Special Issue

flagship journal with a focus on emerging issues

HORIZON JOURNALS

VOL. 7 (S) AUG. 2025

ASAIHL Conference

University's Role in Advancing Climate Crisis Reduction

Editors: Astri Dewayani, MD, Ph.D. & Nayan Kanwal, Ph.D.

doi Crossref Content

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Journal of Humanities and Social Sciences Research

About the Journal

Overview

Horizon Journal of Humanities and Social Sciences Research (JHSSR) is an **open-access academic journal** published by BP Services, independently owned, dependent upon contributions and run on a non-profit basis for the benefit of the world-wide social science community. It neither accepts nor commissions third party content. It is an online scientific journal and does not impose any publication or page fee on authors intending to publish in the journal. It publishes the scientific outputs.

Recognized internationally as a leading peer-reviewed scholarly journal devoted to the publication of original papers, it serves as a forum for practical approaches to improving quality in issues pertaining to social and as well as the humanities.

JHSSR is currently a **bi-annual** (*July* and *December*) periodical that considers for publication original articles as per its scope. The journal publishes in **English** and it is open to authors around the world regardless of the nationality.

The Journal is available world-wide online.

Aim and scope

Horizon Journal of Humanities and Social Sciences Research aims to develop as a pioneer journal for the social sciences with a focus on emerging issues pertaining to the social sciences as well as the humanities.

JHSSR is a principal outlet for scholarly articles. The journal provides a unique forum for theoretical debates and empirical analyses that move away from narrow disciplinary focus. It is committed to comparative research and articles that speak to cases beyond the traditional concerns of area and single-country studies. JHSSR strongly encourages transdisciplinary analysis of contemporary and historical social change particularly in Asia, or beyond by offering a meeting space for international scholars across the social sciences.

Scope of the journal includes HUMANITIES– Field of Languages, Linguistics, Literature, and Education. SOCIAL SCIENCES–Anthropology, Economics, Law, psychology, Political Sciences, sociology, music, sport, and Technology Management.

History and Background

A premier journal in its field, JHSSR was established in 2019, and has been in circulation continuously since then. Horizon is an open access scholarly journal that currently publishes *semi-annually*. The journal uses a stringent yet relatively rapid **double-blind peer-review process**, which translates to benefits such as timeliness of publication, widespread dissemination, high visibility, and likelihood of high citations and broader impacts. JHSSR follows code of conduct stipulated by the Committee on Publication Ethics (COPE).

It primarily publishes for dissemination of academic research meant for scholars and scientists worldwide. We seek to present the cutting-edge innovations and/or latest insights and strive to maintain the highest standards of excellence for JHSSR. The journal publishes on a non-profitable basis and does not have any income from subscription or other sources. It does not impose any publication or page fee on authors intending to publish in JHSSR.

JHSSR is distributed worldwide to more than 1000 institutions via e-alerts, in addition to authors upon request. To provide expert evaluation of the various segments of the broad spectrum of Humanities and Social Sciences research, the editorial office is assisted by scholars who serve as Associate Editors, editorial board members, Emeritus editors and international advisory board members from academic institutions across 35 countries, and ad-hoc reviewers chosen for their expertise. They provide constructive evaluation and, fair and rapid editorial processing. The frequency of citations to articles published in JHSSR by scientists, students, and others increases each year.

To facilitate review, the Editor-in-Chief and the Chief Executive Editor previews all submitted manuscripts and independently or in consultation with an Associate Editor, decides if a manuscript is appropriate for review by members of JHSSR's editorial board and/or *adhoc* reviewers. Manuscripts outside of the scope of JHSSR or those articles in poor English are returned without the delay of a full review, generally within a week of submission. Authors may contact the Chief Executive Editor in advance to inquire about the potential suitability of their research topic for review.

Manuscript submissions and inquiries are encouraged. Manuscript style and formatting are described in the "Instructions to Authors". Manuscript submissions should be made using JHSSR online manuscript submission system, or manuscripts should be mailed through email to the Chief Executive Editor. Direct inquiries to CEE.horizon@gmail.com

Goal

Our goal is to bring the highest quality research to the widest possible audience. Our objective is **"Today's research, tomorrow's impact"**.

Quality

We aim for excellence, sustained by a responsible and professional approach to journal publishing. Submissions are guaranteed to receive a decision within 14 weeks. The elapsed time from submission to publication for the articles averages 3-4 months.

Editorial and International Advisory Board

The editorial and the advisory board of the Horizon has a presence of an international base of renowned scholars from various disciplines of research with diverse geographical background.

Our editorial team is engaged with **universities in 35 countries across the world** including **Australia, Bangladesh, Canada, Fiji, Finland, Germany, India, Iran, Jordon, Lithuania, Malaysia, Morocco, Nepal, Netherlands, New Zealand, Nigeria, Pakistan, Philippines, Portugal, Saudi Arabia, South Africa, Sweden, Taiwan, Thailand, Turkey, United Kingdom, USA,** and **Vietnam**.

Abstracting and indexing of *Horizon*

As is the case with any new journal, indexing in all prestigious relevant databases takes some time, and is heavily dependent upon citations the articles generate.

The Horizon Journal of Humanities and Social Sciences Research (Online ISSN 2682-9096) is a *high-quality, peer-reviewed* academic journal in its field.

It is a Gold Open Access journal and indexed in major academic databases to maximize article discoverability and citation. The journal follows best practices on publication ethics outlined in the COPE Code of Conduct. Editors work to ensure timely decisions after initial submission, as well as prompt publication online if a manuscript is accepted for publication.

Upon publication, articles are immediately and freely available to the public. The final version of articles can immediately be posted to an institutional repository or to the author's own website as long as the article includes a link back to the original article posted on JHSSR. All published articles are licensed under a Creative Commons Attribution 4.0 International License.

The journal has been indexed and abstracted in: SSRN, CrossRef, Directory of Open Access Journals (DOAJ), Google Scholar, EBSCOhost, ProQuest. The journal has been listed in: CiteFactor, Cornel University Library, CrossCheck, DRJI, Journalseek, openaccessarticles.com, Open Access Library, Rubrig, Scirus, Ulrichs. In addition, the journal has been archived in: Academia.edu, National Library of Malaysia, and Malaysian Citation Index (MyCite).

The journal editors and the publisher continue to do their best for this journal to be included in the top abstracting and bibliographic databases around the world; however, for the journal to be indexed in any indexing body is beyond the Journal's direct control. Nevertheless, the journal ensures that the papers published are of high quality. The publisher from time to time recommends the journal to the indexing and abstracting bodies.

The authors must also ensure that the manuscripts they submit to JHSSR are of top quality and are innovative.

Citing journal articles

The abbreviation for *Horizon* Journal of Humanities and Social Sciences Research is ***Horizon J. Hum. Soc. Sci. Res.***

Publication policy

Horizon publishes original work and its policy prohibits an author from submitting the same manuscript for concurrent consideration by two or more publications, and is not under concurrent consideration elsewhere at the time of submitting it to Horizon. It prohibits as well publication of any manuscript that has already been published either in whole or substantial part elsewhere in any language. It also does not permit publication of manuscript that has been published **in full** in Proceedings.

Originality

The author must ensure that when a manuscript is submitted to Horizon, the manuscript is an original work. The author should check the manuscript for any possible plagiarism using any software such as **TurnItIn, i-Thenticate** or any other similar program before submitting the manuscripts to the Horizon journal.

All submitted manuscripts must be in the Journal's acceptable **similarity index range:**
< 25%– PASS; **30-35%**– RESUBMIT MS; **> 35%– REJECT**.

Publication Ethics and Publication Malpractice Statement

Code of Conduct

The Horizon Journals takes seriously the responsibility of all of its journal publications to reflect the highest in publication ethics. Thus, all journals and journal editors abide by the Journal's codes of ethics. Refer to Horizon's **Code of Conduct** for full details at the Journal's web link https://horizon-jhssr.com/code-of-conduct.php

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To publish an article and make it available, we need publishing rights from you for that work. We therefore ask authors publishing in Horizon journals to sign an author contract which grants us the necessary publishing rights. This will be after your manuscript has been through the peer-review process, been accepted and moves into production. Our editorial office will then send you an email with all the details. Horizon publishes under the open access publishing— **Attribution (CC BY) under a Creative Commons Attribution 4.0 International License**.

In case of any queries, contact the Journal's Editorial office via email to info@horizon-jhssr.com

Article Processing Charges (APC)— Open Access Journal

Open access publishing proposes a relatively new model for scholarly journal publishing that provides immediate, worldwide, barrier-free access to the full-text of all published articles. Open access allows all interested readers to view, download, print, and redistribute any article without a subscription, enabling far greater distribution of an author's work than the traditional subscription-based publishing model. Many authors in a variety of fields have begun to realize the benefits that open access publishing can provide in terms of increasing the impact of their work world-wide.

Horizon JHSSR **does not impose** any submission fees, publication fees or page charges for those intending to publish their research in this journal. However, as JHSSR is an open access journal, in norms with all open access journals, the journal imposes an Article Processing Charge (APC). To publish in JHSSR, authors are currently required to pay an APC of **USD100 per article** (*subject to revision*). A waiver to this available for academics with a heavily subsidized fee of USD50 per accepted manuscript.

In addition, this journal offers discount on Article Processing Charges to authors based in any of the countries which were classified by the World Bank as Low-income economies or Lower-middle-income economies. All requests can be sent directly to the journal's Chief Executive Editor.

In an open access model, the publication costs of an article are paid from an author's research budget, or by their supporting institution, in the form of Article Processing Charges. These Article Processing Charges replace subscription charges and allow publishers to make the full-text of every published article freely available to all interested readers. In addition, authors who publish in JHSSR open access journal retain the copyright of their work, which is released under a **"Creative Commons Attribution 4.0 International License,"** enabling the unrestricted use, distribution, and reproduction of an article in any medium, provided that the original work is properly cited.

However, in case of a print version, if it is necessary for the figures to be reproduced in color, a charge of USD50 per figure will apply.

International Standard Serial Number (ISSN)

An ISSN is an 8-digit code used to identify periodicals such as journals of all kinds and on all media–*print and electronic*. All Horizon journals have an e-ISSN.

Horizon Journal of Humanities and Social Sciences Research: **e-ISSN 2682-9096**.

Lag time

A decision on acceptance or rejection of a manuscript is reached in 3 to 4 months (average 12 weeks). The elapsed time from submission to publication for the articles averages 4-5 months.

Authorship

Authors are not permitted to add or remove any names from the authorship provided at the time of initial submission without the consent of the Journal's Chief Executive Editor. Requests for changes to authorship must be directed to the journal's chief executive editor. Changes in authorship will only be permitted where valid reasons are provided and all authors are in agreement with the change. Post-publication changes to authorship will typically be made via a published correction and authors may be charged for this additional service.

One author will need to be identified as the corresponding author, with their email address normally displayed in the article. Authors' affiliations are the affiliations where the research was conducted. If any of the named co-authors moves affiliation during the peer-review process, the new affiliation can be given as a footnote. Please note that no changes to affiliation can be made after your paper is accepted.

Manuscript preparation

Refer to Horizon's **INSTRUCTIONS TO AUTHORS** at the back of this journal or visit
https://horizon-jhssr.com/manuscript-prepparation.php

A well-formatted manuscript follows all journal instruction. All elements of the manuscript are printed in English with 1-inch margins at top, bottom, and sides. Right margins are unjustified. Horizon journals accept manuscript submissions which uses any consistent text— Format-free Submission! This saves you time and ensures you can focus on your priority: the research.

However, citations/ references must be formatted by you as per APA format.

Checklist for Manuscript Submission

- Cover letter
- Declaration form
- Referral form
- Manuscript structure

(Title, Author details and affiliation, Abstract, Keywords, etc. using the **IMRAD** style).

Each submission must fulfil the following criteria and documents listed below must be submitted along with the manuscript for intended publication.

1) Cover letter

Your cover letter should be complete and make a strong pitch. The cover letter should include all these details:

- Author(s): Full contact details (email, institutional address, telephone number, etc.) of all authors listed including who the corresponding author will be [full name(s) written as First Name then Last Name]. Understand the differences between lead author and co-author(s). Lead-author: who has done most of the research and writing; Co-author: Has collaborated with the lead author and contributed some parts.
- A brief explanation of your article's relevance and impact.
- Disclosure of whether you have published this study previously elsewhere or if it is in consideration by another journal.
- Disclosure of any commercial or financial relationship that may be viewed as any potential conflict of interest.
- A brief statement explaining why the journal should publish your study.

(Refer to sample available at https://horizon-jhssr.com/download.php).

2) Declaration form

Do not forget to complete the declaration form and submit it along with your manuscript. Sign the declaration that your manuscript is original, you have NOT published this study previously elsewhere in any language and is not under concurrent consideration elsewhere at the time of submitting it to Horizon.

3) Referral form

The authors are strongly recommended to complete the "Reviewers Suggestion" form along with the manuscript during submission. Authors should suggest up to 3 names of potential reviewers experts in the subject area of the manuscript, and are not the co-authors listed in the manuscript submitted. The suggested reviewers may be from any part of the world. The journal is not, however, bound by these suggestions.

4) Language and flow

A well-written manuscript has greater chances of acceptance. Some tips:

- Avoid long, complicated sentences; keep it simple. Your sentences should be understandable.
- Your ideas should flow smoothly.
- Use correct terminology, avoid excessive jargon and grandiose language.
- Make sure there are no grammatical mistakes.
- It is highly recommended to approach an editing service for help with polishing your manuscript. The journal has a long-term proven affiliation with a good certified editor at Beyond Proofreading Services PLC.

You may contact **Dr. Brown at Beyond Proofreading,** beyondproofreading@gmail.com at your own discretion.

Language Accuracy

JHSSR **emphasizes** on the linguistic accuracy of every manuscript published. Articles must be in English and they must be competently written and argued in clear and concise grammatical English. Contributors are strongly advised to have the manuscript checked by a colleague with ample experience in writing English manuscripts or a competent English language editor.

Author(s) **should provide a certificate** confirming that their manuscripts have been adequately edited. A proof from a certified editing service should be submitted together with the cover letter at the time of submitting a manuscript to Horizon.

All editing costs must be borne by the author(s). This step, taken by authors before submission, will greatly facilitate reviewing, and thus publication if the content is acceptable.

Refer to JHSSR's **Manuscript Format Guide** at https://horizon-jhssr.com/online-submission.php

Editorial process

Authors are notified with an acknowledgement containing a *Manuscript ID* upon receipt of a manuscript, and upon the editorial decision regarding publication.

JHSSR follows a **double-blind peer-review process**. Authors are encouraged to suggest names of at least three potential reviewers at the time of submission of their manuscript to Horizon using the **Referral form**. The editors are not, however, bound by these suggestions.

The Journal's peer-review

In the peer-review process, three referees independently evaluate the scientific quality of the submitted manuscripts.

Peer reviewers are experts chosen by journal editors to provide written assessment of the **strengths** and **weaknesses** of written research, with the aim of improving the reporting of research and identifying the most appropriate and highest quality material for the journal.

The Review process

What happens to a manuscript once it is submitted to *Horizon*? Typically, there are seven steps to the editorial review process:

1. The Journal's chief executive editor and the editorial board examine the paper to determine whether it is appropriate for the journal and should be reviewed. If not appropriate, the manuscript is rejected outright and the author is informed. Linguistically hopeless manuscripts will be rejected straightaway (e.g., when the language is so poor that one cannot be sure of what the authors really mean).

2. The chief executive editor sends the article-identifying information having been removed, to three reviewers. Typically, one of these is from the Journal's editorial board. Others are external specialists in the subject matter represented by the article. The chief executive editor requests them to complete the review in three weeks.

   Comments to authors are about the appropriateness and adequacy of the theoretical or conceptual framework, literature review, method, results and discussion, and conclusions. Reviewers often include suggestions for strengthening of the manuscript. Comments to the editor are in the nature of the significance of the work and its potential contribution to the literature.

3. The chief executive editor, in consultation with the Editor-in-Chief, examines the reviews and decides whether to reject the manuscript, invite the author(s) to revise and resubmit the manuscript, or seek additional reviews. Final acceptance or rejection rests with the Editor-in-Chief, who reserves the right to refuse any material for

publication. In rare instances, the manuscript is accepted with almost no revision. Almost without exception, reviewers' comments (to the author) are forwarded to the author. If a revision is indicated, the editor provides guidelines for attending to the reviewers' suggestions and perhaps additional advice about revising the manuscript.

4. The authors decide whether and how to address the reviewers' comments and criticisms and the editor's concerns. The authors return a revised version of the paper to the chief executive editor along with specific information describing how they have answered' the concerns of the reviewers and the editor, usually in a tabular form. The author(s) may also submit a rebuttal if there is a need especially when the author disagrees with certain comments provided by reviewer(s).

5. The chief executive editor sends the revised paper out for re-review. Typically, at least one of the original reviewers will be asked to examine the article.

6. When the reviewers have completed their work, the chief executive editor in consultation with the editorial board and the Editor-in-Chief examine their comments and decide whether the paper is ready to be published, needs another round of revisions, or should be rejected.

7. If the decision is to accept, an acceptance letter is sent to all the author(s), the paper is sent to the Press. The article should appear in print in approximately three months.

The Publisher ensures that the paper adheres to the correct style (in-text citations, the reference list, and tables are typical areas of concern, clarity, and grammar). The authors are asked to respond to any minor queries by the Publisher. Following these corrections, page proofs are mailed to the corresponding authors for their final approval. At this point, **only essential changes are accepted**. Finally, the article appears in the pages of the Journal and is posted on-line.

SUBMISSION OF MANUSCRIPTS

Owing to the volume of manuscripts we receive, we must insist that all submissions be made electronically using the **online submission system™**, a web-based portal. For more information, go to our web page and click **"Online Submission"**.

Please do **not** submit manuscripts to the Editor-in-Chief or to any other office directly. All submissions or queries must be directed to the **Chief Executive Editor** via email to CEE.horizon@gmail.com

Visit our Journal's website for more information at https://horizon-jhssr.com/index.php

DOI: https://doi.org/10.37534

Horizon Journal of
HUMANITIES & SOCIAL SCIENCES RESEARCH

JHSSR

A Special Edition:

University's Role in Advancing Climate Crisis Reduction

Editors: Astri Dewayani, MD, Ph.D. & Nayan Kanwal, Ph.D.

Vol. 7 (S) Aug. 2025

HORIZON JOURNALS

An international peer-reviewed scientific journal published by BP Services

Horizon JHSSR

Volume 7
Issue (S) *Special ASAIHL Issue*

August 2025

Journal of Humanities and Social Sciences Research

An Open access Peer-reviewed Scholarly Journal

Recommended Citation
Horizon J. Hum. Soc. Sci. Res.

Available at: https://horizon-jhssr.com/index.php

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For more information, please contact info.JHSSR@gmail.com

Do not raise the bar unnecessarily by exaggerating requirements for successful publication, but rather encourage young researchers to try and experiment. Researchers can raise their ambition level through gained experience.

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Message from Dr. Ninnat Olanvoravuth, Secretary-General Emeritus of ASAIHL on the Occasion of the ASAIHL-JHSSR Special Issue

Mobilizing Knowledge for a Sustainable Future

Dr. Ninnat Olanvoravuth, Ph.D.
Secretary-General Emeritus of ASAIHL

The publication of this ASAIHL 2024 Special Issue of the *Journal of Humanities and Social Sciences Research (JHSSR)* is a moment of profound significance for all of us committed to the ideals of sustainable education and regional cooperation.

The 2024 ASAIHL Conference, graciously hosted by Universitas Airlangga, centered on the urgent theme *"University's Role in Advancing Climate Crises Reduction."* This topic could not be more timely, nor more vital. Around the world, climate change is reshaping lives, landscapes, and livelihoods. It challenges us not only as citizens but as educators, researchers, and thought leaders.

ASAIHL has long stood as a platform for advancing academic collaboration and leadership across Southeast Asia. Today, it must also stand as a vanguard of climate-conscious scholarship. Our universities must mobilize knowledge not merely for publication, but for purpose—for the transformation of systems, the empowerment of communities, and the safeguarding of our shared future.

This special issue brings together an array of voices—diverse, thoughtful, and committed—who remind us that knowledge must always be in service to humanity and the Earth. I commend the editors, contributors, and reviewers of *JHSSR* for their dedication to academic integrity and sustainable vision.

Let this publication serve not only as a record of scholarly dialogue but as a catalyst for action. May it deepen our resolve to ensure that the legacy of ASAIHL is not only one of academic growth, but of ecological and ethical stewardship.

With warm regards,

Dr. Ninnat Olanvoravuth, Ph.D.

Secretary-General Emeritus of ASAIHL
Association of Southeast Asian Institutions of Higher Learning (ASAIHL)
Chulalongkorn University
Bangkok, Thailand

August, 2025

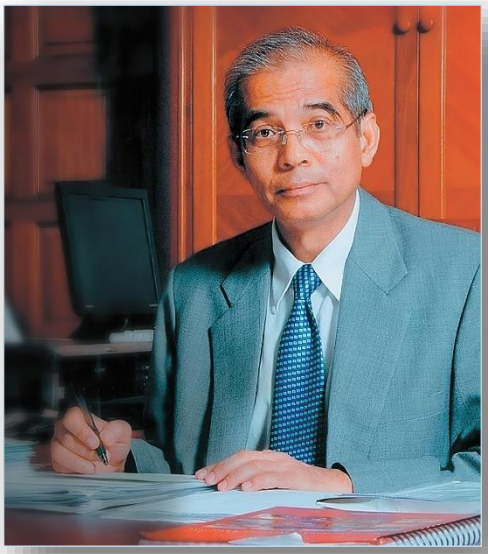
◆Dr. Ninnat Olanvoravuth has served as secretary-general of the Association of Southeast Asian Institutions of Higher Learning (ASAIHL) since 1987. Dr. Olanvoravuth is the director of the M.B.A. and M.S. accounting program at Thammasat University, the second oldest university in Thailand. He is chairman of the governing board of Srisophon College, the first private institution of higher learning in the South of Thailand to provide an educational opportunity within the different provinces of Thailand to earn bachelor's and master's degrees in several disciplines. Dr. Olanvoravuth received his undergraduate and graduate education at San Diego State University, and his Ph.D. degree in leadership and organizational behavior from U.S. International University.

CITE THIS ARTICLE

Ninnat Olanvoravuth. Message from Dr. Ninnat Olanvoravuth. *Horizon J. Hum. Soc. Sci. Res.***7 (S),** xix–xx (2025). https://doi.org/10.37534/bp.jhssr.2025.v7.nS.id1.pxix-xx

Foreword from Academician Emeritus Professor Tan Sri Dato' Dr. Syed Jalaludin bin Syed Salim, Reflections on the ASAIHL Special Issue

Harnessing Academic Excellence for Planetary Well-being



Academician Emeritus Professor Tan Sri Dato' Dr. Syed Jalaludin bin Syed Salim, FASc
P.S.M., D.P.M.P., D.S.S.A., J.S.M.
BVSc, BSc (AH) [PUNJ], MPhil, PhD [LON], Hon DSc (HULL), Hon Doctor (SOKA), Hon D Agri Tech (THAKSIN), Hon DSc (OUM), Hon D Eng. (UMP), Hon DVM (UMK), Hon D Arts (EAU), Hon DFdSc (UPM), Hon MCVS.

In an era increasingly defined by planetary challenges, the 2024 ASAIHL Conference convened at Universitas Airlangga, Surabaya, has demonstrated the profound potential of academic institutions to serve not only as centers of knowledge but also as catalysts of global transformation. With the theme *"University's Role in Advancing Climate Crises Reduction,"* the conference reinforced a fundamental truth: that higher education institutions bear a moral and intellectual responsibility to lead the response to climate change.

This special issue of the *Journal of Humanities and Social Sciences Research (JHSSR)* is both a scholarly milestone and a clarion call. It captures the vibrant dialogues, critical reflections, and pioneering ideas presented during the ASAIHL 2024 gathering. More importantly, it embodies the shared commitment of Southeast Asian institutions of higher learning to contribute solutions grounded in science, ethics, and sustainable development.

As Chairman of the ASAIHL Executive Committee, I am deeply encouraged by the collective resolve of our member universities. Academic excellence must now be measured not only by scholarly output, but by its relevance to the most pressing crises of our time. Climate change is not just an environmental issue—it is a human, social, and educational concern.

Let this volume inspire continued interdisciplinary collaboration, forward-looking research, and actionable outcomes. Let it serve as a beacon for how education, when rooted in integrity and guided by shared values, can become a force for planetary well-being.

I congratulate Professor Dr. Nayan Kanwal and the editorial board of *JHSSR* for curating this timely special issue and express my gratitude to all contributors for advancing the mission of ASAIHL.

With sincere appreciation,

Academician Emeritus Professor Tan Sri Dato' Dr. Syed Jalaludin bin Syed Salim, FASc

P.S.M., D.P.M.P., D.S.S.A., J.S.M.

BVSc, BSc (AH) [PUNJ], MPhil, PhD [LON], Hon DSc (HULL), Hon Doctor (SOKA), Hon D Agri Tech (THAKSIN), Hon DSc (OUM), Hon D Eng. (UMP), Hon DVM (UMK), Hon D Arts (EAU), Hon DFdSc (UPM), Hon MCVS.

Chairman, ASAIHL Executive Committee

August, 2025

◆Academician Professor Emeritus Tan Sri Dato' Dr. Syed Jalaludin bin Syed Salim graduated with a Bachelor of Veterinary Science from the University of Punjab, Pakistan in 1967, followed by a Master of Philosophy and a Doctor of Philosophy (PhD) from the University of London, United Kingdom, in 1969 and 1977, respectively. He was also conferred eight (8) honorary degrees, namely Doctor of Science from the University of Hull in 1999, Doctor Honorary Causa from Soka University in 2000, Doctor of Agriculture Technology from Thaksin University in 2005, Doctor of Science from Open University Malaysia in 2007, Doctor of Engineering from University Malaysia Perlis in 2008, Doctor of Veterinary Medicine from University of Malaysia Kelantan in 2015, Doctor of Arts from Eastern Asia University in 2020, and Doctor of Food Security from University Putra Malaysia in 2024.

Tan Sri Dato' Dr. Syed Jalaludin began his career as an assistant lecturer in the Faculty of Agriculture at the University of Malaya in 1969. He later joined University Putra Malaysia (UPM) as a lecturer in the Faculty of Veterinary Medicine and Animal Science in 1975 before retiring as Vice Chancellor of UPM in 2001. He was later appointed as Pro Chancellor of UPM from October 2018 until October 2024. During his academic career, he was bestowed with the National Science Laureate in 1993 and the National Academic Laureate in 2008. He is also a founder and senior fellow (which carries the title of Academician) of the **Academy of Science Malaysia**. Academician Syed Jalaludin has also been conferred emeritus professorship by University Malaysia Terengganu and UPM. He is still active in the academic sector as a chancellor of Taylor's University, chairman of Asia e University (AeU), and chairman of the board of governors of University College Fairview. He was a member of the Executive Committee and Governing Board of the International Centre for Education in Islamic Finance (INCEIF).

Academician Tan Sri Dato' Dr. Syed Jalaludin was decorated for his contribution towards national and private sector developments as follows: Darjah Kebesaran Dato' Sultan Salahuddin Abdul Aziz Shah (D.S.S.A.) and Darjah Paduka Mahkota Perlis (D.P.M.P.), which carries the title of Dato' by both the Sultan of Selangor and the Raja of Perlis. He was also conferred Johan Setia Mahkota (J.S.M.) and Panglima Setia Mahkota (P.S.M) which carry the title of Tan Sri, by His Majesty, the Yang Di-Pertuan Agong of Malaysia.

CITE THIS ARTICLE

Syed Jalaludin bin Syed Salim. Foreword from Academician Emeritus Professor Tan Sri Dato' Dr. Syed Jalaludin bin Syed Salim— Reflections on the ASAIHL Special Issue. *Horizon J. Hum. Soc. Sci. Res.***7 (S),** xxi–xxii (2025). https://doi.org/10.37534/bp.jhssr.2025.v7.nS.id2.pxxi-xxii

Foreword from Prof. Dr. Mohammad Nasih◆, Rector, Universitas Airlangga, Surabaya

Strengthening Academic Synergies: A Message for the ASAIHL Commemorative Issue, A Foreword to the ASAIHL 2024 Special Issue

It was a great honor for Universitas Airlangga to host the 2024 ASAIHL Conference in Surabaya, Indonesia. Under the theme "*University's Role in Advancing Climate Crises Reduction*," the conference brought together scholars, policymakers, and academic leaders in a shared effort to address one of the most critical challenges facing humanity today: the climate crisis.

Prof. Dr. Mohammad Nasih, M.T., Ak., CA
Rector 2015-2025
Universitas Airlangga, Surabaya

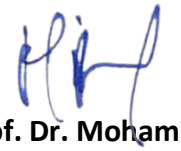
Higher education institutions have long served as beacons of knowledge and innovation. Yet, in this era of unprecedented environmental disruption, our responsibilities must go further. We must become active agents of change—integrating sustainability across curricula, promoting interdisciplinary research, and forming strategic alliances that bridge knowledge with action.

The publication of this special issue of the *Journal of Humanities and Social Sciences Research (JHSSR)* is both a timely reflection and a lasting contribution to this mission. It documents the spirited academic exchange and urgent calls for collaboration that defined the 2024 ASAIHL Conference. More importantly, it reinforces the message that meaningful change must be grounded in academic excellence, ethical leadership, and collective will.

Universitas Airlangga is proud to contribute to this regional momentum. As host of ASAIHL 2024, we reaffirmed our institutional commitment to environmental stewardship, educational leadership, and the strengthening of academic synergies across Southeast Asia and beyond. We believe that only through such united efforts can we build a more resilient and sustainable future.

I express my sincere gratitude to all contributors and the editorial team of JHSSR particularly Professor Dr Nayan Kanwal for ensuring that the insights and aspirations of the conference will continue to inspire action through this special publication. May it serve as a reference, a resource, and a rallying point for the academic community.

With highest regards,



Prof. Dr. Mohammad Nasih, **M.T., Ak., CA**

Rector
Universitas Airlangga Surabaya,
Indonesia

August, 2025

◆Prof. Dr. Mohammad Nasih has served as Rector of Universitas Airlangga (UNAIR), Indonesia, from 2015 to 2025. Prior to his rectorship, he held key leadership roles at UNAIR, including Vice Rector for Finance (2010–2015) and Director of Finance (2007–2010).

He earned his Doctorate in Economics (Accounting) from Universitas Airlangga in 2005, following a Master's degree in Technology and Industrial Management from the Bandung Institute of Technology (ITB) in 1997, and a Bachelor's degree in Accounting from UNAIR in 1991.

During his tenure as Rector, Prof. Nasih has significantly advanced the university's global standing. Under his leadership, UNAIR achieved notable rankings, including #308 in the QS World University Rankings, #52 in the QS Asia University Rankings, #1201+ in the Times Higher Education (THE) World University Rankings, #101–200 in the THE Impact Rankings, and #83 in the UI GreenMetric. Additionally, UNAIR received the "Excellent" designation in the Integrity Zone Development Assessment and national recognition for transparency in public information from the Central Information Commission of Indonesia in 2022.

His academic expertise encompasses management accounting, public finance, intellectual capital (particularly human capital), governance, and business strategy.

CITE THIS ARTICLE

Mohammad Nasih. Foreword from Prof. Dr. Mohammad Nasih, Rector, Universitas Airlangga, Surabaya—Strengthening Academic Synergies: A Message for the ASAIHL Commemorative Issue, a Foreword to the ASAIHL 2024 Special Issue. *Horizon J. Hum. Soc. Sci. Res.***7 (S),** xxiii–xiv (2025). https://doi.org/10.37534/bp.jhssr.2025.v7.nS.id3.pxxiii-xxiv

Opening Remarks on the ASAIHL Special Issue

Empowering Academia, Inspiring Action: Advancing Climate Solutions Through Southeast Asian Scholarship

Nayan Kanwal, FRSA, ABIM, AMIS, Ph.D.
Chief Executive Editor, JHSSR

It is with great pride and a deep sense of purpose that I write this Foreword as one of the Guest Editors of this distinguished special issue of the *Horizon Journal of Humanities and Social Sciences Research (JHSSR)*, dedicated to the 2024 ASAIHL Conference. This edition marks a significant milestone, not only for the Journal but also for the Association of Southeast Asian Institutions of Higher Learning (ASAIHL) and its longstanding commitment to regional and global academic collaboration.

Founded in 1956, ASAIHL is one of Southeast Asia's most enduring academic associations. Conceived by visionary university leaders and supported from its inception by the Thai government, ASAIHL has championed the advancement of higher education through mutual self-help among its member institutions. Its objectives—strengthening teaching, research, and public service capacities—reflect a bold and inclusive mission to cultivate regional identity, interdependence, and excellence across borders. Over the decades, ASAIHL has become a vibrant clearing-house of academic innovation, offering platforms for dialogue, resource sharing, and international cooperation among universities striving to address pressing societal challenges.

The 2024 ASAIHL Conference, hosted by the esteemed Universitas Airlangga in Surabaya, Indonesia, from November 19–22, served as a timely and urgent call to action. With the theme *"University's Role in Advancing Climate Crises Reduction,"* the conference underscored the vital position of higher education institutions in confronting one of the greatest existential threats of our time: climate change. Through robust discussions and pioneering research, participants explored transformative strategies, including green curriculum design, community-based environmental services, and sustainable university-industry partnerships. The conference reaffirmed the indispensable leadership of academia in crafting climate-responsive policies, knowledge systems, and solutions.

I would like to extend our special thanks and heartfelt appreciation to the ASAIHL Executive Committee members, particularly **Academician Emeritus Professor Tan Sri Dato' Dr. Syed Jalaludin bin Syed Salim**, Chairman of the Executive Committee, and **Dr. Ninnat Olanvoravuth**,

Secretary-General Emeritus of ASAIHL, whose strong support and steadfast commitment made this publication possible. Their vision and leadership have been instrumental in enabling this special edition to come to fruition, and in reinforcing the role of scholarly dissemination as a catalyst for positive regional and global change.

This renewed commitment to excellence comes at a time when Asian universities are gaining unprecedented global recognition for their impact and innovation. **Notably, Universitas Airlangga has risen to 10th place in the latest Times Higher Education Impact Rankings, reflecting the region's growing influence in advancing sustainable development goals (SDGs)**. With 22 of the top 50 universities now based in Asia—surpassing many traditional academic powerhouses—this shift signals a broader transformation in how global academia values contribution over legacy. However, amidst these successes, critical reflection persists. The integration of artificial intelligence, such as ChatGPT, into scholarly writing has raised questions about originality and the preservation of personal voice in academic expression. These trends underscore the importance of intentional, ethical scholarship that combines technological innovation with human creativity and regional insight.

In this context, I am honoured that *Horizon JHSSR* (ISSN: 2682-9096) was selected as the publication platform for this ASAIHL special issue. As a journal committed to high-impact, interdisciplinary scholarship, JHSSR has consistently showcased rigorous research in the humanities and social sciences with global relevance. Our growing reputation is built on a foundation of academic integrity, timely dissemination, and thought leadership. Being entrusted by ASAIHL to curate and publish the finest contributions from this landmark conference is both a validation of our mission and a reaffirmation of our responsibility.

This special issue is more than a collection of conference papers. It is a testament to the intellectual dynamism and ethical urgency with which ASAIHL member institutions approach climate-related challenges. The works presented here blend critical inquiry with practical innovation, demonstrating how academic institutions can—and must—serve as engines of environmental transformation. By foregrounding regional perspectives and grounded solutions, this edition enriches the global discourse on climate justice, ecological resilience, and sustainable development.

I believe this issue will significantly enhance the image of ASAIHL as not only a facilitator of academic exchange but also a leader in championing solutions to global crises. It represents a powerful example of how scholarly collaboration across Southeast Asia can yield insights that resonate far beyond the region.

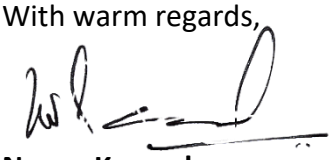
Looking ahead, *Horizon JHSSR* is hoping to publish another special issue based on the forthcoming 2025 ASAIHL Conference, to be hosted by Beltei International University in Phnom

Penh, Cambodia from July 6–8. JHSSR eagerly anticipates another rich dialogue among scholars and leaders committed to impactful research and regional advancement.

In closing, I extend my deepest gratitude to all contributors, reviewers, the ASAIHL Secretariat, and the organizing committee at Universitas Airlangga. May this special edition inspire continued collaboration and bold thinking in our shared pursuit of a more sustainable and just future.

Thank you for reading JHSSR.

With warm regards,



Nayan Kanwal, FRSA, ABIM, AMIS, Ph.D.
Guest Editor (Malaysia), ASAIHL 2024 Special Issue
Chief Executive Editor (JHSSR)
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CITE THIS ARTICLE

Nayan Kanwal. Opening Remarks on the ASAIHL Special Issue — Empowering Academia, Inspiring Action: Advancing Climate Solutions Through Southeast Asian Scholarship. *Horizon J. Hum. Soc. Sci. Res.***7 (S),** xxv–xxvii (2025). https://doi.org/10.37534/bp.jhssr.2025.v7.nS.id4.pxxv-xxvii

Guest Editor Note and Introduction to the Special Issue

It is our great pleasure to present this special issue of Horizon: Journal of Humanities & Social Sciences Research (JHSSR), which compiles selected papers from the 2024 ASAIHL International Conference, held at Universitas Airlangga, Surabaya, Indonesia in November 2024.

