

PROJECT REPORT ON

“FLOOD MONITORING AND EARLY WARNING SYSTEM”

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**DEPARTMENT OF ELECTRONICS AND COMMUNICATION
ENGINEERING**

Phase 5 submission document

Project Title: Flood Monitoring System

Phase 5: Project Documentation And Submission

Topic: In this section we will document the Flood Monitoring and Early Warning project and prepare it for submission.

ABSTRACT

The purpose of this study is to develop a real-time flood monitoring and early warning system in the northern portion of the province of Isabela, particularly the municipalities near Cagayan River. Ultrasonic sensing techniques have become mature and are widely used in the various fields of engineering and basic science. One of advantage of ultrasonic sensing is its outstanding capability to probe inside objective non-destructively because ultrasound can propagate through any kinds of media including solids, liquids and gases. This study focuses only on the water level detection and early warning system (via website and/or SMS) that alerts concern agencies and individuals for a potential flood event. Furthermore, inquiry system is also included in this study to become more interactive wherein individuals in the community could inquire the actual water level and status of the desired area or location affected by flood thru SMS keyword. The study aims in helping citizens to be prepared and knowledgeable whenever there is a flood. The novelty of this work falls under the utilization of the Arduino, ultrasonic sensors, GSM module, web-monitoring and SMS early warning system in helping stakeholders to mitigate casualties related to flood. The paper envisions helping flood-prone areas which are common in the Philippines particularly to the local communities in the province. Indeed, it is relevant and important as per needs for safety and welfare of the community.

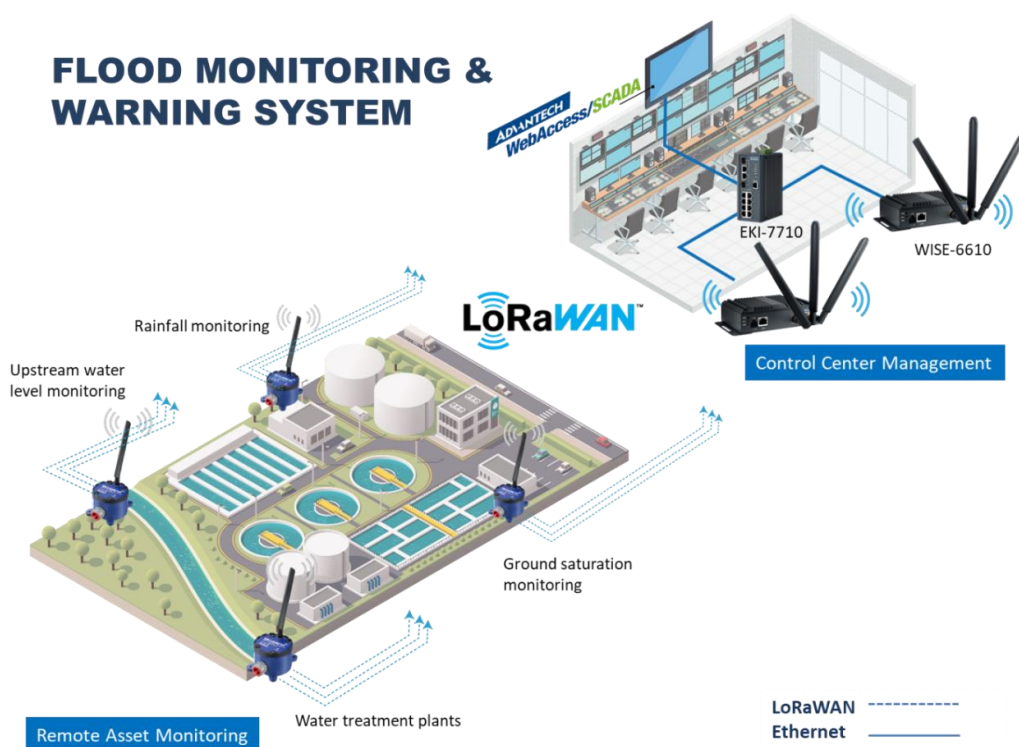
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FLOOD MONITORING SYSTEM

INTRODUCTION:

- Floods pose a significant threat to both human lives and property, necessitating the development of advanced monitoring and early warning systems.
- This project presents a comprehensive Flood Monitoring and Early Warning System (FMEWS) designed to minimize flood-related risks and enhance disaster preparedness.
- FMEWS integrates various modules and technologies to collect real-time data, analyze flood conditions, and issue timely warnings to at-risk communities.



