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# COMMUNITY-LEVEL GREENHOUSE GAS QUANTIFICATION SYSTEM USING GEOGRAPHIC INFORMATION SYSTEMS AND DATA ANALYTICS: AN INPUT TO CLIMATE CHANGE MITIGATION

Charisma T. Ramos
Laguna State Polytechnic University,
MSIT Student charisma.ramos@lspu.edu.ph
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**Abstract**

Climate change remains a significant environmental concern, highlighting the need for effective greenhouse gas (GHG) monitoring systems at the local level. This study developed a Community-Level Greenhouse Gas Quantification System integrating Geographic Information Systems (GIS) and data analytics to support climate change mitigation efforts in Biñan City, Laguna. The system was designed to improve existing greenhouse gas inventory processes by providing a centralized platform for data collection, emission computation, visualization, and reporting. A developmental research design using the Agile methodology was employed. Greenhouse gas data from the Agriculture, Waste, Industry, Transportation, Forestry, and Energy (AWITFE) sectors were collected, analyzed, and mapped using GIS technologies. Results revealed that the Energy sector produced the highest greenhouse gas emissions among all sectors. Spatial analysis identified Canlalay, Biñan Poblacion, and De La Paz as major emission hotspots. Forecasting analysis further indicated a gradual decline in emissions over the next five years. The developed system was evaluated using the System Usability Scale (SUS) and ISO 25010 software quality standards. Findings showed that the system was highly acceptable to both end-users and information technology experts. The study demonstrates that GIS and data analytics can enhance local greenhouse gas monitoring, support evidence-based environmental planning, and strengthen climate change mitigation initiatives at the community level.

***Keywords*** *– Greenhouse Gas Emissions, Geographic Information System, Climate Change Mitigation, Data Analytics, Environmental Monitoring*

## INTRODUCTION

Climate change has become one of the most pressing environmental issues worldwide. Greenhouse gas emissions from various sectors contribute significantly to global warming and environmental degradation. In the Philippines, local government units play a crucial role in implementing climate change mitigation strategies. However, greenhouse gas inventories are often managed through manual and fragmented processes, making data collection, analysis, and reporting inefficient. To address these challenges, this study developed a Community-Level Greenhouse Gas Quantification System that integrates Geographic Information Systems (GIS) and data analytics. The system provides a

centralized platform for greenhouse gas inventory management, emission mapping, forecasting, and reporting. Through spatial visualization and automated computations, the system supports data-driven decision making and environmental planning in Biñan City, Laguna.

## OBJECTIVES OF THE STUDY

The study aimed to develop a Community Level Greenhouse Gas Quantification System for Biñan City, Laguna. Specifically, it sought to:

1. Develop a centralized greenhouse gas inventory management system.
2. Integrate GIS-based emission mapping and visualization.
3. Analyze greenhouse gas emissions across AWITFE sectors.
4. Generate emission forecasts for future planning. 5. Evaluate the system using SUS and ISO 25010 standards.

## METHODOLOGY

The study utilized a developmental research design and followed the Agile Software Development Methodology. System development included planning, requirements gathering, design, development, testing, and evaluation phases. Greenhouse gas inventory data were collected from the Agriculture, Waste, Industry, Transportation, Forestry, and Energy (AWITFE) sectors of Biñan City. Geographic Information Systems were utilized to visualize emission distribution across barangays. Data analytics techniques were applied to identify trends and forecast future emissions. The developed system was evaluated by end-users and information technology experts using the System Usability Scale (SUS) and ISO 25010 software quality standards. Descriptive statistics, including weighted mean and standard deviation, were evaluation results.

## RESULTS AND DISCUSSION

The greenhouse gas inventory analysis revealed that the Energy sector generated the highest emissions among all monitored sectors. Transportation and Waste sectors also contributed substantially to the city's overall greenhouse gas emissions.

Table 1. Summary of Greenhouse Gas Emissions by Sector

| Sector | Total Emissions ($CO_2e$) | Rank |
|---|---|---|
| Energy | 42,995.51 | 1 |
| Transportation | 26,315.55 | 2 |
| Industry | 24,040.00 | 3 |
| Agriculture | 17,847.06 | 4 |
| Forestry | 2,547.27 | 5 |
| Waste | N/A | N/A |

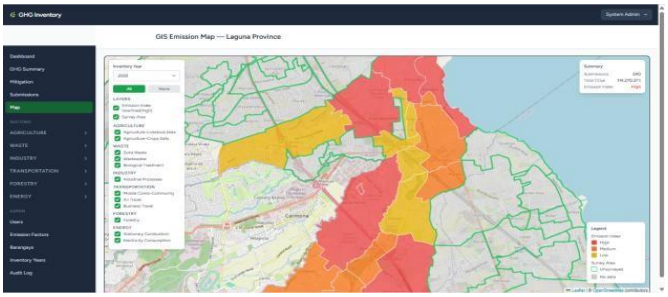
The results indicate that energy-related activities remain the primary source of greenhouse gas emissions in Biñan City. The substantial contributions from the Transportation and Waste sectors further highlight the impact of urbanization, increased vehicle usage, and waste generation on local emissions. These findings emphasize the need for targeted mitigation measures, including energy efficiency programs, renewable energy adoption, sustainable transportation initiatives, and improved waste management practices.

The Waste sector was excluded from the emission analysis due to the unavailability of sufficient and validated activity data required for greenhouse gas computation. Consequently, no emission estimate was generated for this sector during the study period.

