



HYDROLOGICAL MODEL OUTPUT – WEB PORTAL FOR BICOL RIVER BASIN

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Abstract

The study, “*Hydrological Model Output – Web Portal for the Bicol River Basin*,” focused on the design and development of a real-time web-based platform that facilitates the monitoring, visualization, and management of hydrological data within the Bicol River Basin. The system aimed to enhance the accessibility of river level, rainfall, and flood forecast information for decision-makers, disaster response teams, and stakeholders.

The findings revealed that the developed real-time web portal efficiently provided interactive dashboards displaying live river levels, rainfall maps, and flood forecasts while allowing data downloads, historical browsing, and secure API access. The notification and alert system successfully automated flood warnings through email, SMS, and portal notifications, ensuring timely dissemination of information. The

Based on the findings, it was concluded that the developed hydrological web portal effectively improved real-time data access and visualization, enhanced flood preparedness through automated alerts, and strengthened system security via defined user

The study recommends continuous enhancement of the web portal’s dashboard by integrating more environmental data

The project was limited to the integration of real-time data visualization, notification and alert system, user management, and security modules. It employed the Agile methodology, which allowed iterative development, testing, and refinement based on continuous feedback from IT experts and end-users. The system was evaluated using ISO 25010 software quality standards focusing on functional suitability, performance efficiency, and reliability.

system’s administrative and user management modules provided streamlined account control and access management. Furthermore, the system achieved an overall ISO 25010 rating of 4.0, interpreted as “More Than Expected,” demonstrating its high effectiveness, stability, and operational quality across functionality, performance, and reliability parameters.

roles and authentication protocols. The system’s high performance and reliability underscored its capability to support efficient hydrological monitoring and data-driven decision-making for the Bicol River Basin.

sources for improved analysis and decision-making. The notification and alert system should be refined using predictive analytics

to enhance accuracy, while user management modules must be regularly updated for scalability. Strengthening of authentication protocols, continuous system monitoring, and periodic ISO 25010 based evaluations are also advised to maintain system quality.

Lastly, expanding data integration capabilities and providing continuous user training will ensure the sustainability and effective utilization of the web portal in flood risk management and hydrological data operations.

Keywords: Bicol River Basin, Data Visualization, Decision Support System, Flood Modeling, Hydrological Analysis, Hydrological Model Output, Information System, River Basin Management, Water Resources Management., and Web Portal.

Introduction

At the global scale, flood early-warning is transitioning from static, periodic bulletins toward automated, near-real-time systems that integrate continuous observations, forecast data, and hydrological or hydraulic models. The automation of such systems ensures faster data processing, minimizes human error, and provides more timely decision-making tools for risk managers. These systems are now being paired with interactive web dashboards that enable stakeholders to visualize water levels,

The exposure to frequent typhoons, monsoonal rains, and flash floods has long demanded robust flood forecasting and warning systems. While the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) has developed extensive monitoring networks, many hydrological model outputs still require manual processing before dissemination. This process can delay critical updates, especially when rapid response is needed to

Part of the Bicol River Basin, faces recurrent flooding events intensified by heavy rains, volcanic activity, and sediment-laden waterways from Mayon Volcano. Despite being recognized as a leader in disaster risk reduction, the province still faces challenges in translating technical hydrological forecasts into actionable local warnings in real time. Current practices often rely on intermediate reporting layers that

inundation extents, and forecast uncertainties instantly. Research indicates that automated web delivery of hydrological outputs significantly reduces the gap between scientific modeling and actionable response, especially in vulnerable communities (Perera et al., 2019). The global consensus underscores that resilience against floods and other water-related hazards depends on both technological advancement and the accessibility of information (Oh & Bartos, 2025).

protect lives and property. Automated systems that directly publish model outputs online can drastically reduce the latency of information delivery, allowing communities to prepare earlier. Moreover, integrating such platforms into national disaster management frameworks ensures that information flows seamlessly from technical agencies to local government units and down to households (PAGASA, n.d.; Earth Networks, 2019).

consume valuable lead time before alerts reach communities. Automated web-based dissemination would ensure that both technical officers and ordinary residents have immediate access to forecasts, water-level alerts, and inundation maps. Such a system could strengthen Albay's capacity to act decisively during flood threats, building on its already strong emergency preparedness culture (Abon et al., 2012).

