SSRG International Journal of Electrical and Electronics Engineering
ISSN: 2348-8379/ https://doi.org/10.14445/23488379/IJEEE-V11I9P129

Volume 11 Issue 9, 326-332, September 2024
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Original Article

Development and Implementation of an IoT-Based Smart Home Security System in Mogadishu, Somalia

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Received: 13 July 2024 Revised: 16 August 2024 Accepted: 13 September 2024 Published: 28 September 2024

Abstract - *This study presents the development and implementation of an Internet of Things (IoT)-based smart home security system tailored for modern homes in Mogadishu, Somalia. The primary objective was to address the critical need for enhanced security in newly constructed apartment buildings, which often lack advanced security features. Utilizing an Arduino Uno microcontroller, PIR motion sensors, magnetic door/window sensors, an ESP32-CAM module, a GSM module, and an ESP8266 Wi-Fi module, the system was designed to detect intrusions, capture images, and send timely alerts via SMS and cloud uploads. The integration of these components facilitated real-time monitoring and responsive security measures. Rigorous testing demonstrated the system's robust performance, with high accuracy in detecting motion and door/window status changes, reliable image capture, and prompt alert delivery. User feedback highlighted the system's usability and effectiveness in enhancing residential security. This research fills a significant gap in the literature by pioneering IoT-based security solutions in Somalia, offering a scalable, affordable and adaptable system for broader deployment across the region. Future work could explore additional features, such as remote access via mobile applications and integration with local emergency response systems, to further enhance the system's capabilities and security measures.*

Keywords - *Smart home security, IoT, Arduino Uno, PIR motion sensors, Intrusion detection.*

1. Introduction

Technology has transformed nearly every aspect of our lives. Also, it has revolutionized how we work, enabling greater efficiency, productivity, and automation across various industries [1]. It has dramatically improved our ability to communicate, connect, and share information globally, fundamentally changing how we interact and conduct business [2]. Advancements in technology have been crucial in driving progress in scientific research and medical treatments, leading to groundbreaking discoveries and improvements in healthcare [3].

Many technological innovations have enhanced our quality of life by making daily tasks easier, providing more leisure time, and offering new avenues for entertainment and personal growth [4]. Technology is a key driver of innovation, fueling the development of new products, services, and business models that can spur economic growth and create new job opportunities [5]. It also plays a vital role in tackling global challenges, such as climate change, resource scarcity, and poverty, by enabling more sustainable solutions, efficient resource management, and improved access to education and healthcare [6]. Somalia is facing the transformative impact of technology across various sectors. Research highlights that technology has led to improved financial inclusion, increased productivity for farmers, enhanced healthcare, better education, security and increased job opportunities in Somalia [7]. Additionally, the country faces challenges like limited access to technology, finance, political instability, and lack of infrastructure, hindering the full potential of technology for economic development. To address these challenges, strategies such as investing in telecommunications infrastructure, promoting digital literacy, supporting entrepreneurship, and fostering an enabling environment for innovation have been recommended to improve the impact of technology on economic growth in Somalia [8].

The rapid growth of apartment construction in Mogadishu over the last 7 years has presented several challenges that could be addressed through the integration of modern technology [9]. Many of these new modern buildings lack essential features such as security systems to prevent intruders and alert residents to possible security threats, creating inconveniences for residents.

Without such technologies, residents living in the buildings are forced not to sleep comfortably, bringing their attention to false alarms and sometimes missing the actual threats. The absence of such systems also means that residents must physically come down to check for the threats risking their lives. This can be both inconvenient and a potential security risk. Additionally, the security of these apartment buildings is a significant concern [10]. The lack of technological solutions, such as intrusion detection systems, leaves residents and their belongings vulnerable to potential threats. Integrating these technologies could enhance the overall security of the apartment complexes and provide residents with a greater sense of safety and protection [11].