**Spatial Distribution of Greenhouse Gas Emissions**

The developed system utilized Geographic Information Systems (GIS) to visualize the spatial distribution of greenhouse gas emissions across the barangays of Biñan City.

**Figure 1.** GIS-Based Greenhouse Gas Emission Map of Biñan City




GIS-based mapping identified Canlalay, Biñan Poblacion, and De La Paz as the major emission hotspots within the city. These barangays exhibited higher greenhouse gas concentrations due to increased commercial, residential, and transportation activities. Specifically, Canlalay contributed approximately 16.3% of total emissions, followed by Biñan Poblacion at 15.4% and De La Paz at 11.7%.

**Table 2.** Top Greenhouse Gas Emission Contributing Barangays

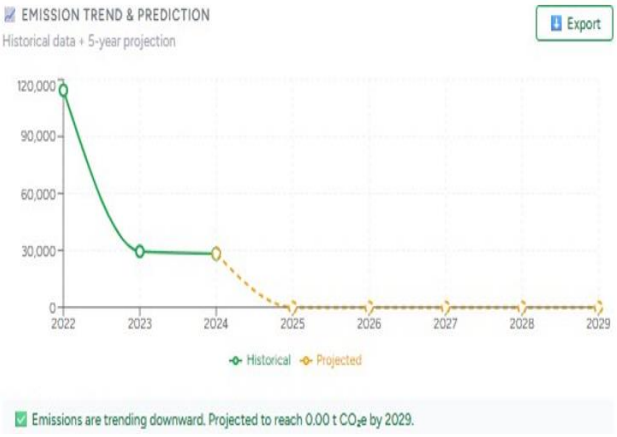
| Barangay | Percentage Contribution |
|---|---|
| Canlalay | 16.3% |
| Biñan Poblacion | 15.4% |
| De La Paz | 11.7% |

The GIS visualization enabled the identification of areas requiring priority intervention and provided decision-makers with a clearer understanding of the spatial distribution of greenhouse gas emissions. This feature supports evidence-based planning and the development of localized climate change mitigation strategies.

**Forecasted Greenhouse Gas Emissions**

The system incorporated forecasting functionality to support long-term environmental planning and policy development.

**Figure 2**. Forecasted Greenhouse Gas Emissions (2025–2029




Trend analysis and forecasting results indicated a gradual decrease in greenhouse gas emissions over the projected five-year period. The decline may be attributed to the implementation of environmental programs, climate mitigation initiatives, and increasing public awareness regarding sustainable practices. While the projected trend is favorable, future emission levels remain dependent on factors such as population growth, economic development, transportation demand, and policy implementation.

The forecasting capability of the system provides local government units with valuable information for strategic planning and supports proactive climate action initiatives.

**System Evaluatio**

The developed Community-Level Greenhouse Gas Quantification System was evaluated using the System Usability Scale (SUS) and ISO 25010 Software Quality Standards.

Table 3. Summary of System Evaluation Results

| Evaluation Criteria | Mean | Interpretation |
|---|---|---|
| Functional Suitability | 4.80 | Highly Acceptable |
| Reliability | 4.90 | Highly Acceptable |
| Interaction Capability | 4.83 | Highly Acceptable |
| Flexibility | 4.90 | Highly Acceptable |
| Performance Efficiency | 4.93 | Highly Acceptable |
| Security | 4.93 | Highly Acceptable |
| Maintainability | 4.88 | Highly Acceptable |
| Compatibility | 5.00 | Highly Acceptable |
| Safety | 4.88 | Highly Acceptable |
| SUS Score | 3.68 | Highly Acceptable |

System evaluation results demonstrated high acceptability among users. The SUS assessment showed that the platform was user-friendly and effective, while the ISO 25010 evaluation confirmed high ratings in functionality, reliability, usability, performance efficiency, security, maintainability, and compatibility. The findings indicate that the system effectively meets the operational requirements of local government units for greenhouse gas monitoring, reporting, and environmental analysis.

Overall, the findings suggest that integrating GIS and data analytics into greenhouse gas monitoring systems can significantly improve environmental data management and support climate change mitigation initiatives. The system enhances data accessibility, strengthens evidence-based decision-making, and provides a scalable platform for local environmental governance and sustainability planning.

## CONCLUSION AND RECOMMENDATION

The Community-Level Greenhouse Gas Quantification System successfully provided a centralized and GIS-enabled platform for greenhouse gas inventory management in Biñan City. The system improved data collection, emission analysis, visualization, and reporting processes while supporting evidence-based environmental decision-making.

The Energy sector was identified as the largest contributor to greenhouse gas emissions, while Canlalay, Biñan Poblacion, and De La Paz emerged as major emission hotspots. System evaluations confirmed that the platform met usability and software quality standards.

However, the greenhouse gas emissions presented in this study may not fully represent the total emissions of Biñan City, as emissions data from the Waste sector were not included in the analysis due to data limitations. Considering the substantial contribution of the Waste sector to greenhouse gas emissions, the actual total emissions of the city may be higher than those reported in this study.

It is recommended that the system be adopted by local government units to strengthen greenhouse gas monitoring and climate change mitigation efforts. Furthermore, local government agencies should prioritize the collection and monitoring of Waste sector data to improve the completeness and accuracy of greenhouse gas inventories and support more effective climate change mitigation planning. Future studies may incorporate real-time data integration, advanced predictive analytics, and comprehensive sectoral data, including Waste sector emissions, to further enhance system capabilities and improve the accuracy of greenhouse gas assessments.

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