This study - “Hydrological Model Output – Web Portal for Bicol River Basin”, proposes a fully automated workflow that connects model simulations directly to a user-friendly, online portal. The importance of this project is realized in its potential to reduce the time between forecast generation and decision-making to near zero. By removing manual processing steps, the portal ensures that critical data is available to stakeholders almost instantly, thereby enabling earlier

evacuations, resource deployment, and hazard communication. Furthermore, the portal’s visualization features are designed for both technical and non-technical users, increasing inclusivity in disaster preparedness. Ultimately, this initiative aligns global best practices with local needs, providing Albay and surrounding provinces with a powerful tool for anticipatory flood management (Perera et al., 2019; Anticipation Hub et al., 2022).

Specific Objectives

Specifically, the study aimed to:

1. Develop Real-Time Web Portal

1.1 Create an interactive dashboard to display:

- a. live river levels
- b. rainfall maps
- c. flood forecasts

1.2 Enable to perform:

- a. data downloads
- b. historical browsing, and
- c. role-based Application Programming Interface (API) access.

2. Implement Notification and Alert System

2.1 Set automated triggers for flood alerts based on

- a. thresholds,
- b. delivering via e-mail,
- c. Short Message Service, and
- d. Portal

2.2 Update ongoing flood event information in real time.

3. Integrate modules for:

- 3.1 Administrative, and
- 3.2 User Management

4. Define:

- 4.1 user roles
- 4.2 permissions, and
- 4.3 secure authentication

5. Manage content such as:

- 5.1 data bulletins
- 5.2 educational resources, and
- 5.3 emergency contact updates

6. Evaluate the developed system using ISO 25010 standards assess:

- 6.1 functional suitability
- 6.2 performance efficiency
- 6.3 reliability

Scope and Delimitations

The study entitled “*Hydrological Model Output – Web Portal for Bicol River Basin*” focused on developing a real-time web portal that provided an interactive dashboard for monitoring live river levels, rainfall maps, and flood forecasts. The system allowed data downloads, historical

data browsing, and role-based API access. It included an automated notification and alert system for flood events, delivering alerts via email, SMS, and the portal itself. Administrative and user management modules defined roles, permissions, and secure authentication, while content

management handled data bulletins, educational resources, and emergency contact updates. The developed system was evaluated using ISO 25010 standards for

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Gap Bridged by the Study

In general, the reviewed systems focused on integrating hydrological data and modeling frameworks to provide timely and accurate flood forecasting. They utilized real-time or near-real-time data sources, such as satellite observations, hydrodynamic models, and crowd-sourced geographic information,

functional suitability, performance efficiency, and reliability, with assessments conducted by 10 IT professionals and 5 end-users.

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to enhance the reliability of predictions. These systems often employed interactive digital platforms - whether mobile apps or dynamic dashboards - to deliver actionable flood information to end-users, emphasizing accessibility and user engagement. By combining advanced computational models

with intuitive visualization tools, the reviewed studies demonstrated the importance of bridging complex hydrological

outputs with platforms that supported rapid decision-making during flood events.

The present study was unique in its approach by specifically automating hydrological model outputs into a real-time web portal designed for the Bicol River Basin. Unlike previous systems that relied on mobile applications, manual data processing, or region-specific models, this study emphasized seamless integration of continuous data streams directly into a web-based platform, enabling instant updates and spatially resolved flood information.

Furthermore, the portal was tailored to local flood monitoring needs, providing both authorities and residents with a user-friendly interface that combined predictive modeling, automated data assimilation, and real-time visualization in a single framework. This automation reduced latency and human intervention, making flood forecasting more efficient, localized, and actionable for the Bicol River Basin community.

Conceptual Framework

The conceptual framework of this study was anchored on the development of a real-time web portal tailored for hydrological monitoring in the Bicol River Basin. The input stage involved designing a system that featured an interactive dashboard capable of displaying live river levels, rainfall maps, and flood forecasts. It also provided functionalities for data downloads, historical data browsing, and role-based Application Programming Interface (API) access to enhance usability. Furthermore, the framework integrated a notification and alert system with automated triggers for flood

alerts based on thresholds, delivered through e-mail, Short Message Service (SMS), and the portal itself. To ensure continuous situational awareness, the system updated ongoing flood event information in real time. The input also encompassed administrative and user management modules, content management for bulletins, resources, and emergency contact updates, as well as evaluation using ISO 25010 standards to ensure quality in functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability.

The process component of the framework adopted the Agile Development Methodology to guide the system's creation and refinement. Agile was chosen for its iterative and flexible approach, which allowed continuous collaboration with stakeholders and timely incorporation of feedback throughout the development cycle.