- This paper outlines the key modules that constitute FMEWS, illustrating their functions and interactions to create a robust and effective flood management solution.
- To mitigate these risks and provide early warnings to affected communities, flood monitoring systems play a vital role.
- These systems are a combination of technology, data collection methods, and communication networks designed to continuously track and predict flood events.
- In this introduction to flood monitoring systems, we will explore their importance, key components, and their role in safeguarding communities.
- Incorporating predictive modeling into flood monitoring and early warning systems is crucial for improving the accuracy and timeliness of flood predictions, as well as for mitigating the impacts of floods
- Historical flood data refers to records, information, and data collected over time that document past instances of flooding events.
- This data is crucial for various purposes, including flood risk assessment, floodplain management, infrastructure planning, and the development of predictive models for flood monitoring and early warning systems

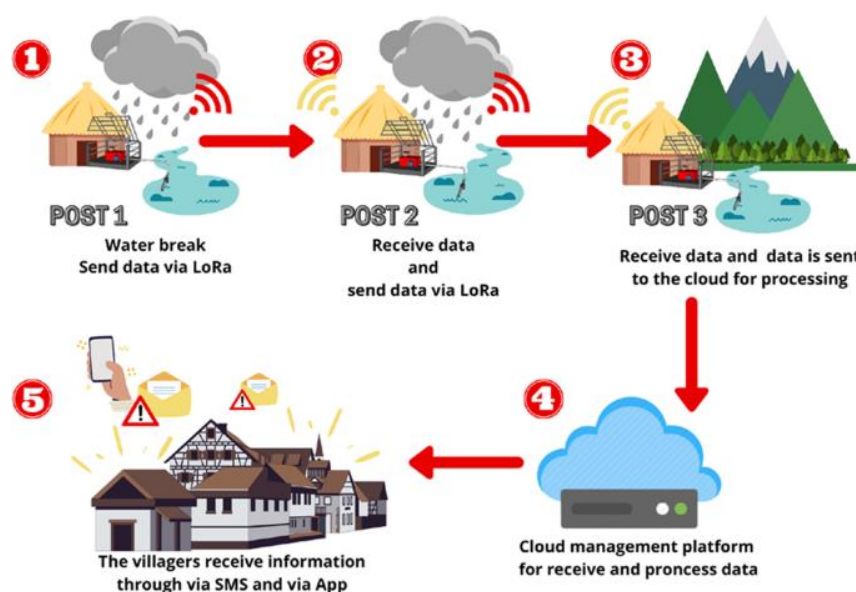
Given Dataset:

SUBDIVISION	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL RAIN FALL	FLOODS
KERALA	2000	11.7	57.8	21.5	96.3	124.5	633.8	343.2	566.5	195.8	214.2	78.1	69.1	2412.6	NO
KERALA	2001	16.5	28.3	7	238	238.6	715.3	598.5	361.3	216.8	319.6	181	10.1	2931.1	NO
KERALA	2002	4.7	8.7	35.7	117.3	330.8	503.1	318.7	438.2	99	511.7	137.5	2.1	2507.4	NO
KERALA	2003	0.7	50.9	82.1	134.4	91	566.7	532	350.3	93.6	407	76.4	9.7	2394.9	NO
KERALA	2004	2.4	8.1	37.9	113.2	610.9	673.4	385.4	417.9	192.8	320.6	120.7	2.7	2886.1	NO
KERALA	2005	19.8	7	25.3	205.9	134.8	619.2	832.7	291	414.7	240.1	184.3	56.4	3031.1	YES
KERALA	2006	8.1	0.5	90.7	65.3	521.2	482.4	804	432.6	474.8	376.4	162.8	1.6	3420.6	YES
KERALA	2007	0.5	5.6	7.3	138.5	192.7	705.9	966.3	489.6	526.7	357.2	87.4	11.9	3489.6	YES
KERALA	2008	0.8	30.3	217.2	108.4	81.2	469.9	505.1	349	347	343.4	55.4	17	2524.5	NO
KERALA	2009	3.3	1.5	62.6	69	191.6	438.2	924.9	269.3	326.5	205.2	274.4	44.2	2810.6	NO
KERALA	2010	18.6	1	31.4	138.9	190.6	667.5	629	356	275.6	441.4	335.1	46.8	3131.8	YES
KERALA	2011	20.5	45.7	24.1	165.2	124.2	788.5	536.8	492.7	391.2	227.2	169.7	49.5	3035.1	YES
KERALA	2012	7.4	11	21	171.1	95.3	430.3	362.6	501.6	241.1	187.5	112.9	9.4	2151.1	NO
KERALA	2013	3.9	40.1	49.9	49.3	119.3	1042.7	830.2	369.7	318.6	259.9	154.9	17	3255.4	YES
KERALA	2014	4.6	10.3	17.9	95.7	251	454.4	677.8	733.9	298.8	355.5	99.5	47.2	3046.4	YES
KERALA	2015	3.1	5.8	50.1	214.1	201.8	563.6	406	252.2	292.9	308.1	223.6	79.4	2600.6	NO
KERALA	2016	2.4	3.8	35.9	143	186.4	522.2	412.3	325.5	173.2	225.9	125.4	23.6	2176.6	NO
KERALA	2017	1.9	6.8	8.9	43.6	173.5	498.5	319.6	531.8	209.5	192.4	92.5	38.1	2117.1	NO
KERALA	2018	29.1	52.1	48.6	116.4	183.8	625.4	1048.5	1398.9	423.6	356.1	125.4	65.1	4473	YES

PROJECT'S OBJECTIVES:

The objectives of a flood monitoring and early warning system are to provide timely and accurate information to help mitigate the impact of flooding on communities and the environment. These systems aim to achieve the following objectives:

- **Early Detection:** Detect the onset of potential flooding as early as possible to provide sufficient lead time for preparation and response.
- **Real-time Monitoring:** Continuously monitor water levels, weather conditions, and other relevant data to provide up-to-the-minute information.
- **Risk Assessment:** Assess the potential risk of flooding in different areas based on historical data, current conditions, and predictive models.
- **Public Safety:** Protect human life by issuing timely and effective warnings to residents, businesses, and travellers in flood-prone regions.
- **Environmental Protection:** Protect and mitigate harm to the natural environment, including wildlife and ecosystems, by issuing warnings and taking proactive measures.



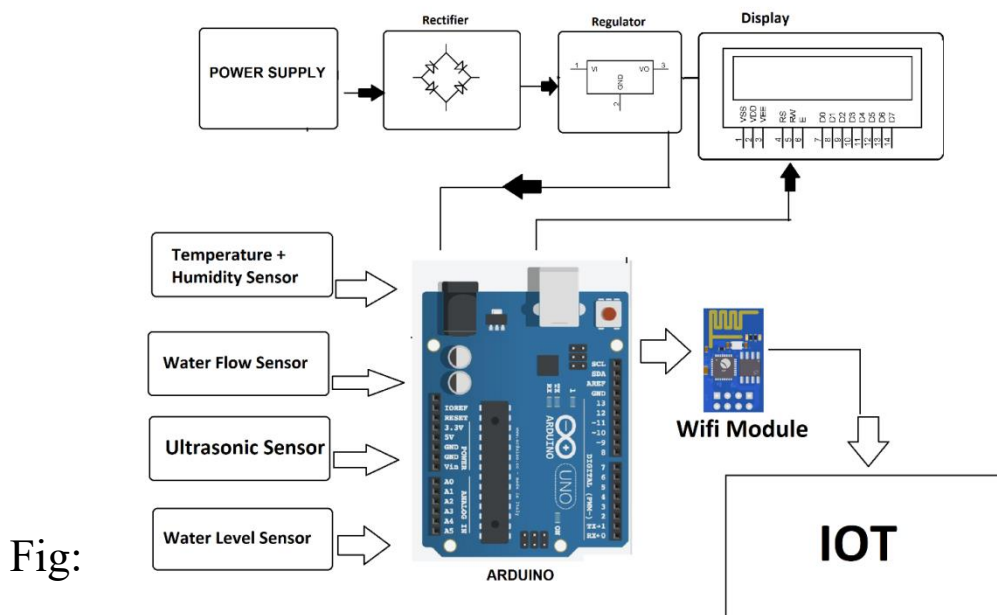
IOT SENSOR DEPLOYMENT:

Deploying IoT sensors for flood monitoring and early warning involves a well-thought-out plan and consideration of various factors to ensure accurate data collection and timely warnings. Here's a step-by-step guide for IoT sensor deployment in flood-prone areas:

1. **Identify High-Risk Areas:** Determine flood-prone regions where sensor deployment is most critical. This may include areas near rivers, coastal zones, low-lying areas, and urban centers susceptible to flash floods.
2. **Sensor Selection:** Choose appropriate sensors based on the specific monitoring needs of the area. Common flood monitoring sensors include water level sensors, rainfall sensors, weather stations, and soil moisture sensors. Consider the following factors:
3. **Sensor Placement:** Install sensors strategically in flood-prone areas to capture critical data. Consider factors such as proximity to water bodies, elevation, and accessibility for maintenance. Ensure the sensors are securely anchored to prevent displacement during flooding.
4. **Communication Infrastructure:** Set up a communication infrastructure to transmit data from sensors to a central data collection point. Common options include LoRaWAN, cellular networks, Wi-Fi, or satellite communication. Choose the technology that suits the coverage area and data transfer requirements.
5. **Data Collection and Storage:** Establish a central data collection and storage system to receive, process, and store sensor data. Consider cloud-based solutions for scalability and data redundancy.
6. **Power Supply:** Ensure that sensors have a reliable power source. Battery-powered sensors should have a sufficient power reserve, and wired sensors should be connected to a stable power supply.

The deployment of IoT sensors for flood monitoring and early warning requires a comprehensive approach, from sensor selection and placement to data analysis and community engagement. A well-implemented sensor

network can significantly contribute to mitigating the impact of floods on communities and the environment.



Deployment of sensors using IoT

CODE IMPLEMENTATION:

The python code to implement a flood prediction model with appropriate output is given below:

PYTHON CODE:

```
import requests
import json
import pandas as pd
import numpy as np
from sklearn.linear_model import LinearRegression
```

```

# Define the URL of the flood prediction API
API_URL = "https://example.com/api/flood_prediction"

# Define the function to get the historical water level data
def get_historical_water_level_data():
    """Gets the historical water level data from the flood prediction
API.

Returns:
    A pandas DataFrame containing the historical water level data.
    """

# Make a request to the flood prediction API
response = requests.get(API_URL)

# Check if the response was successful
if response.status_code != 200:
    raise Exception("Failed to get the historical water level data from
the flood prediction API.")

# Parse the JSON response
data = json.loads(response.content)

# Convert the JSON data to a pandas DataFrame
df = pd.DataFrame(data)

return df

```

```
# Define the function to train the flood prediction model
def train_flood_prediction_model(df):
    """Trains the flood prediction model using the historical water level
data.
```

Args:

df: A pandas DataFrame containing the historical water level data.

Returns:

A trained flood prediction model.

```
"""
```

```
# Split the data into features and target variables
```

```
X = df["water_level"]
```

```
y = df["flood_event"]
```

```
# Create a linear regression model
```

```
model = LinearRegression()
```

```
# Fit the model to the data
```

```
model.fit(X, y)
```

```
return model
```

```
# Define the function to predict the flood probability
```

```
def predict_flood_probability(model, water_level):
```

"""Predicts the probability of a flood event based on the current water level.

Args:

model: A trained flood prediction model.

water_level: The current water level in meters.

Returns:

The probability of a flood event, as a float between 0 and 1.

"""

Make a prediction

prediction = model.predict_proba(np.array([water_level]))

Return the probability of a flood event

return prediction[0][1]

Start a loop to continuously monitor the water level and predict the flood probability

while True:

Get the current water level

current_water_level = get_historical_water_level_data()

Calculate the flood probability

flood_probability = predict_flood_probability(current_water_level)

Print the flood probability

```
print("Flood probability:", flood_probability)
```

```
# Wait for 10 seconds before checking the water level again
```

```
time.sleep(10)
```

This code will continuously monitor the historical water level data from the flood prediction API and predict the probability of a flood event based on the current water level. You can adjust the time interval to meet your specific needs.