In today's increasingly fragile world, the climate crisis has intensified environmental, economic, and social vulnerabilities—altering global dynamics and threatening sustainable development. As one of the key actors in the pentahelix model—alongside government, industry, community, and media—Higher Education Institutions (HEIs) play a critical role in driving solutions for the Sustainable Development Goals (SDGs). HEIs are uniquely positioned to foster transdisciplinary collaboration, generate impactful research, and provide future leaders with the knowledge and values necessary to face climate-related challenges. By integrating sustainability into education, creating community-based interventions, and partnering with industry and policy makers, universities can actively contribute to climate crisis mitigation and adaptation efforts.

The Association of Southeast Asian Institutions of Higher Learning (ASAIHL) is a prestigious regional consortium that brings together universities across the ASEAN region to promote academic collaboration, knowledge exchange, and collective contributions to global challenges. The November 2024 conference theme "The University's Role in Advancing Climate Crisis Reduction" served as a timely platform for scholars and practitioners to share innovative ideas and best practices in addressing the climate crisis through higher education.

This special issue features selected articles that showcase impactful programs and initiatives implemented by ASAIHL member institutions. The contributions divided into sub-theme:

- Climate-oriented curricular integration
- Green economy principles through academic-industry partnerships
- Community engagement programs aimed at fostering climate resilience

We hope this compilation will not only serve as a reference for future academic and institutional efforts but also inspire further cross-border collaborations in addressing one of the most pressing challenges of our time.

We are extremely grateful to *Horizon: Journal of Humanities & Social Sciences Research (JHSSR)* for providing us with this valuable opportunity and an esteemed academic platform to publish our specially curated themed issue. The journal's commitment to scholarly excellence and its openness to diverse global perspectives have made it an ideal avenue for showcasing research that bridges academia and real-world challenges. JHSSR has steadily earned a reputation as a leading interdisciplinary journal in the region, recognized for publishing high-quality, peer-reviewed works that address contemporary issues in the humanities and social sciences. Its rigorous editorial standards, international reach, and inclusive approach to knowledge dissemination have significantly contributed to its growing academic impact and relevance. We are honored to be part of this continuing tradition of excellence.

We extend our sincere appreciation to all contributors, reviewers, and the editorial team for their invaluable efforts in bringing this issue into publication.

Astri Dewayani, MD., Ph.D.
Guest Editor (Indonesia), ASAIHL 2024 Special Issue
Horizon Journal of Humanities and Social Sciences Research (JHSSR)
Head Coordinator for International Grants and Immigration, Airlangga Global Engagement, Indonesia

astri.dewayani@fk.unair.ac.id

CITE THIS ARTICLE

Astri Dewayani. Guest Editor Note and Introduction to the Special Issue. *Horizon J. Hum. Soc. Sci. Res.***7 (S),** xxix–xxx (2025). https://doi.org/10.37534/bp.jhssr.2025.v7.nS.id5.pxxix-xxx

Introducing the Guest Editors

Meet the Editors

Astri Dewayani, MD, PhD
GUEST EDITOR, ASAIHL-JHSSR Special Issue,
INDONESIA

Astri Dewayani, MD, PhD, is a medical doctor who graduated from Universitas Airlangga and currently serves as academic staff at the Department of Anatomy, Histology, and Pharmacology, Faculty of Medicine, Universitas Airlangga. Her expertise includes anatomical aspects of the immune system and cancer immunology. In addition to her academic role, she is the Head Coordinator for International Grants and Immigration at Airlangga Global Engagement, reflecting her strong passion for higher education internationalization.

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Nayan Kanwal, FRSA, ABIM, AMIS, Ph.D.
GUEST EDITOR, ASAIHL-JHSSR Special Issue,
MALAYSIA

Nayan Kanwal is a highly respected academic leader, publisher, and editor with a distinguished career dedicated to advancing scholarly communication and interdisciplinary research. He currently serves as the Chief Executive Editor of the *Horizon Journal of Humanities and Social Sciences Research (JHSSR)* and is affiliated with BP Group Publishing, where he has led numerous international publishing and academic initiatives.

Professor Kanwal's long-standing academic service includes nearly **26 years of exemplary contribution at Universiti Putra Malaysia (UPM)**, where he played a pivotal role in academic development, research dissemination, and internationalization. His dedication at UPM set a benchmark in institutional excellence and has left a lasting legacy in the Malaysian higher education landscape.

Widely recognized for his commitment to enhancing global research visibility and mentoring emerging scholars, Professor Kanwal has championed the cause of open-access publishing and

ethical scholarly practices. He has founded and led several high-impact journals, significantly contributing to knowledge exchange across borders and disciplines.

Over the years, Professor Kanwal has received numerous accolades for his contributions to academia and publishing. Among these honors are the **International Academic Excellence Award**, the **Asia Pacific Distinguished Scholar Award**, and the **Award for Innovation in Scholarly Publishing**, underscoring his impact in advancing research and academic integrity.

With visionary leadership and a tireless dedication to academic progress, Professor Kanwal continues to inspire transformative scholarship and remains a key figure in shaping the future of global research dissemination.

https://horizon-jhssr.com/

August, 2025.
ISSN 2682-9096 Online
DOI: doi.org/10.37534

PUBLISHED: 2025-07-30.

CITE THIS ARTICLE

Astri Dewayani and Nayan Kanwal. Introducing the Guest Editors— Meet the Editors. *Horizon J. Hum. Soc. Sci. Res.***7 (S),** xxxi–xxxii (2025). https://doi.org/10.37534/bp.jhssr.2025.v7.nS.id6.pxxxi-xxxii

FOREWORD

Editor's Introduction to the ASAIHL Special Edition–

JHSSR, Vol. 7 (S) August 2025

Behind Every Great Journal Is a Team of Unsung Heroes — Here's to the Dedication, Passion, and Precision That Make Every Page Possible!

It is with great pleasure that I welcome you to this **special commemorative issue** of the of the *Horizon Journal of Humanities and Social Sciences Research* (JHSSR), Volume 7 (S), August 2025. This edition is published in conjunction with the 2024 ASAIHL Conference, held from November 19–22 at Universitas Airlangga in Surabaya, Indonesia, under the timely theme: *"University's Role in Advancing Climate Crises Reduction."*

JHSSR (eISSN 2682-9096) is an open-access, peer-reviewed journal committed to advancing high-impact interdisciplinary research in the humanities and social sciences. Independently owned and operated on a **not-for-profit** basis, the journal serves as a platform for innovative scholarship with global relevance, bridging the gap between academia and practice. Find out more here.

This special edition reflects ASAIHL's enduring legacy of fostering academic collaboration across Southeast Asia and beyond. It opens with messages from distinguished leaders: Dr. Ninnat Olanvoravuth *(Secretary-General Emeritus, ASAIHL),* Emeritus Professor Tan Sri Dato' Dr. Syed Jalaludin *(Chairman, ASAIHL Executive Committee),* Professor Dr. Mohammad Nasih *(Rector, Universitas Airlangga),* and introductory remarks by Professor Dr. Nayan Kanwal, Chief Executive Editor, JHSSR.

The volume features **11 carefully selected articles** that exemplify the scholarly breadth and depth of the 2024 ASAIHL Conference. It begins with a forward-looking editorial by Professor Nayan Kanwal and Dr. Trần Thị Vân Dung titled *"Charting the Future: AI, Ethics, and Scholarly Publishing in the Humanities and Social Sciences."* The piece explores the integration of artificial intelligence in academic publishing, assessing its impact on research ethics, peer review, and editorial practices, and issues a call for responsible and inclusive innovation.

The second article, a comprehensive review by Professor Tika Widiastuti and colleagues, investigates university-industry collaboration in vocational education within green innovation hubs as a key strategy for climate crisis mitigation.

Eight subsequent research articles present a diverse range of perspectives:

1) **Prof. Andres Winston C. Oreta** evaluates experiential learning in disaster resilience education for civil engineering students.
2) **Prof. Luchman Hakim and team** examine community service programs at Brawijaya University contributing to climate mitigation.
3) **Dr. Jennifer T. Ramos** assesses the eco-impact of promotional campaigns by Philippine associations.
4) **Dr. Maya Dania** presents a mixed-methods study on climate crisis integration in higher education at Mae Fah Luang University.
5) **Dr. Edie Boy M. Dela Cruz** introduces a web-based geoinformatics system for predictive weather forecasting using machine learning.
6) **Julia Anne L. De Guzman et al.** analyze coastal vulnerability in Leyte, Philippines, providing community-based solutions for sustainable coastal management.
7) **Nopparuj Suetrong and colleagues** demonstrate the potential of high-performance computing and graph networks in optimizing CO_2 transportation for carbon capture and storage.
8) **Dr. Reni Juwitasari** outlines the role of schools and universities in disaster risk reduction, grounded in global frameworks like the Sendai Framework and SDGs.

The edition concludes with a case study by **Muniroh et al.** on curriculum maturity in sustainable development within Airlangga University's Industrial Engineering Program, measuring the real-world impact of student engagement and sustainability awareness.

Together, these contributions highlight the critical role of Southeast Asian institutions in addressing global environmental challenges through education, research, technology, and community engagement.

We extend our sincere gratitude to the ASAIHL Secretariat, the organizing team at Universitas Airlangga, and all the contributing authors and peer reviewers whose dedication has ensured the quality and integrity of this publication.

We hope this special issue will inspire continued academic collaboration, policy innovation, and transformative action toward a more sustainable and resilient future.

As we celebrate the journal's accomplishment of surpassing **1,316 submissions,** with only 257 accepted and published, we acknowledge the rigorous standards maintained in the review process. This high acceptance rate reflects our commitment to ensuring the publication of high-quality research that aligns with the journal's scope and contributes significantly to the academic community.

Our Quality

All the papers except the book-review published in this edition underwent a rigorous yet relatively rapid **double-blind peer-review process** involving a minimum of three reviewers comprising internal as well as external referees, which translates to benefits such as timeliness of publication, widespread dissemination, high visibility, and likelihood of high citations and broader impacts. This was also to ensure that the quality of

the papers justified the high ranking of the journal, which hopes to be one at par with one of the renowned and heavily-cited journals not only by authors and researchers in Malaysia and America but by those in other countries around the world as well.

While I hope this issue will have particular appeal to new readers across this region and beyond, I am confident that the articles published will raise interest among our regular readership of scholars and postgraduate students elsewhere, thanks to the relevance and diversity of contributions on a region whose future bears central importance to us all.

I would also like to express gratitude to all the contributing authors for their trust, patience, and timely revisions, who have made this issue possible, as well as the reviewers and editors for their professional contribution. Last but not least, the assistance of the journal's editorial office in Texas, particularly Jessica Whitsitt, Lucy Fernandez, and Judy Meester—my adorable assistants, is greatly appreciated.

The Editorial Board of JHSSR welcomes your contributions and looks forward to many years of fruitful research to come. We continue to welcome submissions in all fields of humanities and social sciences. Horizon JHSSR is currently accepting manuscripts for its **2025-26 issues** based on original qualitative or quantitative research that opens new areas of inquiry and investigation. Empirical articles should demonstrate high rigor and quality. Original research collects and analyses data in systematic ways to present important new research that adds to and advances the debates within the journal's fields. The editors hope that the authors publishing in this journal can support the noble cause of JHSSR in reaching its goals.

JHSSR also invites call for proposals for **2025-26 Special Issues**. Our journal aims to provide a platform for researchers and technical experts to publish original papers, reviews and communications on all aspects of humanities and social sciences research. We strive to maintain a high standard of scientific objectivity, and we ensure that all submitted articles undergo a stringent yet relatively rapid double-blind peer-review process, which translates to benefits such as timeliness of publication, widespread dissemination, high visibility, and likelihood of high citations and broader impacts. Alongside a mission-driven Editor-in-chief, the globally diverse Editorial Board works with prominent scientific community to create a fast moving and rigorous editorial reviews. JHSSR follows code of conduct stipulated by the Committee on Publication Ethics (COPE). Proposals can be submitted directly via email to cee.horizon@gmail.com

Let me conclude by saying that with the publication of this issue, we are now leaping forward soon into the eighth year of continuous and successful scholarly publication of Horizon JHSSR. Changing publishing norms and expectations have given rise to a new wave of publishing standards that we'll be riding into 2026 soon and beyond. I am confident that the upcoming year will bring yet another challenging year of emerging scholarly articles.

Only time will tell what the next decade has in store, but one thing for sure is we will likely see greater innovation in all areas of scholarly publishing with emphasis on A.I. If you are observing other scholarly publishing trends, please do share your thoughts with the Chief Executive Editor!

Thank you for your continued support. We hope you find these articles thought-provoking and valuable in your academic pursuits, and look forward to further enriching the scholarly discourse in future issues.

Warm regards,

Chief Executive Editor
Nayan Deep S. KANWAL, FRSA, ABIM, AMIS, Ph.D.
CEE@horizon-jhssr.com

Aug. 2025.
ISSN 2682-9096 Online
DOI: doi.org/10.37534

PUBLISHED: 2025-07-30.

CITE THIS ARTICLE

Kanwal, Nayan D.S. Foreword From The Chief Executive Editor. *Horizon J. Hum. Soc. Sci. Res.* 7 (S), xxxiii–xxxvi (2025). https://doi.org/10.37534/bp.jhssr.2025.v7.nS.id0017.pxxxiii-xxxvi

Horizon J. Hum. & Soc. Sci. Res. 7 (S): 1 – 6 (2025)

Journal of Humanities and Social Sciences Research
www.horizon-JHSSR.com

EDITORIAL
Peer-reviewed | Open Access

Charting the Future: AI, Ethics, and Scholarly Publishing in the Humanities and Social Sciences

Nayan Deep S. Kanwal[1]◆*, (Professor Dr.) **and Trần Thị Vân Dung[2],** (Dr.)

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ARTICLE INFO

Article history
Received: 10-Jun-25
Revised: 13-Jun-25
Accepted: 16-Jun-25
Published: 15-Jul-25

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Citation: Nayan Deep S. Kanwal, Ph.D. (Professor Dr.) and Trần Thị Vân Dung, (Dr.) (2025). Charting the Future: AI, Ethics, and Scholarly Publishing in the Humanities and Social Sciences. Horizon J. Hum. Soc. Sci. Res. 7 (S), 1–6. https://doi.org/10.37534/bp.jhssr.2025.v7.nS.id1300.p1-6

ABSTRACT

The integration of artificial intelligence (AI) in scholarly publishing is reshaping the landscape of academic communication, improving efficiency, accuracy, and inclusivity. This editorial explores the evolving role of Artificial Intelligence (AI) in scholarly publishing, especially within the humanities and social sciences. As AI tools become increasingly integrated into academic workflows—from data analysis to editorial support—researchers and journals face opportunities and ethical challenges. Using secondary data from indexed journals, policy publications, and institutional guidelines, this paper assesses the emerging trends, differentiates between AI-enabled and AI-created works, and proposes strategic recommendations for journals such as the Horizon Journal of Humanities and Social Sciences Research (JHSSR). Special attention is given to the role of AI in enhancing peer review, academic writing, and research integrity. The editorial concludes with proposed future directions, including thematic issues on AI's socio-cultural impact and frameworks for responsible AI usage in academia. The article concludes with an invitation to researchers to submit their work to JHSSR, emphasizing its commitment to rigorous peer review and global academic discourse.

Keywords: Artificial Intelligence, Academic integrity, AI in humanities, AI-enabled criticism, Editorial policy, JHSSR, Scholarly publishing, Open Access, Transparency.

1) INTRODUCTION

Artificial intelligence (AI) is rapidly transforming scholarly publishing, bringing forth innovations that touch every stage of the publication process. The integration of Artificial Intelligence (AI) into academic publishing has become both inevitable and transformative. From machine translation to AI-driven peer review tools, AI applications are reshaping the way knowledge is created, evaluated, and disseminated (Van Dis et al., 2023; Kwok, 2023; **Else, 2023; Heaven, 2023**). The Horizon Journal of Humanities and Social Sciences Research (JHSSR), with its mission to bridge global scholarship and digital innovation, is well-positioned to lead this transformation (JHSSR, 2025). However, while AI offers opportunities for efficiency and accessibility, it also raises pressing questions about authorship, accountability, and quality control (Stokel-Walker, 2023).

This editorial explores how AI is currently being used in scholarly publishing and what policies or practices can

◆Kanwal, N.D.S is currently the Chief Executive Editor, JHSSR, Cyberjaya, Malaysia.

help maintain academic rigor and ethical standards. It further discusses the distinction between AI-enabled and AI-created works and suggests strategic orientations for journals to manage AI's socio-cultural impact.

2) METHODS

This paper employs qualitative desk research through the review of secondary data from:

- Indexed journals in Scopus and Web of Science,
- Policy publications from organizations such as COPE (2023),
- Academic commentary on AI's integration into research workflows.

These sources were selected based on their scholarly credibility and direct relevance to editorial policy, authorship ethics, and AI applications in academia. Table 1 below summarizes these data sources.

Table 1 summarizes the secondary sources analyzed for emerging trends in AI integration in scholarly publishing. The data were collected from indexed journals and policy platforms, including Scopus, Web of Science, and COPE.

Table 1: Summary of Secondary Data Sources on AI Integration in Scholarly Publishing

Source Type	Title / Description	Key Insights	Database / Publisher
Peer-reviewed Article	Open science saves lives: Lessons from the COVID-19 pandemic (Besançon et al., 2021)	Demonstrates how digital and AI tools enhanced data sharing and peer review efficiency	Scopus / BMC
Peer-reviewed Article	ChatGPT: Five priorities for research (Van Dis et al., 2023)	Proposes critical AI research priorities, including ethical usage and bias detection	Web of Science / Nature
Peer-reviewed Article	ChatGPT listed as author on research papers: Many scientists disapprove (Stokel-Walker, 2023)	Highlights ethical concerns around AI authorship in academic publications	Scopus / Nature
Industry Guideline	Authorship and AI tools in research publication (COPE, 2023)	Offers policy guidelines for transparent AI tool disclosure during manuscript preparation	COPE (Policy Publication)
Peer-reviewed Article	How AI could help — or hinder — academic writing (Kwok, 2023)	Discusses potential of AI to improve or distort scholarly writing and communication	Web of Science / Nature
Peer-reviewed Article	Navigating the use of AI tools for academic writing (Yeo et al., 2022)	Explores AI writing tools' benefits for non-native English speakers in manuscript preparation	Scopus / Journal of Academic Writing
Policy Resource	About the journal (JHSSR, 2025)	Outlines JHSSR's editorial scope, AI-friendly practices, and open-access model	JHSSR Official Website
Peer-reviewed Article	AI-powered translation in academic publishing (Jiang et al., 2023)	Analyzes the role of AI translation in cross-lingual scholarly dissemination	Scopus / Journal of Scholarly Communication

3) RESULTS AND DISCUSSION

1. AI-Enabled Criticism

AI can greatly assist in improving the quality and integrity of research through:

- **Plagiarism detection tools** (e.g., Turnitin, iThenticate),
- **Logical consistency checks** using NLP algorithms,
- **Statistical validation** tools that help verify data claims (Besançon et al., 2021).

While these tools offer unprecedented support, the final decision regarding publication must remain a human responsibility. Editors and reviewers must use AI outputs as guides, not substitutes for judgment.

As illustrated in **Figure 1**, AI tools are currently utilized most prominently for plagiarism detection and language editing, followed by statistical validation, translation, and peer review support. These patterns highlight both the strengths and limitations of current AI applications in scholarly workflows.

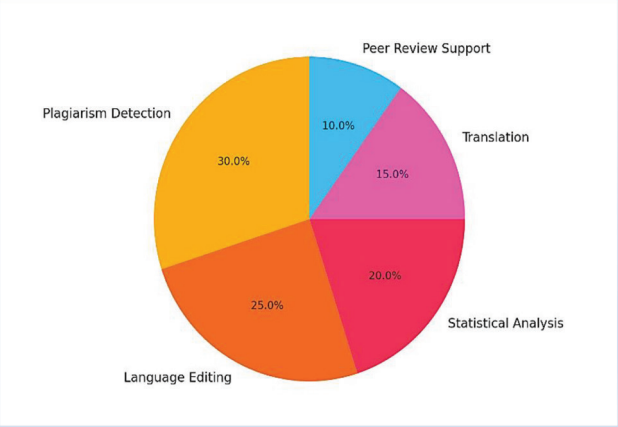

Figure 1: Usage of AI Tools in Academic Publishing.

Note*: This figure illustrates estimated proportions of AI tool usage in typical academic publishing workflows.*

2. Distinguishing AI-Enabled vs. AI-Created Content

There is an urgent need to differentiate between:

- **AI-enabled content:** Research or writing supported by AI tools under human control,

- **AI-created content:** Work substantially generated by AI with minimal human input.

This distinction has ethical and procedural implications. Journals like JHSSR should develop a set of **transparent disclosure criteria** that clarify AI usage during manuscript submission (COPE, 2023).

3. Ethical Considerations

The Committee on Publication Ethics (COPE) and other scholarly bodies recommend that authors disclose any AI tool used in the research or writing process (COPE, 2023). JHSSR should integrate these guidelines to ensure transparency. The Committee on Publication Ethics (COPE) and other scholarly bodies recommend that authors disclose any AI tool used in the research or writing process (COPE, 2023; **Hosseini, Hilpert, & Mahdavi, 2023**).

4. Proposed Strategic Orientation for JHSSR

To stay ahead in this evolving landscape, JHSSR will:

- **Launch a special issue** on "AI in the Humanities and Social Sciences,"
- **Invite submissions** on:
  - Experiences using AI in research and teaching,
  - Socio-cultural impacts of AI,
  - Philosophical, anthropological, and educational reflections,
  - Best practices and failure cases in AI use.

This initiative will not only attract diverse scholarly voices but also position JHSSR as a leader in this critical discourse.

JHSSR has kept pace with these developments, implementing advanced editorial workflows that ensure timely peer review and transparency. Its scope—which covers education, philosophy, psychology, sociology, cultural studies, and more—encourages interdisciplinary contributions that reflect the complexity of contemporary social issues (JHSSR, 2025). JHSSR has integrated these capabilities ensuring rapid peer review, ethical publishing practices, and global outreach.

Journals must adapt by establishing clear guidelines on AI usage and transparency. For instance, Springer Nature, Elsevier, and COPE now recommend that authors disclose any AI tools used during manuscript preparation (COPE, 2023). Researchers must also remain vigilant, critically evaluating AI outputs and ensuring data accuracy (Van Dis et al., 2023).

JHSSR stands out as a publication that upholds ethical integrity while embracing innovation. As an open-access journal indexed in Academia, Google Scholar, and MyCite etc, it offers scholars a reputable platform for the dissemination of interdisciplinary work and provides global visibility to authors and fosters inclusive academic dialogue.

Recommendations and Limitations

Recommendations*:*

1. Hosting webinars or forums on responsible AI usage.
2. Researchers should be transparent about their use of AI in their methodology or writing processes.
3. Editors should combine AI tools with human oversight to maintain ethical standards and contextual sensitivity (**O'Connor & Chatfield, 2023**).

Limitations:

This editorial represents Part 1 of an ongoing investigation and is based solely on secondary data and desk research, without the inclusion of original empirical evidence. As such, its findings are preliminary and exploratory in nature. In Part 2 of this article, the authors intend to undertake a more rigorous experimental evaluation, incorporating primary data collection through surveys and interviews with authors, editors, and reviewers to gain nuanced insights into real-world AI practices and perceptions within scholarly publishing. Moreover, the forthcoming study will introduce at least five specific comparative criteria—focusing on perception, academic standards, moral responsibility, the author's role, and the ability to integrate digital technology effectively. These criteria will provide a more structured and analytical framework for assessing AI's impact in the academic domain. Given the rapidly evolving landscape of AI tools, continual reassessment and updating will be essential to ensure the relevance and accuracy of any conclusions drawn.

4) CONCLUSION

AI's integration into scholarly publishing represents both a technological leap and an ethical imperative. AI is reshaping the academic publishing landscape in profound ways. Its role in enhancing review quality, improving access, and supporting multilingual publication is undeniable. However, to maintain ethical integrity and research quality, journals must:

- **Adopt clear policies distinguishing AI-enabled from AI-created work,**
- **Support responsible AI usage through editorial guidelines,**
- **Promote dialogue through thematic issues and interdisciplinary collaboration.**

The Horizon Journal of Humanities and Social Sciences Research stands as a model in this evolving landscape—responsive to technological change, rooted in scholarly excellence, and committed to global engagement.

Benefits of Publishing in JHSSR:

The Horizon Journal of Humanities and Social Sciences Research (JHSSR), eISSN 2682-9096 offers a trusted platform for authors aiming to publish high-quality, interdisciplinary work. With a transparent and efficient peer review system, indexing in some of the major indices, and open-access availability, JHSSR ensures wide dissemination and academic recognition. JHSSR offers an inclusive platform for scholars worldwide, with open-access dissemination, rigorous peer review, and a focus on interdisciplinary topics that reflect pressing global challenges. Its commitment to ethical and innovative scholarship makes it a highly suitable venue for AI-related academic work.

The journal also emphasizes inclusivity, making it ideal for researchers from diverse regions and backgrounds seeking international reach. Its editorial board comprises leading scholars committed to maintaining ethical publishing standards and academic excellence.

We encourage scholars across the humanities and social sciences to submit their work to JHSSR, where human insight meets technological advancement in the pursuit of impactful scholarship. Together, we can shape a future where technology enriches—not replaces—human insight in the pursuit of knowledge.

JHSSR has taken a forward-thinking approach by developing and implementing clear AI disclosure policies to promote digital literacy among authors and reviewers. It has already incorporated ethical and technological guidelines well ahead of time to ensure responsible AI usage. JHSSR is collaborating with ethics committees to formulate robust standards and is actively building partnerships with AI developers to better understand the limitations and capabilities of emerging tools. These proactive steps not only enhance the credibility and innovation of the journal but also position JHSSR as a leader in navigating the complex landscape of AI in scholarly publishing.

Strategic Collaborations and Future Directions

In its ongoing efforts to foster academic collaboration and broaden scholarly engagement, the Horizon Journal of Humanities and Social Sciences Research (JHSSR) has formalized Memoranda of Understanding (MOUs) with several esteemed institutions, including Infrastructure University Kuala Lumpur (IUKL), GlobalNXT University and Unitar International University. These strategic partnerships aim to co-organize national and international academic conferences and seminars, with the potential for publishing selected outputs in the form of peer-reviewed journal articles or as part of a formal Book of Proceedings under the Horizon imprint. These collaborative initiatives will enable faculty members, students, and editorial board representatives to actively participate in academic events, contributing both as speakers and attendees. The scale and thematic focus of such events will be tailored through mutual consultation with partnering institutions. Moreover, JHSSR can serve as a resource hub, supporting training workshops on academic publishing, including sessions on publishing in indexed and peer-reviewed journals. These events—whether in-person or virtual—are designed to enhance accessibility, visibility, and global academic discourse.

In addition to welcoming innovative papers for its regular issues (Figure 2)—which remain open for submissions throughout the year—the *Horizon Journal of Humanities and Social Sciences Research (JHSSR)* actively invites proposals for special or thematic issues (Figure 3). One such edition is this issue dedicated to the **2024 ASAIHL Conference**, marking a significant milestone not only for the Journal but also for the **Association of Southeast Asian Institutions of Higher Learning (ASAIHL)** and its enduring commitment to regional and global academic collaboration.

Figure 2: *Regular Issues*: July & December.

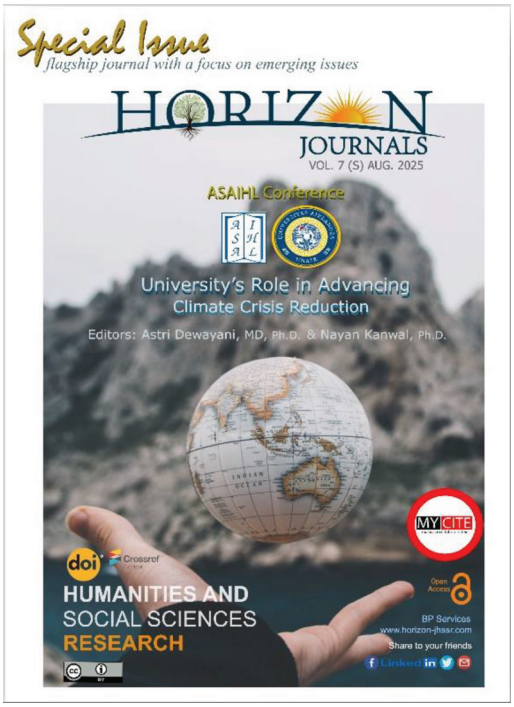

Figure 3: Special/Thematic Issues: As Requested.

Join a community dedicated to advancing knowledge and fostering meaningful international scholarship. We look forward to your valuable contributions to JHSSR.

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Biographical Statement of Author(s)

Professor Nayan Deep Singh Kanwal is a distinguished academic editor, researcher, and publishing consultant with over three decades of experience in international development, education, and scholarly publishing. He is the Chief Executive Editor of the *Horizon Journal of Humanities and Social Sciences Research (JHSSR)*. Prior to the successful launch of the JHSSR in 2018, Professor Kanwal was instrumental in developing Universiti Putra Malaysia's (UPM) three *Pertanika* titles into top-tier Malaysian academic journals. He played a pivotal role in elevating the scholarly reputation of Universiti Putra Malaysia's (UPM) academic ranking via enhanced publications and citations.

Over his 26-year tenure at UPM, he was instrumental in transforming the *Pertanika* journal series into top-tier Malaysian-International publications and securing their indexing in Scopus and the Web of Science (Emerging Sources Citation Index), earning several accolades for editorial excellence. Under his editorial leadership, *Pertanika* journals earned multiple national and institutional tributes for excellence in academic publishing.

As the Chief Executive Editor of JHSSR, he continues to champion ethical publishing practices, interdisciplinary collaboration, and open-access dissemination. His ongoing mission is to support scholars—both emerging and established—in producing high-impact research that advances knowledge in the humanities and social sciences globally. Prof. Kanwal's current interests include the ethics of AI in scholarly communication, academic integrity, and innovations in digital publishing.

Professor Kanwal is a Fellow of the Royal Society of Arts (FRSA), a Life Member of the British Institute of Management (BIM), an Associate Member of the Marketing Institute of Singapore (AMIS), and an Associate Member of the Australian Institute of Agricultural Science and Technology (AIAST).

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Since 2020, she has served as the main lecturer at Thua Thien Hue Pedagogical College. She is also a valued editorial board member of the Horizon Journal of Humanities & Social Sciences Research, a distinguished peer-reviewed scholarly journal. In addition, she holds the position as the Vice Chairman of Thua Thien Hue Writers Association, Vietnam.

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Horizon J. Hum. & Soc. Sci. Res. 7 (S): 7 – 19 (2025)

Journal of Humanities and Social Sciences Research
www.horizon-JHSSR.com

REVIEW ARTICLE
Peer-reviewed | Open Access

Green Innovation Hubs: A Systematic Review of University-Industry Research Collaboration in Vocational Education for Climate Crisis Mitigation

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ARTICLE INFO

Article history
RECEIVED: 10-Mar-25
REVISED: 06-Jun-25
ACCEPTED: 14-Jun-25
PUBLISHED: 15-Jul-25

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Citation: Tika Widiastuti, Anwar Ma'ruf, Eighty Mardiyan Kurniawati, Novianto Edi Suharno and Riska Nur Rosyidiana (2025). Green Innovation Hubs: A Systematic Review of University-Industry Research Collaboration in Vocational Education for Climate Crisis Mitigation. Horizon J. Hum. Soc. Sci. Res. 7 (S), 7–19. https://doi.org/10.37534/bp.jhssr.2025.v7.nS.id1291.p7-19

ABSTRACT

Introduction: Green Innovation Hubs are increasingly recognized as vital mechanisms for fostering collaboration between universities and industries in addressing the climate crisis. Despite growing interest, the specific role of **vocational education** within these collaborative frameworks remains underexplored. This study aims to examine the intersection of green innovation, university-industry collaboration, and vocational education in the context of climate crisis mitigation. **Methods:** A systematic and bibliometric review was conducted using data from **Scopus-indexed international journals** published between **1993 and 2024**. A total of **118 articles** were identified and analyzed to explore thematic trends, dominant research areas, and existing gaps in the literature concerning Green Innovation Hubs and vocational education. **Results:** The analysis revealed that Green Innovation Hubs are instrumental in advancing research collaboration between universities and industries, particularly in the development and transfer of green technologies. Frequently cited keywords included "sustainable development," "collaboration," "green innovation," and "technology transfer." However, the literature shows a significant lack of focus on the integration of **vocational education** into these collaborations, despite its potential to support practical, workforce-driven solutions to climate challenges. **Discussion and Conclusion:** The findings underscore the need for a conceptual shift in understanding the role of vocational education in sustainability initiatives. Vocational education institutions, especially those affiliated with universities, should be more actively engaged in designing green innovation-based curricula that align with industry needs. Future research should prioritize integrated models that bring together **vocational training, green innovation**, and **university-industry partnerships** to accelerate efforts in climate crisis mitigation.

Keywords: Green Innovation Hubs, Climate Crisis, Vocational Education, University, Industry

1. INTRODUCTION

The global climate crisis is an urgent challenge requiring immediate action from various sectors, including education and industry. Green innovation plays an important role in creating sustainable solutions that can help mitigate the effects of climate change. Green innovation also correlates with energy efficiency, carbon and fossil fuel emission control, waste management,

renewable production, and corporate environmental protection (Ahmed et al., 2023)this research aims to examine the effect of green innovation on environmental performance, which leads to organizational performance. Another objective is to measure the impact of two dimensions of green innovation, such as green process & green product measures, on green innovation. The second prime aim of this research is to evaluate the moderation of management commitment & human resource practices in an association between green innovation and organizational & environmental performance. A total of 320 employees provided their perspectives on a self-administrated questionnaire from the textile industry of Pakistan. We have employed SEM-based multivariate modeling to examine the data. This research has measured the reflective indicators measurement model through confirmatory factor analysis, an obvious choice of structural equation modeling to examine observed and unobserved variables and indicators using PLS-SEM (partial least square-structural equation modeling. Green innovation focuses on reducing the risk of environmental exploitation and the resulting negative impacts on resources, including energy(Basana et al., 2022). *The United Nations Environment Programme*in Hasid (2022) attributes green growth to strengthening social justice, people's welfare, and ecological deficiencies and reducing the resulting environmental impacts. Green innovation is relevant in the face of climate change and promotes sustainable economic growth by strengthening the industrial and energy sectors. Collaboration between universities and industry has a great impact on the development of green innovation(Yan et al, 2024).

Universities have a pivotal role in the research and development of green innovations, while industry can implement such solutions on a large scale. For example, research conducted byYan (2024;0 Li & Zhou (2022)shows that collaboration between universities and industry can accelerate the adoption of green innovations in various industrial sectors. This collaboration facilitates technology transfer and enables the creation of more practical and applicable innovations in climate crisis mitigation.

Vocational education can deliver immense potential impact on the mitigation of climate crises, with millions of students around the world. The introduction of green technologies and innovations into vocational training will significantly quicken the pace at which these sustainable practices take hold in various industries because it is a large arena with many participants involved. The mass numbers within vocational education multiply its potential manifold to develop a workforce that is not only endowed with the use of technical skills but also aligned with the demands for a low-carbon economy. The vocational education also furthers positive social change by creating pathways to employments in the green industries that address the environmental concern but at the same time reduce social inequalities in the offers of opportunities for underrepresented communities to the green economy. This addresses the global demands of achieving social justice through sustainable development initiatives.

However, the role of vocational education in fostering green innovation has been underrepresented in the literature. Vocational education is critical as it prepares a workforce with the technical skills needed to support the implementation of green technologies in the field (Kaliappan & Hamid, 2021). According to Rosenberg, Lotz-Sisitka, & Ramsarup (2018), the green innovation transition will impact an economy increasingly, leading to a green economy and has become a concern for some countries in recent years. The development of green innovation in various sectors, especially the economy, will undoubtedly significantly impact the labour market and curriculum development, and these changes will be a challenge for vocational education (Baumgarten & Kiag, 2016). Vocational education can, therefore, be the bridge that connects university research with industry practice, ensuring that the future workforce has green skills that match the demands of a low-carbon economy. Vocational education integrated with green innovation can also support climate change mitigation efforts more effectively by providing hands-on skills relevant to the industrial sector.

The Green Innovation Center is a platform that brings together universities, industry and vocational education to develop sustainable solutions to the climate crisis. However, there is a lack of previous research on the gap in integrating vocational education into green innovation. However, many previous studies have shown that industry-university collaboration has been successful in various sectors. Research by Giannopoulou et al. (2019) shows that universities and Research and Technology Organizations (RTOs) have different but complementary contributions to innovation development. In addition, research (Guan & Zhao, 2013)shows that collaboration between industries and universities in interdisciplinary fields is growing rapidly. Therefore, this research addresses the gap by highlighting the importance of closer collaboration between universities, industry and vocational education to accelerate the adoption of green innovations that support climate crisis mitigation.