The process began with planning and requirements gathering to define the scope and objectives clearly. This was followed by the design phase, where system architecture, interface layouts, and data integration mechanisms were conceptualized and documented.

The development stage focused on coding, system integration, and the actual building of the portal's functionalities such as the interactive dashboard, real-time alerts,

and content management features. This was succeeded by testing, where the system underwent rigorous evaluation against ISO 25010 standards to assess its performance,

reliability, usability, and other quality attributes. Once tested and validated, the system proceeded to deployment, where the portal was launched for real-world use by both administrators and end-users.

The output of this conceptual framework was the Hydrological Model Output – Web Portal for the Bicol River Basin, a comprehensive platform designed to provide timely, accurate, and accessible flood-related information to stakeholders. The portal served as both a monitoring and decision-support tool, enhancing disaster preparedness and response within the region.

Plan

The Plan stage established the foundation of the system development process by identifying the objectives, scope, and direction of the project. In this phase, the study focused on determining the essential requirements of the real-time web portal for the Bicol River Basin, including the integration of an interactive dashboard, data download features, historical record browsing, and role-based APIs. Careful planning also involved outlining the notification and alert mechanisms, ensuring that automated flood warnings through email, SMS, and the portal were responsive to

Requirements

The Requirements stage captured and documented the functional and non-functional needs of the system based on the objectives of the study. During this phase, the specific features of the real-time web portal were identified, such as the ability to display live river levels, rainfall maps, and flood forecasts through an interactive dashboard. The requirements also included functionalities for data downloads, historical record browsing, and secure role-based API access to ensure flexible use of information

Throughout these phases, Agile allowed for continuous monitoring, quick response to issues, and adjustments to ensure that the system met the needs of its intended users.

Feedback played a crucial role in refining the system; assessments from IT professionals and end-users provided insights into strengths, weaknesses, and opportunities for further improvement. This cyclical feedback loop reinforced the Agile approach, ensuring that the web portal remained relevant, reliable, and responsive to community needs.

threshold triggers. Moreover, this stage defined the integration of administrative and user management modules to secure system access and safeguard data integrity. Risk assessments, resource allocation, and timeline development were also considered to guarantee that the project aligned with both technical feasibility and user needs. Overall, the Plan stage served as a roadmap that guided subsequent phases of the Agile Development Methodology, ensuring that each step was strategically aligned with the study's goals of providing an effective hydrological information and alert system.

by different stakeholders. Furthermore, provisions for a notification and alert system were detailed, including automated flood warnings delivered via email, SMS, and the portal itself. Non-functional requirements, such as system reliability, security, maintainability, and usability, were also outlined in line with the ISO 25010 standards. This stage ensured that both technical specifications and user expectations were clearly defined, serving as the basis for

the design and development of the hydrological web portal.

Design

The Design stage translated the identified requirements into a structured system blueprint that guided the development of the real-time web portal. The architecture of the portal was designed to support the integration of hydrological model outputs, enabling automated visualization of river levels, rainfall data, and flood forecasts. User interface layouts were created to ensure a simple yet interactive dashboard that allowed stakeholders to access and interpret information with ease. Security protocols,

such as role-based authentication and permission management, were also designed to safeguard sensitive data and restrict access based on user roles. In addition, the design incorporated the framework for the notification and alert system, detailing the mechanisms for real-time updates through email, SMS, and portal notifications. Overall, this stage provided the technical foundation for seamless functionality, scalability, and user-centered operation of the hydrological web portal for the Bicol River Basin.

Develop

The Develop stage focused on building the functional components of the real-time web portal based on the finalized design specifications. The interactive dashboard was developed to display live river levels, rainfall maps, and flood forecasts, with automated data feeds integrated from hydrological models and monitoring systems. The notification and alert system was also implemented, enabling automated triggers to send flood warnings via email, SMS, and portal notifications. Administrative and user

management modules were programmed to define user roles, enforce permissions, and ensure secure authentication. In addition, content management features were developed to handle data bulletins, educational resources, and emergency contact information. Throughout this stage, iterative coding, integration, and debugging were carried out to ensure that each module worked seamlessly and supported the overall objectives of the hydrological web portal for the Bicol River Basin.