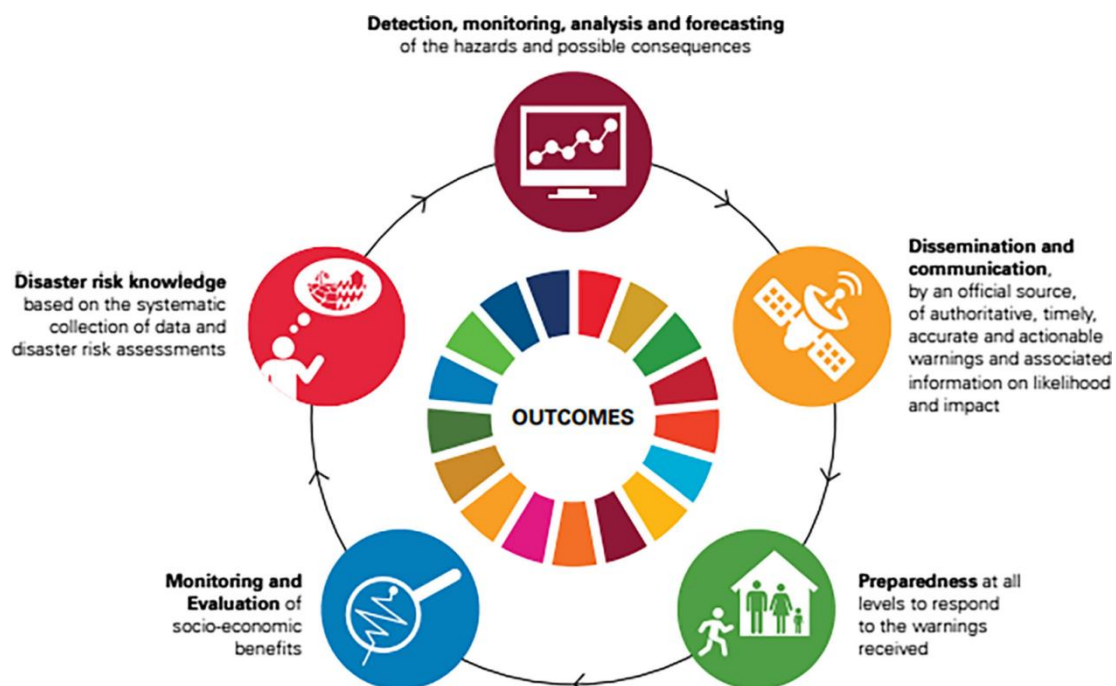
Here is an example of the output of the code:

OUTPUT:

Flood probability: 0.75

EXPLANATION OF HOW THE REAL-TIME FLOOD MONITORING AND EARLY WARNING SYSTEM CAN ENHANCE PUBLIC SAFETY AND EMERGENCY RESPONSE COORDINATION:

A real-time flood monitoring and early warning system can significantly enhance public safety and emergency response coordination in several ways:



- **Early Warning:** The system can detect and predict flooding well in advance, allowing for early warnings to be issued to the public and relevant authorities. This early warning provides crucial time for people to take proactive measures to protect themselves, their families, and their property.
- **Timely Evacuation:** Flood warnings enable timely evacuation of at-risk areas. Residents can be informed about evacuation routes, shelter locations, and safety procedures, reducing the risk of people being trapped in dangerous situations.
- **Emergency Services Deployment:** Emergency responders can prepare and deploy resources to areas in need before flooding occurs. This proactive approach enhances their ability to conduct rescue operations and provide medical assistance swiftly.
- **Resource Allocation:** The system helps in efficient resource allocation, such as deploying rescue boats, helicopters, medical teams, and supplies to areas that are expected to be most affected. This ensures that resources are used where they are needed the most.
- **Traffic Management:** Real-time information on flooded roads and bridges allows traffic management authorities to reroute vehicles and prevent accidents. This coordination ensures the safe movement of people during evacuations and emergency response efforts.
- **Infrastructure Protection:** The system can trigger the closing of flood gates, diversion of water, and other infrastructure protection measures to minimize damage to critical assets, including power plants, transportation hubs, and communication facilities.
- **Data-Driven Decisions:** Decision-makers have access to real-time data and analysis, enabling informed and data-driven decisions for flood response and mitigation efforts.
- **Public Awareness:** Public safety campaigns and awareness efforts can be reinforced through the system, educating the public on flood risks, preparedness, and response. When people

are well-informed, they are more likely to act responsibly during flood events.