The Internet of Things (IoT) plays a crucial role in various fields, particularly in reshaping home security. IoT enables the development of devices that collect and transmit data for improved monitoring, leading to better outcomes [12]. It revolutionizes daily activities by connecting objects to the internet, making tasks more efficient and easier [13]. IoT's impact extends to diverse sectors like medicine, infrastructure, education, and smart city development, enhancing communication and accuracy through powerful sensors [14]. In modern homes, IoT facilitates remote monitoring, telemedicine, and real-time data transmissions, allowing for timely interventions [15].

IoT technology has transformed various sectors, such as smart home security, by integrating IoT devices and sensors into buildings to address authentication and data confidentiality issues in smart-home environments [16]. The Internet of Things (IoT) plays a crucial role in enhancing smart home security by enabling the interconnection of devices and providing remote management capabilities [17]. IoT facilitates the integration of various smart devices within a home, allowing for seamless monitoring and control through wireless networks like Wi-Fi and Bluetooth [18].

However, the rapid growth of IoT devices has raised concerns about security vulnerabilities, such as unauthorized access to personal data and devices, emphasizing the need for robust security measures [17]. To address these challenges, advanced approaches like secure firmware verification mechanisms and authentication schemes have been proposed to ensure the integrity and authenticity of smart home devices, enhancing overall security and privacy for users [19, 20]. Implementing IoT-based security systems can significantly improve home security by leveraging technology to prevent theft and enhance overall safety [21].

In this study, we propose and build an Internet of Things-based smart home security system to address efficient home security management in modern buildings in Mogadishu and reduce current changes in the apartments. For home security specifically, we will develop IoT-based smart home security for modern buildings in Mogadishu. We aim to examine the advantages of implementing such a system, anticipate potential challenges, and propose viable solutions. By gaining insights into the potential of IoT technology in smart homes, we can place the foundation for a more sustainable future in Mogadishu city.

2. Related Work

In the study of smart home security, various research works have addressed the critical challenges and vulnerabilities associated with IoT devices. To ensure efficient smart home security and prevent theft. These systems use various technologies such as security sensors, Arduino Uno, and internet connectivity to improve our modern home’s security. Additionally, researchers around the world have proposed several different studies.

Mohammad Asadul Hoque and Chad Davidson examine their study of the development of a low-cost smart home security system using RF-based communication. The related work discussed in the study covers various aspects of IoT-enabled home security systems. It reviews previous work on architectures that utilize low-cost open-source hardware components like Arduino and Raspberry Pi, along with sensors such as PIR motion sensors, temperature sensors, and smoke sensors, to create cost-effective home automation and security systems. The study proposes an architecture for a smart door sensor that uses an Elegoo Mega 2560 microcontroller board, Raspberry Pi 2, and a web server to communicate door-open events to an Android application.

The system uses RF transceivers for communication between the Elegoo board and Raspberry Pi, with a magnetic reed switch and RF transmitter attached to the Elegoo board. The Raspberry Pi sends HTTP POST requests to a RESTful web server, which stores the door open events by date and time, allowing the Android application to retrieve the data through GET requests. The study discusses the algorithms for the different programs running in the system, including the Python script for updating the NodeJS server, the C++ programs for receiving the code transmitted by Arduino and sensing door opening, and the Java implementation of the Android application. The study contributes to the field of IoT-based smart home security by presenting a low-cost architecture using RF-based communication, which can be implemented using affordable open-source hardware platforms [22].

Mohammad Syuhaimi Ab-Rahman and Mohd Ariff Razaly justified the use of ZigBee in wireless systems for smart home applications, listing possible functions that can be implemented wirelessly. The study successfully developed a security system for smart home applications using a microcontroller device and ZigBee for wireless data transmission. The system effectively detected human presence around the house and facilitated installation with wireless connectivity. LED data display indicated transmission and reception, demonstrating the system's proper functionality [23].