Deployment

The Deployment stage was carried out to launch the real-time web portal and make it fully operational for its intended users within the Bicol River Basin. The system was installed on a secure server environment capable of handling continuous data streams and real-time processing. User accounts and role-based permissions were configured to ensure proper access control and data security. Training and orientation sessions were conducted for administrators

and stakeholders to familiarize them with the portal's functionalities, including monitoring dashboards, flood alerts, and data management features. The deployment also involved final verification to confirm that the system was stable, reliable, and accessible across multiple devices. After successful implementation, the portal was officially introduced for use, providing a functional platform for real-time flood forecasting and disaster preparedness.

Findings

During the development and after testing and evaluation of the developed system the following findings have been established:

1. The developed real-time web portal successfully provided an
2. The implemented notification and alert system effectively automated flood alerts based on predefined thresholds, delivering
3. The system successfully integrated administrative and user management modules, allowing efficient account control, role-
4. The system effectively defined user roles, permissions, and secure authentication protocols, ensuring controlled access, data
5. The system efficiently established clearly defined user roles, permissions, and secure authentication measures,
6. The developed system, evaluated using ISO 25010 standards, achieved an overall rating of 4.0, interpreted as “More Than Expected,” indicating that it performed beyond baseline

interactive dashboard displaying live river levels, rainfall maps, and flood forecasts, while enabling users to perform data downloads, historical data browsing, and secure role-based API access efficiently.

timely warnings via email, SMS, and the portal, while continuously updating real-time information on ongoing flood events.

based access, and streamlined management of user activities within the web portal.

integrity, and protection of sensitive hydrological information within the web portal.

providing controlled system access and safeguarding critical hydrological data and user information.

requirements in terms of functional suitability, performance efficiency, and reliability, thereby demonstrating high effectiveness, stability, and operational quality.

Conclusions

Based on the findings of this study the following conclusions were formulated:

1. The developed real-time web portal effectively enhanced data

accessibility and visualization, supporting timely decision-making through interactive and user-friendly features.

2. The notification and alert system significantly improved flood preparedness by providing real-time and reliable alerts through multiple communication channels.
3. The integration of administrative and user management modules strengthened the system's efficiency in handling user accounts and maintaining operational control.
4. The defining user roles, permissions, and authentication protocols ensured system security and maintained the integrity of hydrological data.
5. The system's well-structured access control and authentication mechanisms effectively protected sensitive information and enhanced user trust.
6. The system's overall performance, with an ISO 25010 rating of 4.0, surpassed expectations, proving its reliability, functionality, and efficiency in managing hydrological data and operations.

Recommendations

Based on the conclusions drawn from this study, the following recommendations were formulated:

1. The web portal's interactive dashboard may be continuously updated and enhanced to incorporate additional real-time hydrological and environmental data sources for improved decision-making.
2. Continuously update and enhance the notification and alert system by integrating advanced predictive analytics to improve the accuracy and timeliness of flood warnings.
3. Regularly review and upgrade the administrative and user management modules to ensure scalability and adaptability to future system developments.
4. Strengthen user authentication and permission protocols through the adoption of multi-factor authentication and periodic security audits.
5. Continuously monitor and refine access control measures to uphold data security and user privacy as the system expands.
6. Conduct periodic ISO 25010-based evaluations to sustain and enhance the system's functional suitability, performance

- efficiency, and reliability over time.
7. Expand the system's data integration capabilities to include additional environmental sensors and external data sources for more comprehensive hydrological monitoring.
 8. Provide continuous training and technical support for system users to ensure effective utilization and encourage data-driven decision-making in flood risk management.