The paper contributes to the creation of new knowledge by revealing the often-neglected role of vocational education in green innovation. This meets the need for vocational curricula to further integrate green technologies and create new opportunities for research

into how best to design curricula in concert with industrial demands for sustainability.

2. MATERIAL AND METHODS

This research used two quantitative methods to answer the researcher's question. In RQ 1, we mapped green innovation and university-industry collaboration in vocational studies in response to climate change. This part requires quantitative analysis to describe the overall research productivity, so we used bibliometric analysis. Furthermore, in RQ2 researchers need a deeper understanding of the content to explore specific themes to clarify the important role of vocational education and green innovation hubs in response to climate change. In brief, this research design follows the Delle Foglie & Keshminder (2022) pattern, namely, Data selection, and bibliometric analysis. The first stage of data selection is searching keywords on a trusted database, namely Scopus, to find peer-reviewed articles. Since this research combines two different concepts, namely green innovation and vocational studies, a combined effort was made to obtain coincide articles. The keywords (TITLE-ABS-KEY ("green" OR "renewable energy" OR "climate") AND TITLE-ABS-KEY (university) AND TITLE-ABS-KEY (industry) AND TITLE-ABS-KEY (collaboration) AND (LIMIT-TO (LANGUAGE, "English") AND (LIMIT-TO (SRCTYPE, "j") to get articles specialized in green innovation in vocational studies. A total of 155 articles were found at this stage. Further filtering efforts were made to eliminate articles sourced from predatory journals (n=3), non-English (n=3), and non-article & journal type (n=24). This stage successfully eliminated 36document that did not fit the data criteria.

In the bibliometric analysis part to answer RQ1, researchers mostly used R-BiblioshinyBibliometrix (Aria and Cuccurullo, 2017). The main information displays a three-plane plot graph as the opening graph. After that, we proceeded to the Source Analysis section, which consisted of the most relevant Sources, Production over time, and Reference publication year spectroscopy (RPYS) which is a scientometric method that studies the annual distribution of references cited in an article (Ballandonne and Cersosimo, 2021). Furthermore, the Author Analysis session consists of three: Countries' Collaboration World Map, and Affiliations' Production over Time, and Factor Analysis to find affiliations. This analysis will display item labels with colored circles by year to avoid overlapping labels between items and see the direction of topic development each year. The more important a theme is, the bigger the label and circle (van Eck and Waltman, 2010). Furthermore, we visualize the keywords with thematic maps to identify the most important keywords in a theme and provide gaps for future research.

3. RESULTS

This study analyzes the relationship between university and industry collaboration, focusing on green innovation in vocational education to address the climate crisis. Using bibliometric analysis, 436 authors wrote 119 documents from 1993 to 2024. During that period, the annual growth rate was 9.96%, averaging 35.6 citations per document. These results show that the study of green innovation in vocational education and collaboration between universities and industry is growing. Document types vary but are dominated by 93 documents in the form of scientific articles.

Figure 1 illustrates the annual scientific production, with 2024 recording the highest number of publications with 19 documents. In addition, there has been an increasing trend of publications in the last three years. This increase is driven by the growing prominence of the Sustainable Development Goals (SDGs) and Environmental Social Governance (ESG) agenda, which encourages academics at various universities to focus their research on green innovation, particularly in

Table 1. Main Information

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	1993:2024
Sources (Journals, Books, etc)	95
Documents	119
Annual Growth Rate %	9.96
Document Average Age	6.73
Average citations per doc	35.6
References	6031
DOCUMENT CONTENTS	
Keywords Plus (ID)	886
Author's Keywords (DE)	477
AUTHORS	
Authors	436
Authors of single-authored docs	15
AUTHORS COLLABORATION	
Single-authored docs	15
Co-Authors per Doc	3.75
International co-authorships %	21.85
DOCUMENT TYPES	
article	93
conference paper	6
editorial	1
erratum	1
letter	1
note	2
review	15

Source: *Biblioshiny Report (2024).*

vocational education that involves collaboration between universities and industry. Overall, publications on green innovation, climate change, and university-industry collaboration show a significant upward trend, reflecting a growing awareness among academics of the importance of these studies.

The average citations in Table 2 show that 2009 had the highest average citations, at 62.5 citations per year, followed by 1998 with 21.33 citations per year. However, although 2024 recorded the highest number of publications, the average citations in that year were the lowest after 1998, where no articles were cited.

Figure 2 displays the Three-Fields Plot, which provides a comprehensive view of the relationship between different aspects of the research in one visualization. In the figure, it can be seen that the most researched documents are closely related to the keywords "sustainability" and "university-industry collaboration." In addition, other keywords such as "innovation," "climate change," "renewable energy," and "partnership" also highlight the importance of green innovation in vocational education through university-industry collaboration.

Figure 3 shows the journals with the highest number of publications. "Sustainability (Switzerland)" ranked first with 11 documents, followed by 'Joule' and 'Technological Forecasting and Social Change,' each with 3 documents. "Sustainability (Switzerland)" is a Q1 journal that focuses on the Social Sciences category, with the subcategory of Geography, Planning, and Development, which is highly relevant to topics related to green environment, climate change, and renewable energy. Therefore, it makes perfect sense that this journal has the highest number of publications related to green innovation in vocational education through university and industry collaboration. On the other hand, "Joule" focuses on the general energy and energy category, while "Technological Forecasting and Social Change" focuses on the Business, Management, and Accounting, and Psychology categories.

Figure 4 shows the most relevant affiliations, with University College London (UCL) coming out on top with 28 documents. In addition, is Washington State University, with 9 documents, and the University of Macerata, with 8 documents. University College London is currently focusing on discussions related to green innovation, with its Green Innovation Policy Commission focusing on the impact of implementing green innovation.

Furthermore, Figure 5 shows the collaboration between countries depicted by SCP (Single Country publication) in green and MCP (MultipleCountry Publication) in red. The analysis shows that publications on green innovation and collaboration between universities and industry in vocational education are generated mainly by single-country publications, indicating a lack of collaboration between countries. This is an important note for academics to increase international collaboration to broaden perspectives in research on green innovation hubs in vocational education.

The World Cloud shown in Figure 6 visualizes the most frequently occurring words in the document under analysis. In Figure 6, the three most used keywords

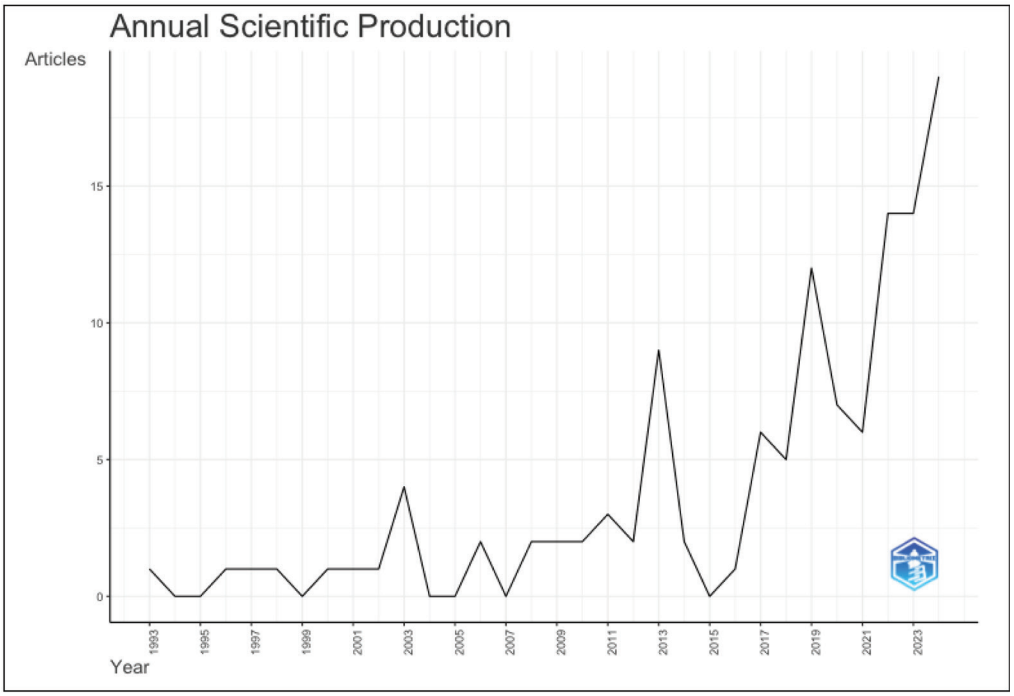

Figure 1. Anuual Scientific Production.

Source: *Biblioshiny Report (2024).*

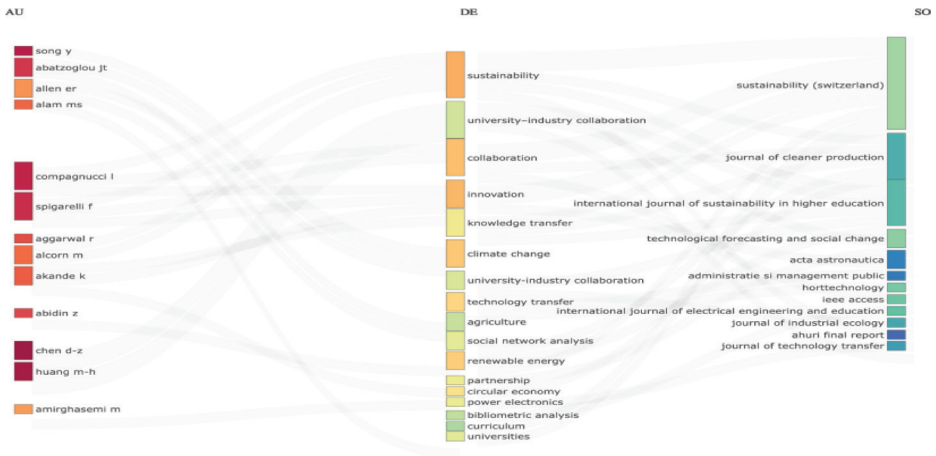

Figure 2. Three-Fields Plot.

Source: *Biblioshiny Report (2024).*

Table 2. Average Citation

Year	Mean TC per Art	N	Mean TC per Year	Citable Years
1993	5	1	0.16	32
1996	15	1	0.52	29
1997	0	1	0	28
1998	576	1	21.33	27
2000	25	1	1	25
2001	2	1	0.08	24
2002	0	1	0	23
2003	65	4	2.95	22
2006	24	2	1.26	19
2008	23	2	1.35	17
2009	1000	2	62.5	16
2010	42	2	2.8	15
2011	8.67	3	0.62	14
2012	16	2	1.23	13
2013	21	9	1.75	12
2014	2	2	0.18	11
2016	7	1	0.78	9
2017	21.67	6	2.71	8
2018	14.8	5	2.11	7
2019	21.83	12	3.64	6
2020	31.43	7	6.29	5
2021	18	6	4.5	4
2022	4.86	14	1.62	3
2023	3.64	14	1.82	2
2024	0.21	19	0.21	1

Source: *Biblioshiny Report (2024).*

are “sustainable development”, “innovation”, and “climate change”. This shows that discussions related to sustainable development, innovation, and climate change are the main focus in the study of research collaboration between universities and industry. The concept of green innovation hubs examined in this research is closely connected to efforts to deal with the climate crisis through innovations made in vocational education and effective collaboration between academia and the industrial sector. This word cloud emphasizes the importance of cross-sector collaboration in developing innovative solutions to support climate crisis mitigation through skills-based and vocational education.

In terms of trends in the topics most researched by academics, as shown in Figure 8, the most discussed topics in the last 5 years to date are “alternative energy”, “sustainability”, and “climate change”. The focus on alternative energy and sustainability suggests that academia increasingly focuses on innovations supporting the transition to a low-carbon economy. In the context of vocational education, collaboration between universities and industry is critical in developing green innovation hubs capable of producing a skilled workforce to support climate crisis mitigation. This research trend underscores the importance of integrating education, technological innovation and sustainable practices to address global challenges related to climate change.

Factorial analysis in bibliometrics visualizes the relationships between terms or concepts from the articles (Figure 9). The results of the factorial analysis show that the main themes in university-industry collaboration for green innovation in climate crisis mitigation include governance and policy approaches, which are important factors in directing this collaboration. Terms such as energy efficiency, renewable energy and environmental protection also stand out, emphasizing the focus on green technologies. In addition, the theme of vocational education and technology transfer demonstrates the significant role of the education sector in supporting skills development and green innovation, with close collaboration between institutions being crucial to success.

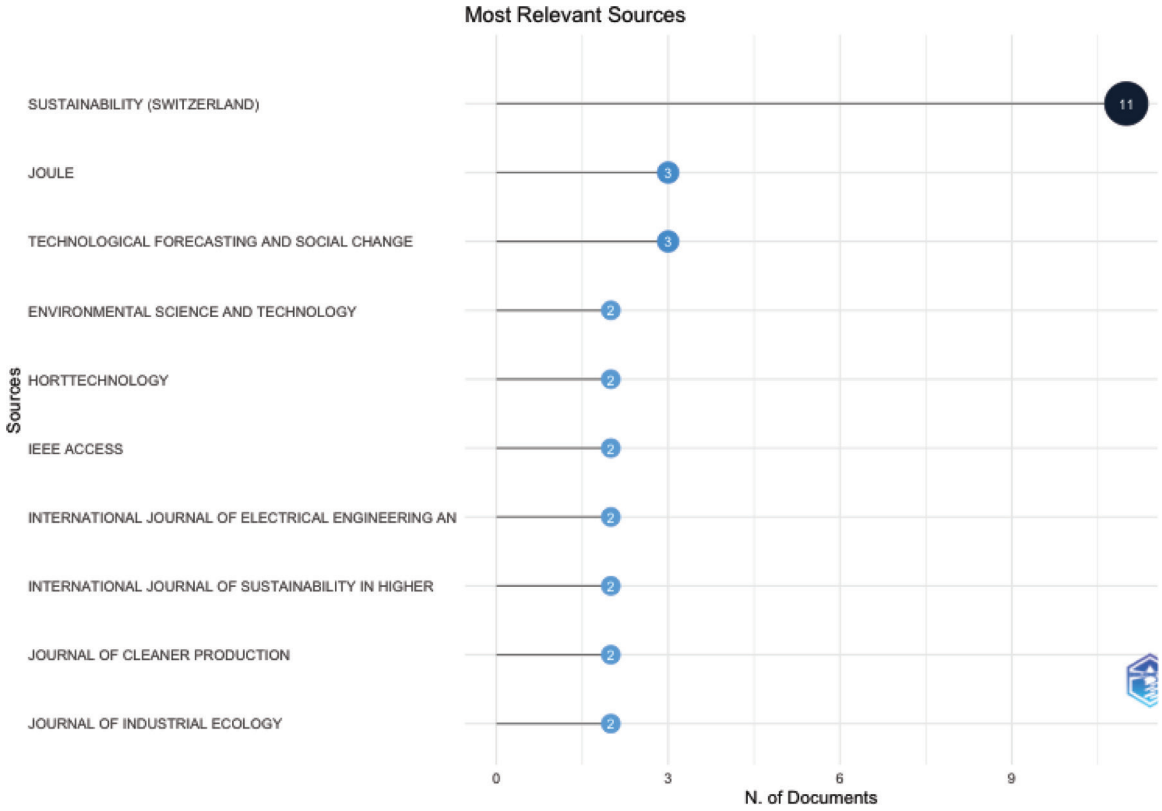

Figure 3. Most Relevant Sources.

Source: *Biblioshiny Report (2024).*

Figure 4. Most relevant Affiliations.

Source: *Biblioshiny Report (2024).*

4. DISCUSSION

This research analyzes the relationship between university and industry collaboration, focusing on green innovations in vocational education to address the climate crisis. There are important points that can be highlighted in the study of green innovation hubs in vocational education to mitigate climate change's impact. Through factorial analysis, the results show that the governance

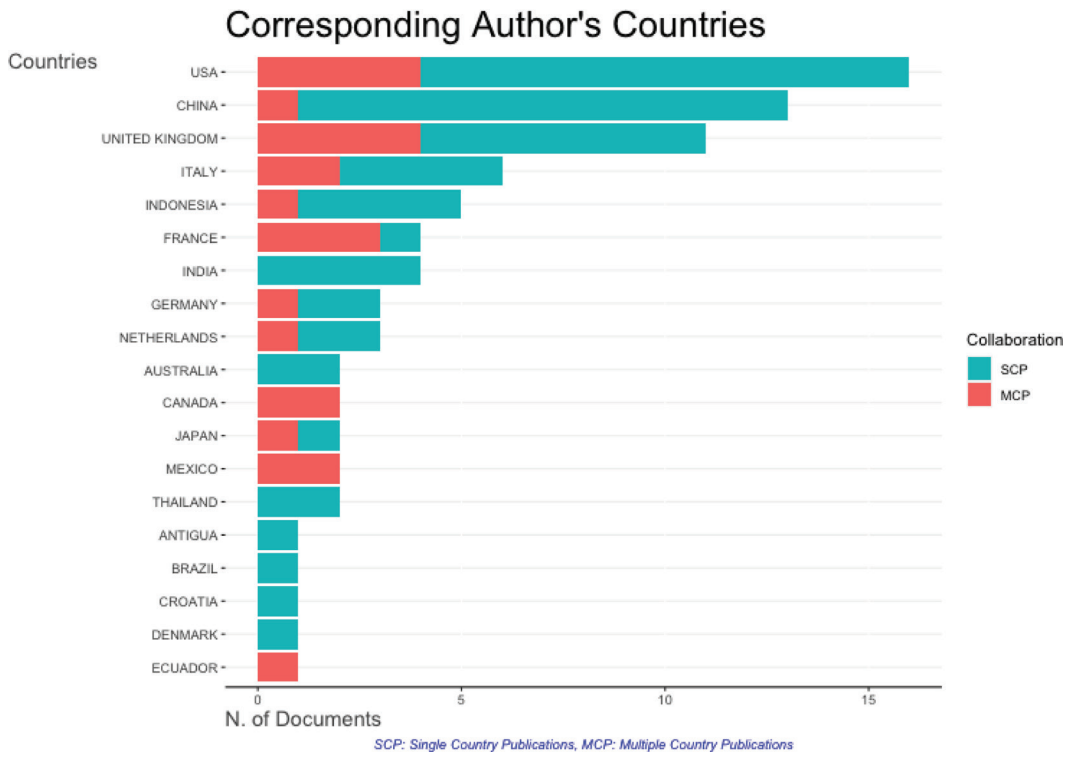

Figure 5. Countries Collaboration.

Source: *Biblioshiny Report (2024).*

Figure 6. World Cloud.

Source: *Biblioshiny Report (2024).*

approach is at the top, indicating that governance aspects are an important element in university-industry collaboration focused on green innovation and climate crisis mitigation. Terms such as policy approach and university sector are also very close, indicating a strong interaction between policy, the role of academic institutions and environmental management. In addition, it is noticeable that the dominant research areas include terms such as sustainable development, energy efficiency and renewable energy. This confirms that much of the research in this area focuses on energy-related innovation and sustainability, which is an important part of efforts to mitigate the climate crisis. Other terms such as innovation, technology transfer and environmental impact were also crucial topics, demonstrating the importance of research in developing new technologies and knowledge transfer from academia to industry.

Geographically, terms such as China and the United Kingdom indicate that the studies analyzed in this review involve diverse regions, with significant contributions from these countries in climate innovation. The role of universities also takes centre stage, as evidenced by the multiple occurrences of the term universities, which underscores the importance of higher education institutions in driving green innovation. Other terms such as mergers and acquisitions, policy approach, and public health indicate that research in this field also includes policy, economic, and health dimensions, reflecting the complexity of addressing climate change through a multidisciplinary approach. While the term vocational

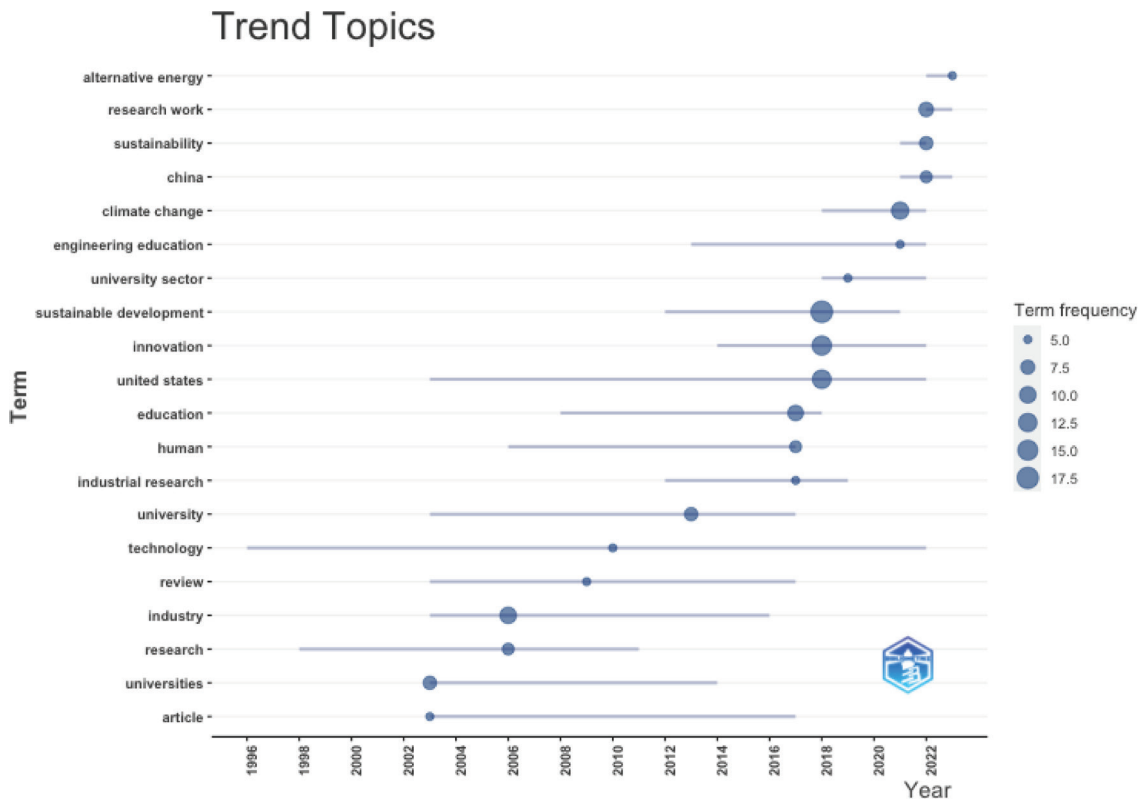

Figure 8. Trend Topics.

Source: *Biblioshiny Report (2024).*

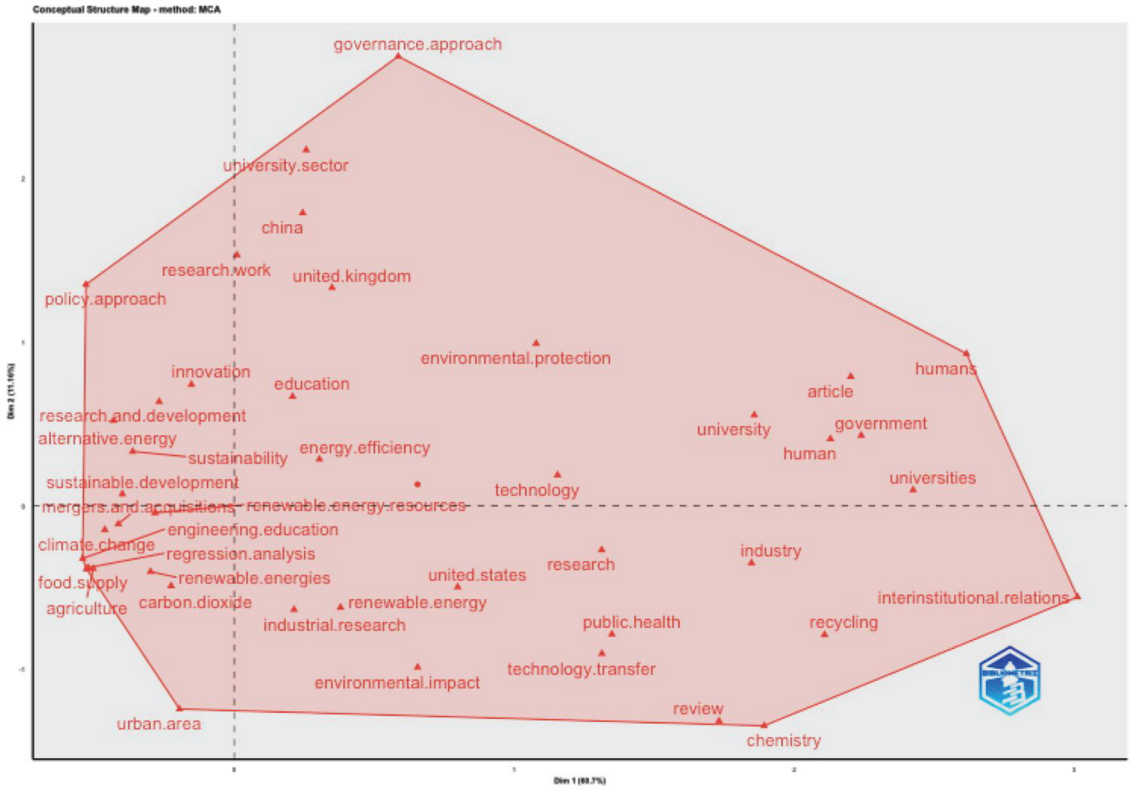

Figure 9. Factorial Analysis.

Source: *Biblioshiny Report (2024).*

education is not explicitly visible in this map, related terms such as engineering education suggest that research also highlights educational strategies to train future industry professionals in green technologies.

In the context of climate change mitigation, the role of vocational education is critical, especially as it directly involves the development of technical skills relevant to industry needs (Hausia Havea et al., 2020; Pavlova, 2019; Thunqvist et al., 2023)author(s. Collaboration between universities and industry in green innovation hubs for vocational education should be strategically designed to accelerate the adoption of green technologies, prepare a workforce capable of adapting to climate change, and create innovative and sustainable solutions(Amante & Fernandes, 2023)but there has been a shift in both the education and workforce settings to work closely together, coordinating initiatives across all sectors, namely higher education (HE. Vocational education prepares graduates with practical skills directly connected to industry needs. In the context of climate crisis mitigation, vocational education can focus on developing skills in renewable energy, energy efficiency, natural resource management, sustainable agriculture and other green technologies. The practical application of skills makes vocational education a vital component in supporting the shift to a green economy.

Collaboration between universities and industry to create Green Innovation Hubs in vocational education should include several key elements. First, Industry-Based Curriculum Development: Vocational education curricula should be developed based on industry needs relevant to green solutions and sustainability (Handayani et al., 2021). Industry knows the latest technologies and market needs, while universities can provide research-based training and technical skills. Curriculum development incorporating renewable energy technologies, energy efficiency techniques and innovative solutions for waste management can help produce graduates ready to enter the green sector (Ciriminna et al., 2016; Kumar et al., 2024).

Second, Collaborative Research and Technology Development: In green innovation hubs, collaborative research between universities and industry is indispensable for developing new environmentally friendly technologies (Chandran et al., 2014; Ramli et al., 2013). Universities can provide research laboratories, while industry can provide resources and real-world application trials. For example, the renewable energy industry can work with universities to develop more efficient solar panel technology or environmentally friendly waste management systems. This collaboration also allows vocational education to use the latest innovations in training.

Third, Work-Based Learning projects: Real-world projects based on climate issues, such as energy efficiency, sustainable building, or water management technologies, can be an important part of vocational education (Batchelder et al., 2023; Bohvalovs et al., 2023; Friess, 2011)and the application of appropriate strategies to reduce instantaneous and yearly energy consumption. The respective course syllabi often focus on examples applicable within the range of the regional or national climatic conditions; for example, in the UAE little time is typically spent on discussing heating equipment; the focus is on air conditioning and reduction of solar gains. In addition to climatic considerations, building energy-efficiency related coursework requires developing an understanding of what the consumption is when instantaneous energy use is integrated over the hours of the day and over the course of a year. This step is not intuitive, as, while the theoretical background is primarily developed in steady state (such as heat transmission through walls and windows, infiltration, solar gains, heating and air conditioning loads, etc.. Through partnerships with industry, vocational students can be involved in hands-on projects in the field. This helps them understand the practical application of the skills learned and prepares them to work in the green sector after graduation.

Fourth, Skills Training for Green Technology: A significant focus of vocational education in green innovation hubs is to train a workforce with green technology skills. For example, training technicians in the maintenance and installation of solar, wind, or water treatment technologies. Industry can provide input on the required skills and assist universities in designing training programs that align with the latest technological developments.

Fifth, Internships and Job Placements in Green Industries: Good collaboration between universities and industry can expand internship and work placement opportunities at companies in the renewable energy, waste management, or green infrastructure sectors. This will give vocational students hands-on experience in green industries and ensure that the skills they acquire are relevant to labour market needs. Sixth, Cross-Disciplinary Competency Development: Vocational education in green innovation hubs should also encourage the development of cross-disciplinary competencies. By involving fields of study such as engineering, agriculture, information technology and management, students can understand how green technologies and sustainability solutions can be practically applied in various industrial sectors.

Seventh, Use of Digital Technology in Vocational Education: Using digital technologies, such as virtual simulations, energy management software, or distance

learning platforms, can help vocational students learn green technologies more effectively. These technologies can also be used for remote training, allowing students from remote areas to access education relevant to green industry needs. Overall, this factorial analysis shows how various themes are interlinked in the existing literature, providing direction for policymakers, educational institutions and industry to collaborate on green innovation and vocational education to mitigate climate change.

5. CONCLUSION

This study aims to assess the contribution of vocational education in university-industry collaboration focused on green innovation for climate crisis mitigation by conducting a systematic and bibliometric review of 119 works of literature published in Scopus-indexed international journals from 1993 to 2024. The method used involved bibliometric analysis to identify trends, research focus and gaps in the related literature. The results showed that green innovation in vocational education is receiving increasing attention, especially about university-industry collaboration. However, the integration of vocational education in discussions on climate crisis mitigation remains under-explored. The findings indicate the need to develop vocational curricula that are more integrated with green technology and sustainability and strengthen cross-country collaboration. This research implies the importance of designing vocational education strategies that are more responsive to climate challenges through strengthening partnerships between academia and industry. The limitation of this study is the lack of in-depth empirical studies on the specific context of vocational education in developing countries. Therefore, suggestions for future research are to conduct field studies that focus more on the direct influence of vocational education on the application of green technology in the industrial sector and expand the geographical coverage to explore cross-country collaboration.

Acknowledgements

We are very grateful to Faculty of Vocational Studies, Universitas Airlangga for their support. In addition, we would like to express our gratitude to the editors and editorial staff of JHSSR for their assistance during publication period.

Funding

The authors received no financial support for the research.

Declaration of Conflicting Interests

The authors declare that they have no competing interests.

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Horizon J. Hum. & Soc. Sci. Res. 7 (S): 20 – 30 (2025)

Journal of Humanities and Social Sciences Research
www.horizon-JHSSR.com

RESEARCH ARTICLE
Peer-reviewed | Open Access

Making Cities Resilient Assessment: A Proactive Experiential-Based Learning Activity for Graduate Students to Enhance Climate and Disaster Risk Reduction Awareness

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ARTICLE INFO

Article history
RECEIVED: 06-Mar-25
REVISED: 18-Apr-25
ACCEPTED: 04-Jun-25
PUBLISHED: 15-Jul-25

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Citation: Andres Winston C. Oreta (2025). Making Cities Resilient Assessment: A Proactive Experiential-Based Learning Activity for Graduate Students to Enhance Climate and Disaster Risk Reduction Awareness. Horizon J. Hum. Soc. Sci. Res. 7 (S), 20–30. https://doi.org/10.37534/bp.jhssr.2025.v7.nS.id1290.p20-30

ABSTRACT

Introduction: As climate change and disaster risks increasingly threaten urban areas, education must evolve to equip future engineers with practical tools for resilience assessment and planning. The *Graduate Seminar on Disaster Risk Reduction and Infrastructure Development (DRRID)* at De La Salle University (DLSU), Manila, integrates proactive, experience-based strategies to foster student engagement with real-world challenges in disaster risk reduction. **Methods:** A core component of the course is the *Making Cities Resilient* group project, grounded in Kolb's Experiential Learning Theory. Using the United Nations Office for Disaster Risk Reduction (UNDRR)'s **Ten Essentials for Making Cities Resilient** and the **Disaster Resilience Scorecard for Cities**, student groups select a city or municipality in the Philippines for evaluation. The assessment process involves internet-based research, field surveys, and interviews with local government officials and community stakeholders. Findings are synthesized into a comprehensive scorecard analysis, along with tailored recommendations for enhancing urban resilience. **Results:** The activity enabled students to critically evaluate urban resilience capacities, identify systemic gaps, and suggest actionable improvements. Students demonstrated increased comprehension of the Sendai Framework's principles and the multifaceted nature of resilience-building. Written reports and presentations—delivered either onsite or online—showcased their ability to bridge theory and practice in disaster risk reduction. Discussion: This hands-on approach fostered student engagement, critical thinking, and interdisciplinary collaboration. It highlighted the importance of participatory governance, data-driven assessments, and local knowledge in building resilient cities. The project also underscored the educational value of experiential learning in preparing students for complex, real-world challenges. Conclusion: Integrating the *Making Cities Resilient assessment* into the DRRID seminar significantly enhanced students' awareness and competencies in climate and disaster risk reduction. The experiential format provided a meaningful platform for applying academic concepts to tangible community-based problems, thus strengthening the educational foundation for future civil engineers committed to urban resilience.

Keywords: Making Cities Resilient, Experiential Learning, Civil Engineering, Graduate Seminar, Disaster Risk Reduction Disabilities, Numbered Heads Together (NHT), Science Education, Teaching Strategies.

1. Introduction

Post-graduate programs in civil engineering at Higher Education Institutions (HEIs) aim to train professionals to become leaders in specialized fields such as Construction Technology and Management, Geotechnical Engineering, Structural Engineering, Transportation Planning and Engineering, and Hydraulics and Water Resources Engineering. However, it is equally important for HEIs to broaden the knowledge and awareness of PhD, MSCE, and Master of Engineering graduates on societal issues, aligning with one of the fundamental principles of the Civil Engineering Code of Ethics: "Civil engineers shall uphold and advance the integrity, honor, and dignity of the civil engineering profession by using their knowledge and skill for the enhancement of human welfare and the environment." To this end, De La Salle University's Graduate Studies in Civil Engineering program also emphasizes training professional civil engineers to provide solutions to contemporary issues, particularly sustainability and disaster risk. In the PhD program at De La Salle University (DLSU), students are required to complete 30 academic units, including a graduate seminar (De La Salle University., n.d.). One such seminar is graduate seminar on "Disaster Risk Reduction and Infrastructure Development (DRRID)," which aims to produce civil engineering graduates who are not only experts in their technical fields but also "leaders and advocates for creating a more resilient built environment."

How to effectively deliver the DRRID graduate seminar to professional civil engineers is a challenge. The author aims to introduce the students to a very broad field of study related to Disaster Risk Reduction and Management (DRRM) which is not included in the undergraduate curriculum. A DRRM course needs to cover the basic principles and terminology related to disasters, hazards, risk and resilience and the relationship among these basic concepts which can be done a lecture type approach. Various learning materials on DRRM (e.g. Nakano, G., & Yamori, K., 2021; King, W. (Ed.), 2012) have been developed to promote DRR education. Nakano and Yamori (King, W. (Ed.)., 2012) pointed out in their paper on DRR education and also based on their review of literature that "increased knowledge and skills in DRR do not necessarily lead to behavioral changes in learners because the three approaches common in DRR education: (1) active instructor/passive learner approach, (2) knowledge-transmission approach, and (3) short-term knowledge evaluation approach inhibit the fostering of a proactive attitude." To overcome the barrier between knowledge and behavior, Nakano and Yamori propose a new "proactive attitude paradigm" which consists of the (1) instructor/learner fusion approach, (2) participation in a community of practice approach, and (3) long-term commitment evaluation approach. This new proactive approach is suited in the DRRID graduate seminar. With the target students in the DRRID graduate seminar being professional civil engineers and researchers, they appreciate more the new knowledge through actual application and research. A similar proactive teaching and learning approach is "Experiential Learning" which is "learning from experience" or "learning by doing." Experiential education first immerses learners in an experience and then encourages reflection about the experience to develop new skills, new attitudes, or new ways of thinking." Kolb's experiential learning theory (ELT) (Kolb, A., & Kolb, D. A., 2017) is the most widely recognized and used concept in experiential learning. Experiential learning often involves teamwork, enabling students to practice collaboration and develop interpersonal skills. Fieldwork experiences, in particular, provide students with the opportunity to explore and apply classroom knowledge in real-world settings. These experiences bridge educational content with external communities, whether at a building site, within a neighborhood, or across a broader community or city. Examples of ELE activities include hands-on laboratory experiments, internships, practicums, field exercises, study abroad programs, and undergraduate research. In civil engineering, experiential learning modules have been integrated into the undergraduate curriculum through laboratory-based courses such as Geotechnical Engineering (Kershaw, D., et al., 2021), Reinforced Concrete (Lovell, M., et al., 2021), and Steel Design (Carroll, R., et al., 2022). The challenge in this paper is how can a Proactive Experiential Learning be introduced in a seminar so that the broad field of DRRM will be appreciated by the graduate civil engineering students and professionals.