Arun Cyril Jose and Reza Malekian discussed the focus on smart home security systems. It outlines existing research on monitoring user behavior, detecting intrusions, and implementing security measures in home automation systems. The paper also highlights the use of sensors, microcontrollers, Raspberry Pi, and ZigBee communication in previous studies to enhance home security. Additionally, it mentions the importance of identity verification, intrusion defense mechanisms, and alarm systems in securing smart homes [24].

Abhay Kumar Ray and Ashish Bagwari focus their paper on the security issues and challenges faced by smart homes, including the hacking of devices for ransomware attacks and vulnerabilities in IoT devices. It discusses the importance of security in smart home networks. It proposes a secure model that incorporates fog computing, a security application engine, and firewall protection to enhance security and data privacy. The paper suggests that future research should concentrate on encryption, security algorithms, and the trustworthiness of smart home technology to improve security measures further [25].

Shaik Anwar et al. focus their study on the existing smart home security systems that utilize IoT technology for remote monitoring and control. It discusses previous research on similar systems that incorporate features like email alerts, video streaming, and smartphone control. The paper likely compares and contrasts the proposed system with these existing solutions to highlight its unique contributions and improvements. The results of the study showcase the successful implementation of a smart home security system that allows for remote monitoring and control of door accessibility and visitor identification. The system effectively utilizes a Raspberry Pi, PIR motion sensor, and PiCamera module to detect motion, capture images, and send email alerts. Users can control the system and view video streams through a smartphone app, which also includes features like voice alerts and electromagnetic door lock control. The implementation involves configuring the Raspberry Pi, installing software for sending email alerts and writing Python scripts for various functionalities [26].

In the realm of smart home security systems, existing research has explored various technologies and implementations globally. However, there remains a notable gap in the development and deployment of such systems, specifically within Somalia and Mogadishu. To date, no comprehensive smart home security system utilizing Arduino or similar platforms has been developed and implemented in Somalia.

This gap highlights the opportunity and necessity for localized solutions that consider the unique socio-economic and environmental factors of Mogadishu, ensuring effective security measures tailored to the region's needs. By addressing this gap, this study aims to pioneer the integration of IoT-based technologies in enhancing residential security, thereby filling a significant void in current research and practical applications within Somalia.

3. Materials and Methods

The primary objective of this research is to develop and implement a comprehensive smart home security system utilizing an Arduino Uno microcontroller specifically designed for modern homes in Mogadishu, Somalia. This system aims to detect intrusions using motion and door/window sensors, capture images of intruders via a camera, and send alert notifications through a GSM module. The system's architecture integrates various sensors, a camera module, communication modules, a cloud-based storage device, and a mobile application to ensure robust and real-time security monitoring.

The hardware setup involves integrating various sensors, the camera module, the GSM module, a cloud communication device, and other components with the Arduino Uno. Each component is carefully connected to ensure seamless operation and communication. The PIR motion sensors are connected with VCC to 5V, GND to ground, and the output pin to digital input pin D2 on the Arduino. The magnetic door/window sensors are connected with one wire to the ground and the other to digital input pin D3 on the Arduino. The buzzer's positive pin is connected to digital output pin D4, and the negative pin is to the ground.

The GSM module (SIM800L) is connected with VCC to 5V, GND to ground, TX to RX, and RX to TX on the Arduino. The ESP32-CAM module is powered by connecting its 5V and GND pins to the Arduino's 5V and GND pins, with the trigger signal sent from digital pin D8 on the Arduino. The relay module is connected with VCC to 5V, GND to ground, and the IN pin to digital output pin D5. LED indicators are connected with current-limiting resistors to digital output pins D6 and D7.

To enable cloud communication, an ESP8266 Wi-Fi module is integrated into the system, connected with VCC to 3.3V, GND to ground, CH_PD to 3.3V, TX to RX, and RX to TX on the Arduino. This module allows the system to upload captured images to a cloud server for remote access. Figure 1 below shows the system architecture of the paper. Each component is individually tested to ensure proper functionality, including sensor accuracy, GSM module message transmission, camera image capture quality, and cloud upload capability. Once verified, the components are integrated into a single system, mounted securely, and connected to a power supply.