References

1. Abon, C. C., David, C. P. C., & Tabios, G. Q. III. (2012). Community-based monitoring for flood early warning system: An example in Central Bicol River Basin, Philippines. *Disaster Prevention and Management*, 21(1), 85–96. <https://doi.org/10.1108/09653561211202728>
2. Alsabhan, W., & Dudin, B. (2023). Real-Time Flood Forecasting and Warning: A Comprehensive Approach toward HCI-Centric Mobile App Development. *Multimodal Technologies and Interaction*, 7(5), 44.
3. Anticipation Hub / Philippine Red Cross (PRC), German Red Cross (GRC), & Finnish Red Cross (FinnRC). (2022). Flood Early Action Protocol (EAP) – Philippines. https://www.anticipation-hub.org/Documents/Briefing_Sheets_and_Fact_Sheets/Flood_EAP_-_Final.pdf
4. Beck, H. E., Wood, E. F., Pan, M., Fisher, C. K., Miralles, D. G., van Dijk, A. I. J. M., McVicar, T. R., & Adler, R. F. (2019). *MSWEP V2 global 3-hourly 0.1° precipitation: Methodology and quantitative assessment*. *Bulletin of the American Meteorological Society*, 100(3), 473–500.
5. Bernardo Palos (2025). *Architecting for Real-Time Alerts and Notifications* — a comprehensive guide covering architecture, message processing, delivery mechanisms, scalability, latency, and reliability considerations in alert system design.
6. Contreras, M. T., Gironás, J., & Escauriaza, C. (2020). Forecasting flood hazards in real time: A surrogate model for hydrometeorological events in an Andean watershed. *Natural Hazards and Earth System Sciences*, 20(12), 3261–3277. <https://doi.org/10.5194/nhess-20-3261-2020>
7. De Lara-Tuprio, E., Queaño, K. L., Tuprio, E. P., Alvarado, R., Bandong, A., Gatdula, C., Cayas, R. R., Doria, C., & Sombilon, J. (2024). Real-Time and Long-Term Forecasting Tools for Flood Management and Quick Response. Ateneo de Manila University Conference Proceedings.
8. Development and deployment of the impact-based flood forecasting system: Lagmay, A. M. F., Bagtasa, G., Andal, D. F., Andal, F. D., Aldea, J., Bencito, D. C., & Liporada, K. (2024). *An Impact-Based Flood Forecasting System for Citizen Empowerment*. *Asian Journal of Agriculture and Development*, 21 (20th Anniversary Issue), 129–148.
9. Earth Networks. (2019, March 25). Earth Networks announces completion of severe weather early warning system for PAGASA. <https://www.earthnetworks.com/blog/early-warning-pagasa/>
10. Harrigan, S., Zsoter, E., Cloke, H., Salamon, P., & Prudhomme, C. (2023). Daily ensemble river discharge reforecasts and real-time forecasts from the operational Global Flood Awareness System. *Hydrology and Earth System Sciences*, 27(1).
11. Jha, R., Sharma, A., & Mohapatra, P. K. (Eds.). (2022). *Hydrological modeling: Hydraulics, water resources and coastal engineering*. Springer. <https://doi.org/10.1007/978-3-030-81358-1>

12. Jurjen Wagemaker, “Real-time flood monitor for the Philippine Red Cross” (2024), demonstrating how FloodTags enables fast detection of flood events via Tagalog media scanning
13. Lagmay, A. M. F., Bagtasa, G., Andal, D. F., Andal, F. D., Aldea, J., Bencito, D. C., Liporada, K., & Delmendo, P. A. (2024). An Impact-Based Flood Forecasting System for Citizen Empowerment. *Asian Journal of Agriculture and Development*, 21 (20th Anniversary Issue), 129–148. This article details the development, methodology, and community-based aspects of the Philippines’ impact-based flood forecasting system.
14. Ma, (2024). A New Generation of Hydrological Condition Simulator Employing Physical Models and Satellite-Based Meteorological Data. *Earth and Space Science*.
15. Ming, X., Liang, Q., Xia, X., Li, D., & Fowler, H. J. (2020). Real-Time Flood Forecasting Based on a High-Performance 2-D Hydrodynamic Model and Numerical Weather Predictions. *Water Resources Research*, 56(7), e2019WR025583. <https://doi.org/10.1029/2019WR025583>
16. Nguyen, T. H., Bhattacharya, S., Wong, J. S., Didry, Y., Phan, D. L., Tamisier, T., & Matgen, P. (2025). Towards Digital Twin in Flood Forecasting with Data Assimilation Satellite Earth Observations: A Proof-of-Concept in the Alzette Catchment. arXiv preprint, May 13, 2025. This study demonstrates how integrating satellite-derived flood probability maps into a digital twin framework and assimilating them into a hydrodynamic model can significantly improve forecast accuracy and extend lead time
17. Nguyen, T. H., Bhattacharya, S., Wong, J. S., Didry, Y., Phan, D. L., Tamisier, T., & Matgen, P. (2025). Towards Digital Twin in Flood Forecasting with Data Assimilation Satellite Earth Observations—A Proof-of-Concept in the Alzette Catchment.
18. Oh, J., & Bartos, M. D. (2025). Machine learning improves continental-scale flood forecasting. *Nature Communications*, 16, 748. <https://doi.org/10.1038/s41467-025-51845-9>
19. PAGASA (Philippine Atmospheric, Geophysical and Astronomical Services Administration). (n.d.). Flood Forecasting and Warning System. <https://bagong.pagasa.dost.gov.ph/flood>
20. Perera, D., Seidou, O., Agnihotri, J., Rasmy, M., Smakhtin, V., Coulibaly, P., & Mehmood, H. (2019). Flood Early Warning Systems: A review of benefits, challenges and prospects (UNU-INWEH Report Series, Issue 08). United Nations University Institute for Water, Environment and Health. https://www.icfm.world/public/upload/2019/08/31/20190831003905_143.pdf
21. Phil-LiDAR 1 (Caraga State University & UP Diliman). (2023). Web-based Near-real Time Flood EViDens: Flood Hazard Mapping and Visualization for Lake Mainit and Surrounding Water Bodies. [Project output, CSU Phil-LiDAR 1 WordPress].
22. Project NOAH (Philippines). (2017). Disseminating Near-real-time Hazards Information and Flood Maps in the Philippines through Web-GIS. ScienceDirect / Web-GIS initiative.
23. ScienceDirect (2025). Hydrological Modeling. Hydrological Modeling - an overview | ScienceDirect Topics
24. Tatnall, A. (Ed.). (2005). Web portal design, implementation, integration, and optimization. IGI Global. <https://doi.org/10.4018/978-1-59140-550-7>
25. Tolentino, L. K. S., Baron, R. E., Blacer, C. A. C., Aliswag, J. M. D., De Guzman, D. C. E., Fronza, J. B. A., Valeriano, R. C., Quijano, J. F. C., Padilla, M. V. C., Madrigal, G. A. M., Valenzuela, I., & Fernandez, E. (2022). Real Time Flood Detection, Alarm and Monitoring System Using Image Processing and Multiple Linear Regression. *Journal of Computational Innovations and Engineering Applications*, 7(1). Retrieved from SSRN.
26. University of the Philippines Resilience Institute (UPRI). (2023). From Streets to Screens: Real-time Flood and Rainfall Monitoring Through IoT-based Sensors. [News Report, UP Resilience Institute].
27. Xu, Q., Shi, Y., Bamber, J., Ouyang, C., & Zhu, X. X. (2024). Large-scale flood modeling and forecasting with FloodCast.