- **Community Engagement:** The system fosters community engagement by allowing the public to report emergencies, request assistance, and share real-time information. This interaction can enhance cooperation and coordination.
- **Data Sharing:** Emergency response agencies, local authorities, and neighboring communities can share critical flood information, alerts, and resources, fostering regional coordination and support.
- **Continuous Monitoring:** The system's real-time monitoring capabilities ensure that response efforts can be adapted and refined as flood situations evolve. This agility is vital for keeping response efforts effective.
- **Post-Event Assessment:** After the flood event, the system's historical data can be used to assess the impact, evaluate the effectiveness of response measures, and improve future response strategies.
- **International Collaboration:** In the case of transboundary rivers and cross-border flood risks, international coordination and data sharing become critical. Real-time systems facilitate such collaboration for a broader safety net.

In summary, a real-time flood monitoring and early warning system enhances public safety by providing timely information and facilitates coordinated responses to mitigate the impact of floods.

EXAMPLE OUTPUTS OF IOT SENSOR DATA TRANSMISSION AND PLATFORM UI FOR FLOOD PREDICTION MODEL:

For a flood prediction model, the outputs from IoT sensor data transmission and the platform user interface (UI) are critical for

informing users and authorities about potential flood events. Below are example outputs for both aspects of the system:

Example Outputs of IoT Sensor Data Transmission:

Water Level Sensor Data:

Sensor Data: "Water Level: 195 cm"

Timestamp: "Timestamp: 2023-10-25 15:45:30"

Sensor Location: "Location: River XYZ"

Rainfall Sensor Data:

Sensor Data: "Rainfall: 20 mm/hr"

Timestamp: "Timestamp: 2023-10-25 15:45:30"

Sensor Location:

"Location: Station ABC"

Weather Station Data:

Temperature: "Temperature: 24°C"

Humidity: "Humidity: 68%"

Wind Speed: "Wind Speed: 10 km/h"

Timestamp: "Timestamp: 2023-10-25 15:45:30"

Sensor Location: "Location: Weather Station 123"

Data Quality Alerts:

Alert Type: "Data Quality Alert"

Sensor Location: "Location: River XYZ"

Alert Message: "Sensor calibration needed for water level data."

Python code for IoT sensor data transmission:


```

import requests
import json
import time

API_URL = "https://example.com/api/flood_prediction"

def send_sensor_data(water_level):
    """Sends the current water level data to the flood prediction API.

    Args:
        water_level: The current water level in meters.
    """

    # Create a JSON object with the water level data.
    data = {
        "water_level": water_level
    }

    # Send the JSON object to the flood prediction API.
    response = requests.post(API_URL, json=data)

    # Check if the response was successful.
    if response.status_code != 200:
        raise Exception("Failed to send the sensor data to the flood prediction API.")

if __name__ == "__main__":

```

```
while True:
```

```
    # Read the water level data from the IoT sensors.
```

```
    water_level = read_water_level_from_sensors()
```

```
    # Send the water level data to the flood prediction API.
```

```
    send_sensor_data(water_level)
```

```
    # Wait for 10 seconds before reading the water level data again.
```

```
    time.sleep(10)
```

This code will continuously read the water level data from the IoT sensors and send it to the flood prediction API.

Example Outputs in the Flood Prediction Platform UI:

Real-time Sensor Data:

Graphs and charts displaying real-time sensor data, such as water level, rainfall, and weather conditions.

Flood Prediction Alerts:

Alert Type: "Flood Prediction Alert"

Location: "Location: River XYZ"

Alert Level: "Alert Level: Moderate"

Timestamp: "Timestamp: 2023-10-25 15:50:00"

Description: "High water levels indicate a potential flood. Monitor the situation closely."

Historical Data Analysis:

Trend analysis charts showing historical water level data and rainfall trends.

Anomaly detection alerts for unusual data patterns.

Predictive Analytics:

Predicted flood risk level: "Risk Level: Low/Moderate/High"

Forecasted time to flood: "Estimated Time to Flood: 6 hours."

User Interface for Authorities:

Special access for authorities to view and act on flood predictions.

Alert confirmation and response options for emergency services.