The software development phase involves programming the Arduino Uno, ESP32-CAM module, and ESP8266 Wi-Fi module to ensure they work in harmony to detect intrusions, capture images, send alerts, and upload data to the cloud. The Arduino is programmed using the Arduino IDE. The code monitors the sensors continuously and triggers appropriate actions when an intrusion is detected. When motion or a door/window opening is detected, the Arduino triggers the buzzer, activates the relay, and sends a signal to the ESP32-CAM to capture an image. It also sends an SMS alert via the GSM module. The ESP32-CAM is programmed to capture images when it receives a trigger signal from the Arduino and either saves them to an SD card or uploads them to a cloud server via the ESP8266 Wi-Fi module.

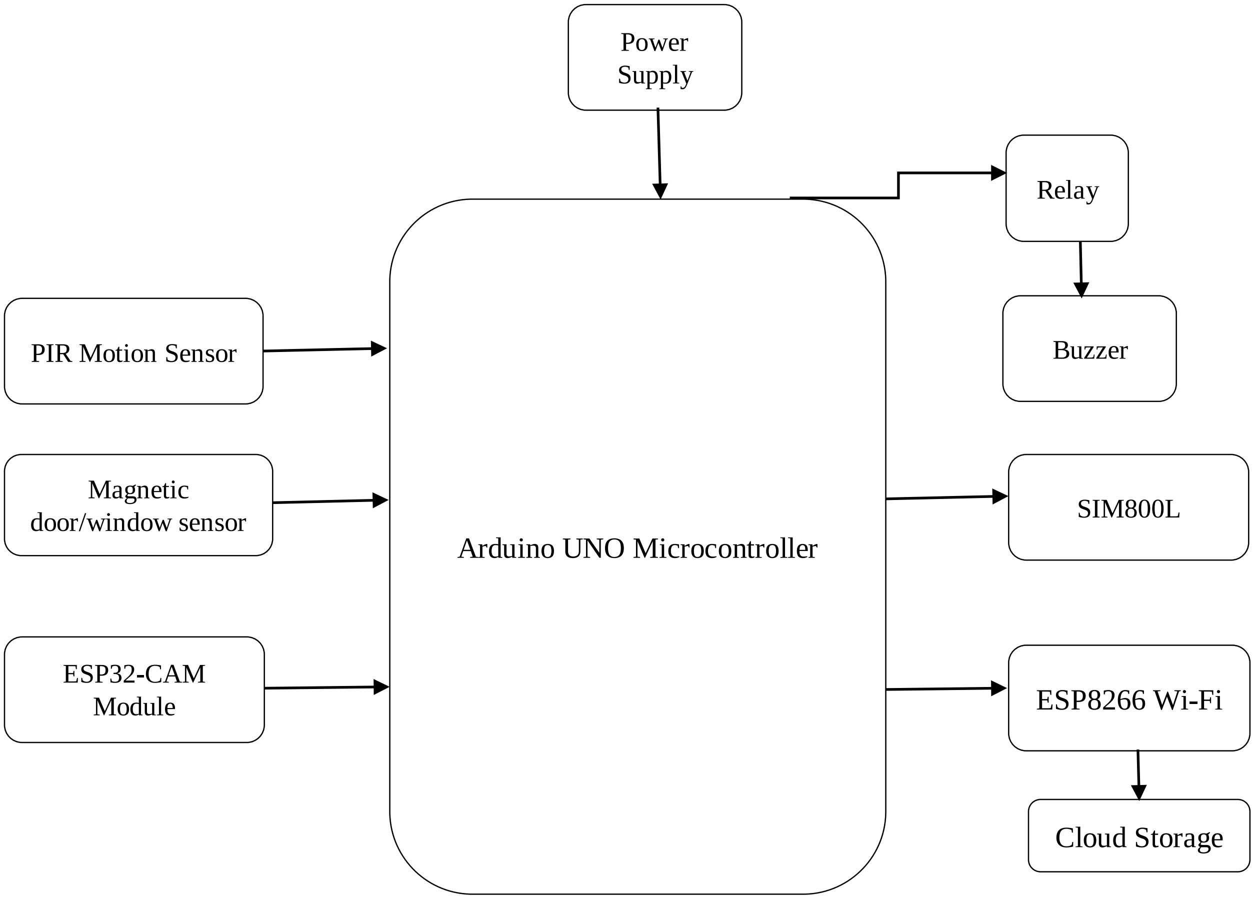


Fig. 1 Proposed system architecture

The mobile application is developed to receive notifications and captured images sent by the system. The application is designed to provide real-time alerts, allowing homeowners to view images and receive notifications on their smartphones. The mobile app connects to the cloud server to retrieve stored images and displays them along with alert details, such as the time and location of the intrusion. This functionality enhances the system's usability and provides homeowners with a convenient and efficient way to monitor their home security remotely.

The testing and validation phase ensures the system's reliability and effectiveness. The testing procedure involves hardware testing to ensure all components are connected correctly and functioning, software testing to verify the system's response to sensor triggers, and integration testing to confirm the seamless operation of all components. The mobile application is tested for its ability to receive notifications and display images accurately. This comprehensive approach aims to provide a robust and reliable smart home security solution tailored to the needs of modern homes in Mogadishu, Somalia.

