**2.1 Introduction**

In this chapter, a comprehensive review of the existing literature and relevant research is presented to establish the foundation for the current project on IoT-based gas detection systems. The review focuses on examining theoretical frameworks, methodologies, and empirical findings related to sensor technologies, IoT integration, and alert mechanisms—while deliberately excluding studies that do not address remote monitoring or dual-alert functionality. By critically evaluating previous research and projects that have tackled similar challenges, this chapter aims to identify gaps in sensor calibration, network reliability, and user interface design that the present study seeks to address. Key topics discussed include sensor performance and limitations, communication protocols and cloud integration, dual alert mechanisms (audible and digital), and system performance evaluation. Overall, this chapter provides the necessary contextual backdrop for the project, demonstrating its significance within the broader landscape of research and development in IoT-enabled safety solutions.

**2.2 Review of Objective One: Investigate the Limitations of Existing Flammable Gas Detection Systems**

As outlined in Chapter One, the first specific objective is to investigate the limitations of current flammable gas detection systems—especially regarding real‑time monitoring and remote notification. Existing systems predominantly rely on standalone gas sensors (such as the MQ‑series) to detect gases like LPG, methane, and hydrogen. While these sensors are cost‑effective, literature reveals recurring issues: sensor drift, cross‑sensitivity to other chemicals, and reduced accuracy under varying environmental conditions. Several studies have reported that without continuous calibration and robust signal processing, such systems may produce false alarms or fail to detect leaks in time. This review reveals a significant gap in achieving consistent reliability in dynamic environments—a challenge that this project aims to overcome through advanced calibration routines and integrated digital filtering.

**2.3 Review of Objective Two: Design and Develop an IoT‑Enabled Detection and Alert System**

The second objective, as stated in Chapter One, is to design and develop an IoT‑based detection system by integrating flammable gas sensors with a GSM module for automated SMS alerts. Recent research in IoT‑enabled safety solutions demonstrates the advantages of connecting sensors to microcontrollers (such as Arduino or ESP8266) and coupling them with communication modules. These systems allow real‑time data transmission to remote devices, ensuring that alerts are sent promptly—even when the user is off‑site. However, literature also points out challenges like maintaining stable network connectivity and ensuring low power consumption. Studies using similar architectures indicate that careful selection of communication protocols and cloud integration is vital. This project builds on those insights by proposing a system that not only sends SMS alerts but also integrates push notifications through a web and mobile dashboard.

**2.4 Review of Objective Three: Implement a Web and Mobile‑Based Monitoring Dashboard**

According to the objectives defined in Chapter One, the third goal is to implement a web and mobile‑based dashboard for real‑time monitoring and management of gas levels. Existing projects have successfully employed cloud services and IoT platforms to visualize sensor data, yet many systems remain limited by non‑intuitive user interfaces and inadequate data presentation. Literature shows that an effective dashboard should display historical and real‑time data clearly, allow for system configuration, and provide actionable insights. Reviews from various IoT projects emphasize the importance of user‑centered design to ensure that both technical and non‑technical users can easily interpret the data. This section of the literature indicates a clear need for a dashboard that is both robust in functionality and simple to navigate, which is a key focus in the development of the current system.

**2.5 Review of Objective Four: Evaluate System Performance by Analyzing Detection Accuracy, Response Time, and User Feedback**

The final objective highlighted in Chapter One is to evaluate the performance of the developed gas detection system. Performance metrics typically include detection accuracy, response time, and overall reliability, alongside qualitative feedback from end‑users. Prior research has utilized controlled experiments and field tests to benchmark sensor performance and communication reliability. Studies have also underscored the importance of user feedback to refine alert mechanisms and dashboard usability. Although several IoT‑based gas detection systems have been reported in the literature, comprehensive evaluations that encompass both technical and user experience parameters are still limited. This project intends to fill that gap by conducting systematic testing under varying conditions and gathering user insights to improve both system accuracy and interface design.

**2.4 Concept Map/Conceptual Diagram**

This section presents a conceptual diagram that visually represents the relationships between key concepts, independent variables, and dependent variables identified through the literature review. The diagram serves to integrate relevant theories and research findings, illustrating how the various elements interact to influence the overall performance of the IoT‑based flammable gas detection system.

**Key Concepts and Definitions:**

1. **Gas Sensor Performance:**  
   Refers to the operational characteristics of MQ‑series sensors (e.g., sensitivity, calibration, cross‑sensitivity, and drift) that determine how accurately gas concentrations are measured.
2. **IoT Integration:**  
   Involves connecting the gas sensor modules to a microcontroller (e.g., Arduino UNO or ESP8266) and further interfacing with communication modules (GSM/Wi‑Fi) for real‑time data transmission.
3. **Communication Protocols:**  
   Encompass the methods and standards (e.g., SMS, push notifications, cloud connectivity) used to relay sensor data to remote servers and user devices.
4. **User Interface and Dashboard:**  
   The web and mobile application through which end‑users receive real‑time monitoring data, alerts, and can interact with the system for configuration and feedback.
5. **Environmental Conditions:**  
   External factors such as temperature and humidity that can influence sensor outputs and the overall system performance.

**Relationships:**

1. **Independent Variables:**  
   Factors like sensor calibration, inherent sensor characteristics, environmental conditions, and network connectivity. These variables directly affect the quality and reliability of the data collected by the sensors.
2. **Intervening Variables:**  
   Signal processing algorithms and communication protocols act as mediators. Advanced digital filtering and robust data transmission methods ensure that raw sensor data are accurately processed and communicated.
3. **Dependent Variables:**  
   The final outcomes measured in the system, such as detection accuracy, response time to gas leakage, and user satisfaction with the interface and alert mechanisms.

**Diagram Description (Figure 2.1):**