Guided by the new "proactive attitude paradigm" introduced by Nakano and Yamori and Kolb's ELT, the author introduced a simple but effective group exercise on "Making Cities Resilient" where the students assess a city's resilience to disasters. The project is guided by the UNDRR's Ten Essentials for Making Cities Resilient Framework (United Nations Office for Disaster Risk Reduction., n.d.). The MCR project exemplifies a proactive teaching and learning approach and "experiential learning," through an engaged process where students "learn by doing" and reflect on their experiences as they conduct onsite inspection and desktop assessment of a city's resilience to disasters. Through this group exercise, the students have a deeper understanding on the relevance of their civil engineering profession in resilience building.

2. PROACTIVE EXPERIENTIAL LEARNING IN THE CLASSROOM

The new "proactive attitude paradigm" (Nakano, G., & Yamori, K., 2021) consisting of three approaches namely, (1) the "instructor/learner fusion approach", (2) "participation in a community of practice approach" and (3) "long-term commitment evaluation approach" is described below:

1) *Instructor/learner fusion approach* – Students are not just passive recipients of knowledge but they actively engage in research and application and they share their learnings and experiences to their teachers.
2) *Participation in a community of practice approach* – Learning is enhanced when the student becomes a member of community in "doing things together.
3) Long-term commitment evaluation approach – Student assessment is not based on the students' present knowhow of concepts but on the learners' attitudes on future application and relevance to their career and professional practice. In the case of DRR education, "the students are evaluated how learners have committed to activities related to DRR in areas such as their career choices, participation in DRR activities after graduation, self-affirmation and self-confidence, and their responses in the event of a disaster as well as the damage-mitigation effects of their DRR activities (Nakano, G., & Yamori, K., 2021)".

Experiential learning experience (ELE) is an innovative approach that goes beyond traditional classroom teaching. It involves actively engaging students in real-world experiences, allowing them to "learn by doing." Kolb's experiential learning theory (ELT) (Kolb, A., & Kolb, D. A., 2017) is the most widely recognized and used concept in experiential learning. Kolb developed from the Lewin cycle model (Kolb, A., & Kolb, D. A., 2017) the idea that students have a dominant phase of the cycle during which they prefer to learn and therefore will have preferred modes of learning.

The four phases of Kolb's theory on ELE are summarized in Figure 1.

(1) *Concrete Experience* - Engaging directly in authentic or real-world situation,
(2) *Reflective Observation* - Relating observations to past experience and knowledge,
(3) *Abstract Conceptualization* - Generating ideas and distilling perceptions, and
(4) *Active Experimentation* - Testing new ideas and designs and honing new skills in a new experience

For teachers, providing students with opportunities to engage in experiences related to their learning is essential. Figure 1 presents the description of the four stages of ELE. Teachers should design environments and student-centered assessment tasks that allow students to learn through direct experience. In a typical classroom setting, content is readily available for students to read, understand, and analyze. While mastering content is important, the core of experiential learning lies in learning through the process. The initial phase of an Experiential Learning Experience (ELE) involves immersing students in a real-world situation. Following this experience, students

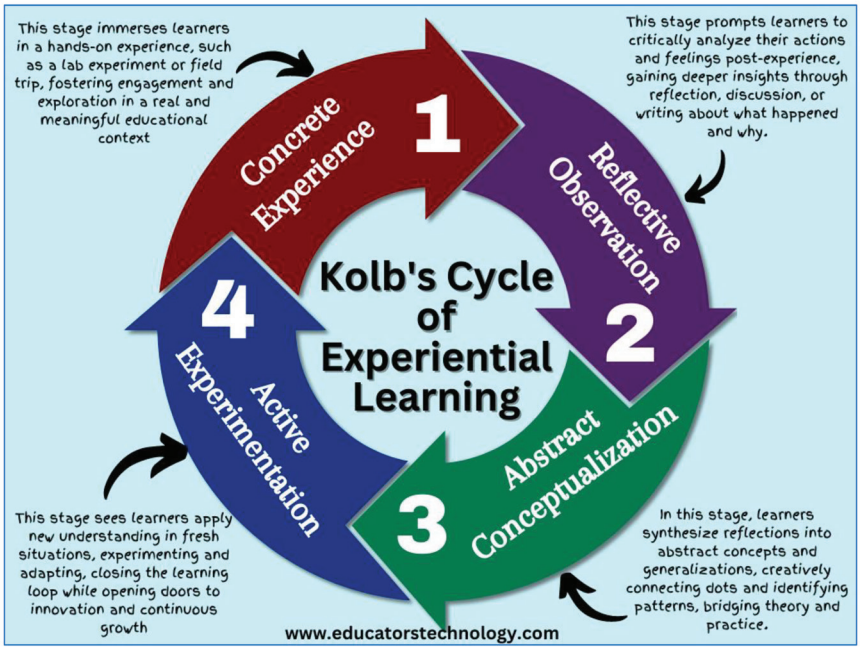


Figure 1. Cycle of Experiential Learning Experience.

engage with the content, reflect on their experiences, and apply their newfound knowledge to different contexts.

The following section will explore how a proactive ELE, incorporating both fieldwork and desktop research, was implemented in a group project within the DRRID seminar to achieve the course learning outcomes.

3. OVERVIEW OF THE DRRID GRADUATE SEMINAR

Course Lectures

The Disaster Risk Reduction and Infrastructure Development (DRRID) graduate seminar aims to introduce practicing and research engineers on the basic concepts and applications of Disaster Risk Reduction and Management (DRRM) especially in relation to Infrastructure Development in order to enhance and broaden their perspectives in research and application to DRRM. Lectures, videos and reading materials will highlight the impact of natural hazards on the built environment and ways of reducing the adverse effects of the natural hazards to improve infrastructure and community resilience. Among the DRRID lectures delivered during the seminar are various topics related to the theme of the course which are listed as follows:

1) DRRID-01: *Understanding Hazards and Disasters*
2) DRRID-02*: Introducing Infrastructure Resilience*
3) DRRID-03: *Disaster Risk Reduction & Assessment*
4) DRRID-04: *Making Cities Resilient*
5) DRRID-05: *Promoting Safe Schools & Hospitals*
6) DRRID-06: *Preserving Heritage Structures*
7) DRRID-07: *DRRM and ICT*

Resource speakers are also invited to deliver complementary lectures on specialized topics related disaster risk reduction and resilient structures such as *Climate Change Adaptation, Low Impact Development, Land Use Planning, Geographical Information System, Information and Communication Technology, Resilient Transportation, Earthquake Engineering and Community Resilience.* The lectures are usually introductory with some sample applications. Students who want to know more about the specific topics are advised to refer to the related literature.

Course Requirements

To develop the students' understanding and interest on the seminar's theme on disaster risk reduction and infrastructure development and resilience, the students are required to accomplish assignments and group projects. *Individual assignments*consist of a report on a recent natural disaster, a review of related literature based on specified keywords like natural hazards (earthquake, wind, flood, tsunami, landslide, etc.), critical infrastructures (schools, hospitals, bridges, water systems, etc.) and resilience. The students are also required to take a *Knowledge-Check Quiz* on basic concepts about the theme of the seminar. Another individual assignment is a*DRRID Seminar Paper* which they need to write and present in the DRRID Forum The seminar paper must address the issue of development and disasters in relation to the role of civil engineers or engineers, in general, to DRR and resilience building. The paper aims to assess the student's ability to conduct library and internet research, to develop a concept paper for future research or to apply tools and concepts discussed in class and learned from lectures and readings. One group project is required in this seminar. This is *the Making Cities Resilient (MCR) assessment project*.

4. MAKING CITIES RESILIENT ASSESSMENT PROJECT

Launched in May 2010 by the United Nations on Disaster Risk Reduction (UNDRR), the Making Cities Resilient (MCR): "My city is getting ready!" campaign addresses local governance and urban risk issues. The Making Cities Resilient Campaign "aims at getting Mayors, local governments and national authorities to take actions towards making cities resilient as part of sustainable urbanization" (United Nations Office for Disaster Risk Reduction., n.d.). The first phase (2010-2015) of the campaign was based on the Hyogo Framework for Action, while the second phase (2015 – 2030) adopted the Sendai Framework for Disaster Risk Reduction. The MCR campaign was promoted through a checklist referred to as the "Ten Essentials for Making Cities Resilient." The Ten-Point checklist of the Essentials for Making Cities Resilient (Figure 2) consists of key questions aligned for each essential which are used for self-assessment. A handbook (United Nations Office for Disaster Risk Reduction., 2017) is available to guide the users on the MCR checklist. In the present MCR campaign, a Disaster Resilience Score Card for Cities Figure 3 is available to all to use in the self-assessment of a city or municipality.

- ***E01:*** *Organize for Disaster Resilience*
- ***E02:*** *Identify, Understand and Use Current and Future Risk Scenarios*
- ***E03:*** *Strengthen Financial Capacity for Resilience*
- ***E04:*** *Pursue Resilient Urban Development and Design*
- ***E05****: Safeguard Natural Buffers to Enhance the Protective Functions Offered by Natural Ecosystems*
- ***E06****: Strengthen Institutional Capacity for Resilience*
- ***E07:*** *Understand and Strengthen Societal Capacity for Resilience*
- ***E08:*** *Increase Infrastructure Resilience*
- ***E09:*** *Ensure Effective Preparedness and Disaster Response*
- ***E10:*** *Expedite Recovery and Build Back Better*

Figure 2. The Ten Essentials for Making Cities Resilient.

Figure 3. Disaster Resilience Scorecard for Cities (United Nations Office for Disaster Risk Reduction., n.d.).

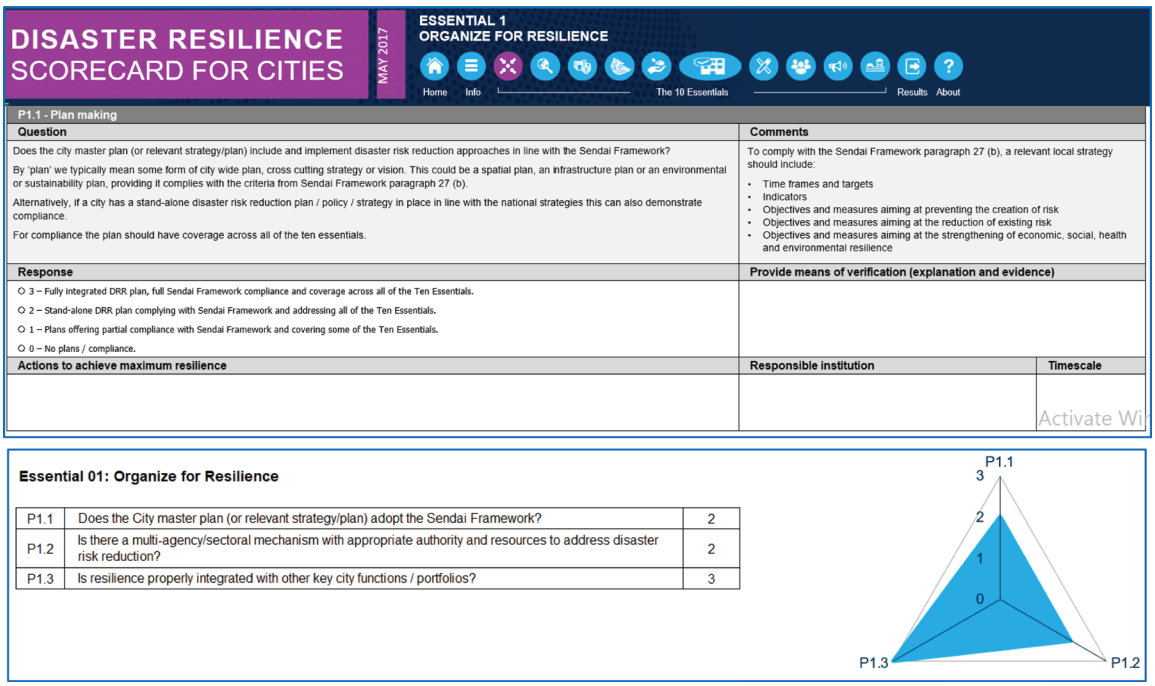


Figure 4. Preliminary Assessment Tool Page in MS Excel for E01.

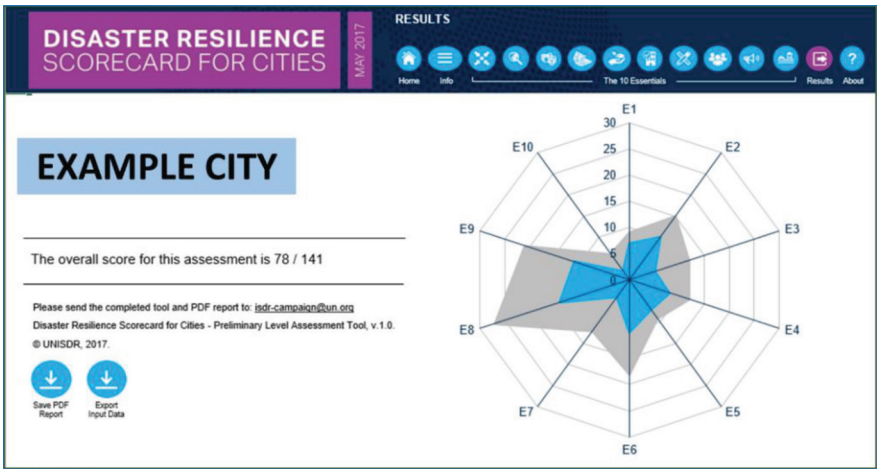


Figure 5. Scorecard of a City using the MCR Assessment Tool.

There are two sets of guides on Disaster Resilience Score Card for Cities – preliminary assessment which consists of 47 questions or indicators, each with a score of 0 – 3 and detailed assessment which consists of 117 indicator criteria, each with a score of 0 – 5.

To guide the user in the assessment, there are tools for both preliminary and detailed assessment in MS Excel which can be downloaded freely. Shown in Figure 4, is a page of the preliminary assessment tool for Essential 1. For Essential 1, there are actually three questions, with the first question as shown. Shown in the tool are comments that serve as a guide to the user on what factors and data are needed to answer reasonably the question.

The rating system for the preliminary assessment follows a scale from 0 to 3 described as follows:

- **3** = *Achieved (Documented, Implemented, Visible Outputs)*
- **2** = *Policies in Place but only Partially Achieved*
- **1** = *There is a plan (Proposal stage only)*
- **0** = *No idea or information*

After completing the assessment per essential, a summary represented by a radar chart is produced, similar to Figure 5 for Essential 01. After all essentials are assessed the final score card is summarized as shown in Figure 6 showing the scores for the 10 essentials. Using the final score, the city can identify the strengths and weaknesses in relation to the 10 essentials.

5. THE MAKING CITIES RESILIENT ASSESSMENT PROJECT AS A PROACTIVE EXPERIENTIALLEARNING ACTIVITY

Each group is required to choose a city or municipality in the Philippines as a case study in the application of the preliminary level assessment using the Disaster Resilience Score Card for Cities. Through internet research, site survey and interviews of local government officials and the community, the students must identify the strengths/weaknesses of the city in relation to the ten essentials. The final output of the project is a Disaster Resilience Score Card of the city. From there, they can recommend possible improvements to increase the city's resilience. The report must be supported with online reports, site surveys, interviews, city website information and official documents. A written and oral report is required for this project.

The three phases of the proactive learning paradigm is demonstrated in this group exercise.

1) *Instructor/learner fusion approach* – Students conduct research and apply the 10 Essentials for Making Cities Resilient
2) *Participation in a community of practice approach* – Students engage with various stakeholders in the community and in the local government as they conduct onsite inspection and assessment with respect to the 10 Essentials
3) *Long-term commitment evaluation approach* – The results of the MCR assessment have long term effects to the city while the students being familiarized now on the 10 Essentials can apply the principles and requirements for building resilient communities.

With respect to Kolb's Cycle of Experiential Learning, the MCR exercise shows the alignment the various students' tasks as shown in Figure 6:

a) *Concrete Experience*- The activity involves real world field work through site surveys and interviews (Figure 7) and online research (e.g., browsing the city's website, gathering news reports about the city),
b) *Reflective Observation* – The students record their observations at the site and reflect on them in relation to the MCR questions,
c) *Abstract Conceptualization* – The students interpret what scores to assign based on the

Figure 6. The MCR Activity as a Proactive Experiential Learning.

Figure 7. Students conduct interviews at the site.

observed strengths and weaknesses of the city with respect to an essential and

d) *Active Experimentation* – The students recommend improvements to the city to improve its resilience to disasters. The next cycle will follow after the preliminary assessment.

The radar score card for the essentials is presented in the reports. The score assigned for each essential were based by the group after assessing the documents, internet reports, website and site observations. The group as a team decides on the preliminary score. Figure 8 presents a sample report of a group on their assessment of a city with respect to the Ten Essentials, while Figure 8 presents the detail for the assessment of a specific essential with a summary of strengths and weaknesses with respect to an essential (e.g. Essential 09 in this figure.)

This activity addresses the course learning outcomes:

a) *The students must be able to identify and describe the various factors that affect the resilience of cities and communities to disasters*. By simply reading the "Ten Essentials for Making Cities Resilient" and analyzing the MCR Assessment Tool, the students get to know the important indicators that must be given importance by LGUs and stakeholders to make cities resilient. And when they visit the site to gather information, they observe and reflect on the deficiencies of the city with respect to the 10 essentials. They are made aware of the issues and problems in local government units that needs to be addressed.

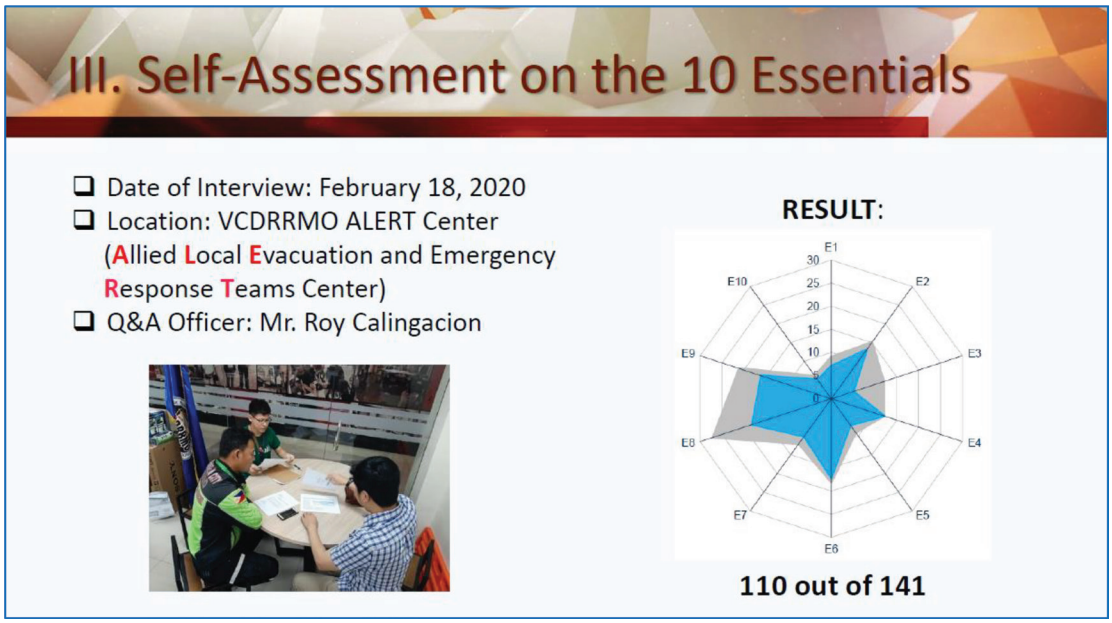


Figure 8. Students' Assessment of a City with respect to the Ten Essentials.

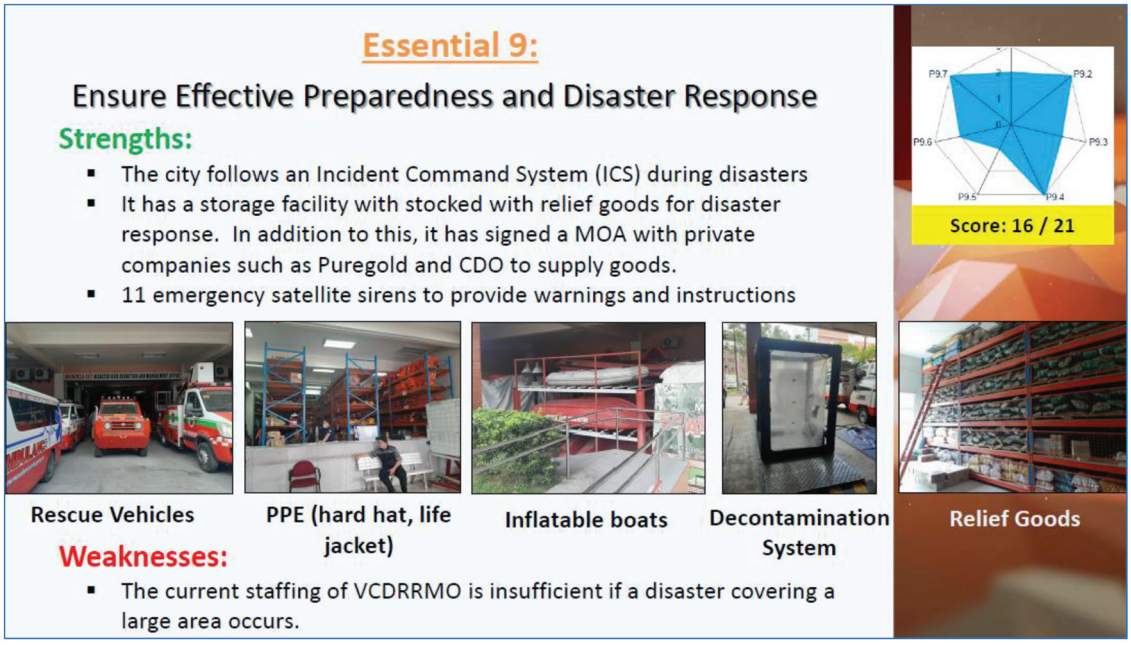
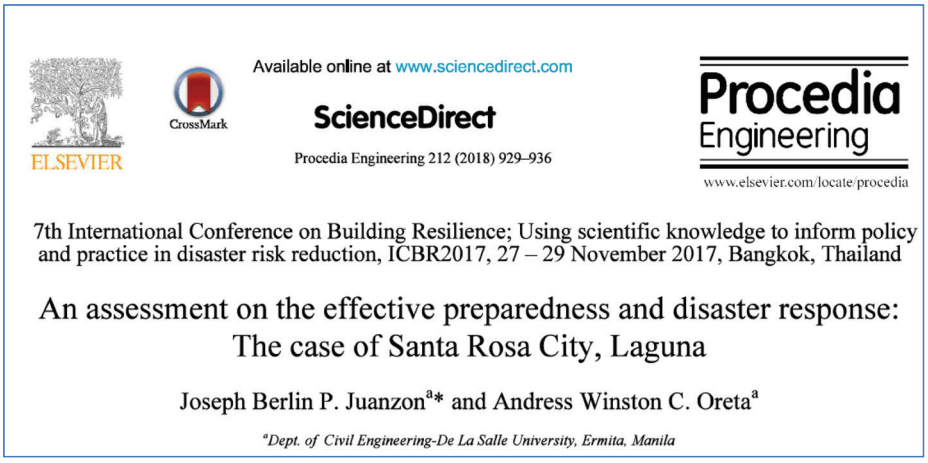


Figure 9. Students' Assessment of a City with respect to an Essential - E09.

b) *The students can apply their knowledge in the conduct of a preliminary disaster risk and resilience assessment of a city.* The onsite survey of the city, its infrastructures and the community, itself and the actual interviews of the LGU officers and the people provide factual information to the students on the actual situation in the city with respect to resilience using the ten essentials as a guide.

The UNDRR Making Cities Resilient framework is used in the DRRID graduate seminar since the Disaster Resilience Score card provides a comprehensive list of important criteria with guide questions that must be considered in the assessment of resilient cities to disasters. More focused researches can be conducted instead of considering all ten essentials. Research can be derived per theme like (a) Role of Governance in Resilience – E01, E02 and E03, (b) Physical, Environmental Social and Infrastructure Resilience – E04 to E08 and (c) Response Planning – E09 and E10. Actually, a comprehensive study can be conducted also for a city for a specific essential only, similar to the paper by Juanzon (Juanzon, J. B., 2018). The ten essentials for MCR and the tools provide useful and rich information for topics for research on resilient cities.



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Procedia Engineering 212 (2018) 929–936

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7th International Conference on Building Resilience; Using scientific knowledge to inform policy and practice in disaster risk reduction, ICBR2017, 27 – 29 November 2017, Bangkok, Thailand

An assessment on the effective preparedness and disaster response: The case of Santa Rosa City, Laguna

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Figure 10. A paper about the MCR presented at ICBR2017 Conference (Thailand) (Juanzon, J. B., 2018).

Figure 11. Poster Presentation at the PAASE Conference 2024 (Philippines).

Best examples of the success of the DRRID graduate seminar are the paper/poster presentations about the MCR of the students in conferences. Among the significant papers presented by the students are as follows:

a) Joseph Berlin Juanzon (PhD student), *"An assessment on the effective preparedness and disaster response: The case of Santa Rosa City, Laguna,"* Procedia Engineering 212 (2018) 929–936, 7th International Conference on Building Resilience (7ICBR), Nov. 26-29, 2017, Bangkok, Thailand. See Figure 10 below.

b) Joseph Bianes (MSCE student). Co-authors: Dustin Glenn Cuevas and Earl John Salamat. "*Mandaluyong City Disaster Resiliency Assessment*," Poster presentation winner during the PAASE Conference, July 22, 2024, EVSU, Tacloban City, Hosted by the Philippine-American Academy of Science & Engineering (PAASE)

c) Mary JoaneAninon (PhD student) *"Assessing the Disaster Resilience of a City: The Case of Davao City, Philippines*," Poster presentation 3rd place during the PAASE Conference, July 22, 2024, EVSU, Tacloban City, Hosted by the Philippine-American Academy of Science & Engineering (PAASE). Figure 11 shows the students at the PAASE Conference with their posters and certificates.

6. CONCLUSION

The Graduate Seminar on Disaster Risk Reduction and Infrastructure Development (DRRID) is a pivotal course within the civil engineering graduate program at De La Salle University. Through the Making Cities Resilient

(MCR) Assessment, students gain practical, hands-on experience by applying their knowledge of disaster resilience in real-world settings. Using the UNDRR's Ten Essentials for Making Cities Resilient assessment tool, they conduct both on-site and online research to critically evaluate the role of these essentials in enhancing city resilience. This proactive experiential learning approach not only deepens their understanding of disaster risk reduction and resilience building but also equips them with the skills to integrate these insights into their professional careers as civil engineers. It is hoped that the graduate students will be inspired to explore innovative and sustainable strategies for mitigating the adverse effects of hazards while strengthening infrastructure and community resilience.

Acknowledgements

The author would like to express his gratitude to the editors and editorial staff of JHSSR for their assistance during publication period.

Funding

The authors received no financial support for the research.

Declaration of Conflicting Interests

The author declares that he has no competing interests.

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His research collaborations include projects with University College London, notably the *Philippines Resilience of Schools to Multi-Hazards (PRISMH)* and *Cultural Heritage Resilience and Sustainability to Multi-Hazards (CHeRiSH)*. He has played leading roles in organizing national and international conferences of the Association of Structural Engineers of the Philippines (ASEP), including the Asia Conference on Earthquake Engineering (ACEE).

Dr. Oreta is a Life Member of the Philippine-American Academy of Science and Engineering (PAASE) and a Founding Member of the Philippine Academic Society for Climate and Disaster Risk (PASCDR).

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Horizon J. Hum. & Soc. Sci. Res. 7 (S): 31 – 46 (2025)

Journal of Humanities and Social Sciences Research
www.horizon-JHSSR.com

RESEARCH ARTICLE
Peer-reviewed | Open Access

Brawijaya University's Community Service Programs in Climate Change Mitigation

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ARTICLE INFO

Article history
RECEIVED: 12-Mar-25
REVISED: 24-Feb-25
ACCEPTED: 05-Jun-25
PUBLISHED: 15-Jul-25

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Citation: Luchman Hakim, Yusron Sugiarto, Dian Siswanto, Irfan Mustofa, Rita Parmawati and Brian Rahardi (2025). Brawijaya University's Community Service Programs in Climate Change Mitigation. Horizon J. Hum. Soc. Sci. Res. 7 (S), 31–46. https://doi.org/10.37534/bp.jhssr.2025.v7.nS.id1292.p31-46

ABSTRACT

Introduction: Climate change presents critical global challenges, particularly in climate-vulnerable regions such as Indonesia, where agricultural systems and coastal ecosystems are at significant risk. In response, Brawijaya University in Malang has implemented two major community service initiatives—**Doktor Mengabdi (DM)** and **Mahasiswa Membangun Desa (MMD)**—to foster climate change mitigation and community resilience through academic-community partnerships. **Methods:** This study employs a mixed-method approach, combining qualitative interviews with 80 faculty members, quantitative surveys of 13,600 students, and participatory discussions with local community leaders across East Java. The research evaluates the implementation and impact of DM and MMD programs, focusing on sustainable practices in reforestation, agriculture, renewable energy, and waste management. **Results:** The DM program facilitated the planting of over 5,000 trees, monitored through the Tetenger Bumi mobile application, which also promoted sustained community engagement. In agriculture, 65% of 300 participating farmers adopted environmentally sustainable practices such as organic farming and crop rotation, leading to improved yields and reduced chemical input. Workshops conducted on renewable energy and waste management led to 75% of participants expressing intent to implement solar or biogas systems. Moreover, waste management programs initiated by MMD students resulted in 60% of villages establishing recycling initiatives and a 65% improvement in household waste separation. Tree-planting efforts contributed to a 15% reduction in landslide incidents in targeted areas, with 90% of residents endorsing the effectiveness of the 3R (Reduce, Reuse, Recycle) approach. **Discussion:** These outcomes demonstrate the tangible benefits of integrating academic expertise with grassroots engagement to promote environmental stewardship. However, challenges persist, including limited resources, infrastructural constraints, and initial community resistance. **Conclusion:** Brawijaya University's community service programs represent a promising model for climate change mitigation in developing regions. Ensuring their long-term sustainability and scalability requires strategic investment, ongoing stakeholder collaboration, and adaptive policy frameworks to address existing barriers and amplify community impact.

Keywords: Climate change, community service, sustainable development, reforestation, waste management, university engagement

1. INTRODUCTION

Climate change is an urgent issue that poses significant risks to ecosystems, economies, and human livelihoods worldwide. The scientific consensus on the impacts of global warming highlights the need for effective strategies to reduce greenhouse gas emissions, promote environmental sustainability, and strengthen vulnerable communities (Develay & James, 2024; Puppim de Oliveira & Bhuiyan, 2024). Governments and industries play a key role in addressing these challenges, but institutions of higher education also have a crucial part to play (Filho et al., 2023a) Universities, with their research, education, and community engagement capabilities, are well-positioned to lead initiatives for sustainability and climate action (Leal Filho et al., 2018).

In Indonesia, a country highly vulnerable to climate change due to its extensive coastlines and reliance on agriculture, universities have become key players in fostering environmental awareness and action. Brawijaya University, located in Malang, East Java, has a long history of successful research and community engagement programs aimed at addressing various social and environmental issues(Sugiarto, Ahmad, et al., 2024; Suroto et al., 2014). For instance, the *Kuliah Kerja Nyata* (KKN) or Community Service Program engages students in practical problem-solving projects with rural communities and has long served as a model for fostering collaboration between the university and local residents(Nurul et al., 2018). Another initiative, the Green Campus Program, focuses on waste management and energy conservation within the university's campus and successfully demonstrates the potential of environmental stewardship within academic institutions. These prior successes laid the foundation for more focused and ambitious community projects, specifically in the areas of climate change mitigation.

The paper explores Brawijaya University's initiatives to address climate change, focusing on two main programs: "*Doktor Mengabdi*" (DM) and "*Mahasiswa Membangun Desa*" (MMD). DM is a community service program led by university lecturers that applies academic expertise to address community needs. In contrast, MMD is a student-driven initiative aimed at involving students in hands-on community service projects, which promote local development and sustainability. These programs effectively combine academic expertise with local community action to tackle the causes and effects of climate change. By working closely with rural communities, the DM and MMD programs not only promote sustainable practices like reforestation, waste management, and renewable energy use but also empower local residents to take an active role in environmental stewardship. In the upcoming sections, this paper will conduct a thorough analysis of these programs, emphasising their structure, implementation, and impact on climate change mitigation. Through an examination of the accomplishments and obstacles of these initiatives, this study aims to contribute to the wider discussion on the role of universities in promoting sustainable solutions to global environmental issues.

2. MATERIALS AND METHODS

This research assesses the community service initiatives at Brawijaya University, specifically the DM and MMD programs. These programs are instrumental in local climate change mitigation efforts. This paper used both qualitative and quantitative methods for analysis. These methods allowed for the examination of both the measurable impacts of the programs and the perspectives and experiences of participants and local communities. The study encompassed rural and semi-urban areas across East Java, Indonesia, selected for their susceptibility to climate change, including issues such as deforestation, agricultural challenges, and flooding.

Study Area and Program Design

Both the DM and MMD programs focus on initiatives to combat climate change. The DM program engages university lecturers in community service, collaborating with local communities to address environmental challenges through activities such as reforestation, sustainable agriculture, renewable energy education, and waste management. In parallel, the MMD program involves students in rural development efforts, promoting sustainable practices like 3R (Reduce, Reuse, Recycle) education, establishing community recycling centres, and leading tree planting campaigns. While these programs target different participants—lecturers for DM and students for MMD—they share the common aim of fostering environmental stewardship and sustainable development. These programs aim to combine academic knowledge with community collaboration to create long-term environmental and social impact.

Data Collection Techniques

A mixed-method approach was used to collect data. Program documentation, including reports, schedules, and implementation plans, was reviewed to understand the scope and goals of the DM and MMD programs. These documents offered insights into the evolution of the programs over time and their alignment with sustainable development objectives (Yin et al., 2018). For DM program, an interview was conducted with 80 lecturers to explore their roles, challenges, and strategies for engaging communities. The DM Program was conducted in 25 cities and regencies across East Java (Figure 1). There were

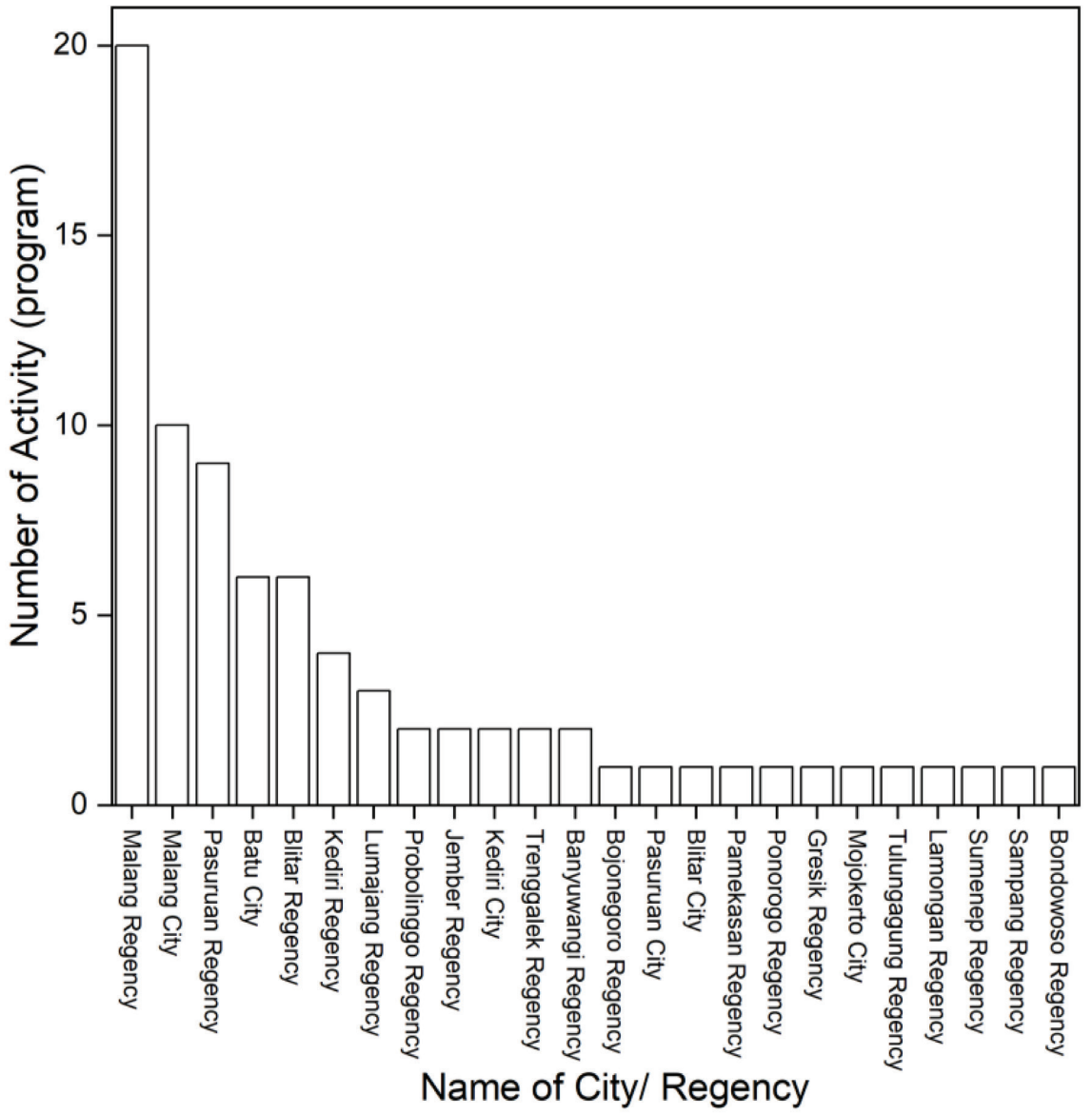

Figure 1. The location of the DM Program.