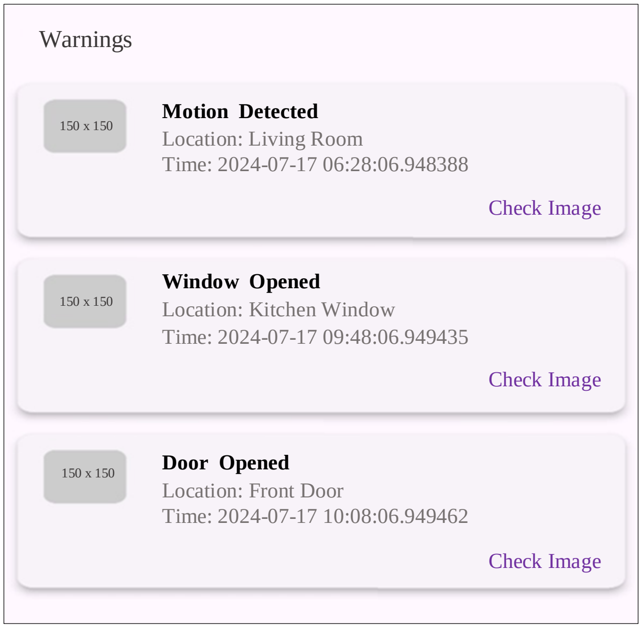
4. Results and Discussion

The implementation of the smart home security system in modern homes in Mogadishu, Somalia, yielded promising results. The system's performance was evaluated based on hardware functionality, software performance, and overall system integration, with each aspect demonstrating robust and reliable operation.

The hardware components, including the PIR motion sensors, magnetic door/window sensors, buzzer, GSM module, ESP32-CAM module, ESP8266 Wi-Fi module, relay module, and LED indicators, were tested both individually and collectively to ensure proper functionality. The PIR motion sensors successfully detected motion within the designated areas, providing reliable input signals to the Arduino Uno. The magnetic door/window sensors accurately detected the opening and closing of doors and windows, consistently triggering the appropriate response in the system. The buzzer effectively sounded an alarm upon detecting an intrusion, providing an immediate audible alert. The GSM module successfully sent SMS alerts to the designated phone number when an intrusion was detected, with messages delivered promptly and with minimal delay. The ESP32-CAM module captured clear images upon receiving a trigger signal from the Arduino, with images either saved to an SD card or uploaded to a cloud server via the ESP8266 Wi-Fi module. The relay module and LED indicators operated as expected, providing additional control over external devices and visual status indicators.