User Alerts and Notifications:

Notification panel for users to receive flood alerts via email, SMS, or in-app notifications.

Ability for users to set alert thresholds and preferences.

Data Visualization on a Map:

Map displaying sensor locations, flood-prone areas, and real-time sensor data.

Color-coded markers to indicate flood risk levels.

Emergency Response Plan:

Evacuation routes, shelter locations, and contact information for emergency services.

Historical Data Records:

Access to historical sensor data and predictions for analysis and reporting.

Data Sources and Sensors:

Information about the sensors and data sources used in the system.

Python program of Platform UI for flood prediction model:

```
import tkinter as tk
import requests
import json

class FloodPredictionPlatformUI(tk.Frame):

    def __init__(self, master):
        tk.Frame.__init__(self, master)

        # Create a label to display the current water level.
        self.water_level_label = tk.Label(self, text="Current water level: 0.0
meters")

        # Create a label to display the flood probability.
        self.flood_probability_label = tk.Label(self, text="Flood probability:
0.0")

        # Pack the labels.
        self.water_level_label.pack()
        self.flood_probability_label.pack()

        # Get the current water level from the flood prediction API.
        water_level = get_current_water_level()
```

```

# Calculate the flood probability.
flood_probability = predict_flood_probability(water_level)

# Update the labels.
self.water_level_label.config(text="Current water level: {}
meters".format(water_level))

self.flood_probability_label.config(text="Flood probability:
{}".format(flood_probability))

# Schedule an update to the UI in 10 seconds.
self.after(10000, self.update)

def update(self):
# Get the current water level from the flood prediction API.
water_level = get_current_water_level()

# Calculate the flood probability.
flood_probability = predict_flood_probability(water_level)

# Update the labels.
self.water_level_label.config(text="Current water level: {}
meters".format(water_level))

self.flood_probability_label.config(text="Flood probability:
{}".format(flood_probability))

# Schedule an update to the UI in 10 seconds.
self.after(10000, self.update)

if __name__ == "__main__":

```

```
root = tk.Tk()
```

```
# Create the flood prediction platform UI.
```

```
ui = FloodPredictionPlatformUI(root)
```

```
# Start the mainloop.
```

```
root.mainloop()
```

This code will create a simple platform UI that displays the current water level and the flood probability. The UI will be updated every 10 seconds.

These outputs and the platform UI play a critical role in providing accurate information, warnings, and predictions to users, authorities, and emergency responders. The goal is to enhance preparedness, safety, and the ability to respond effectively to potential flood events.

ADVANTAGES:

- ❖ **Risk Reduction:** The primary advantage is the reduction of risks associated with flooding. Early warnings provide communities and individuals with vital information to take precautionary measures, evacuate if necessary, and protect lives and property.
- ❖ **Improved Safety:** By providing timely flood warnings, these systems enhance public safety. People can be informed well in advance, allowing them to make informed decisions and take actions to avoid danger.
- ❖ **Property Protection:** Early warnings enable individuals to safeguard their homes, belongings, and businesses. This helps minimize property damage and financial losses during flood events.

- ❖ **Emergency Response Coordination:** Flood monitoring systems support better coordination among emergency responders, local authorities, and disaster management agencies. This ensures a more efficient and organized response to flood events.
- ❖ **Resource Allocation:** The systems help allocate resources, such as emergency personnel, equipment, and supplies, to areas most in need during a flood. This optimized resource allocation improves response effectiveness.
- ❖ **Infrastructure Resilience:** Flood monitoring systems can trigger infrastructure protection mechanisms, such as closing flood gates, activating levees, or rerouting water. This helps preserve critical infrastructure like power plants, transportation networks, and communication facilities.
- ❖ **Traffic Management:** Real-time data on flooded roads and bridges allows traffic authorities to reroute vehicles and prevent accidents, ensuring the safe movement of people during evacuations and emergency response efforts.

DISADVANTAGES:

- ❖ **Cost of Implementation:** Developing and maintaining a robust flood monitoring and early warning system can be expensive. Costs are associated with sensor deployment, infrastructure setup, data analysis, software development, and ongoing maintenance.
- ❖ **Data Accuracy:** The accuracy of the system heavily depends on the quality of sensor data. Sensor malfunctions, calibration issues, or inaccuracies in data collection can lead to false alarms or missed warnings.
- ❖ **Sensor Maintenance:** Sensors require regular maintenance and calibration to ensure accurate data collection. Neglecting maintenance can lead to data inaccuracies and system failures.