Malang Regency, Malang City, Pasuruan Regency, Batu City, Blitar Regency, Kediri Regency, Lumajang Regency, Probolinggo Regency, Jember Regency, Kediri City, Trenggalek Regency, Banyuwangi Regency, Bojonegoro Regency, Pasuruan City, Blitar City, Pamekasan Regency, Ponorogo Regency, Gresik Regency, Mojokerto City, Tulungagung Regency, Lamongan Regency, Sumenep Regency, Sampang Regency, Bondowoso Regency. The semi-structured format allowed for open-ended discussion, capturing both planned outcomes and unexpected insights (Lewis, 2015).

To evaluate student engagement, surveys were distributed to 13,600 students who took part in the MMD program between 2023. The students were assigned to 30 districts in East Java (Figure 2). There were Malang Regency, Blitar Regency, Jombang Regency, Kediri Regency, Tulungagung Regency, Batu City, Madiun Regency, Magetan Regency, Nganjuk Regency, Ngawi Regency, Pacitan Regency, Ponorogo Regency, Trenggalek Regency, Bangkalan Regency, Bojonegoro Regency, Gresik Regency, Lamongan Regency, Mojokerto Regency, Pamekasan Regency, Sampang Regency, Sidoarjo Regency, Sumenep Regency, Tuban Regency, Banyuwangi Regency, Bondowoso Regency, Jember Regency, Lumajang Regency, Pasuruan Regency, Probolinggo Regency, and Situbondo Regency. The survey aimed to gather feedback on participants' experiences, the impact of their projects, and the long-term sustainability of their environmental initiatives after finishing the program.

Village-level interviews and focus group discussions were conducted with community leaders and residents to gather in-depth qualitative data on the community's perspective regarding the effectiveness of the programs. The discussions brought to light themes such as reforestation outcomes, participation in recycling programs, and the adoption of renewable energy. The

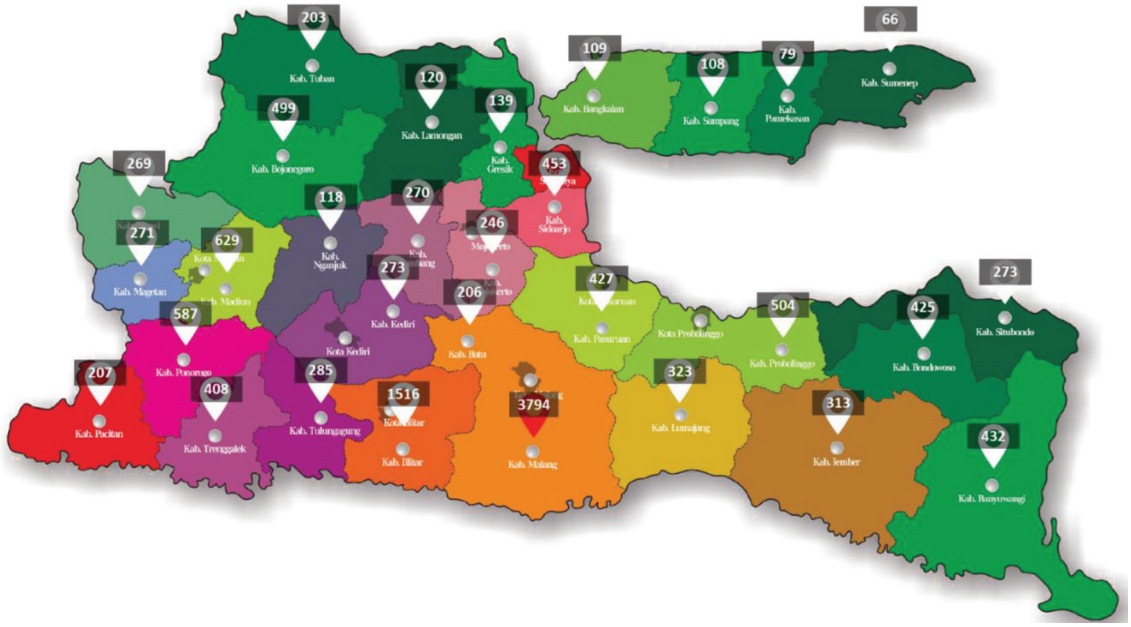

Figure 2. The area of MMD program in East Java.

involvement of community leaders ensured that local opinions and experiences were incorporated into the analysis.

3. RESULTS

The results of this study provide an in-depth analysis of Brawijaya University's community service programs, DM and MMD and their effectiveness in promoting climate change mitigation practices in local communities. The findings are organised into two sections: (1) outcomes of the DM program and (2) outcomes of the MMD program.

a. Reforestation Program

Reforestation is essential for community services, especially in mitigating climate change, enhancing local ecosystems, preventing natural disasters, and supporting local livelihoods. Trees absorb CO_2, helping reduce greenhouse gases while also restoring biodiversity and stabilising soil, which is crucial in areas prone to erosion and flooding (IPCC, 2021). The *Doktor Mengabdi* (DM) program at Brawijaya University exemplifies this approach by engaging faculty and local communities in reforestation efforts. This program emphasises community involvement through education on sustainable practices and hands-on tree-planting activities, fostering ownership and responsibility for environmental stewardship (Ministry of Environment and Forestry, 2019). By providing training on species selection and sustainable land use, the DM program ensures long-term maintenance of reforested areas and addresses specific local challenges in East Java, leading to measurable environmental benefits and increased community participation (Leal Filho et al., 2015; UNESCO, 2020).

One of the primary activities of the *Doktor Mengabdi* (DM) program was reforestation in deforested and degraded areas. Over the study period, approximately 5,000 trees were planted in 6 regencies across East Java (Figure 3). There were *Kabupaten Malang, Kabupaten Kediri, Kabupaten Bojonegoro, Kabupaten Banyuwangi, Kabupaten Blitar*, and *Kabupaten Tulungagung*. The species planted included kepel or burahol (*Stelechocarpus burahol*), guava (*Psidium guajava*), mango (*Mangifera indica*), mangosteen (*Garcinia mangostana*), jackfruit (*Artocarpus heterophyllus*), longan (*Dimocarpus longan*), starfruit (*Averrhoa carambola*), and sapodilla (*Manilkara zapota*).

One of the activities for the reforestation program is Tetenger Bumi. During this program, Tetenger Bumi created an Android application that allows users to monitor the condition of the planted trees, fostering ongoing engagement and care (Figure 4). The Tetenger Bumi UB information system application was developed to monitor and evaluate tree planting activities in East Java, involving local officials and residents. The system includes a mobile application for recording tree data, such as location (tagging), species, age, and other relevant details. Training for users is essential and can be conducted either in person or online. The outcome is the Tetenger Bumi UB information system application, which tracks tree growth information to raise public awareness about the importance of environmental protection and natural resource conservation. It also supports the achievement of tree planting targets, especially in East Java. The Android-based Tetenger Bumi application offers a comprehensive solution for monitoring tree planting activities. It functions as both a mobile app and a

Figure 3. Activity of *Tetenger Bumi* Program in *Kabupaten Kediri, Kabupaten Bojonegoro and Kabupaten Malang.*

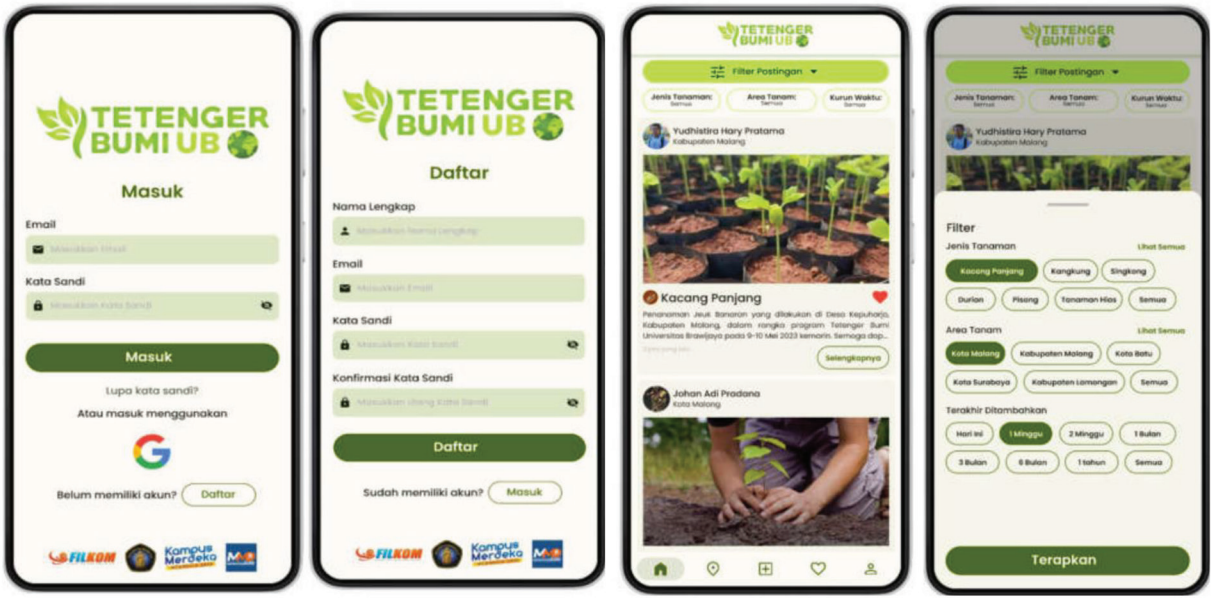

Figure 4. Tetenger Bumi Application.

web-based platform, making it accessible to a wider range of users. This allows individuals to easily and practically use the application anytime and anywhere.

Interviews with local leaders indicated that these initiatives have raised awareness about the ecological and economic benefits of reforestation, including the restoration of local biodiversity and the prevention of soil erosion. This combined approach not only enhances the effectiveness of reforestation efforts but also empowers communities to take an active role in environmental stewardship. In addition to planting activities, the DM program organised community workshops on reforestation, which were attended by 1,500 local members in 6 regencies across East Java. The workshops aimed to raise awareness of the ecological and economic benefits of reforestation while also providing training in tree care and sustainable land use. As a result of these efforts, 80% of attendees expressed very interest in participating in tree-planting activities during the DM program (Figure 5). The study showed that local involvement and commitment encouraged a sense of environmental stewardship.

b. Sustainable Agricultural Practices

Sustainable agricultural practices are essential for ensuring food security, protecting the environment,

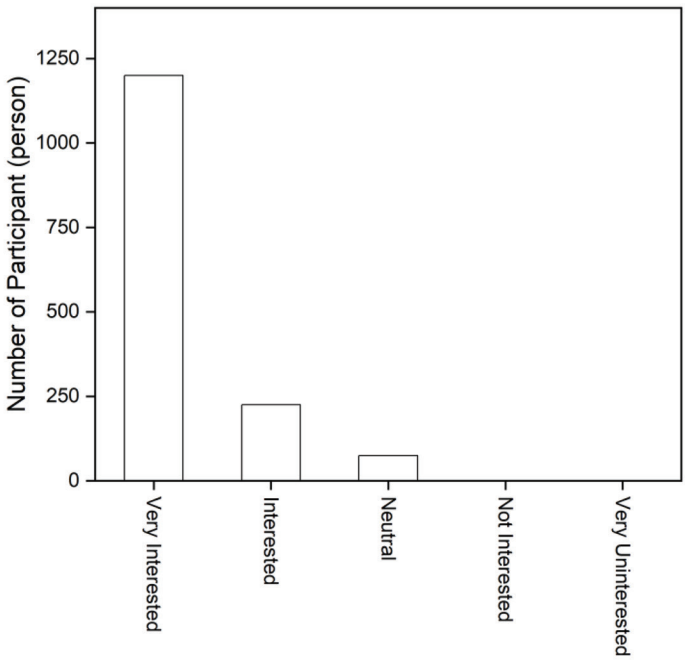

Figure 5. Response of the community expressed interest in participating in tree-planting activities.

and promoting economic viability. These practices aim to minimise the negative impacts of farming on natural resources by using methods that enhance soil health, conserve water, and reduce dependency on chemical fertilisers and pesticides. By integrating crop rotation, organic farming, and agroforestry, sustainable agriculture fosters biodiversity, improves resilience to climate change, and enhances the overall productivity of the land (Rosati et al., 2021; Sugiarto, Nugrayani, et al., 2024). Moreover, these practices contribute to the livelihood of farmers by promoting local markets and reducing costs associated with synthetic inputs (Zou et al., 2024).

The DM program introduced sustainable agricultural methods, including organic farming and agroforestry, to promote environmental conservation and improve farmers' livelihoods. A survey of 300 local farmers found that 65% of participants adopted at least one sustainable practice after attending DM workshops (Figure 6). These practices included reducing the use of chemical fertilizers, implementing crop rotation to maintain soil fertility, and integrating livestock with crop farming to lower methane emissions and enhance farm productivity. The adoption of these practices offers several benefits to farmers. Using organic fertilizers and reducing reliance on chemical inputs not only lowers farming costs but also decreases the risk of soil degradation (Filho et al., 2023b; Pandian et al., 2024). Crop rotation helps disrupt pest cycles, improves the stability of crop yields, and promotes long-term soil health. Integrating livestock into farming systems allows farmers to produce their own organic manure, which reduces methane emissions and enhances nutrient cycling on the farm(Zou et al., 2024). Additionally, agroforestry practices provide an alternative source of income through the sale of timber or fruit crops, thereby increasing the farm's resilience against market fluctuations (Filho et al., 2023b).

Field observations confirmed that several communities have started producing their own organic fertilizers, reducing their dependence on costly chemical alternatives. This practice not only enhances soil health but also boosts crop productivity, enabling farmers to achieve higher yields while adhering to sustainable practices. These methods enhance environmental stewardship and economic stability for local farmers, helping them adapt to climate change challenges.

c. Renewable Energy and Waste Management

Renewable energy and waste management are crucial for addressing climate change, reducing pollution, and promoting sustainable development. Transitioning to renewable energy sources, such as solar, wind, and biomass, helps decrease reliance on fossil fuels, which are major contributors to greenhouse gas emissions. This shift not only mitigates climate change but also improves air quality and public health by reducing harmful pollutants associated with fossil fuel combustion. Effective waste management practices, including recycling and composting, minimise waste sent to landfills, conserve natural resources, and promote circular economies (Erdiwansyah et al., 2024; Hassan et al., 2024; Swadi et al., 2024).

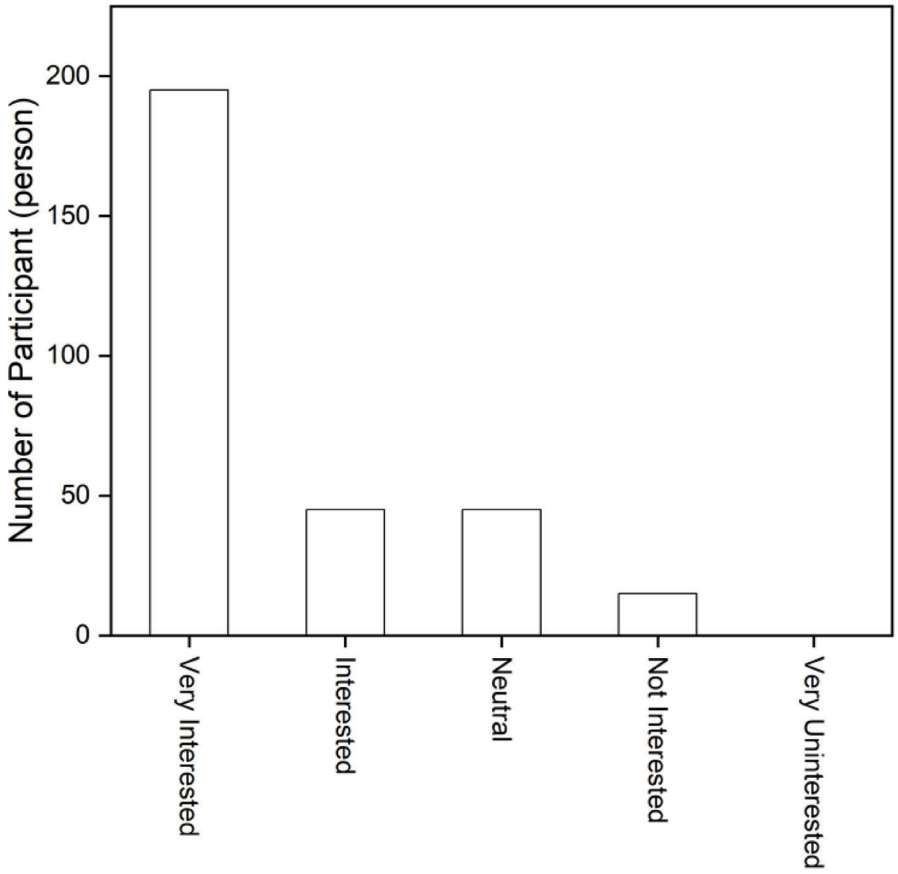

Figure 6. Response of the community to adopt the sustainable practice.

The DM program focused on education related to renewable energy and waste management (Figure 7). Eight workshops were conducted on the use of solar energy and biogas, which 587 participants attended. Post-workshop surveys revealed a significant increase in knowledge about renewable energy technologies, with 75% of attendees expressing very interest in adopting solar panels or biogas systems in their households (Figure 7).

One of the solutions for waste management during the DM program is making coenzyme (Figure 8). Furthermore, 60% of villages implemented new waste management practices, such as community-based recycling centres, composting programs, and the production of ecoenzyme. Ecoenzyme, a natural multipurpose cleaner made from organic waste, gained traction in the workshops as an innovative approach to converting kitchen scraps into useful cleaning products and fertilizers (Benny et al., 2023). This not only helped reduce household waste but also promoted sustainable living practices within the community.

d. Circular Economic

Circular economics is intricately linked to waste treatment as it emphasises minimising waste generation and maximising resource recovery. By adopting circular economy principles, industries are encouraged to design products for longevity, reparability, and recyclability, which directly reduces the volume of waste produced (Chowdhury & Asiabanpour, 2024). Effective waste treatment becomes a critical component of this system, focusing on transforming waste materials into valuable resources rather than viewing them as mere refuse. Practices such as composting, recycling, and upcycling not only divert waste from landfills but also facilitate the recovery of materials that can be reintegrated into production processes (Oyejobi et al., 2024). This closed-loop approach minimises environmental impacts, conserves natural resources, and reduces greenhouse gas emissions associated with waste disposal. Furthermore, implementing circular economy strategies in waste management can foster innovation, create jobs in recycling and resource recovery sectors, and enhance community resilience by promoting sustainable local economies.

The *Doktor Mengabdi* (DM) program has demonstrated significant outcomes in promoting circular economics and effective waste treatment in the communities it serves. Through targeted initiatives, the program has successfully raised awareness about the importance of reducing waste and reusing materials, contributing to a circular economy framework. In

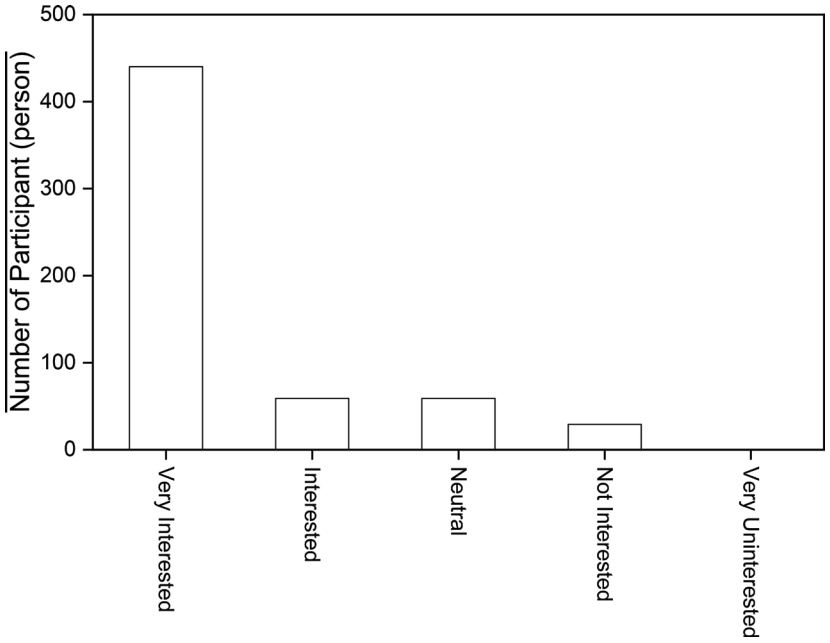

Figure 7. Community response to learning about adopting household solar panels or biogas systems.

Figure 8. The workshop on ecoenzyme from organic waste.

particular, community-based recycling programs established by the DM program have enabled local residents to separate and recycle their waste more effectively, resulting in 65% of participants in households participating in recycling initiatives (Figure 9). This shift has significantly reduced the amount of waste sent to landfills, promoting the recovery of valuable materials that can be reintegrated into the local economy. Moreover, the program's workshops on sustainable practices have educated 1,220 community members on the principles of circular economics, highlighting the importance of resource efficiency and waste reduction. As a result, many participants have adopted practices such as composting organic waste, which not only minimises landfill use but also enhances soil quality and supports local agriculture. The integration of circular economy principles within the DM program has led to the formation of local environmental committees that oversee ongoing waste management initiatives, ensuring sustainability and community engagement(Elia et al., 2024; Sugiarto et al., 2021; Suroto et al., 2014).

2. Student activity in the *Mahasiswa Membangun Desa* (MMD) Program

a. Youth Planting Initiatives

Youth represent a vital human resource in tree-planting initiatives aimed at mitigating global warming, particularly in rural areas where such efforts can have a

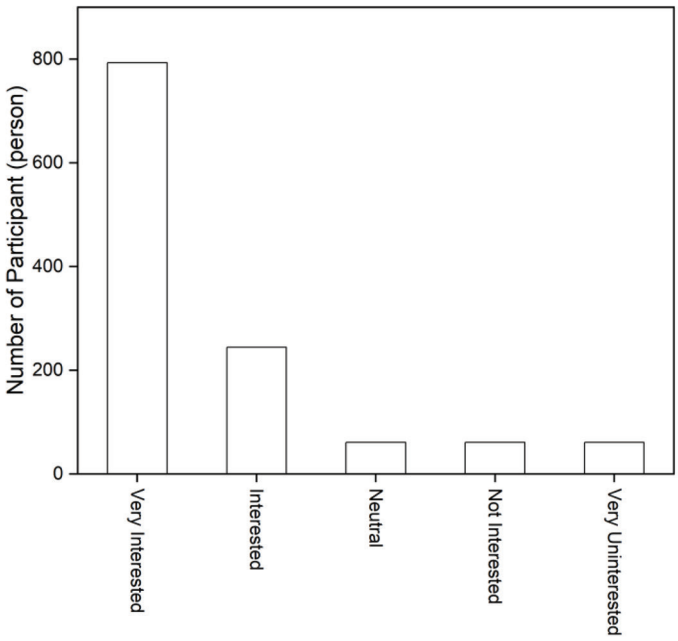

Figure 9. Response of the community to household participation in recycling initiatives.

Figure 10. The activity of students during MMD.

significant impact. Engaging young people in tree planting not only helps combat climate change by enhancing carbon sequestration but also fosters environmental stewardship and community involvement (Pearsall et al., 2024). Their energy and enthusiasm can drive innovative approaches to reforestation and sustainable land management while providing them with valuable skills and knowledge about ecological conservation (Raman et al., 2024; Sousa-Silva et al., 2023). In designated villages, youth-led initiatives can empower local communities, promoting sustainable practices and ensuring the longevity of reforestation projects. By involving the younger generation in these activities, communities can build resilience against climate change, improve local biodiversity, and enhance their overall environmental health.

As part of the MMD program, students led tree-planting campaigns in partnership with local residents (Figure 10). A total of 7,000 trees were planted across 30 regencies, with a specific emphasis on species that aid in carbon sequestration and soil stabilisation. Observational data indicated that villages involved in tree-planting activities experienced a 15% decrease in landslide incidents during the rainy season, demonstrating the immediate environmental advantages of the initiative.

b. Youth Community-Based Recycling Programs

Youth community-based recycling programs play a crucial role in promoting environmental sustainability and fostering a culture of waste reduction among younger generations. These programs engage youth in hands-on activities that educate them about the importance of recycling and waste management, encouraging them to take an active role in their communities (Raman et al., 2024). By participating in local recycling initiatives, young people not only learn about environmental stewardship but also develop leadership skills and a sense of responsibility towards their surroundings(MacDonald et al., 2023). Such programs have been shown to increase recycling rates significantly, as youth mobilize their peers and families to adopt more sustainable practices (Buttazzoni et al., 2024). Additionally, these initiatives help create awareness about the circular economy, illustrating how materials can be repurposed and reused, ultimately reducing waste and conserving resources for future generations.

The MMD students helped establish community-based recycling programs in rural areas. The students played a key role in establishing community-based recycling programs that encouraged local residents to engage in waste management efforts actively. As a result of these initiatives, 65% of households started practising waste separation and participated in recycling, significantly reducing the amount of waste sent to local landfills. This shift not only addresses waste disposal challenges but also conserves natural resources by promoting recycling. The students introduced the 3R framework—Reduce, Reuse, Recycle—as an effective method for managing waste. This framework emphasizes minimizing waste production, repurposing materials, and recycling to lessen environmental impact. In fact, 90% of surveyed community members reported that the 3R framework was highly effective in reducing plastic waste, underscoring its significance in promoting sustainable behaviour. Through these initiatives, the MMD students not only enhanced waste management practices but also encouraged long-term environmental awareness and responsibility among local residents.

c. Youth Sustainability of Practices

Youth sustainability of practices programs is essential for empowering young people to adopt and promote sustainable behaviours that contribute to environmental stewardship and community resilience. These initiatives focus on educating youth about sustainability concepts, including energy conservation, waste reduction, and biodiversity protection, while encouraging them to implement these practices in their daily lives (Buttazzoni et al., 2024). Involving youth in hands-on projects, like community gardens or renewable energy workshops, fosters practical skills and a deeper understanding of ecological systems (Leal Filho et al., 2018). Moreover, when young individuals actively engage in sustainable practices, they become advocates for change within their communities, influencing their peers and families to adopt similar behaviours (Filho et al., 2023a). This ripple effect not only enhances the overall sustainability of local practices but also cultivates a generation of environmentally conscious citizens committed to addressing climate challenges.

The MMD program has significantly advanced youth sustainability of practices by actively engaging students in grassroots initiatives that promote environmental awareness and sustainable behaviours in rural communities. Through this program, students work collaboratively with local residents to implement projects such as community gardens, waste management systems, and renewable energy workshops, which not only educate youth about sustainable practices but also empower them to take leadership roles within their communities (Filho et al., 2023b, 2023a). As a result, participants have reported increased knowledge and commitment to sustainability, leading to a measurable improvement in local environmental practices. Surveys indicate that approximately 70% of youth involved in the MMD program continued to apply sustainable practices, such as recycling and organic farming, even after project completion. This ongoing engagement highlights the program's effectiveness in fostering a culture of sustainability among young people, equipping them with the skills and motivation to address climate challenges and advocate for environmental stewardship in their communities.

3. DISCUSSION

The findings from this study highlight the important role that universities can play in addressing climate change through community engagement, education, and direct action. The DM and MMD programs at Brawijaya University have shown how academic institutions can bridge the gap between research and practical implementation, especially in rural communities vulnerable to the impacts of climate change (Develay & James, 2024; Filho et al., 2023a).

1. University-Community Partnerships for Climate Action

One of the central takeaways from this research is the value of university-community partnerships in promoting climate change mitigation. The DM and MMD programs offer examples of how university expertise can be translated into actionable strategies that benefit both the local environment and the community. By engaging

both lecturers and students, these programs provide a model for integrating theoretical knowledge with practical applications.

The success of the DM program in reforestation and sustainable agriculture highlights the importance of targeted, expert-led interventions in mitigating climate change. The adoption of sustainable farming practices by 65% of participating farmers, as well as the extensive community participation in reforestation efforts, showcases the effectiveness of these knowledge-sharing programs. Furthermore, the workshops on renewable energy and waste management led to significant shifts in community practices, particularly in waste management, where 60% of villages adopted new systems. The MMD program's grassroots approach demonstrated the power of student involvement in climate action. The widespread adoption of the 3R framework and the establishment of community-based recycling programs underscore the capacity of student-led initiatives to drive behavioural change. The positive results in tree planting and environmental education further indicate that when students have the right tools and knowledge, they can act as catalysts for long-term change in local communities (Buttazzoni et al., 2024; Filho et al., 2023b)

2. Challenges to Scaling Climate Mitigation Programs

Despite the positive outcomes, there are several challenges that may limit the scalability and long-term sustainability of these programs. One of the main obstacles encountered was the limited availability of resources. Both DM and MMD faced logistical and financial challenges, especially in ensuring a consistent supply of materials needed for reforestation and renewable energy projects. Addressing these resource gaps will be critical for scaling the programs and ensuring that their benefits can be sustained over time (Develay & James, 2024; Puppim de Oliveira & Bhuiyan, 2024).

In some cases, we observed that the community was resistant to change, especially when it came to new agricultural and waste management practices. This resistance usually stems from long-standing traditional practices and a lack of trust in new technologies. While the DM and MMD programs were successful in bringing about change in many areas, future initiatives may need to include more targeted strategies to overcome resistance. This could involve providing ongoing support, offering more hands-on demonstrations, and working closely with local leaders to build trust and ensure that the community is fully on board (Develay & James, 2024).

3. Sustainability and Long-Term Impact

The long-term sustainability of the initiatives introduced through DM and MMD remains an important consideration. While 70% of villages that participated in MMD projects continued the environmental practices after the program ended, there is still a need for stronger institutional frameworks to ensure that these practices can be maintained and scaled. One potential strategy for enhancing long-term impact is the establishment of local environmental committees that can oversee ongoing activities, as was observed in some communities (Ardoin et al., 2020).

Furthermore, it is crucial to maintain ongoing collaboration between Brawijaya University and local governments to ensure that these programs are not isolated initiatives but are integrated into broader regional and national climate change strategies. Although the establishment of local regulations, such as those targeting the reduction of plastic waste and land use management, represents a positive step in this direction, there is still a need for further efforts to institutionalise these initiatives (Arifin et al., 2023; Sinha et al., 2024)

4. The Role of Universities in Climate Change Mitigation

The results of this study add to the growing evidence that universities have a unique and critical role in mitigating climate change. This is particularly evident through their ability to conduct research, educate future leaders, and directly engage with local communities (Filho et al., 2023b; Leal Filho et al., 2018). The DM and MMD programs are examples of how academic institutions can use their knowledge to address real-world problems, empowering communities to take meaningful action against climate change.

These programs provide environmental benefits and help communities adapt to climate change, fostering social resilience. For instance, by adopting sustainable agricultural practices, communities can reduce carbon emissions and better withstand climate-related economic disruptions (Sinha et al., 2024; Sugiarto, Ahmad, et al., 2024). Similarly, focusing on waste management and renewable energy brings long-term economic and environmental benefits that enhance community sustainability (Sinha et al., 2024; Sugiarto et al., 2023).

5. CONCLUSION

The study emphasises the important role that universities, specifically Brawijaya University, can play in addressing climate change through community engagement and education. By examining the DM and MMD programs, it is clear that academic institutions have the potential to make significant contributions to climate change mitigation at both the local and regional levels. The DM program, through initiatives such as reforestation, sustainable agricultural practices, and educational workshops on renewable energy and

waste management, effectively raised environmental awareness and encouraged concrete actions within communities. Similarly, the MMD program enabled students to lead grassroots climate action, resulting in community-based recycling programs, tree-planting campaigns, and increased climate literacy. Despite these successes, challenges such as limited resources, community resistance, and the sustainability of practices persist. Addressing these issues will be crucial to ensuring the long-term impact and scalability of these programs. Boosting resource support, overcoming resistance through targeted outreach, and strengthening institutional frameworks can help maintain and expand these climate mitigation efforts.

Acknowledgements

The authors would like to express their sincere gratitude to Brawijaya University for the support in the implementation of the "*Doktor Mengabdi*" (DM) and "*Mahasiswa Membangun Desa*" (MMD) programs. Special thanks are extended to the faculty members, students, and local community leaders whose active participation and collaboration were essential to the success of these initiatives. In addition, we would like to express our gratitude to the editors and editorial staff of JHSSR for their assistance during publication period.

Funding

The authors received no financial support for the research.

Declaration of Conflicting Interests

The authors declare that they have no competing interests.

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Horizon J. Hum. & Soc. Sci. Res. 7 (S): 47 – 56 (2025)

Journal of Humanities and Social Sciences Research
www.horizon-JHSSR.com

RESEARCH ARTICLE
Peer-reviewed | Open Access

Eco-Impact: Evaluating the Effectiveness of Promotional Strategies Among Key Philippine Associations

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ARTICLE INFO

Article history

RECEIVED: 10-Mar-25
REVISED: 24-May-25
ACCEPTED: 18-Jun-25
PUBLISHED: 15-Jul-25

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Citation: Jennifer T. Ramos (2025). Eco-Impact: Evaluating the Effectiveness of Promotional Strategies Among Key Philippine Associations. Horizon J. Hum. Soc. Sci. Res. 7 (S), 47–56. https://doi.org/10.37534/bp.jhssr.2025.v7.nS.id1293.p47-56

ABSTRACT

Introduction: The Philippines faces multifaceted ecological challenges, including widespread deforestation, air and water pollution, and the intensifying effects of climate change. These environmental issues render the country particularly vulnerable to natural disasters such as typhoons, flooding, and droughts, thereby threatening both biodiversity and socio-economic stability. In response, various stakeholders, including associations from the business sector and academia, have undertaken initiatives to promote environmental sustainability. This study seeks to evaluate the effectiveness of promotional strategies implemented by key Philippine associations in fostering ecological awareness and encouraging environmentally responsible behaviors. **Methods:** A qualitative research design was employed, involving in-depth listening exercises and thematic analysis. The participants included servant leaders, Presidents, and members of the Boards of Directors from select Philippine associations representing the business industry and academic institutions. The study assessed a range of ecosystem-focused promotional campaigns, such as tree planting, energy and water conservation, paper and plastic use reduction, waste segregation, composting, and the promotion of renewable energy and sustainable consumer habits. **Results:** Findings revealed that while public awareness regarding environmental issues has significantly increased due to these campaigns, the translation of awareness into consistent, sustainable practices remains limited. Campaigns that incorporated culturally resonant messaging and context-specific strategies were more successful in influencing public attitudes. Furthermore, initiatives that encouraged collaboration between academic and private sector actors demonstrated greater outreach and community engagement. **Discussion and Conclusion:** The study underscores the need for an integrated communication strategy that leverages both traditional and digital media platforms to enhance the eco-impact of promotional efforts. Collaboration across sectors and the use of culturally meaningful narratives are critical in fostering deeper behavioral change. This research contributes to the evolving discourse on environmental communication strategies in Southeast Asia and offers actionable insights for designing future campaigns aimed at preserving the Philippine ecosystem.