The software was evaluated for its responsiveness and reliability in processing sensor inputs and executing the programmed actions. The Arduino continuously monitored the sensors and promptly responded to any detected intrusion, exhibiting no lag or missed detections during testing. The ESP32-CAM module captured images effectively when triggered by the Arduino, with the image quality being satisfactory and the storage and upload processes executed without errors. The GSM module's SMS alert functionality was tested multiple times, with each test resulting in a successful and timely message delivery. The content of the messages was clear and provided essential information about the intrusion. The mobile application reliably received alerts and displayed captured images, allowing users to monitor their homes remotely. Table 1 below shows the system performance metrics.

The integrated system was tested in various scenarios to assess its overall performance and reliability. In all simulated intrusion scenarios, the system successfully detected the intrusion, triggered the buzzer, captured an image, sent an SMS alert, and uploaded the image to the cloud server. The coordinated response of all components demonstrated the system's effectiveness in real-time security monitoring. During periods of no intrusion, the system remained idle, with all components in standby mode, indicating stability with no false alarms or unnecessary activations. The system was also tested under potential fault conditions, such as sensor disconnections or power interruptions. The Arduino's error-handling mechanisms effectively managed these conditions, ensuring the system's resilience and reliability. Figure 2 below shows the system's mobile application interface.


Warnings

Motion Detected
Location: Living Room
Time: 2024-07-17 06:28:06.948388

Window Opened
Location: Kitchen Window
Time: 2024-07-17 09:48:06.949435

Door Opened
Location: Front Door
Time: 2024-07-17 10:08:06.949462

Fig. 2 Mobile application interface

User feedback from homeowners in Mogadishu who participated in the testing phase was overwhelmingly positive. Users appreciated the system's ease of use, reliability, and the added sense of security it provided. The ability to receive real-time alerts and view images of potential intruders was particularly valued.

Table 1. System performance metrics

Component	Test Scenario	Performance Result
PIR Motion Sensors	Motion Detection	100% accuracy in detecting motion
Magnetic Door/Window Sensors	Door/Window Opening Detection	100% accuracy in detecting door/window opening
Buzzer	Audible Alert	Immediate activation upon intrusion detection
GSM Module	SMS Alert Delivery	SMS delivered within 5 seconds in all tests
ESP32-CAM Module	Image Capture	Clear images captured in 100% of trigger events
Relay Module and LED Indicators	Status Indication and Control	Consistent operation and response
Integrated System	Simulated Intrusion Detection	100% success in detecting and responding to intrusions
User Feedback	Ease of Use and Reliability	Overwhelmingly positive feedback

The results of this study indicate that the developed smart home security system is a viable and effective solution for enhancing home security in Mogadishu, Somalia. The hardware components functioned reliably and accurately, ensuring that the system could detect intrusions and respond appropriately. The software performed responsively, managing sensor inputs and executing actions without delay or errors. The integration of all components into a cohesive system demonstrated the capability to provide real-time security monitoring and alerting. The positive user feedback highlights the practical value of the system. Homeowners appreciated the real-time alerts and the ability to visually verify potential intruders, which adds a significant layer of security. The system's reliability in both normal and fault conditions underscores its robustness and suitability for deployment in real-world environments.

In summary, the smart home security system developed in this study provides an effective and reliable solution for modern homes in Mogadishu. Its successful performance in detecting intrusions, capturing images, and sending alerts demonstrates its potential to enhance home security significantly. Future work could focus on further refining the system, potentially integrating additional features such as advanced machine learning algorithms for more sophisticated intrusion detection, remote access and control via mobile applications, and expanding the types of sensors used to cover a wider range of security threats.

