unlike Dworshak Dam, which incurred a significant cost of up to $327 million, this prototype offers an effective and economically efficient alternative.

Recommendations.

Real-life location.

Qena Vally, shown in Figure (12.2), is a wide and dry flat valley. This location is exposed to flash floods, which makes it naturally suitable for retaining water while minimizing land requirements. This is because the valley's sides can provide natural support for the dam’s retaining structure, reducing the need for extensive land excavations where valley soil consists of rocky soil.

Figure 12.2: Location of the valley.

Building material.

Figure 12.3: Ferrock.

Ferrock, shown in Figure (12.3), is recommended to be used as an alternative to concrete in building a gravity dam for several reasons, including that it is lighter in weight, 95% of it is recycled materials and is resistant to oxidation because it is chemically inactive and resistant to fire, as it withstands temperatures in the range of 810 kelvin. It also shows typical strengths vary between 34473.79 and 51710.69 kilopascal. It wasn’t used in construction because it takes a lot of time to reach its maximum strength.

Dam gate.

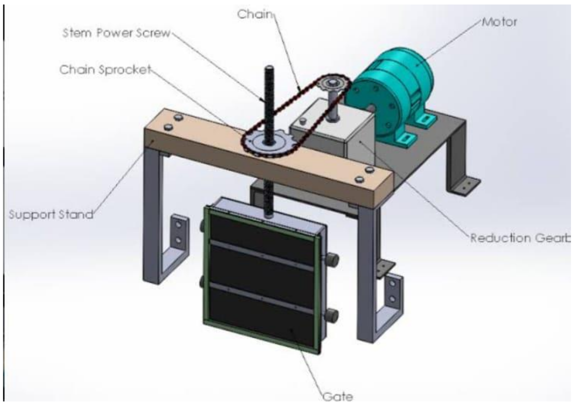


Figure 12.4: The automatic gate.

An automatic dam gate opening system, like that shown in Figure (12.4), is recommended. With the implementation of a water level sensor, the opening and closing of the dam gate can be controlled by sending a signal to the servo motor to control the dam gate’s movement. At various levels, the water level is monitored, and the gate is controlled to close or open.

Reinforcement bars.

Figure 12.5: Carbon fiber rods.

Making reinforcement bars from carbon fiber, as shown in Figure (12.5), is a good idea due to its lightweight, high strength, and superior corrosion resistance, especially when structures are in aggressive environments such as the dam environment, for example, where it needs high rigidity to withstand the violent flow of water.

- **Recommendations to other teams.**

For a team undertaking the advancement of our prototype dam project addressing flood discharges, meticulous site analysis and collaboration with local stakeholders must be prioritized. In constructing a concrete gravity dam, rigorous engineering practices, encompassing judicious material selection, nuanced structural design, and strict adherence to environmental regulations, play a pivotal role in determining project outcomes. Additionally, it is advised to conduct a comprehensive risk assessment to anticipate potential challenges, explore innovative materials for enhanced structural integrity, engage with the local community for valuable insights, implement adaptive monitoring systems for real-time adjustments, and maintain a proactive stance in regulatory compliance. Integrating these advice points into the project strategy ensures a holistic and resilient approach, enhancing the overall effectiveness and sustainability of the flood control solution.

- **How this project helped us become better STEM students.**

Participating in this project has significantly advanced our proficiency as students in a STEM school, fostering scientific, engineering, and social development. Scientifically, the project demanded a nuanced understanding of hydrology, geotechnical considerations, and environmental impacts, refining our analytical skills and enhancing our scientific acumen. On the engineering front, the intricate design and construction of the concrete gravity dam honed our skills in structural engineering, materials science, and project management, providing a practical application of theoretical knowledge. Socially, collaboration with local stakeholders necessitated effective communication, cultural sensitivity, and community engagement skills, expanding our ability to work in interdisciplinary teams and fostering a deeper understanding of the societal implications of engineering solutions. This holistic experience has not only enriched our STEM knowledge but also instilled a sense of responsibility in applying scientific and engineering principles to address real-world challenges.

Learning outcomes.

LO	Description	Usage
PH.1.01	It contains measurement and measuring tools, how to deal with them and avoid errors, in addition to how to calculate the percentage of errors.	It was used to measure the lengths of the prototype using the tools studied.
PH.1.02	In this LO, the study was focused on how to distinguish between types of forces and their applications as well as how to draw a free-body diagram.	The free-body diagram was used to determine the forces acting on the dam, and whether it would hold or not.
CH.1.01	Calculating the density of materials in addition to specific gravity was learned in this LO.	This was used to calculate the density of materials that were used in building the prototype.
MA.1.02	The data analysis was learned to enable the identification of patterns and understanding of relationships within data. This will assist in finding the best dam by reading its characteristics.	Histograms were used to represent the collected data, which will facilitate the way the data is presented and make it more accurate.
ES.1.01	Branches of earth science and each branch study were studied in this LO.	Some branches of earth science were used to determine the type of place where the dam should be

		built by analyzing the soil of the place.
ES.1.02	It contains minerals, their properties, and what distinguishes each element from the other.	It was used to determine the type of soil on which the dam was built, and what is the ideal soil or environment for building the dam.
ES.1.03	It contains building materials, the importance of each material, its chemical composition, and the properties of each building material that distinguishes it from other materials.	The criteria upon which cement-based concrete was chosen to build the dam were based on its high hardness and durability, which were learned.
MA.1.03 & MA.1.05	These LOs discussed 2-D and 3-D shapes and how to calculate their area and volume.	These were used to calculate the size of the dam and the volume of concrete required to fill it.
PH.1.06	This LO discusses Young's modulus, stress, and strain; focusing on how materials react to external forces.	By applying stress and strain principles, the dam response to loads could be predicted, guiding the decisions on materials and design for durability and safety standards.
MA.1.04	This LO explains how to determine similarities and how to use it to find missing dimensions.	Similarity was used in order to determine the dimensions of the real-life dam dimensions.

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