Keywords: Environmental sustainability, Ecosystem Promotional strategies, Philippine associations, Environmental stewardship

1. INTRODUCTION

In today's competitive business environment, the effectiveness of promotional strategies is crucial for the success of organizations, particularly within key associations that represent various industries and sectors. In the Philippine context, these associations play a pivotal role in shaping and maintaining the ecosystem landscape, advocating for industry interests, and promoting the growth of their respective sectors. Understanding the impact of ecosystem promotional strategies, these associations employed is essential for optimizing their influence and ensuring long-term sustainability. According to Huong and Lan (2022), indices of coastal and marine ecosystem economic values have not been satisfactorily developed although indices have been identified as evaluation tools as used in most fields of socio-economic and environmental sciences. This issue is of utmost urgency as most coastal areas in Viet Nam are under increasing threat from developmental pressure, and indices of ecosystem economic valuations were indispensable (Houng & Lan, 2022). Young et. al (2021) identified six barriers that often inhibit a company's ability to address sustainability challenge where business ecosystems could provide a solution. These include fragmented demand, fragmented supply, matching challenge, lack of trust, insufficient co-innovation, and lack of close coordination across industries (Young et al., 2021). Companies are looking to tackle sustainability to address the challenges accompanied in the business ecosystem. This provided an opportunity to increase active engagement of the members of an association toward a business ecosystem with enhanced sustainability performance. This was supported by Choudhury, et. al (2023) and Mandal (2022) who stated that the marketing of sustainable and eco-friendly products entails distinct obstacles and prospects. Companies that successfully market these products did not only make a positive contribution towards a more sustainable future, but also appealed to a consumer base that is ecologically aware. In addition, business companies are called to act on the promotion of sustainable marketing, consumerism, environmentalism towards maintaining a sustainable environment while increasing member engagement towards advocacy success and public awareness (Choudhury & K.S, 2023; Mandal, 2022). Hence, companies and businesses realized that their responsibilities and commitment towards their customers and the society at large is important towards creating and maintaining a sustainable environment. Given the circumstances as previously discussed in this paper, this study titled, Eco-Impact: Evaluating the Effectiveness of Promotional Strategies Among Key Philippine Associations, sought to evaluate how these strategies contributed to the associations' overall objectives, such as member engagement, advocacy success, and public awareness. By analyzing the ecosystem promotional activities of selected key Philippine associations, this study aimed to identify best practices, challenges, and areas for improvement. This study employed a qualitative approach, combining document analysis and listening exercises with qualitative insights from key servant leaders and the board of directors within these associations. This comprehensive evaluation provided valuable information on the effectiveness of different promotional tactics, including digital marketing, public relations, events, and member communications. The findings of this study offered practical recommendations to enhance the Philippine ecosystem's promotional efforts while enabling the associations to serve their members and the broader community better. By doing so, this research sought to contribute to the overall strengthening of industry associations in the Philippines, ensuring they remain vital contributors to the nation's sustainable development.

Statement of the Objectives

In general, this paper evaluated the effectiveness of promotional strategies among key Philippine associations with a focus on ecosystem impact on the following parts:

1. To evaluate the reach and engagement of current promotional strategies used by key Philippine associations in fostering ecosystem awareness and participation among stakeholders.
2. To analyze the effectiveness of different promotional channels in driving ecosystem-related initiatives and partnerships within key Philippine associations, in terms of:
   a best practices
   b) challenges,
   c) areas for improvement
3. To evaluate the impact of promotional strategies on the long-term sustainability and growth of ecosystem programs supported by key Philippine associations.

Conceptual Model and Operational Framework

The study was guided by two frameworks. The Robert F. Lusch and Stephen L. Vargo (2019) framework that has gained traction in marketing ecosystems is the Service-Dominant Logic (S-D Logic), particularly its application to ecosystems and networks. This theory emphasized value co-creation through interactions between various stakeholders in a network, including businesses, customers, and partners. In the context of ecosystems, effective promotional strategies foster collaboration and value co-creation among these participants. The following

are its key points in ecosystem promotion (Lusch & Vargo, 2019):

1. *Co-creation of Value*: Promotions should focus on creating value collaboratively rather than just pushing a product or service. This involves engaging customers and partners in the promotion process.
2. *Resource Integration*: Ecosystems are about integrating resources from different stakeholders. Effective promotions leverage the unique resources and strengths of various participants in the ecosystem.
3. *Relational Exchange*: Long-term relationships are more valuable than one-time transactions. Promotional strategies should aim to build and maintain relationships within the ecosystem.
4. *Service as the Basis of Exchange*: The focus is on service provision rather than just goods. Promotions should highlight the service aspect and how it meets the needs of the ecosystem's participants.

Concurrently, the second framework from Cham and Lim's Sustainable Branding & Green Promotion published in 2021 helped this study in the conceptualization of sustainable branding which involves the alignment of an organization's brand identity with environmental values to attract socially responsible consumers or members. One approach is through *green brand positioning* which emphasized the company's commitment to sustainability, a key aspect noted in sustainable marketing literature. Its core strategies are as follows (Cham & Lim, 2021):

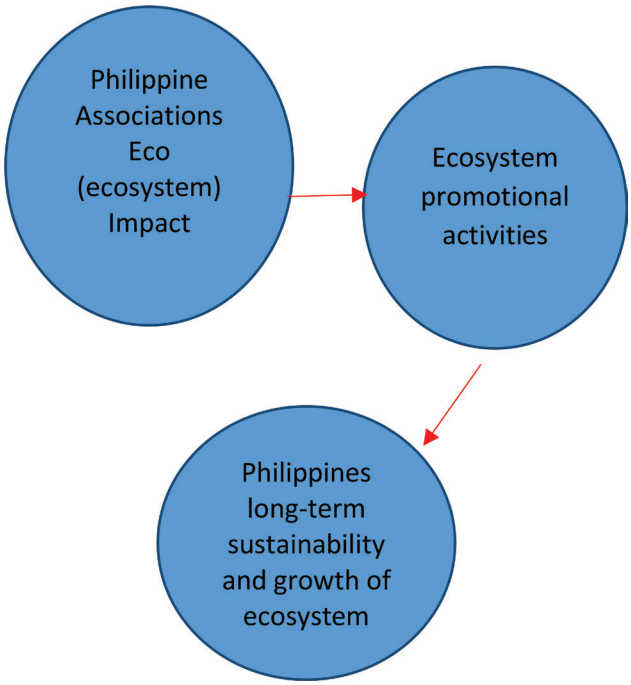

Figure 1. Operation Framework of the Study.

a. *Sustainable Branding*: Reinforce the association's identity with sustainability values to appeal to socially responsible members.
b. *Eco-friendly Communication Channels*: Utilize digital platforms over printed materials and adopt green hosting for websites.
c. *Advocacy and Education*: Conduct campaigns that increase awareness among members about ecosystem preservation and sustainability.

The effectiveness of promotional strategies among key Philippine associations with a focus on ecosystem impact in terms of the following:

2. MATERIALS AND METHODS

To explore the eco-impact promotional strategies of Philippine Associations, this study employs a qualitative research design, specifically suited to capture in-depth insights and contextual understanding.

Research Design. A qualitative approach is chosen because it allows for a deeper understanding of the complexities and nuances of eco-impact promotional strategies.

Sampling Procedure. Participants will be selected based on their direct involvement in eco-impact promotional activities within associations through purposive sampling. This may include marketing CEOs, directors, sustainability coordinators/chairs, and association managers.

Research Instrument. A semi-structured interviews were employed to capture the participants' perspectives on eco-friendly promotions, focusing on elements such as strategy implementation, challenges, and outcomes.

Research Analysis. A framework was developed to identify recurring themes, trends, and unique insights from the interviews about eco-impact on evaluating the effectiveness of promotional strategies among key Philippine Associations.

This structured analysis aims to draw a comprehensive picture of eco-impact promotional strategies within Philippine Associations to identify effective practices and potential areas for improvement.

3. RESULTS

3.1 Reach and engagement of the Association's current promotional strategies to foster ecosystem awareness and participation:

In the listening exercises through the interview, the interviewees emphasized on reach and engagement of the association's current promotional strategies to foster ecosystem awareness and participation by its servant leaders. Through this, the research found out the

2.1 Tables

2.1.1 Table on Reach and Engagement Association's current promotional strategies to foster ecosystem awareness and participation:

Themes of Responses	Sample Statement from Business Industry Associations	Sample Statement from Academe Associations
Promotional Strategies in taking care of the Philippine ecosystem: 1. Special Events 2. Fund Raising 3. 3.Selling Green Products & Packaging	*"theme of association of sustainability" (tagline)* *"fundraising through fashion show"(event/fundraising) "selling of eco-friendlyproducts" (selling)* *"SDGs Global awareness"(awareness)* *"60 members who signed up for SDGs in the Philippines"(commitment)* *"Sustainable Materials Packaging & materials" (Green Packaging)* *"Content & talks on Sustainability"(event)* *"Bio-degradable products in Baguio Summit"(green products, events)* *"anchor secularity",* *"help the community upcycle" (project based/event), X-Cool Project-Bamboo Learning App"(event)* *"Hike for a Cause"(fund raising)* *"merchandise made by bamboo materials (fund raising), "donating water pump (poso) to help provide the tribe with access for clean water" (fund raising)* *"General Membership Meetings"*	*"program sustainability practices"* *"encourage students with sustainability practices through reels competition 2X""promotion on digital marketing (less paper)" (awareness)*

2.1.2 Table on Reach and Engagement Among Association's Measure the Reach and Engagement of these Promotional Strategies:

Themes of Responses	Sample Statement from Business Industry Associations	Sample Statement from Academe Associations
Measure the Reach and Engagement of these Strategies- 1. number of participants/commitments (4X) 2. social media responses/analytics 3. sales and other KPIs 4. increase funding	*"number of participants"* *"gathered of funding's"* *"sales of eco-friendly products & hand me downs products"* *"number of corporate members"* *"annual sustainability report"* *"Social Media responses"* *"conversion to inquire"* *"social media analytics"* *"right people"* *"number of water pump(poso) for clean water"* *"attendance"*	*"number of participants"* *" campaign no printing more on digital"* *"top 3 winners to share their video on their respective SocMed pages"*

2.1.3 Table on Promotional Channels have been most Effective in Driving Ecosystem-Related Initiatives:

Themes of Responses	Sample Statement from Business Industry Associations	Sample Statement from Academe Associations
Promotional Channels have been most Effective in Driving Ecosystem-Related Initiatives: 1. Social Media 2. Buzz Marketing (WOM) 3. Collaboration 4. Special Events 5. 5.Trade Promotions 6. 6.PR	*"biggest help is social media" (4X)* *"word of mouth" (2X)"network/connection"* *"support from the company"* *"we do partnership"* *"online"* *"accelerator program for members"* *"peer learning groups"* *"collaboration here in PH and abroad"* *"trade promotions"* *"partnership"* *"collaboration"* *"speaking engagement"* *"TV & Radio became national news"* *"sponsorship from Singapore"* *"safe water to bring poso(water pump"* *"trade fair"* *"story telling"* *'Digital Platforms"*	*"social media" (2X)* *"word of mouth"* *"special events"*

2.1.4 Table on Best Practices Identified in Utilizing these Channels for Promoting Ecosystem Programs:

Themes of Responses	Sample Statement from Business Industry Associations	Sample Statement from Academe Associations
Best Practices Identified in Utilizing these Channels for Promoting Ecosystem Programs: 1. Mindfulness of the use of harmful materials like plastic. 2. Adjust to Digital Platforms/Omni 3. Story telling 4. Purpose Driven Campaign 5. Consumer Behavior on the use of environmental friendly products.	*"stop using of tarpaulin"* *"campaign must be eco-friendly"* *"using digital"* *"we used environmental friendly papers"* *"we do sustainable summit"* *"building relationship with the members"* *"we share sustainable success stories"* *"online platforms anything about sustainability"* *"trade promotions"* *"omni channel"* *"hybrid"* *"Email Marketing is Effective"* *"Integrity is best practice"* *"best servant leaders"* *"hikers with a purpose"* *'Digital group chat or online communities "*	*"we all adapt to changes"* *"buddy system"* *"utilizing SocMed channels for promoting ecosystem programs"*

2.1.5 Table on Challenges Among Associations Leaders Encountered Using these promotional channels:

Themes of Responses	Sample Statement from Business Industry Associations	Sample Statement from Academe Associations
Challenges Among Associations Encountered Using these promotional channels: *1.* Long run sustainability *2.* Conversion to revenue *3.* Time *4.* The right person/company for the right commitment *5.* Cost	*"challenge how sustain the eco-campaign"* *"it must be habit to practice"* *"green washing"* *"increase the rate of success, conversion to number"* *"manpower"" Hikers felt tired"* *"Posting of messages must be repeated"*	*"time only, busy"* *"Not all promotional channel/s willautomatically provide an outright on-line/cyberexposure."* *"boosting will entail a cost"*

2.1.6 Table on Areas Among Associations Leaders believe the Promotional Strategies Could Be Improved:

Themes of Responses	Sample Statement from Business Industry Associations	Sample Statement from Academe Associations
Promotional Strategies Could Be Improved: 1. Full blast use of Digital Channels 2. No to plastic 3. Change Mindset **4.** Conversion to numbers	*" less tarp use"* *"No to food waste"* *Packaging must environmental friendly"* *"no use of plastic"* *"use of your own bottle of water anywhere/everywhere"* *"measure-how changing life"* *"do something today"* *"embrace of multiplatforms"* *"expenses, profitable, investment yield"* *"season of hiking this last Quarter of the Year"* *"strengthen volunteerism & training"* *"commitment"* *"Personalization and continuous periodical notification"*	*"use of digital channels "* *"paper less to reduce the waste"* *"reels" and shorts videos should be generated in a short span of time"*

2.1.7 Table on Promotional Strategies Impacted the Ecosystem Programs' Long-term Sustainability and Growth:

Themes of Responses	Sample Statement from Business Industry Associations	Sample Statement from Academe Associations
Promotional Strategies Impacted the Ecosystem Programs' Long-term Sustainability and Growth: 1. Initiative Programs/Campaigns 2. Opportunities for investment to the environment 3. Going Beyond Marketing/ Promotional Campaigns 4. Better Community	*"not seeing yet in the long term impact from the association"* *"Goal is to reach the SDGs* "We need to do something radical.Catch up through Forward Faster Initiative Program" *"Unified Campaign"* *"business imperative on paper products"* *"seeing opportunities on investing to the environment"* *"not just selling; there must be purpose"* *"increase recipient"* *"4 graduates (teachers) from the tribe"* *"Adapt another/new the community (tribe)"* *"Communication through digital tools and platforms"*	*"not only in marketing campaign but more on environment impact"* *"long term on environment & economic "* *"I can't speak on behalf of the association"*

following strategies: 1)special events (fundraising through fashion show, biodegradable products in Baguio Summit, encourage students with sustainability practices through reels competition, X-Cool Project-Bamboo Learning App, help the community upcycle); 2) fund raising (fundraising through a fashion show, Hike for a Cause, merchandise made by bamboo materials, donating water pump (poso) to help provide the tribe with access for clean water); 3) Selling (selling of eco-friendly products, merchandise made by bamboo materials); 4)Green Products and Packaging (Sustainable Materials Packaging & materials, help the community upcycle); and 5) Awareness ((theme of association of sustainability(tagline), SDGs Global awareness(awareness), 60 members who signed up for SDGs in the Philippines, General Membership Meetings).

3.2 Reach and engagement among Association's measure the reach and engagement of these promotional strategies:

Based on the data gathered through the interview, the interviewees emphasized the reach and engagement among the association's servant leaders to ensure the reach of these promotional strategies: 1) a number of participants/commitments (a number of participants, a number of corporate members, attendance); 2) social media responses/analytics (Social Media responses, social media analytics, to share their video on their respective social media pages, campaign no printing more on digital); 3) sales & other KPIs(sales of eco-friendly products & hand me downs products, conversion to inquire, a number of water pump(poso) for clean water, "right people," top 3 winners), and 4) increased funding (gathered of fundings).

3.3 Promotional Channels have been most effective in driving ecosystem-related initiatives:

In an interview, the interviewees emphasized that promotional channels have been most effective in driving ecosystem-related initiatives such as the following: 1) Social Media (biggest help is social media); 2) Buzz Marketing/WOM (network/connection, word of mouth); 3)Collaboration (collaboration here in PH and abroad, partnership, collaboration, accelerator program for members, peer learning groups); 4) Special Events (sponsorship from Singapore, speaking engagement); 5) Trade Promotions (trade promotions, trade fair); and 6) Public Relations (TV & Radio became national news, storytelling).

3.4 Best practices identified in utilizing these channels for promoting ecosystem programs:

The interviewees emphasized the following best practices as previously identified in utilizing the channels for promoting ecosystem programs: 1) mindfulness of the use of harmful materials like plastic (stop using of tarpaulin, campaign must be eco-friendly, we used environmental friendly papers); 2) adjust to digital platforms/omni (using digital, utilizing social media channels for promoting ecosystem programs, utilizing social media channels for promoting ecosystem programs, omni channel, email marketing is effective, online platforms anything about sustainability, digital group chat or online communities); 3) Storytelling (we share sustainable success stories); 4) purpose driven campaign (Integrity is best practice, best servant leaders, hikers with a purpose, we all adapt to changes); and 5) consumer behavior on the use of environmentally friendly products(we used environmental friendly papers).

3.5 Challenges among Associations leaders encountered using Promotional Channels:

It can be gleaned from the result of the interview that the interviewees emphasized the challenges among the leaders of the Association that they have encountered include the following: 1) long-run sustainability (it must be a habit to practice, greenwashing); 2) conversion to revenue; 3) time (time only, busy, not all promotional channel/s will automatically provide an outright online/ cyber exposure); 4) the right person/company for the right commitment (manpower, hikers felt tired); and 5) cost (boosting will entail a cost).

3.6 Areas among Associations leaders believed that promotional strategies could be improved:

In the listening exercises through the interview, the interviewees emphasized Among Associations Leaders believe that promotional strategies could be improved: 1. Full blast use of digital channels (use of digital channels); 2. No to plastic (no use of plastic, less tarp use, packaging must be environment friendly); 3. change mindset (No to food waste, use of your own bottle of water anywhere/ everywhere, do something today, personalization and continuous periodical notification); and 4) conversion to numbers (expenses, profitable, investment yield).

3.7 Promotional strategies impacted the ecosystem programs' long-term sustainability and growth:

Based on the interview, the interviewees emphasized the impact of promotional strategies on the ecosystem programs' long-term sustainability and growth: 1) initiative programs/campaigns (We need to do something radical, catch up through Forward Faster Initiative Program, unified campaign, communication through digital tools and platforms); 2) opportunities on investment to the environment (seeing opportunities on investing to the environment, not only in marketing campaign but more on environment impact); 3)going

beyond marketing/promotional campaigns (not just selling, there must be purpose, goal is to reach the SDGs, long term on environment & economic); 4)better community (increase recipient, 4 graduates (teachers) from the tribe, adapt another/new the community (tribe).

4. DISCUSSION

4.1 Reach and engagement of the Association's current promotional strategies to foster ecosystem awareness and participation:

Based on the data gathered the association between the business and the academe was mindful of creating its marketing campaign to take care of the ecosystem using different integrated marketing communications. These marketing campaigns proved that the associations are following the one approach through green brand positioning which emphasized the company's commitment to sustainability.

4.2 Reach and engagement among Association's measure the reach and engagement of these promotional strategies:

It can be gleaned from the data that doing your promotional strategies is not enough but instead knowing the performance of your promotional strategies in terms of the number of participants/commitments, social media responses/analytics, increased funding and sales, and other key performance indicators are practices that should be on the list of marketing priorities.

4.3 Promotional channels have been most effective in driving ecosystem-related initiatives:

This means that promotional channels have been most effective in driving ecosystem-related initiatives. These include social media, Buzz Marketing (WOM), collaboration, special events, trade promotions and public relations. The associations used hybrid promotional channels.

4.4 Best practices identified in utilizing these channels for promoting ecosystem programs:

It can be derived from the data that the best practices identified in utilizing the promotional channels in promoting ecosystem programs include mindfulness of using harmful materials like plastic, adjust to digital platforms/omni, storytelling, purpose-driven campaigns, and consumer behavior on environmentally friendly products. Associations could improve their positioning by utilizing channels to promote ecosystem programs. The researcher agreed on the insights of Mandal (2022)who stated that companies and businesses should realize their responsibilities and commitment towards their customers and the society at large and work towards creating and maintaining a sustainable environment (Mandal, 2022).

5. CONCLUSION

The research concludes that the reach and engagement Association's promotional strategies effectively fostered ecosystem awareness and participation by leveraging both traditional and digital approaches. The insights from servant leaders highlighted the importance of this combined strategy in expanding outreach and enhancing engagement. Integrating conventional methods with digital platforms strengthened the association's ability to connect with diverse audiences, reinforcing its commitment to ecosystem advocacy.

In measuring reach and engagement among the association's servant leaders highlighted are the critical role of commitment, social media analytics, and financial outcomes sales and funding grow thin the effectiveness of promotional strategies. The interviewees underscored that a committed leadership amplifies outreach efforts, while data-driven insights from social media analytics ensured targeted engagement. Additionally, achieving sales and funding milestones reflected the successful alignment of promotional strategies with the association's objectives. This approach strengthened the association's ability to connect meaningfully with its audience and enhance overall impact.

This research highlighted that promotional channels, particularly social media, buzz marketing, special events, and trade promotions, play a significant role in advancing ecosystem-related initiatives. Insights from listening exercises and interviews revealed that these channels effectively engaged audiences, fostered awareness, and stimulate participation in sustainability-focused activities. Social media emerged as a powerful tool due to its extensive reach and capacity for interaction, while buzz marketing created organic engagement that enhances message credibility. Special events and trade promotions also generated direct, hands-on experiences, further embedding eco-friendly values. Collectively, these promotional strategies served as critical catalysts in driving awareness and action in ecosystem-related initiatives.

In summary, the best practices for promoting ecosystem programs through effective channels hinged on mindfulness, storytelling, purpose-driven campaigns, and consumer behavior insights. By fostering mindfulness, brands can encourage conscious decision-making and deepen connections with eco-friendly values. Storytelling allowed for authentic communication that resonates emotionally, bringing sustainability messages to life. Purpose-driven campaigns aligned with brand values

on societal goals, enhanced trust and loyalty among consumers. Finally, understanding consumer behavior regarding environment friendly products enabled targeted strategies that fulfill customer expectations for sustainable solutions. Together, these practices support impactful, responsible promotion of ecosystem programs that drive both awareness and action toward a greener future.

The listening exercises conducted through interviews highlighted several significant challenges faced by association leaders in utilizing promotional channels effectively. First, long-run sustainability emerged as a critical concern, indicating the need for ongoing commitment and resources to maintain impactful promotional efforts. Additionally, the conversion of promotional activities into revenue remains a challenging aspect, as leaders strive to align their marketing strategies with tangible financial outcomes. Time constraints were also noted, emphasizing the need for efficient planning and execution to maximize promotional effectiveness. Furthermore, identifying the right person or company to ensure the necessary commitment to promotional initiatives is vital for success. Finally, cost considerations play a crucial role in the decision-making process, as leaders seek to balance budget limitations with the need for effective promotional strategies. Addressing these challenges will be essential for associations aiming to enhance their promotional efforts and achieve sustainable growth.

In conclusion, the insights gathered from the interviewees highlighted the crucial role of promotional strategies in ensuring the long-term sustainability and growth of ecosystem programs. Emphasizing the significance of initiative programs and campaigns, they pointed out the vast opportunities for investment in environmental efforts, showcasing the need to go beyond traditional marketing approaches. Ultimately, these strategies fostered a better community, illustrating that effective promotion is not merely about visibility but is integral to nurturing sustainable practices that benefit both the environment and society as a whole.

6. RECOMMENDATIONS

To further explore the evaluating, the effectiveness of promotional strategies among key Philippine associations with a focus on ecosystem impact on the following:

1. Encourage partnerships with industry bodies like the Philippine Marketing Association (PMA), Council of Marketing Educators, Philippine Chamber of Commerce and Industry (PCCI), and other associations.
2. Developing a comprehensive digital strategy that effectively engages associations and their members in promoting ecosystem impact is imperative. Work with associations to introduce incentive programs for member organizations that adopt sustainable practices or promote Eco-Impact strategies.
3. Collaborate with educational institutions, facilitated through groups like the Council of Marketing Educators and Philippine Collegiate Business Schools (PACSB).
4. Fostering public-private partnerships by engaging with government-linked associations like the Philippine Economic Zone Authority (PEZA) and the Philippine Exporters Confederation (PHILEXPORT) is essential. These partnerships can significantly contribute to promoting sustainable practices and Eco-Impact strategies.

Acknowledgements

I would like to express my gratitude to the editors and editorial staff of JHSSR for their assistance during publication period.

Funding

The author received no financial support for the research.

Declaration of Conflicting Interests

The author declares that she has no competing interests.

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Dr. Ramos has authored several e-books and manuals, including Growth Mindset and Flexibility of Learning @ 50, Project-Based Learning for CHED Memo No. 17 (s. 2017), and the Marketing Intelligence Facilitator's Guide and Manual for the DTI-PTTC's SME Global Academy.

Believing that education is most effective when grounded in experience, she actively engages in business, research, training, consulting, mentoring, and writing. Her life philosophy—"Adversity is not a curse; it is a blessing"—continues to guide her leadership and impact.

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Horizon J. Hum. & Soc. Sci. Res. 7 (S): 57 – 68 (2025)

Journal of Humanities and Social Sciences Research
www.horizon-JHSSR.com

RESEARCH ARTICLE
Peer-reviewed | Open Access

Bringing the Climate Crisis into the Classroom: Lessons from Mae Fah Luang University

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ARTICLE INFO

Article history
Received: 10-Mar-25
Revised: 20-Apr-25
Accepted: 05-Jun-25
Published: 15-Aug-25

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Citation: Maya Dania (2025). Bringing the Climate Crisis into the Classroom: Lessons from Mae Fah Luang University. Horizon J. Hum. Soc. Sci. Res. 7 (S), 57–68. https://doi.org/10.37534/bp.jhssr.2025.v7.nS.id1294.p57-68

ABSTRACT

Introduction: Climate change presents an urgent global challenge that demands action across all sectors, including education. In alignment with Sustainable Development Goal 13 (SDG 13), this study investigates how Mae Fah Luang University (MFU) integrates climate crisis topics into its higher education curricula. The focus is on the "Introduction to Sustainable Development" course, which serves as a lens to assess students' knowledge, attitudes, and practices (KAP) regarding climate change. **Methods:** A mixed-methods research design was employed, combining quantitative and qualitative data. A structured KAP survey was administered to 100 undergraduate students across various disciplines. This was complemented by classroom observations and semi-structured interviews to gain deeper insights into student engagement and instructional methods. **Results:** Findings revealed significant differences in climate awareness based on academic discipline and gender. Health and Medical Sciences students showed the highest understanding of the causes of climate change (53.13%), Humanities and Social Sciences students demonstrated the most awareness of environmental impacts (65.71%), and Science and Technology students exhibited the strongest grasp of SDG 13 objectives (60.61%). Female students consistently scored higher across all indicators of climate awareness compared to male and non-binary peers. Qualitative data indicated a strong student preference for more interactive learning methods and better resource support to deepen their engagement with climate issues. **Discussion:** The data suggest that while MFU's curriculum has initiated meaningful engagement with climate education, there remain gaps in pedagogy and content delivery. Incorporating Bloom's Taxonomy could help scaffold learning from basic understanding to advanced critical thinking and application. Furthermore, interdisciplinary collaboration and community-based learning are essential to build comprehensive climate literacy among students. **Conclusions:** Integrating climate crisis education effectively within university curricula requires more than content inclusion—it demands pedagogical innovation, gender-sensitive strategies, and ongoing assessment. The study recommends adopting active learning frameworks and fostering interdisciplinary and community partnerships to empower students as future leaders in climate action and sustainability.

Keywords: Climate Crisis, University Curriculum, SDG 13, Classroom-Based Research, Mae Fah Luang University

1. INTRODUCTION

Integrating climate crisis education within university curricula is essential for preparing future leaders to address global environmental challenges. Universities serve as pivotal knowledge centers, equipping students with the skills and awareness necessary to respond effectively to climate issues (McCowan, 2021; Guevara et al., 2024). At Mae Fah Luang University (MFU), climate change education has been embedded into the "Introduction to Sustainable Development" course, aligning with Sustainable Development Goal 13 (SDG 13) on climate action. This initiative aims not only to raise awareness but also to foster active participation in climate solutions (Brennan & Quinton, 2020).

The urgency for climate education in higher learning arises from the accelerating impacts of climate change, including rising temperatures and biodiversity loss, which present both environmental and ethical imperatives that intersect social, economic, and political dimensions (Barnett, 2020). Vulnerable populations, particularly in Southeast Asia, are disproportionately affected (Otto et al., 2017). As global awareness of these issues grows, educational institutions must advance beyond purely scientific teaching to deliver interdisciplinary education that connects climate science with social equity and sustainable economic practices (Disterheft et al., 2013). MFU's curriculum addresses this need, encouraging students to engage with climate challenges through critical thinking and collaborative problem-solving.

This study evaluates the integration of climate crisis topics in MFU's curriculum by using a Knowledge, Attitudes, and Practices (KAP) survey administered to 100 students from diverse academic disciplines. The primary objective is to assess students' climate awareness and readiness for climate action, with secondary aims to explore how gender and academic background influence climate perceptions. Recommendations are presented to enhance curriculum design, emphasizing interdisciplinary learning and the structured use of Bloom's Taxonomy to scaffold knowledge progression from foundational to advanced analytical skills (Hargis et al., 2020).

MFU's position in Northern Thailand, a region facing significant climate risks, underscores the relevance of embedding climate education within its curriculum. This initiative aligns with global frameworks while addressing local environmental challenges, supporting the international call for comprehensive climate education across disciplines (Bina & Pereira, 2020; Lozano et al., 2013).

This study contributes to the discourse on climate education within higher education, identifying gaps in fostering interdisciplinary links between climate science, economics, policy, and social justice (Ahmad, 2024). Results indicate that female students generally exhibit higher climate awareness than their male peers, underscoring the value of gender-sensitive approaches. Additionally, the findings emphasize the need for interactive and experiential learning methods that extend beyond traditional instruction, promoting engagement and active learning (Kolb & Koln, 2006).

This paper is structured as follows: a conceptual framework and literature review on climate education in higher education are presented first, followed by the methodology outlining the KAP survey design and mixed-methods approach. The findings discuss climate awareness differences across gender and academic disciplines. Finally, the discussion offers recommendations for strengthening climate education at MFU, with a focus on Bloom's Taxonomy as a framework and strategies for interdisciplinary collaboration and enhanced student engagement in climate action.

1.1. Conceptual Framework

Integrating climate crisis education into university curricula is vital for empowering the next generation of leaders to address pressing global climate challenges. Universities, as centers of knowledge and drivers of social change, play a key role in fostering climate action through education. This study focuses on Mae Fah Luang University (MFU), exploring how its curriculum weaves into climate crisis education, Sustainable Development Goal (SDG) 13, and the Knowledge, Attitudes, and Practices (KAP) framework. These elements form the backbone of MFU's approach to climate education, with Bloom's Taxonomy enriching the curriculum to promote critical thinking and problem-solving skills (Ahmad, 2024; McCowan, 2021). The conceptual framework is presented in Figure 1 below.

Climate change is more than an environmental issue; it's an ethical and social responsibility intricately linked to economic and political dimensions (Barnett, 2020). As climate disruptions intensify, the need for interdisciplinary climate education in universities grows more urgent. Higher education institutions hold a unique role in bridging scientific understanding with social justice, inspiring students to tackle climate issues both in their communities and on a global scale (Bina & Pereira, 2020; Guevara et al., 2024).

At Mae Fah Luang University (MFU), the curriculum integrates climate science, sustainability, and policy, aligning closely with global standards like SDG 13 (Brennan & Quinton, 2020). This study employs the Knowledge, Attitudes, and Practices (KAP) framework to assess students' climate awareness, attitudes, and behaviors across various academic disciplines and genders, fostering

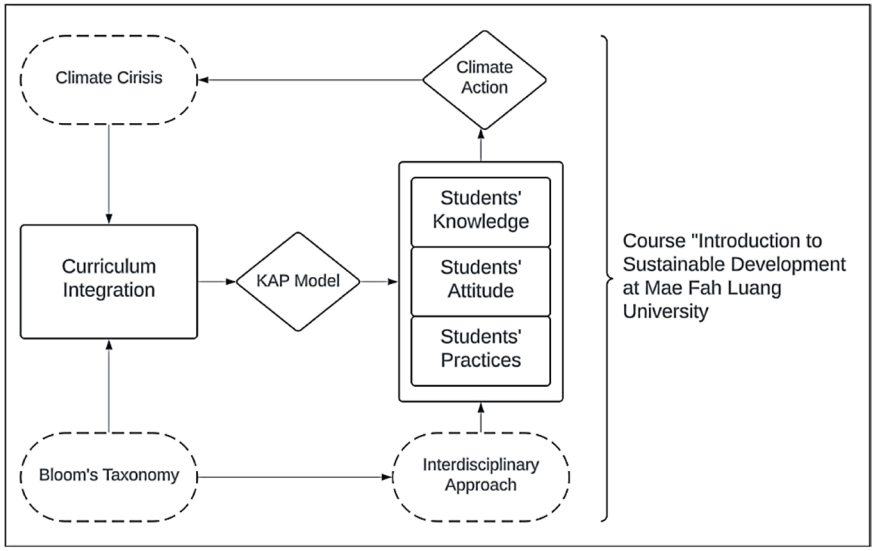

Figure 1. Conceptual Framework.

a shift from rote learning to critical engagement with real-world issues (Disterheft et al., 2013). Bloom's Taxonomy further structures this learning journey, moving students from basic knowledge to applied analytical skills (Hargis et al., 2020).

The framework suggests that a thoughtfully designed interdisciplinary climate curriculum at MFU will elevate students' understanding, attitudes, and actions regarding climate issues. Additionally, it explores how gender and academic background might shape climate awareness and involvement, acknowledging findings that female students often show higher climate sensitivity (Lozano et al., 2013; Otto et al., 2017). This recognition underscores the importance of gender-sensitive strategies in climate education.

This study adds to the broader dialogue on climate education in universities. While steps are being made to incorporate climate topics, challenges remain, especially in linking climate issues with policy, economics, and social justice (Kolb & Koln, 2006). Through its focus on interactive, experiential learning, this research offers actionable insights for enhancing climate literacy and empowering students to take meaningful action (McCowan, 2021; Guevara et al., 2024).

In conclusion, the conceptual framework builds on interdisciplinary climate education, shaped by Bloom's Taxonomy and the KAP model. By evaluating how curriculum design influences student outcomes, this study supports efforts to strengthen climate education and foster proactive climate engagement. It also highlights the significance of addressing gender and disciplinary diversity to ensure climate education is inclusive and impactful (Ahmad, 2024; Hargis et al., 2020).

1.2. Literature Review

1.2.1. Introduction to Climate Crisis Education and Sustainable Development Goals (SDG 13) in Higher Education

Climate crisis education is becoming increasingly urgent for meeting global challenges, especially under Sustainable Development Goal 13 (SDG 13: Climate Action). Education for Sustainable Development (ESD) is about more than knowledge transfer; it's about building real-world skills to address complex environmental, social, and economic challenges. Through ESD, students develop critical thinking, problem-solving abilities, and an active engagement with climate issues, empowering them to contribute to both climate mitigation and adaptation (Barth et al., 2007; Avelar et al., 2023; Bonilla-Jurado et al., 2024).

Universities play a unique role here. As centers of learning and change, they bring together the different threads of environmental, social, and economic issues. However, there are still barriers, including a lack of representation for non-scientific disciplines in sustainability initiatives and constraints around resources and faculty training (Chankseliani & McCowan, 2021; Leal Filho et al., 2022). These gaps make it difficult to deliver truly inclusive ESD programs that reach all corners of academia.

At Mae Fah Luang University (MFU), for instance, climate education is woven into the curriculum through frameworks like Bloom's Taxonomy and the Knowledge, Attitudes, and Practices (KAP) model. This approach encourages students to build skills that go beyond classroom learning, preparing them to address global climate issues actively. Other universities, including those in Latin America and Africa, are adopting similar methods,

reinforcing how crucial interdisciplinary learning is to climate action (UNESCO, 2023; Leal Filho et al., 2022).

The real measure of success in climate education isn't just student understanding but how students' attitudes shift and the practical actions they choose to take. ESD programs that prioritize hands-on learning and community involvement tend to create students who are more motivated and committed to climate action (Leal Filho et al., 2020). Yet, a major gap still exists; without enough long-term studies, we can't fully gauge whether these programs lead to lasting behavioral changes (Orakhelashvili, 2024). Even with progress, there's work to do. Many non-environmental disciplines remain on the sidelines, and we need more data on the lasting effects of climate education. Universities must also step-up faculty training to ensure ESD programs reflect the latest in climate research (UNESCO, 2021; Sustainable Earth Reviews, 2022). A truly interdisciplinary approach is essential for preparing both students and educators to play an active role in climate solutions.

In summary, climate crisis education has the potential to drive change, but universities need to address the gaps in curriculum, educator support, and interdisciplinary collaboration. Only by building a well-rounded, inclusive approach can they contribute meaningfully to SDG 13 and cultivate the climate leaders of tomorrow.

1.2.2. Defining Key Frameworks in Climate Education

Sustainable Development Goal 13 (SDG 13) highlights the urgent need for global climate action, and universities are uniquely positioned to make a difference by integrating climate education across a range of fields. Effective climate education isn't just about understanding the science; it's about equipping students with practical skills to address complex, real-world climate challenges. These challenges are inherently interdisciplinary, bringing together environmental science, social justice, policy, and economics (Monroe et al., 2019; Reimers, 2021).

Climate education aims to cultivate not only climate literacy but also critical thinking and problem-solving. As Monroe et al. (2019) point out, climate education becomes much more impactful when it crosses disciplinary boundaries, showing students the links between environmental and socio-economic issues. By using frameworks like Bloom's Taxonomy, educators can guide students from basic understanding to advanced skills like analysis and problem-solving. This approach transforms students into active thinkers who engage deeply with climate challenges, moving beyond passive learning (Reimers, 2021).