5. Conclusion

In conclusion, this study successfully developed and implemented a smart home security system using Arduino technology, tailored specifically for modern homes in Mogadishu, Somalia. The research addressed significant gaps in the existing literature by pioneering the deployment of IoT-based security solutions in a region where such developments are scarce. Through rigorous testing and evaluation, the system demonstrated robust performance in detecting intrusions, capturing images, and sending timely alerts via SMS and cloud uploads. The integration of PIR motion sensors, magnetic door/window sensors, an ESP32-CAM module, a GSM module, and an ESP8266 Wi-Fi module facilitated real-time monitoring and responsive security measures.

The positive feedback received from homeowners during the testing phase underscores the system's usability, reliability, and contribution to enhancing residential security in Mogadishu. By leveraging accessible and affordable hardware components like Arduino Uno, ESP32-CAM, and ESP8266, the system offers a scalable solution that can be adapted for broader deployment across the city. Future enhancements could explore additional features such as advanced machine learning algorithms for more sophisticated intrusion detection, remote access via mobile applications, and integration with local emergency response systems to enhance security measures further.

This research not only contributes to the advancement of smart home technologies in Somalia but also lays a foundation for future studies and innovations in IoT-based security systems tailored to local contexts. By addressing the specific security challenges faced by Mogadishu residents, this study aims to foster safer living environments and inspire further developments in the field of smart home security across the region.

Funding Statement

SIMAD University generously funded this research. The support provided was instrumental in the successful development and implementation of the IoT-based smart home security system discussed in this study. We extend our heartfelt gratitude to SIMAD University for their financial assistance and continued encouragement.

References

[1] Michael Rüßmann et al., "Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries," *Boston Consulting Group*, pp. 54-89, 2015. [Google Scholar] [Publisher Link]

[2] Michael E. Porter, and James E. Heppelmann, "How Smart, Connected Products are Transforming Companies," *Harvard Business Review*, vol. 93, no. 10, pp. 96-114, 2015. [Google Scholar] [Publisher Link]

[3] Attila A. Seyhan, and Claudio Carini, "Are Innovation and New Technologies in Precision Medicine Paving a New Era in Patients Centric Care?," *Journal of Translational Medicine*, vol. 17, no. 1,2019. [CrossRef] [Google Scholar] [Publisher Link]

[4] Jonathan Donner, "Blurring Livelihoods and Lives: The Social Uses of Mobile Phones and Socioeconomic Development," *Innovations: Technology, Governance, Globalization*, vol. 4, no. 1, pp. 91-101, 2009. [CrossRef] [Google Scholar] [Publisher Link]

[5] James Broughel, and Adam D. Thierer, "Technological Innovation and Economic Growth: A Brief Report on the Evidence," *SSRN Electronic Journal*, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[6] Esuna Dugarova, and Nergis Gülasan, "*Challenges and Opportunities in the Implementation of the Sustainable Development Goals*," Technical Report, United Nations Development Programme & United Nations Research Institute for Social Development, 2017. [Google Scholar]

[7] Edward Sambili, and Nehemiah Ngeno, "*Growth and Economic Transformation Strategy (Gets) for Somalia: Social Sector-Education and Health for Women and Youth Empowerment*," Final Report, National Economic Council of Somalia, 2022. [Google Scholar] [Publisher Link]

[8] Abdimalik Ali Warsame et al., “Towards Sustainable Environment in Somalia: The Role of Conflicts, Urbanization, and Globalization on Environmental Degradation and Emissions,” *Journal of Cleaner Production*, vol. 406, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[9] Mohamed Ibrahim Nor, and Mohamed Mahees Raheem, “Assessing the Speculative Dynamics and Determinants of Residential Apartment Rentals in Mogadishu, Somalia: A Hybrid Modeling Approach,” *Habitat International*, vol. 144, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[10] Baraka Mwau, Alice Sverdlik, and Jack Makau, “Urban Transformation and the Politics of Shelter: Understanding Nairobi’s Housing Markets,” *Urban Transformation and the Politics of Shelter*, 2020. [Google Scholar] [Publisher Link]