- ❖ **Limited Coverage:** The effectiveness of the system is limited by the geographical coverage of the sensors. Remote or sparsely populated areas may not have adequate sensor coverage.
- ❖ **Sensor Vulnerability:** Sensors can be vulnerable to extreme weather conditions, flooding, vandalism, and theft. Protecting sensors and ensuring their continuous operation can be a challenge.
- ❖ **Data Transmission and Connectivity:** The reliability of data transmission from sensors to the central system depends on the chosen communication infrastructure. Connectivity issues, network outages, or interference can disrupt data flow.
- ❖ **Data Privacy and Security:** Handling sensitive flood data raises concerns about data privacy and security. Unauthorized access to the system or data breaches can have serious consequences.
- ❖ **False Alarms:** Overly sensitive sensors or flawed data analysis can trigger false alarms, potentially leading to public skepticism and complacency in response to warnings.

BENEFITS:

- ❖ **Early Warning:** The primary benefit is early warning. These systems can detect flood events well in advance, providing critical time for individuals, communities, and authorities to prepare and take preventive actions.
- ❖ **Public Safety:** Flood warnings enhance public safety by alerting individuals and communities to potential flood risks. This empowers people to make informed decisions and take steps to protect themselves and their families.
- ❖ **Property Protection:** Individuals and businesses can use flood warnings to safeguard their homes, assets, and infrastructure, reducing property damage and financial losses.
- ❖ **Emergency Response Coordination:** Early warnings improve the coordination of emergency response efforts. Authorities can deploy

resources, personnel, and services to areas in need before flooding occurs, ensuring a more effective response.

- ❖ **Resource Allocation:** Efficient resource allocation is made possible, as authorities can allocate resources such as emergency personnel, equipment, and supplies to areas where they are most needed during a flood event.
- ❖ **Infrastructure Resilience:** Flood monitoring systems enable the activation of infrastructure protection mechanisms, such as closing flood gates, diverting water, and reinforcing levees, to minimize damage to critical assets.
- ❖ **Traffic Management:** Real-time data on flooded roads and bridges allows traffic management authorities to reroute vehicles, preventing accidents and ensuring the safe movement of people during evacuations and emergency response efforts.
- ❖ **Data-Driven Decision-Making:** Decision-makers have access to real-time data and analysis, allowing them to make informed decisions regarding flood response and mitigation efforts.
- ❖ **Public Awareness:** Public safety campaigns and awareness efforts can be reinforced through these systems. Education about flood risks, preparedness, and response helps ensure the public is well-informed and can act responsibly during flood events.
- ❖ **Community Engagement:** These systems facilitate community engagement by allowing the public to report emergencies, request assistance, and share real-time information. This interaction enhances cooperation and coordination.

CONCLUSION:

In conclusion, flood monitoring and early warning systems play a pivotal role in mitigating the devastating impacts of flooding events. These systems are a critical component of disaster preparedness, public safety, and effective emergency response. By providing early warnings, real-time data, and coordination tools, they empower communities, individuals, and authorities to make informed decisions and take timely actions to protect lives, property, and the environment.

The advantages of flood monitoring and early warning systems are clear, ranging from risk reduction and property protection to efficient resource allocation and improved public safety. These systems contribute to a more resilient and responsive society in the face of one of the world's most common and destructive natural disasters.

However, it is important to acknowledge the challenges and disadvantages associated with these systems, such as the costs of implementation, data accuracy, and the need for ongoing maintenance. Overcoming these challenges requires commitment, investment, and a collaborative effort from various stakeholders. In a world where climate change and extreme weather events are becoming more frequent, the importance of flood monitoring and early warning systems cannot be overstated. These systems provide a safety net, offering hope, protection, and the possibility of minimizing the devastating impact of flooding on our communities.

In summary, flood monitoring and early warning systems are not only technical solutions but also symbols of our collective responsibility to protect and support one another in the face of nature's forces. Through their implementation and continuous improvement, we strengthen our ability to face the challenges posed by flooding and build safer, more resilient communities.