ACKNOWLEDGEMENT

The researcher extends heartfelt gratitude to the following individuals whose invaluable guidance, support, and inspiration were essential to the successful completion of this study. At *Aemilianum College Inc.*, the researcher has had the privilege of being part of the Aemilian community while pursuing the esteemed MIT degree - an experience that has fostered both academic and personal growth, for which he is deeply grateful.

Heartfelt appreciation is extended to *Rev. Fr. Rey Genaro M. Malabanan, CRS*, Director of Aemilianum College Inc., whose leadership and encouragement continually inspired the researcher to align this study with the institution's vision of excellence and innovation.

Sincere gratitude is also expressed to his adviser, *Mr. Milan E. Bausa, MIT*, for his unwavering support and invaluable guidance in ensuring that the project became fully functional and able to withstand the scrutiny of the panel.

The researcher likewise conveys his profound appreciation to *Dr. Josefina R. Sarmiento*, esteemed adviser and Dean, for her steadfast guidance, patience, and expertise. Her mentorship has been instrumental in the success of this study and has served as a strong foundation throughout the research process.

Deep thanks are also extended to the members of the thesis committee - *Ms. Joannah C. Argote, MIT*; *Mr. Richard G. Rabulan, MIT*; *Mr. Marco L. Espinosa, MIT*; *Dr. Josefina R. Sarmiento, PhD*; and *Rev. Fr. Mande N. Batac, CRS*—for their valuable suggestions and recommendations, which significantly enhanced the system's functionality, reliability, and relevance to its intended stakeholders.

With heartfelt affection, the researcher acknowledges *Christine M. Alvarado*, the love of his life, and his younger sibling, *Christoponz Grae A. Quiapo*, whose joyful presence has been a constant source of motivation and strength. Their unwavering support and encouragement have been invaluable throughout this academic journey. Deepest gratitude is also extended to his parents, *Mrs. Lolita I. Quiapo* and *Mr. Ponciano F. Quiapo*, whose unconditional love, guidance, and sacrifices have profoundly shaped the researcher's pursuit of excellence and perseverance.

To all who have contributed, supported, or inspired him in any meaningful way, the researcher expresses his deepest appreciation. This achievement stands as a testament to the collective kindness, encouragement, and unwavering belief of many.

Above all, the researcher wholeheartedly offers thanks to **God Almighty** for His divine guidance, abundant blessings, and infinite wisdom, which have been his pillar of strength and resilience throughout this journey, making the completion of this study possible.

Thank you, and may God bless you all abundantly!

P. I. Q.