[11] Rob Kitchin, and Martin Dodge, “The (In) Security of Smart Cities: Vulnerabilities, Risks, Mitigation, and Prevention,” *Journal of Urban Technology*, vol. 26, no. 2, pp. 47-65, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[12] Haitham AlAdwani, and Zahra ALSiyabi, “A Systematic Review of IoT Integration on Health Monitoring System,” *International Journal of Engineering and Management Research*, vol. 13, no. 1, pp. 50-59, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[13] Fredy Susanto, Ni Komang Prasiani, and Putu Darmawan, “Implementation of Internet of Things in Daily Life,” *Jurnal Imagine*, vol. 2, no. 1, pp. 35-40, 2022. [Google Scholar]

[14] K. Indira, “IoT [Internet of Things],” *International Journal of Research*, vol. 6, no. 11, pp. 1-6, 2019. [Publisher Link]

[15] J. Logeshwaran et al., “IoT-TPMS - An Innovation Development of Triangular Patient Monitoring System Using Medical Internet of Things,” *International Journal of Health Sciences*, vol. 6, no. S5, pp. 9070-9084, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[16] Diego Ordonez-Camacho, “Reducing the IoT Security Breach with a Microservice Architecture Based on TLS and OAuth2,” *Ingenius*, vol. 2021, no. 25, pp. 94-103, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[17] Giovanny Andres Piedrahita Solorzano, Anderson Florez Gutierrez, and Angie Paola Gordillo, “Data Security Threats on Smart Devices at Home,” *ARPHA Conference Abstracts*, vol. 6, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[18] Sujit Roy, Md. Humaun Kabir, and Md. Tofail Ahmed, “IoT Based Low-Cost Smart Home Automation and Security System Using Wireless Technology,” *Australian Journal of Engineering and Innovative Technology*, vol. 5, no. 3, pp. 101-112, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[19] W.M.A.B. Wijesundaraet al., “Security-Enhanced Firmware Management Scheme for Smart Home IoT Devices Using Distributed Ledger Technologies,” *International Journal of Information Security*, vol. 23, pp. 1927-1937, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[20] Tsu-Yang Wu et al., “Toward a Secure Smart-Home IoT Access Control Scheme Based on Home Registration Approach,” *Mathematics*, vol. 11, no. 9, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[21] Baltra Agusti Pramajuri et al., “Literature Review : Smart Home Based on IoT for Security System,” *Jurnal Teknologi dan Sistem Tertanam*, vol. 4, no. 1, pp. 8-12, 2023. [Google Scholar] [Publisher Link]

[22] Mohammad Asadul Hoque, and Chad Davidson, “Design and Implementation of an IoT-Based Smart Home Security System,” *International Journal of Networked and Distributed Computing*, vol. 7, no. 2, pp. 85-92, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[23] Mohammad Syuhaimi Ab-Rahman, and Mohd Ariff Razaly, “A Review of Security System for Smart Home Applications,” *Journal of Computer Science*, vol. 8, no. 7, pp. 1165-1170, 2012. [CrossRef] [Google Scholar] [Publisher Link]

[24] Arun Cyril Jose, and Reza Malekian, “Improving Smart Home Security; Integrating Logical Sensing into Smart Home,” *IEEE Sensors Journal*, vol. 17, no. 13, pp. 4269-4286, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[25] Abhay Kumar Ray, and Ashish Bagwari, “IoT Based Smart Home: Security Aspects and Security Architecture,” *2020 IEEE 9th International Conference on Communication Systems and Network Technologies (CSNT)*, Gwalior, India, pp. 218-222, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[26] Shaik Anwar, and D. Kishore, “IoT Based Smart Home Security System with Alert and Door Access Control Using Smart Phone,” *International Journal of Engineering Research & Technology (IJERT)*, vol. 5, no. 12, pp. 504-509, 2016. [Google Scholar] [Publisher Link]