The Knowledge, Attitudes, and Practices (KAP) model adds another dimension, helping to measure how well climate programs foster understanding and inspire action. Studies using the KAP model have identified gaps in students' climate awareness and readiness to take action, reinforcing the need for climate curricula that evolve. By tracking how knowledge, attitudes, and practices change, universities can better shape programs that inspire both immediate and long-term engagement with climate issues (Leal Filho et al., 2020; Monroe et al., 2019).

Some universities are already leading the way in this space. The University of Groningen, for example, integrates sustainability themes into courses across law, business, and environmental science, underscoring the importance of making climate education relevant to different fields (Leal Filho et al., 2020). In Latin America, universities blend theoretical learning with hands-on, community-focused climate action, demonstrating how higher education can spark real innovation in tackling climate challenges (UNESCO, 2023).

Measuring success in climate education goes beyond just knowing the facts; it's about fostering practical skills and a proactive mindset that students carry into their lives and careers. However, a significant gap remains: we still need more long-term studies to see if this education results in sustained climate action post-graduation. More research is essential to understand if the climate literacy students gain translates into lasting behavioral changes (Orakhelashvili, 2024). And while environmental science programs tend to cover climate topics well, other areas like business, humanities, and social sciences often lack this focus. This gap is especially apparent in business and economics, where traditional growth models still tend to dominate over sustainable ones (Chankseliani & McCowan, 2021; Reimers, 2021).

In short, universities have a crucial role in advancing SDG 13 by embedding well-rounded, interdisciplinary climate education into their curricula. To reach their full potential, they need to close gaps in curriculum design, faculty training, and cross-disciplinary integration. Expanding climate education into non-environmental fields and conducting long-term studies to assess its impact will be essential for preparing students to tackle the climate issues of today and tomorrow. With a holistic approach, universities can become powerful catalysts for climate action, driving progress toward the ambitious goals of SDG 13 (Orakhelashvili, 2024; UNESCO, 2023).

2. MATERIALS AND METHODS

We designed a mixed-methods study to explore how effectively climate crisis topics are integrated into the "Introduction to Sustainable Development" course at Mae Fah Luang University (MFU), focusing on Sustainable Development Goal 13 (SDG 13). By combining surveys with in-depth interviews, we gathered both broad

Table 1. KAP Questions.

Section	Question Code	Question
Knowledge	K1	I am aware of the main causes of climate change, such as greenhouse gas emissions and deforestation.
	K2	I understand the relationship between climate change and rising global temperatures.
	K3	I am familiar with international climate agreements, such as the Paris Agreement and SDG 13.
	K4	I know how climate change affects global ecosystems and biodiversity.
	K5	I am aware of the local impacts of climate change in my country/region.
	K6	I can explain the main goals of Sustainable Development Goal 13 (SDG 13).
Attitudes	A1	I believe that urgent action is required to combat climate change.
	A2	I feel personally responsible for taking steps to reduce my carbon footprint.
	A3	I am optimistic that global efforts can reverse the effects of climate change.
	A4	I think climate change should be a priority issue for all governments and organizations.
	A5	I believe individual actions can make a significant impact in fighting climate change.
Practices	P1	I actively reduce, reuse, and recycle to minimize my environmental impact.
	P2	I take steps to reduce my carbon footprint, such as using public transportation or conserving energy.
	P3	I participate in environmental campaigns or sustainability initiatives at my university or community.
	P4	I seek out opportunities to learn more about climate change and sustainability.
	P5	I have made lifestyle changes to minimize my contribution to climate change.

statistical insights and personal student perspectives (Creswell & Creswell, 2018).

To capture a diverse range of views, we used stratified random sampling to select 100 students from MFU's clusters in Health and Medical Sciences, Humanities and Social Sciences, and Science and Technology. Within each cluster, we considered gender and academic discipline to see if these factors impacted students' climate awareness and engagement (Leal Filho et al., 2020). Each student completed a Knowledge, Attitudes, and Practices (KAP) questionnaire that measured their understanding, opinions, and actions related to climate change. The survey was divided into three sections—Knowledge, Attitudes, and Practices—and students rated each item on a five-point scale from 1 (Strongly Disagree) to 5 (Strongly Agree) (Cohen et al., 2018). A detailed list of the questions is available in Table 1 below.

The Knowledge section (K1–K6) evaluates how well students grasp the causes and effects of climate change and understand global frameworks like SDG 13. To develop these questions, we drew on research by McCright (2010), which examines public knowledge about climate change, and Fielding et al. (2010), which addresses common misconceptions. The choice to include international frameworks reflects insights from UNESCO (2017) on how global educational frameworks shape climate awareness.

The Attitudes section (A1–A5) explores students' views on the urgency of climate action and their sense of personal responsibility. This section is informed by Heath and Gifford's (2006) work on personal and collective efficacy, which explores how people view their role in addressing climate issues. Finally, the Practices section (P1–P5) looks at how students translate their knowledge and attitudes into actions, such as recycling or conserving resources, inspired by Ajzen's (1991) Theory of Planned Behavior and Vining and Ebreo's (1992) Environmental Action Scale.

To better understand students' engagement and the effectiveness of the curriculum, we collected data through semi-structured interviews with 20 students and classroom observations. In the interviews, students were encouraged to talk about their experiences with climate education, any challenges they faced, and ideas for improvement. Questions like, "How do you feel about climate change topics in your courses?" and "What challenges do you face in learning about climate change?" helped us capture their personal experiences, providing valuable insights for enhancing the curriculum.

Classroom observations added a different perspective, allowing us to see student participation and engagement with climate topics in real-time. Observers noted how students interacted during discussions and group activities, identifying areas where the theory-to-practice link could be strengthened. These observations highlighted the need for more interactive learning experiences, especially where students struggled with complex topics or limited resources. Observers recorded their findings as field notes, and all interviews were transcribed for a detailed thematic analysis (Merriam & Tisdell, 2015). For quantitative analysis, we used SPSS to run descriptive statistics and ANOVA to explore any differences across disciplines and genders (Field, 2013). Qualitative data from interviews and observations were

then analyzed for themes using Braun and Clarke's (2006) method, revealing patterns in how students experience and perceive climate education. This combined approach offered a comprehensive look at how students engage with climate topics and pointed to actionable ways to improve the learning experience.

3. RESULTS

As climate change becomes one of the most pressing challenges of our time, universities are stepping up to prepare future leaders to meet these complex issues head-on. Guided by Sustainable Development Goal 13 (SDG 13), universities are uniquely positioned to build climate awareness and inspire meaningful action. Integrating climate-related topics into courses like "Introduction to Sustainable Development" at Mae Fah Luang University (MFU) is an essential step toward fostering a sense of responsibility and encouraging proactive behaviors among students.

In this study, we used the Knowledge, Attitudes, and Practices (KAP) model to measure how well students understand climate change, their attitudes toward taking action, and the steps they're actually taking to make a difference. We surveyed 100 students from MFU's Health and Medical Sciences, Humanities and Social Sciences, and Science and Technology clusters, aiming to capture a range of perspectives and see if factors like academic background or gender influence their climate awareness and actions. Using SPSS for analysis, we looked at descriptive statistics. We ran ANOVA tests to uncover any significant differences across these groups, giving us valuable insights into how students from different fields approach climate issues and where more support might be needed.

3.1. Climate Change Awareness and Optimism

The analysis of the Knowledge, Attitudes, and Practices (KAP) survey revealed significant differences in climate change awareness across academic clusters and genders. The KAP model assessed students' understanding of climate change causes, environmental effects, and SDG 13, as well as their attitudes and engagement in climate-related practices. Table 2 shows notable variations in how students from Health and Medical, Humanities and Social Sciences, and Science and Technology disciplines engage with climate topics.

Health and Medical students showed the highest awareness of climate change causes, with 53.13% reporting a strong understanding, likely due to the link between climate and public health (Watts et al., 2018). Humanities and Social Sciences students demonstrated the highest awareness of environmental effects (65.71%) and optimism (68.5%), reflecting their focus on socio-economic impacts (Leichenko & Silva, 2014). Science and Technology students were most familiar with SDG 13, with 60.61% showing a strong awareness of global climate frameworks, likely due to their focus on technological solutions. Additionally, female students generally exhibited greater awareness and more proactive attitudes toward climate action than their male and non-binary peers, as shown in Table 3.

The gender-based analysis showed that female students had higher awareness and engagement levels across all categories. For example, 55% of female students knew how to protect themselves from climate change, compared to 44% of males and 42% of non-binary students. Knowledge of climate change reduction strategies was more evenly distributed, with 44% of both male and female students and 36% of non-binary students reporting awareness. Regarding optimism, 52% of female students believed reversing global warming is possible, compared to 46% of males and 48% of non-binary students. These findings align with previous studies indicating that women often show greater environmental concern and are more proactive in climate action (Zelezny et al., 2000).

Table 2. KAP Awareness and Optimism Across Clusters

Academic Cluster	Awareness of Climate Causes (%)	Awareness of Environmental Effects (%)	Awareness of SDG 13 (%)	Optimism (%)
Health and Medical	53.13%	42.5%	35.2%	53.13%
Humanities and Social Sciences	40.5%	65.71%	45.3%	68.5%
Science and Technology	45.7%	50.4%	60.61%	60.61%

Table 3. KAP Awareness Across Genders

Gender	Aware of Climate Protection (%)	Aware of Climate Reduction (%)	Believe Reversing Global Warming is Possible (%)
Female	55%	44%	52%
Male	44%	44%	46%
Non-Binary	42%	36%	48%

3.2. Factors Influencing Climate Awareness and Action

To strengthen the initial findings from the Knowledge, Attitudes, and Practices (KAP) survey, additional statistical analyses were conducted to understand better the factors influencing climate awareness and action. These analyses examined the relationship between knowledge and behavior, variations across academic years, and the impact of gender on climate-related practices, aiming to provide more robust recommendations for curriculum improvements.

By incorporating correlation, ANOVA, and Chi-Square tests, this section explores how academic progression, gender, and specific practices contribute to the effectiveness of climate education. These findings reveal how knowledge and attitudes drive real-world climate action and highlight areas where higher education institutions can enhance their climate education programs. The correlation analysis between students' climate knowledge and their practices (e.g., reducing carbon footprint, recycling) assesses whether increased awareness leads to meaningful actions, as shown in Table 4.

A positive correlation (r = 0.62) between knowledge and practices suggests that students with greater awareness of climate change causes and effects are more likely to engage in climate-friendly behaviors (e.g., reducing their carbon footprint). The p-value (< 0.001) indicates that this relationship is statistically significant. This study also looks at how students' knowledge and practices change as they progress through different academic years (freshman, sophomore, junior, senior), as shown in Table 5. This can help identify whether students' awareness grows as they are more exposed to the curriculum over time.

The ANOVA results show significant differences in both knowledge (F = 5.20, p = 0.004) and practices across academic years, with seniors exhibiting the highest levels of awareness and action. This suggests that students' engagement with climate issues improves as they progress through the university and are exposed to more educational content related to sustainability. Additionally, the study also further investigates gender differences in specific climate-related practices, such as recycling, reducing energy use, or participating in environmental campaigns, as shown in Table 6 below.

The Chi-Square analysis reveals statistically significant gender differences in climate-related practices. Female students consistently show higher participation rates across all categories, particularly in recycling (52%) and environmental campaigns (50%), when compared to male and non-binary students. Non-binary students, while showing slightly higher participation than male students, still fall behind female students in all activities. The p-values indicate that these differences are statistically significant, with values below 0.05, supporting the conclusion that gender plays a significant role in shaping climate-related behaviors.

3.3. Student Engagement, Curriculum Effectiveness, and Barriers to Learning

In addition to the quantitative data from the Knowledge, Attitudes, and Practices (KAP) survey, qualitative data were gathered through semi-structured interviews with 20 students and classroom observations to provide deeper insights into student engagement, curriculum effectiveness, and barriers to learning in climate education. These methods explored how students perceive climate change topics, apply their knowledge in daily life, and face challenges in learning. The qualitative

Table 4. Correlation Between Knowledge and Practices

KAP Category	Correlation Coefficient (r)	P-Value
Knowledge and Practices	0.62	< 0.001

Table 5. ANOVA Results for Climate Awareness Across Academic Years

Academic Year	Mean Knowledge Score	Mean Practices Score	F- Statistic	P-Value
Freshman	3.4	2.9	5.20	0.004
Sophomore	3.8	3.3		
Junior	4.1	3.7		
Senior	4.4	4.1		

Table 6. Gender and Practices

Climate Practice	Male Participation (%)	Female participation (%)	Non-Binary Participation (%)	Chi-Square Value	P-Value
Recycling	38%	52%	44%	6.15	0.013
Reducing Energy Use	45%	60%	50%	4.25	0.039
Participating in Environmental Campaigns	32%	50%	42%	8.33	0.005

findings complement the statistical results, offering important perspectives on refining climate education to foster meaningful engagement and action (Sterling et al., 2018; Leal Filho et al., 2020).

Most students expressed positive engagement with climate content, finding it relevant to global challenges and appreciating the focus on Sustainable Development Goals (SDG 13). Classroom discussions were noted for encouraging critical thinking about climate action. However, many students called for more interactive learning, such as hands-on activities and case studies, to better connect theory to practice (Tilbury, 2011). While students acknowledged the curriculum's strong foundation in climate science, they noted a gap between theory and practical application. One student remarked, "I understand the science, but I feel less prepared for real-world actions." This highlights the need for more practical skills, like carbon footprint reduction and community-based initiatives, as well as interdisciplinary collaboration on climate projects (Leicht et al., 2018).

Challenges such as time constraints and limited resources were common themes. Some students felt that climate topics were rushed due to course overload, while others noted a lack of access to up-to-date materials and digital tools (Sterling, 2001). Additionally, students expressed a desire for more cross-departmental collaboration to develop practical solutions to climate challenges (Tilbury & Wortman, 2004).

In conclusion, while students are knowledgeable about climate change, gaps remain in translating knowledge into action. The findings suggest the need for interactive learning and interdisciplinary collaboration to bridge theory and practice, enhancing student preparedness for real-world climate challenges.

4. DISCUSSION

The findings from this study point to a clear need for a more structured and hands-on approach to climate education. It's not enough for students to understand climate issues in theory; they also need the practical skills and confidence to take action. This gap between knowledge and application is significant, and if universities aim to foster real climate advocates, they must rethink how climate education is delivered. Key strategies to enhance climate education include integrating climate topics more deeply across the curriculum, adopting interactive and experiential learning methods, encouraging interdisciplinary collaboration, supporting climate-related research, engaging students in community initiatives, allocating resources effectively, and implementing regular assessments to track progress and adjust approaches as needed.

Bloom's Taxonomy stands out as an especially useful tool here, providing a step-by-step framework that can guide students from foundational knowledge to the higher-order skills essential for tackling climate challenges head-on. Moving from basic understanding to advanced critical thinking and action requires structured support, and Bloom's framework helps educators scaffold learning to achieve just that (Bloom et al., 1956; Anderson & Krathwohl, 2001). By using this approach, universities can support students in progressing from passive awareness to active problem-solving, as illustrated in Figure 2.

The results of this study reinforce the importance of using Bloom's Taxonomy to bridge the gap between what students know and what they can actually do about climate change. For example, while 53.13% of students in

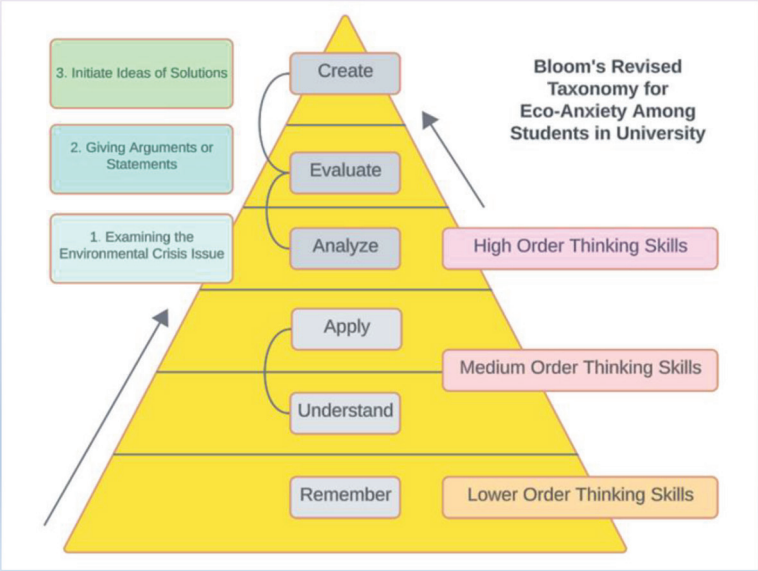

Figure 2. HOTS by Bloom's Revised Taxonomy (adapted from Krathwohl & Anderson, 2010).

the Health and Medical Sciences cluster demonstrated a strong understanding of climate causes, fewer students (44%) felt equipped to take active steps to reduce their climate impact. This shortfall is striking; it suggests that many students, while knowledgeable about climate science, feel less confident or less prepared to translate that knowledge into tangible actions. To us, this points to a missed opportunity in climate education: we are teaching students about the urgency of climate issues, but we're not giving them enough tools to become part of the solution.

At the basic levels of Remembering and Understanding, students seem to grasp key concepts, such as global warming and environmental degradation, with Health and Medical Sciences students, in particular, showing a solid awareness of climate causes. But as students move to more advanced stages, like Applying and Analyzing, where they engage with practical climate actions, the numbers drop. Only 44% of students reported knowing how to actively reduce their impact, which signals a need for a stronger emphasis on critical assessment and hands-on application.

In short, these findings suggest that universities have a powerful opportunity (and responsibility) to improve climate education by embedding more action-oriented, practical learning experiences into their curricula. This way, students can graduate not only as informed citizens but as proactive climate advocates ready to drive meaningful change.

At the advanced stages of Bloom's Taxonomy: Evaluating and Creating, students are not just absorbing information; they're analyzing climate policies and brainstorming innovative solutions. In this study, students from the Humanities and Social Sciences cluster showed a distinct optimism, with 68.57% believing in the possibility of reversing global warming. I found this particularly interesting because it seems to reflect how their exposure to social and policy frameworks shapes a hopeful perspective on climate action. By contrast, Science and Technology students, while more knowledgeable about SDG 13 (60.61%), were less optimistic. This could be due to a more scientific and perhaps more cautious view of the challenges ahead, which underscores how disciplinary backgrounds influence students' attitudes toward climate solutions.

There were also notable gender differences. Female students reported a higher awareness of personal protection strategies (55% compared to 44% of male students), while male students (65.71%) showed greater knowledge of mitigation measures. This difference suggests that each gender might be focusing on distinct aspects of climate preparedness, which makes me think that climate education could benefit from a more tailored, gender-sensitive approach that addresses these diverse perspectives.

Using Bloom's Taxonomy in climate education doesn't just align with curriculum integration and interdisciplinary collaboration; it helps move students from simply learning about climate issues to actively developing solutions. I believe this structured approach is essential to closing the gap we observed in the study: many students understand the concepts, but fewer know how to apply them in real life. By guiding students from foundational knowledge to critical thinking and hands-on problem-solving, universities can equip them to become proactive, solution-oriented climate advocates. This kind of learning isn't just theoretical; it's about preparing students to tackle real-world challenges and contribute meaningful change (Monroe et al., 2019).

5. CONCLUSION

This study makes it clear that embedding climate crisis education across university curricula is essential if we want to prepare students to address the realities of climate change truly. What stood out to us was the variation in climate awareness across disciplines. For example, students in health sciences grasped climate causes, social sciences students showed optimism and awareness of societal impacts, while tech-focused students leaned into solutions yet were more cautious about change. The gender differences also suggest that climate education isn't one-size-fits-all; female students showed stronger engagement in protective strategies, hinting at a need for approaches that resonate across diverse experiences. But perhaps the most critical takeaway is the gap between knowing and doing; students understand the issues but often struggle to act on that knowledge. Using Bloom's Taxonomy as a framework could bridge this gap by guiding students from basic awareness to practical, solution-oriented skills, helping them move from informed to actively engaged. In our view, this shift is crucial if universities are to foster not just climate awareness but genuine climate leadership.

Acknowledgment

The author would like to express her gratitude to the editors and editorial staff of JHSSR for their assistance during publication period.

Funding

This research was supported by MLII-MFU Classroom-Based Research Grant 2023.

Declaration of Conflicting Interests

The author declares that she has no competing interests.

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Horizon J. Hum. & Soc. Sci. Res. 7 (S): 69 – 86 (2025)

Journal of Humanities and Social Sciences Research
www.horizon-JHSSR.com

RESEARCH ARTICLE
Peer-reviewed | Open Access

A Web based Weather & Geoinformatics System using Multiple Linear Regression: Data Analytics Approach

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ARTICLE INFO

Article history
RECEIVED: 12-Mar-25
REVISED: 07-Jun-25
ACCEPTED: 14-Jun-25
PUBLISHED: 15-Jul-25

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Citation: Edie Boy M. Dela Cruz (2025). A Web based Weather & Geoinformatics System using Multiple Linear Regression: Data Analytics Approach. Horizon J. Hum. Soc. Sci. Res. 7 (S), 69–86. https://doi.org/10.37534/bp.jhssr.2025.v7.nS.id1295.p69-86

ABSTRACT

Introduction: Accurate and timely weather forecasting is crucial for disaster preparedness, especially in flood-prone urban areas like Valenzuela City, Philippines. This study aims to develop a localized web-based weather and geoinformatics system that predicts rainfall probabilities using a data analytics approach. **Methods:** The system employs **multiple linear regression (MLR)** algorithms to analyze various meteorological parameters, including wind velocity, atmospheric pressure, temperature, and humidity. Historical weather data were mined to identify patterns and correlations influencing rainfall events. A centralized database was designed to manage the collection, storage, and accessibility of weather-related and geospatial data for key stakeholders. **Results:** Initial implementation of the system demonstrates the potential to produce reliable and location-specific rainfall forecasts. It also provides essential real-time information such as projected floodwater levels and the availability of nearby evacuation centers, thereby enhancing situational awareness and community responsiveness. **Discussion and Conclusion:** The integration of MLR-based predictive modelling within a web-enabled geoinformatics platform offers a cost-effective and scalable solution for urban disaster risk reduction. The system is expected to support local government units and community members in making informed decisions during weather-related emergencies. Future work will focus on refining prediction accuracy through machine learning enhancements and expanding coverage to other high-risk urban areas.

Keywords: weather forecasting, geoinformatics, machine learning, multiple linear regression, data mining, disaster risk management.

1. INTRODUCTION

Weather prediction has emerged as one of the most challenging domains over the past generation, significantly influenced by advancements in data science. Modern forecasting leverages various technological tools that enhance meteorological analysis beyond traditional methods, which primarily rely on surface observations and aerial research (VamsiKrishna, 2015). Recent innovations, particularly in machine learning and data mining, have transformed approaches to analyzing historical data, facilitating better planning and forecasting across multiple fields, including E-commerce and market exchanges (Yadav & Khatri, 2019). As climate research increasingly relies on data mining algorithms to analyze evolving trends—such as temperature extremes, wind intensity, and precipitation—these methods extract valuable insights from extensive historical data, enhancing our understanding of climate variables over the last decade (Ekereke & Akpojaro, 2019).

In the Philippine context, the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA) traditionally oversaw meteorological

forecasting. Meteorological forecasting involves the statistical analysis of potential atmospheric conditions. Climatic conditions refer to the state of the atmosphere at a specific time, expressed in units of key meteorological variables. The accuracy of meteorological predictions varies geographically due to regional disparities in weather patterns. In the Philippines, cloud cover, precipitation, and atmospheric conditions are subject to significant variability and are of particular interest to forecast users. To generate accurate forecasts, meteorologists must possess a comprehensive understanding of atmospheric conditions across a wide area. The precision of their predictions is contingent upon their awareness of regional climate patterns. Forecasting decisions are informed by a variety of predictive methods. The weather chart serves as a foundational tool for meteorologists."

The study aimed to develop a web-based weather forecasting using machine learning. It sought to answer the following questions: (1) How can a web-based system that will mine historical data, provide visualization, and suggest possible actions for the LGU of Valenzuela be developed?, (2) What parameters should the system consider to apply and provide real time results in terms of: (2.a) connectivity, (2.b) hardware, (2.c) (liaison), (2.d) personnel and (2.e) access control, (3) How should the system monitor and assess the weather and flood condition of Valenzuela city and provide possible course of action in the following areas: (3.a) floodwater monitoring, (3.b) high tide, (3.c) evacuation centers and (3.d) available resources. The study focused on the development of a system for weather forecasting and Geoinformatics in the City of Valenzuela. It used multiple linear regression for predicting future forecasts that used available parameter such as a) wind velocity, b) atmospheric pressure, c) temperature, and d) humidity. The proposed system evaluated and provided weather forecast analysis beneficial to the city government in deciding for cancelation and suspension of classes in each barangay and an alert system for flooded areas.

Figure 1 illustrates the conceptual framework, that employs multiple linear regression for meteorological forecasting using relevant weather parameters. The primary objective of this study is to develop a localized, web-based geoinformatics system capable of predicting rainfall probabilities over the next three days, serving as an alternative weather source for Valenzuela City. Additionally, the system will facilitate communication between the municipal administration and various risk and disaster management officials.

The web-based system will benefit the community by providing timely flood data, information on pumping station levels, details about passable and non-passable areas, tidal data, and the availability of evacuation centers in each barangay. Furthermore, the municipal government will benefit from a centralized database management system that allows all relevant personnel—including barangay officials, officers, and staff—to contribute to the system's maintenance through their own accounts.

2. MATERIALS AND METHODS

2.1 Research Design

Calderon (2006) defined descriptive research as a purposive process of gathering, analyzing, classifying, and tabulating data about prevailing conditions, practices, processes, trends, and cause-effect relationships. This process allows for the adequate and accurate interpretation of such data, with or without minimal aid from statistical methods. Additionally, this approach

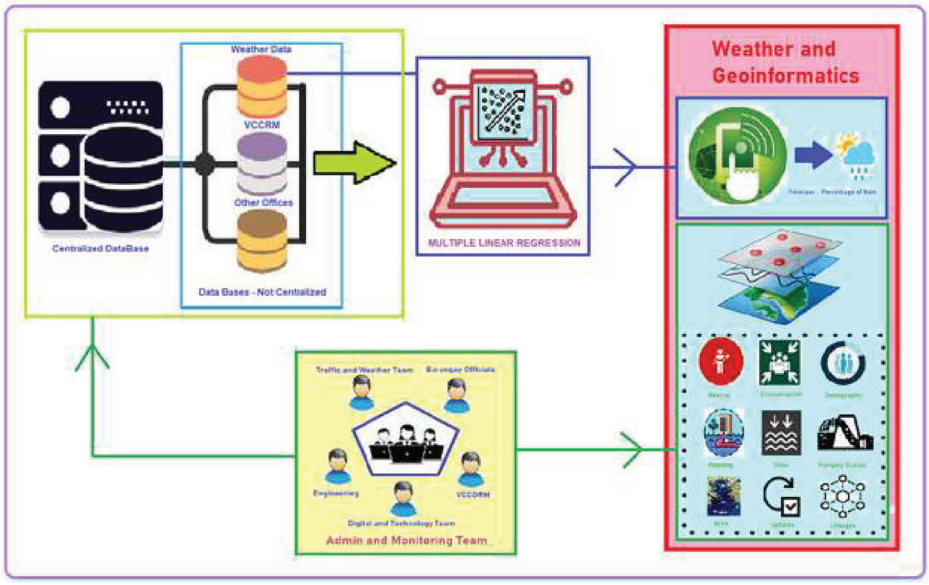

Figure 1. Conceptual Framework.

ascertains the prevailing conditions of facts in a group under study, providing either qualitative or quantitative descriptions—or both—of the general characteristics of the group.

This study employed descriptive research. The web-based system provided a dashboard to display information that assists the citizens of Valenzuela City. The prediction of percentage rainfall through data science aids the government in planning and making timely decisions. This platform also facilitates interactive communication among concerned officials and personnel.

2.2 Software Development Process

During the software development phase, the Agile Programming Approach was utilized. First, the engagement of procedures and methods enabled the researcher to determine the reliability of the tool through monitoring and evaluation. Next, the researcher prioritized functionality over extensive documentary evidence. The validity and quality of the web development process enhanced the system's consistency.

Additionally, the researcher fostered constructive client cooperation during contract negotiations, which resulted in mutual advantages for all parties and ensured seamless execution while minimizing potential problems. Ultimately, time and understanding of the design increased, while the ability to implement effective improvements was reduced, leading to lower expenses. In contrast, agile designs routinely accommodated transitions. Finally, Agile approaches to organizing and prioritizing aided project teams in effectively adapting to challenges.

Figure 2 shows the different components agile modeling method approach for software development. The core of this technique ensured that appropriate modeling was better in providing instructions for the application of these critical success factors and ensured that the modeling algorithm was efficient. This approach aimed at improving the consistency of applications. Additionally, this strategy combines iterative and gradual process models, with an emphasis on process flexibility and usability. In recent years, agile methods have acquired development techniques and tractions to speed up project development. This interest in the issue demonstrates that effectively implementing agile approaches offers several advantages. The research was still in its early phases, and the analysis was in its early stages. Thus, the goal of this research was to investigate and acquire insights into current agile practices and methods, as well as to understand the benefits and downsides of agile processes, and to finally answer a variety of concerns about their application.

2.3 Development and Phasing of the System

Phase 1: Brain storming / Planning Stage

The researcher identified various offices that would be involved in and benefit from this study. Additionally, different variables, parameters, and policies, including relevant protocols, were considered. For the initial system, the researcher incorporated weather attributes, geoinformatics, and other pertinent details about the city, as well as relevant contact numbers, directories, and evacuation centers.

Figure 3 illustrates the operation of the system. The collected data from previous forecasts in Valenzuela City served as the basis for new predictions. As an alternative weather source for Valenzuela, the Geoinformatics system offers weather forecasting capabilities that display the predicted percentage of rainfall for the next three days. This system also facilitates communication between the local government and various risk and disaster management personnel. Additionally, the local government implemented a centralized database management system that enables all authorities—including barangay officials and employees—to contribute to the system's updates.

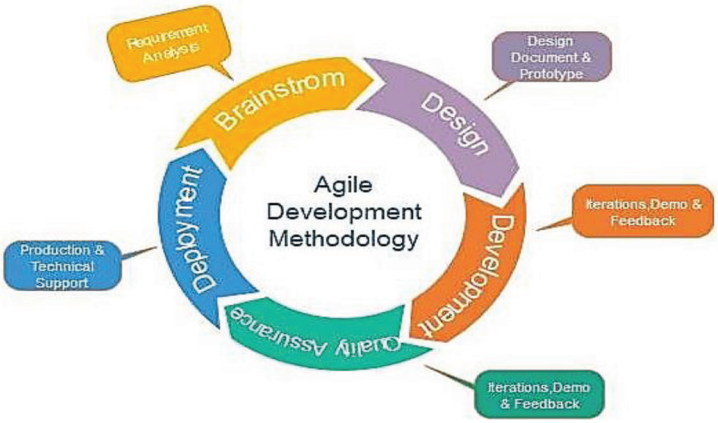

Figure 2. Agile Modeling Methodology used for Software Development (Buric, 2013).

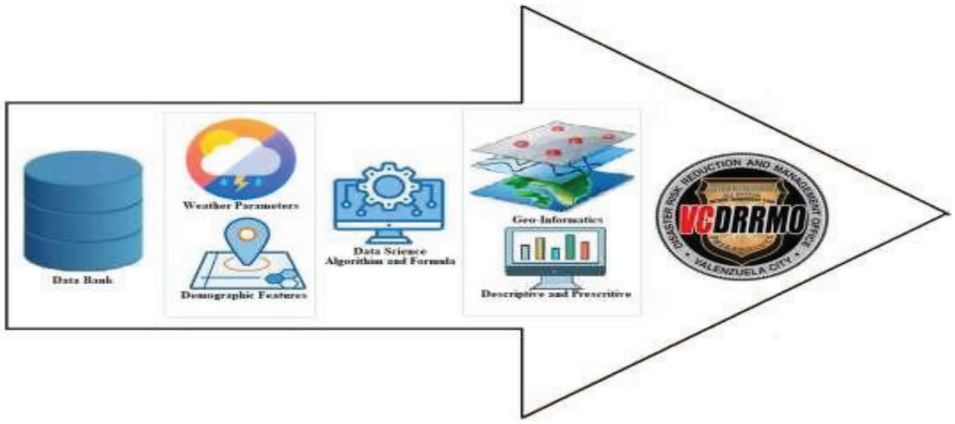

Figure 3. Operational Diagram.

Figure 4. Standard Rainfall Warning System for Philippines.

2.4 Philippine Public Storm Warning Signals

As an archipelagic region, the Philippines is particularly vulnerable to variable-intensity tropical cyclones, which occur at an annual rate of 15 to 20. The National Weather Service of the Philippines, now known as the State Climatological Agency, has established an official warning system for tropical cyclones to mitigate the damaging effects of these catastrophic events. A color-coded system using red, orange, and yellow shades corresponds to three stages of precipitation intensity expected during floods.

In Figure 4, a yellow rainfall warning is issued when the expected rainfall rate ranges from 7.5 mm to 15 mm within one hour and is likely to continue. In light of this alert, people are advised to stay informed about weather conditions and to be aware that flooding may occur in vulnerable areas. If the rainfall within one hour increases to between 15 mm and 30 mm, an orange rainfall alert will be issued for the affected areas. This orange warning indicates a significant risk of heavy rainfall for the population.

When measured precipitation ranges from 30 mm to 65 mm within one hour and is sustained for three hours, a red rainfall warning is issued. Once a red warning is announced by PAGASA, residents should prepare to take action, as large floods are anticipated, and individuals should be ready to seek safety. The weather disruptions within the Philippine Area of Responsibility (PAR) allow for dynamic adjustments to public storm signals based on the severity and predicted path of storms. The assigned warning percentages are influenced by storm intensity and movement, with variations in strength and location affecting the Public Storm Warning Signals for specific regions.

Weather charts, including surface and upper-air maps, illustrate key atmospheric conditions such as air pressure, wind, humidity, and temperature. Upper-air charts are generated twice daily at twelve-hour intervals to ensure timely data collection. Valenzuela City, situated at an average elevation of 38 meters above sea level and bordered by several municipalities, has its geographic data updated annually by the Valenzuela City Disaster Risk Reduction and Management (VCDRRM) office to monitor changes in infrastructure and surface levels. The system employs multiple linear regression (MLR) to predict rainfall probabilities by analyzing various explanatory factors, enhancing forecasting accuracy compared to single-variable regression. Advanced computational physics software is also used to address geographical and environmental research challenges, generating visual representations of critical data, including weather updates and alert notifications for the city.

Phase 2: Design (System and Software Design)

The researcher used various software tools in performing different algorithms and designs. One of which is Python, a high-level language that is suited for the system design. The system is a web-based design

and deployed in alapaap.com as the main webhost. The researcher considered the current website of Valenzuela including the theme, content, and features.

2.5 Software Development Components

The following are the software components of the system: Python, Data Base Management, IP Host, and Server. Python is designed to be simple and easy to understand. Its formatting is clean and straightforward, often favoring English terms over punctuation marks found in other languages. Unlike many other languages, Python does not use curly brackets to delimit code blocks, and while semicolons can be used to end statements, they are rarely employed. In comparison to languages such as C or Pascal, Python features fewer syntactic exceptions and special cases (Bogdanchikov et al., 2013).

Meanwhile, a database management system (DBMS) is a piece of software that allows users to access data stored in databases. The goal of a DBMS is to make defining, storing, and retrieving data in a database as simple and straightforward as possible. The DBMS communicates with the application programs so that the database's contents may be accessed by a variety of applications and users. Furthermore, the DBMS maintains centralized database control, protects data from fraudulent or unauthorized users, and assures data privacy (Gunjal, 2003). Web hosting is a service that allows people and businesses to publish a website or web page on the Internet. A web host, also known as a web hosting service provider, is a company that offers technology and services required to access a website or webpage on the Internet. Websites are kept on servers, which are dedicated computers that host websites. What all Internet visitors need to do is put their website URL or domain into the browser to visit their site. Their machine will then establish a connection with their server, then their websites will be transmitted to them via the browse interface. The system used alapaap web host.

Phase 3. Development (Machine Learning) Phase

Linear Regression Algorithm is a statistical modelling technique that makes use of independent variables to predict the value of the dependent variables. Regression models often vary on the effect of the quality of predictor variables as well as the form of interaction among variables of the study.

Figure 5 shows that there is only one independent variable and it can be seen that there is a positive correlation between independent and dependent variables (x and y respectively). The red line is the regression line, while the dots correspond to the actual data. On the basis of the given data sets, linear regression will attempt to plot a line that better models the points. The line can be modeled on the equations seen below in (1).

Simple Linear Regression is another name for it. It uses a straight line to illustrate the connection between two variables. By determining the slope and intercept that define the line and minimizing regression errors, linear regression aims to construct a line that comes closest to the data. A multiple linear regression occurs when two or more explanatory factors have a linear relationship with the dependent variable. See equations 1 and 2 below.

$$y = \boldsymbol{bo} + \boldsymbol{b}1 * \boldsymbol{x}1 \quad (1)$$

Nonlinear regression is used by statisticians because many data connections do not follow a straight line. Both track a certain reaction from a collection of factors graphically, which is comparable. Nonlinear models, on the other hand, are more difficult to understand than linear models since the function is generated using a sequence of assumptions that may be based on trial and error.

Multiple Linear Regression is defined as when It is unusual for a dependent variable to be explained by only one factor. Multiple regression entails utilizing more

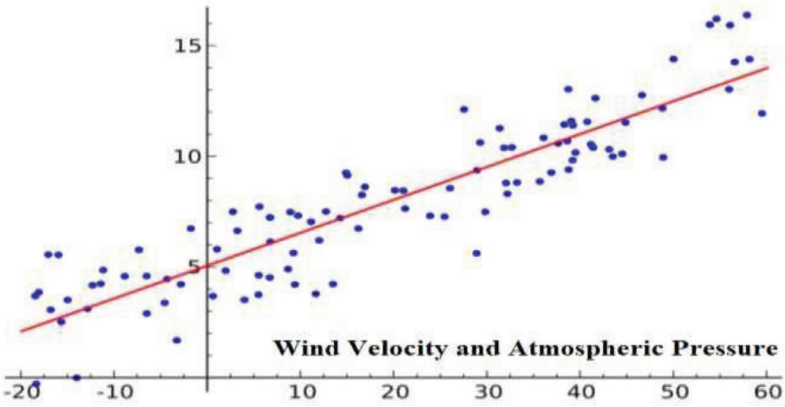

Figure 5. Linear Regression for Wind and Atmospheric Parameters.

than one independent variable to explain a dependent variable. There are two types of multiple regressions: linear and nonlinear. Multiple regressions are predicated on the premise that the dependent and independent variables have a linear relationship. It also presupposes that the independent variables have no significant connection. As previously stated, there are a variety of benefits to employing regression analysis. Businesses and economists can utilize these models to assist them in making practical decisions.

$$y = \boldsymbol{bo}+\boldsymbol{b}1*\boldsymbol{x}1+ \boldsymbol{b}2 * \boldsymbol{x}2+\boldsymbol{b}3 * \boldsymbol{x}3 + \cdots \ldots \ldots .. +\boldsymbol{bn} * \boldsymbol{xn} \quad (2)$$

Phase 4: Quality Assurance and Deployment

Criteria Evaluation Using ISO/IEC 25010. Criteria evaluation is used in evaluating the execution of the algorithms and formulas. Analytics (Descriptive, Prescriptive, and Predictive) & Descriptive Analytics, which includes data collection and data analysis to offer overview of the history and response to: "What occurred?" The system will advise what to do in certain situations and the community. On the other hand, Predictive Analytics, using mathematical simulations and modeling skills to analyze the potential response to: "What will happen?" Finally, Prescriptive Analytics, using design and simulation algorithms, offers guidance on future results and answers: "What should we do?"

3 RESULTS

The main objective of this research was to provide a localized web-based Geoinformatics system with weather forecasting features that deliver rainfall percentages for the next three days, serving as an alternative source of weather updates for Valenzuela City. This system will also facilitate interaction between the city government and various responsible officers assigned to Risk and Disaster Management.

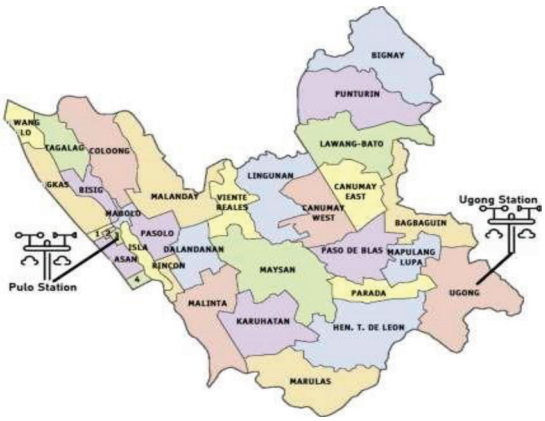

Figure 6. Location of Weather Station (Polo and Ugong Station).

The web-based system will greatly benefit the community by providing timely updates on flood data, the levels of pumping stations in preparation for Disaster Risk Management, monitoring of passable and impassable areas, high tide and low tide information, and current updates on the availability of evacuation centers in each barangay. Additionally, the city government will be equipped with a centralized database management system that allows all barangay officials, officers, and personnel to contribute to system updates through their designated accounts.

How can a web-based system that will utilize historical data, provide visualization, and suggest possible actions for the LGU of Valenzuela be developed?

Valenzuela City Government has two weather station sites. One is located in Barangay Ugong and the other is located in Barangay Pulo. These two stations provide weather data to the city government as one of their sources in forecast update. Ugong Station monitors areas near it such as Marulas, Gen T. De Leon, Parada, Mapulang Lupa, Bagbaguin, Paso De Blas, Canumay West and East, Lawang Bato, Punturin, Bignay, Maysan, and Lingunan while Pulo Station monitors most of the flooded areas such as Wawang Pulo, Coloong, Tagalag, Malanday, Pasolo, Malinta, Katuhatan, Rincon, Daandanan, Pasolo, Isla, Bisig, Mabolo, and other areas. These two stations were acquired and purchased by the city government in 2017.

Machine Learning using Multiple Linear Regression

Multiple Linear Regression is a widely used regression method that models the linear relationship between a single dependent variable and a set of independent variables. It is one of the most important regression algorithms, specifically designed to analyze the linear relationship between a single continuous dependent variable and multiple independent variables. In many linear regressions, the target variable (Y) is expressed as a linear combination of multiple predictor variables {x1, x2, x3, ..., xn} (see Table 1 for the five variables used in the system for forecasting). Since the multiple linear regression equation is an extension of simple linear regression, the equation can be expressed as follows:

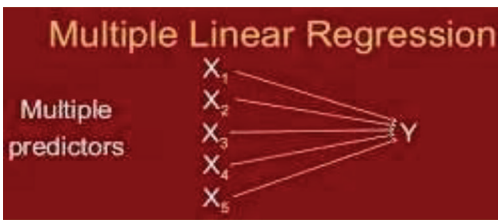

Figure 7. Multiple Linear Regression Illustration.

```
X = dataset[[ 'Wind Speed', 'Wind Direction', 'Atmospheric Pressue',
'Relative Humiditiy', 'Air Temperature', 'Dew Point', 'Precipitation']] # our features
y = dataset['Rain'] # what we want to predict
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.0000001)
lm = LinearRegression()
lm.fit(X_train, y_train)
# print(lm.intercept_) # the intercept
# print(lm.coef_) # the coeficient
```

Figure 8. Source Code Importing Data Set.

Table 1. Sample Data Set from *(Polo and Ugong Stations).*

	Independent Variable					Dependent Variable	
Hourly Monitoring	Wind Spd. & Wind Dir.	Atm.Pressu	Rel. Hum.	Air.Temp.	Dew Point	Precip.Int	Rain Percetage
	2.723729 & 43.78088	1015.04	82.82833	27.27046	24.17673	0	0

Source: *Author, 2024*

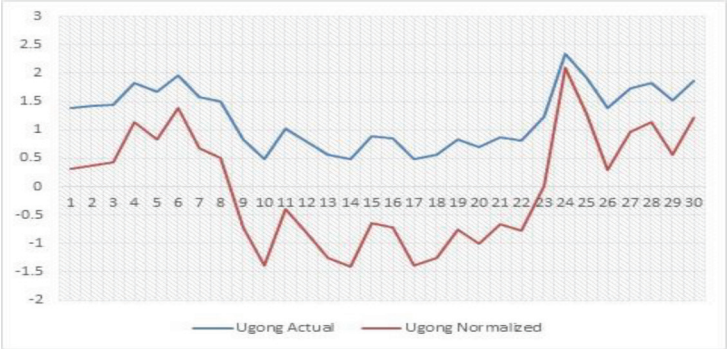

Figure 9. Actual and Normalized Wind Velocity of Polo Station.

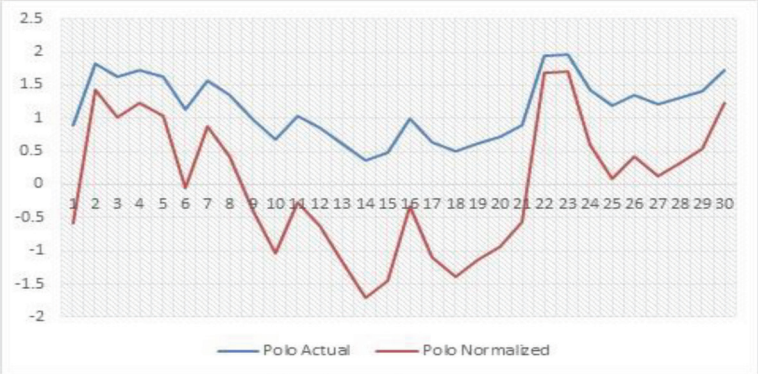

Figure 10. Actual and Normalized Wind Velocity in Ugong Station.

Steps in Data Preparation - The first step in data preparation is composed of two subprocesses namely Importing Libraries and Data Set. The source code in Figure 8 shows the system imported libraries and define data sets.

Data Frames hold information in the form of rectangular grids that can be easily examined. Each column in the grid is a vector representing data for a single variable, while each row contains values for an individual instance. This means that the values in a Data Frame's rows do not need to be of the same data type; they can be numeric, character, logical, and so on. Data Frames are two-dimensional labeled data structures that can accommodate diverse types of columns in Python.

Weather Data / Parameters

The two satellites provide weather data such as wind, atmospheric pressure, humidity, air temperature, and dew point. They also give the percentage of the chance of rain on the said date. The collective data include the hourly monitoring for both stations. Weather data are stored and monitored in the office of Valenzuela in the Disaster Risk Management Building. This is also where the reading and forecasted data from the satellite

are transmitted to the Weather Monitoring Board. Weather data collected from weather stations have an uneven spatial distribution and density. A single weather station's data is solely indicative of that station's location. Therefore, conversion is required to create weather data for locations between stations. One approach is interpolation, which involves creating new data points within the range of a discrete set of known data points. In figure 3.4 x variables serve as independent variables and y represents the dependent variable which is the rain.

Figure shows the analysis between the Actual and Normalized Wind Velocity. A linear regression analysis is an improved version of ratio-based normalization technique. Normalizing fits the original numbers into a certain range; standardization fits them into a distribution with a mean of 0 and a standard deviation of 1.

The mean for actual values of wind velocity in Polo station within seventy-two hours monitoring was 1.15516 while the standard deviation was 0.46579 respectively. Polo station had an actual value of 0.35834 and 1.437672 peak while the normalized value was -1.7107 and 1.7129. While in the Figure 3. 4 The mean for actual values of wind velocity in Ugong station within seventy-two hours of monitoring was 1.22657 while the standard deviation was 0.53287. For the actual value in Ugong Station, 2.338253 and 0.4807527 were the high and low peaks while for the normalized value, -1.3996 and 2.0869 for low and high peaks.

The MLR model fitted to the training equipment

After the system had prepared the dataset for training, the regression model was fitted to the training set. Linear regression model needed to fit the variables which were the weather parameters, namely the X train and Y train used as the container/storage for parameters and rainfall forecasting. For Intercept and Coefficient, the simple linear regression model is essentially a linear equation of the form y = c + b*x, where y is the dependent variable (outcome), x is the independent variable (predictor), b is the line's slope; also known as the regression coefficient, and c is the intercept.

Figure 12 shows the analysis of rainfall forecast by the actual wind velocity and the normalized wind velocity using multiple linear regression. The mean value of actual forecast was 0.0394 while the system forecast mean was 0.0375. Meanwhile, 0.0513 was mean value for normalized wind velocity. Using correlation (Pearson) see equation 5, the correlation coefficient was actual forecast and multiple linear regression. Non normalized wind velocity was 0.98622 while normalized with velocity was 0.97475 with a difference of 0.01147.

Figure 13 shows the analysis of rainfall forecast by the actual wind velocity and the normalized wind velocity using multiple linear regression. The mean value of the actual forecast was 0.0452 while the system forecast mean was 0.0561. Meanwhile, 0.0405 was the mean value for normalized wind velocity. Using correlation (Pearson) see equation 5, the correlation coefficient of the actual forecast and multiple linear regression using non normalized wind velocity was 0.98518 while normalized wind velocity was 0.98518 which had 0.036808 difference.

Predicting the test set's outcome. Checking the model's performance is the model's final step. The system will do so by predicting the outcome of the test set. A y pred vector will be created for prediction. The code is as follows:

The formula is Y = a + bX + e, where a is the intercept, b is the slope of the line, and e is the error term. The mean absolute error of a model with respect to a test set is the

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.0000001)
lm = LinearRegression()
lm.fit(X_train, y_train)
# print(lm.intercept_) # the intercept
# print(lm.coef_) # the coeficient
```

Figure 11. Source Code of Fitting Regression from Dataset.

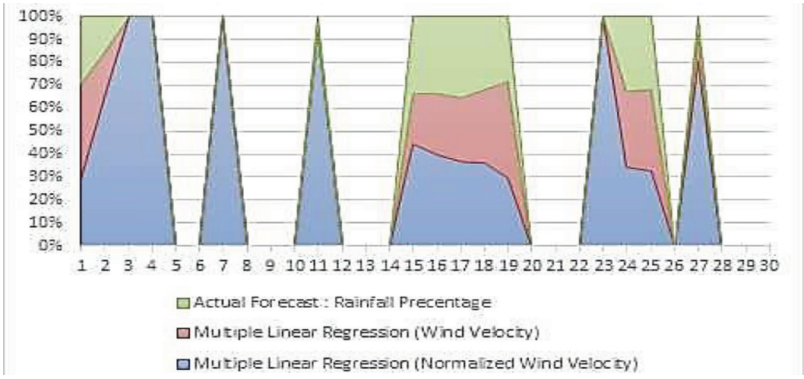

Figure 12. Analysis of rainfall forecast in Ugong Station.

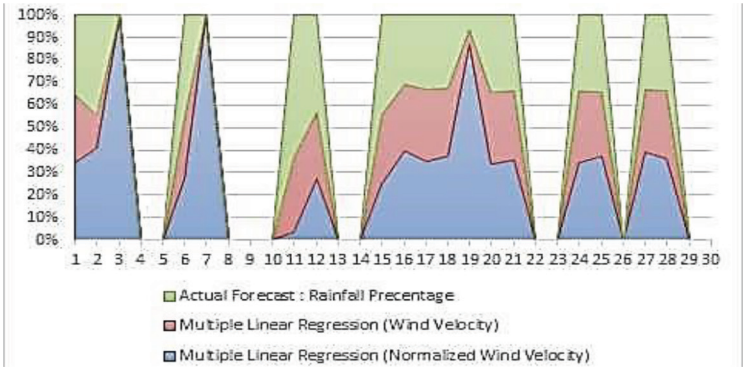

Figure 13. Analysis of rainfall forecast in Polo Station.

```
# print(predictions)
mae = metrics.mean_absolute_error(y_test, predictions) #mae
# print(mae)
mse = metrics.mean_squared_error(y_test, predictions)
# print(mse)
rmse = np.sqrt(metrics.mean_squared_error(y_test, predictions))
# print(rmse)
```

Figure 14. Source Code of fitting prediction from dataset.

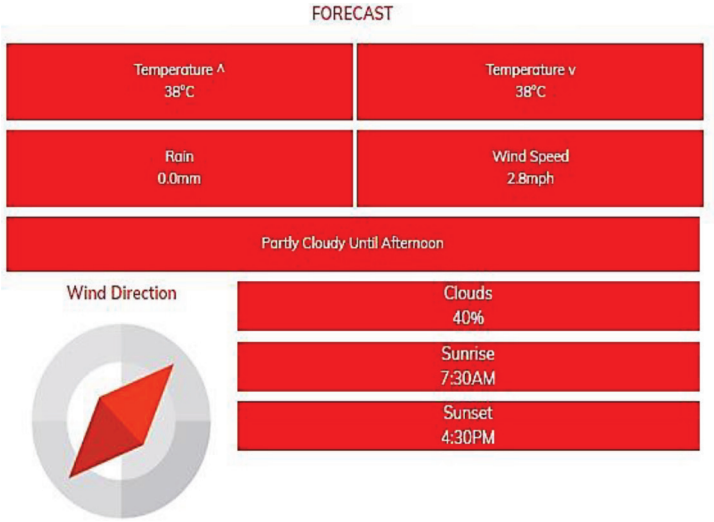

Figure 15. System Interfaces with Rain Forecast.

average of the absolute values of the individual prediction errors across all instances in the test set. In contrast, the mean squared error is calculated by taking the distances from the points to the regression line (these distances represent the "errors") and squaring them. Squaring is necessary to eliminate any negative signs and to give more weight to larger differences. This process results in the mean squared error, which represents the average of a set of squared errors. Together, these two processes contribute to more accurate rainfall forecasts, providing a percentage of expected rainfall. In this context, the independent variable is the rainfall forecast, while the dependent variables are the weather.

This is the Home Page of the Web-Based Weather and Geoinformatics System for Valenzuela City, featuring sections on Home, Evacuation Areas, Geoinformatics, and the Admin Panel. In this section, the web-based system provides information on the actual temperature from both satellites, wind speed, cloud formation, wind direction, the times of sunset and sunrise, and the percentage of expected rainfall.

This is the Home Page of the Web-Based Weather and Geoinformatics System for Valenzuela City, featuring sections on Home, Evacuation Areas, Geoinformatics, and the Admin Panel. In this section, the web-based system provides information on the actual temperature from both satellites, wind speed, cloud formation, wind direction, the times of sunset and sunrise, and the percentage of expected rainfall.

Figure 17 displays a map featuring three colors that represent the level of alertness for each barangay. This map is manually monitored by the assigned administrator for the system, indicating various evacuation center locations along with complete details and information.

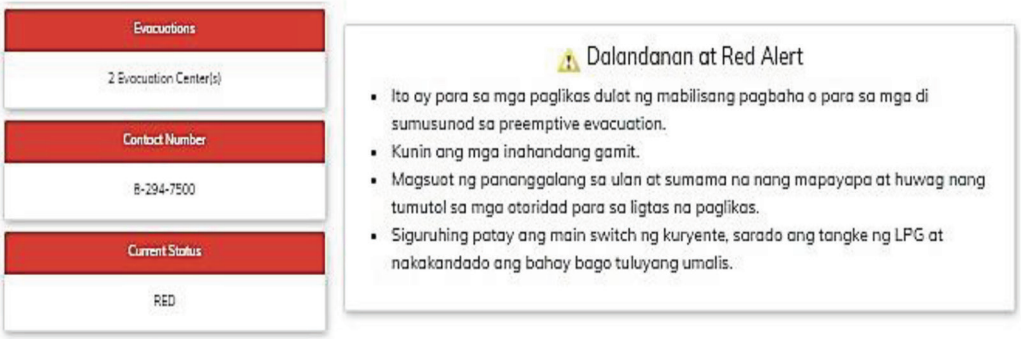

Figure 16. Flood Alert System and Status of each Barangay.

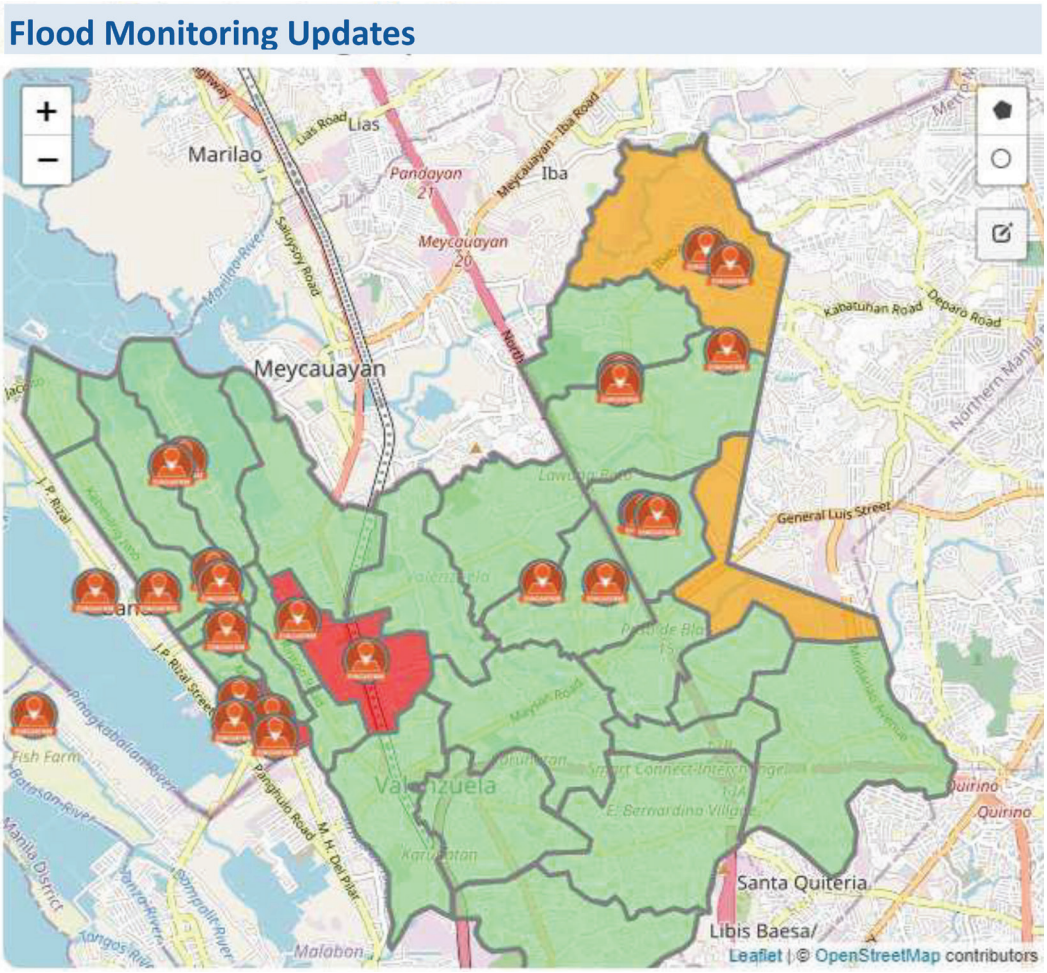

Figure 17. Flood Monitoring Updates and Status of each Barangay.

Finding comparable events, or K-nearest neighbors, in which to make forecasts is a simple yet successful forecasting method that has been documented in books dating back to the 11th century (Chen and Shah, 2018). Meanwhile, multiple linear regression is an extension of simple linear regression in which values on an outcome (Y) variable are predicted from two or more predictor (X) variables. There are three principal objectives of multiple linear regression (Frey, 2018). Two models were the most popular in terms of forecasting as shown in Table 3

Table 3 shows the correlation of forecasting rate of multiple linear regression and K-nearest neighbors' regression with the actual prediction from Valenzuela City (Ugong and Polo Stations). The Pearson correlation of multiple linear regression based on its forecasted data versus the actual was 98.62% which was higher compared with the K-nearest neighbors' regression with the rate of 96.92 percentage. Using the T-test, the two models have. The difference between the target value and the prediction value also shows that the value of error is small and the prediction results using KNN Algorithm have an accuracy of 97.27% (Novitasar, 2019). In multiple linear regression, the R2 reflects the correlation coefficient between the observed and fitted values of the outcome

Table 2. Comparative Analysis of different Model.

Time Duration	Polo Station			Ugong Station		
	K-nearest neighbors regression	Multiple Linear Regression	Actual Forecast : Rainfall Precentage	K-nearest neighbors regression	Multiple Linear Regression	Actual Forecast : Rainfall Precentage
24/01/2022 13:00	0.092	0.183	0.133	0.133	0.100	0.117
24/01/2022 14:00	0.008	0.017	0.014	0.003	0.011	0.033
24/01/2022 15:00	0.000	0.000	0.000	0.000	0.000	0.000
24/01/2022 16:00	0.000	0.000	0.000	0.000	0.000	0.000
24/01/2022 17:00	0.000	0.000	0.000	0.000	0.000	0.000
24/01/2022 18:00	0.000	0.000	0.000	0.007	0.010	0.017
24/01/2022 19:00	0.000	0.000	0.000	0.000	0.000	0.000
24/01/2022 20:00	0.000	0.000	0.000	0.000	0.000	0.000
24/01/2022 21:00	0.000	0.000	0.000	0.000	0.000	0.000
24/01/2022 22:00	0.000	0.000	0.000	0.000	0.000	0.000
24/01/2022 23:00	0.082	0.000	0.001	0.008	0.009	0.017
25/01/2022 0:00	0.018	0.000	0.000	0.013	0.023	0.033
25/01/2022 1:00	0.000	0.000	0.000	0.000	0.000	0.000
25/01/2022 2:00	0.000	0.000	0.000	0.000	0.000	0.000
25/01/2022 3:00	0.009	0.050	0.076	0.013	0.023	0.033

Source: *Author, 2024*

Table 3. Comparison to different Model.

	Multiple Linear Regression	*K-nearest neighbors regression*
Mean	0.0375	0.0336
Variance	0.0092	0.0038
Pearson Correlation	98.62%	96.92%
T Test		
t Stat	-0.4311	-0.4610
P(T<=t) one-tail	0.3348	0.3241
t Critical one-tail	1.6991	1.6991
P(T<=t) two-tail	0.6696	0.6482
t Critical two-tail	2.0452	2.0452

Source: *Author, 2024*

variable (y) in multiple linear regression. As a result, R will always be positive and will vary between zero and one. The amount of variation in the outcome variable y that can be predicted using the values of the x variables is represented by R2. The model explains a considerable percentage of the variation in the outcome variable if the R2 value is near 1. The R2 has the drawback of continually increasing when additional variables are added to the model, even if those variables are only tangentially related to the answer (James et al., 2014).

Provide real time results in terms of:

Connectivity - The main server of Valenzuela City is located at the Alert Division Building, utilizing PLDT and

Table 4. Average mbps of Service Provider Usage.

Internet Provider in Philippines	SPEED	
	PLDT (60mbps)	Globe Telecom (60mbps)
Average Speed	57.99 mbps	57.48 mbps

Source: *Author, 2024*

Globe Telecommunication as its service providers. The connectivity speed is 60 Mbps, and the server operates 24 hours a day, seven days a week. The webpage functions effectively under the same conditions as the internet providers. Additionally, citizens of Valenzuela can access the web-based platforms even in free data mode.

Table 4 presents the average performance of the internet connection speed for PLDT as the primary provider and Globe Telecom as the secondary provider. The City **Government** of Valenzuela required this setup for backup purposes in case one provider fails to perform. According to the head of the Communication Division, who manages their social media accounts, they have not experienced any connectivity failures thus far, thanks to the presence of network backup. The average performance recorded daily (as shown in Table 4) was 57.99 Mbps for PLDT and 57.48 Mbps for Globe Telecom, respectively

Hardwarea - The two satellites are powered by a 12-15 V source and operate 24 hours a day, seven days

a week. The average voltage used at Ugong Station was 12.91 volts, while Polo Station utilized 12.94 volts. Both stations are equipped with backup generators to be used in the event of service interruptions. Valenzuela City acquired the Ugong and Polo stations, which function continuously throughout the week. Additionally, the city has backup sources, such as generators, capable of sustaining operations for 2-3 days during electric power interruptions. The monitoring device is located at the Alert Division Office, which operates with a power requirement of 5V. Valenzuela City also employs CCTV cameras as remote monitoring platforms.

Liaison Officers - The web-based system is composed of Dashboard, Barangays, Streets, Evacuations, Pumping Stations, Flood Levels, and Users Account. For the "Dashboard," it displays all weather parameters and forecast including the geoformations of Valenzuela City. For "Barangay" section, the admin users can edit all information for each barangay including area, population, and officers. Meanwhile, in the "Users" section, that admin can add and delete users that are involved within communication. The system creates generic ways for the creation of accounts.

Barangay Officials – Committee on Disaster Risk Management Office (See Figure 4.7 for reference) Each Barangay office has a department head in the Disaster Risk Management office who is responsible for implementing rules and policies, local monitoring if needed, and supervision of personnel for initial action. They will give each an access for system to input an hourly observation if needed that will contribute to the data monitoring of the city. The committee head in Disaster Risk Management from Barangay Councilor will be given an access based on practice of the City Government for the Unified Response Team.

Personnel - In Figure 19 is part of the system where the Head Admin of the portal can monitor all accounts of personnel, offices, and divisions involved in monitoring and decision making for the suspension and response.

The **Flood Control Division** is responsible for monitoring the 35 pumping stations across Valenzuela City, especially during storm signals. This division operates 24 hours a day, seven days a week, ensuring the continuous monitoring of floods and water flow from various rivers in and around Valenzuela City. However, it is important to note that the division currently lacks a data storage mechanism for archiving previous flood observations.

The **Public Safety Division**, operating under the Public Order and Safety Management Office, develops strategies and programs to maintain peace and order within the city's jurisdiction. This division plays a key role in improving the safety of services in the city by providing updated safety protocols for each barangay, as necessary.

The **Traffic Management Office** manages and regulates any activities that could impact or obstruct vehicular traffic flow within the city. It is tasked with granting permissions for activities that may hinder traffic, ensuring smooth transportation across Valenzuela. As part of its responsibilities, the office also assists in flood

Table 5. Average Voltage Source of Two Satellites.

Voltage Source in Satelite	VOLTAGE SOURCE	
	Ugong Station	Polo Station
Average Voltage	12.91 V	12.94 V

Source: *Author, 2024*

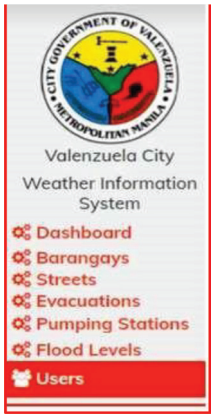

Figure 18. Creation of Unified Users and Access.

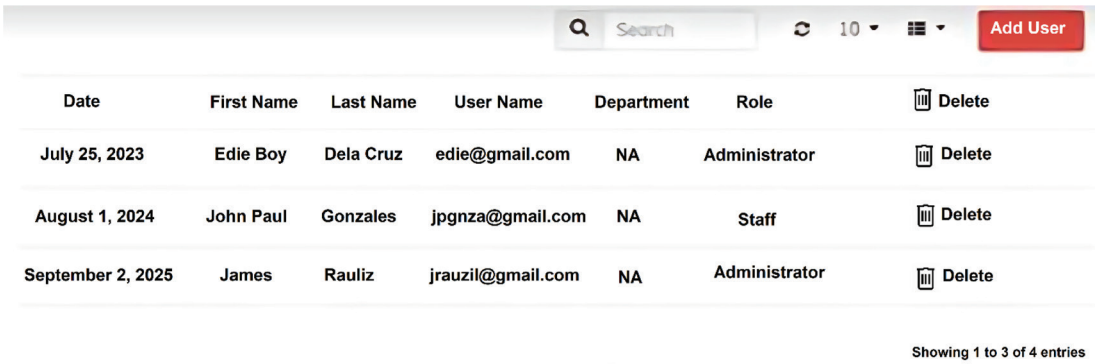

Figure 19. Users Account Section – Administrative Account.

Figure 20. Access Control of Admin for Creation of Account.

Figure 21. Users Account Log In.

monitoring by recording flood levels on a per-street basis, issuing advisories, and updating the status of streets—whether they are passable or not—based on current conditions.

The access protocol, as illustrated in **Figure 20**, outlines that the admin has the authority to add and delete user accounts within the system. The system is regulated by three division offices, with the **Valenzuela City Disaster Risk Reduction and Management Office (VCDRRM)** serving as the Head Admin, responsible for assigning accounts to the appropriate personnel or offices. The **VCDRRM Office**, specifically through the Valenzuela City Rescue Unit, plays a crucial role during calamities and emergencies by assisting residents, while the Planning and Research Office Division monitors storm and flood updates. As the main host of the system, the Rescue Office is central to operations. The **Digital Communication Office** manages the creation, development, and monitoring of the city's digital platforms, including the Valenzuela City webpage, social media channels, and applications, using these tools to disseminate and cascade information effectively. The **Valenzuela Command Center** facilitates access to the system for various offices that contribute to data encoding within the centralized database management system. Each barangay is granted one access point for contributing updates, supported by working CCTV cameras for real-time monitoring. The Flood Control Division, which has its own database management platform for monitoring pumping stations, rivers, and flood levels, shares its data directly to the centralized system, ensuring information is visible through the city's webpage. This collaborative approach provides essential information to various offices and the wider community, enhancing disaster preparedness and response.

The Valenzuela disaster risk officer updates the Geoinformatics, Barangay Information, Contact Persons, Contact Numbers, plotting of rescue places, and assessment of data gathered which serve as the main host of the system. Other supporting offices include Digital Communication offices, which is responsible in information dissemination through digital platforms, Traffic Management office for traffic updates during rainy weather, and Public Safety Division.

While certain places are more vulnerable to flooding than others, installing flood warning systems near any major canal or body of water gives important information that may help preserve property and save lives. In fact, the most successful flood warning systems go beyond installing gages and telemetry equipment; they also use skilled personnel and well-established protocols to offer the earliest possible notice regarding whether a flood is predicted, when it will occur, or how severe it will be. Individuals, towns, and organizations that want to set up and operate flood warning systems can use this handbook for guidance. Valenzuela City Administration using social Media Platforms like Facebook and Twitter in updating citizens. Offices use CCTV cameras in monitoring floods.

Figure 23 shows the different tides. The regular rise and fall of the ocean's waters are referred to as high and low tides. When the tide reaches its maximum level, it covers a large portion of the beach. When the water recedes to its lowest level and moves away from the beach, it is said to be at low tide.

The City of Valenzuela had compiled a list of 97 approved evacuation centers spread around the city's 33 barangays, the bulk of which are public schools, covered courts, and barangay halls, with a few private schools and churches thrown in for good measure. The list was compiled after the Department of Education (DepEd) Division of City Schools - Valenzuela issued Division Memorandum No. 170, Series of 2013, instructing district and school supervisors to prepare public schools in the city for use as evacuation centers.

4 DISCUSSION

The researcher utilized weather data from the Ugong and Polo stations, which are optimally located to serve the entire City of Valenzuela. By employing data science techniques, the system leverages historical data through algorithms embedded within the platform. Multiple

Flood Levels

Barangay	Street	Water Level	Passable
Arkong Bato	Arkong Street	2.0	Yes
Karuhatan	Something Street	5.0	Yes
Bagbaguin	Street in Karuhatan	11.0	No
Canumay West	Test Street	11.0	No

Figure 22. Floodwater Level from Typhoon.

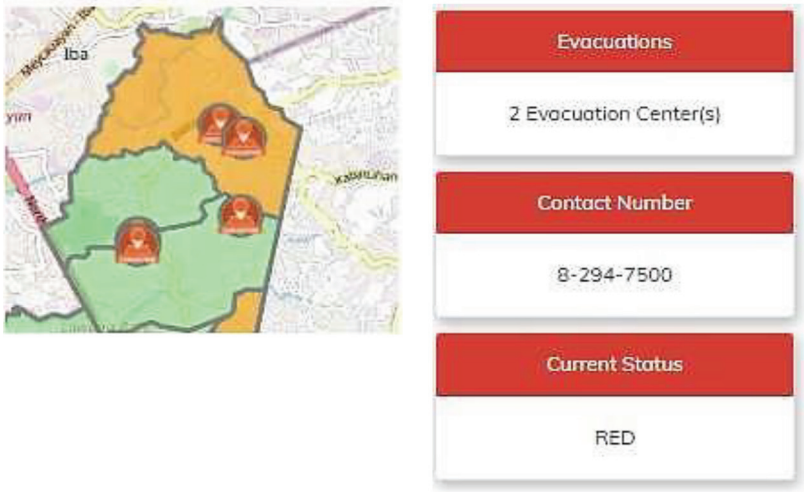

Figure 23. Tides (High Tides and Low Tides Record Level).

Tides

Day	1st Tide	2nd Tide	3rd Tide	4th Tide
11 Sat	12:36am ▲ 0.82 m	6:49am ▼ 0.27 m	1:16pm ▲ 0.79 m	6:41pm ▼ 0.44 m
12 Sun	1:01am ▲ 0.95 m	8:09am ▼ 0.22 m	2:33pm ▲ 0.61 m	6:34pm ▼ 0.49 m
13 Mon	1:34am ▲ 1.07 m	9:42am ▼ 0.17 m		
14 Tue	2:18am ▲ 1.17 m	11:30am ▼ 0.1 m		
15 Wed	3:16am ▲ 1.22 m	1:11pm ▼ 0.02 m		
16 Thu	4:28am ▲ 1.25 m	2:24pm ▼ -0.04 m		
17 Fri	5:50am ▲ 1.26 m	3:18pm ▼ -0.05 m		

Figure 24. Geoinformatics of Centers.

linear regression is used to predict the percentage chance of rainfall based on historical weather data, including humidity, wind speed, atmospheric pressure, air temperature, and dew point. The system also harnesses historical data from the city government's weather records using the same statistical tool. Furthermore, the system provides various visualizations using geo-maps for flood monitoring updates, securing geoinformation for barangays, monitoring pumping stations, and suggesting possible actions through collaborative inputs from different concerned departments, which assists the Valenzuela City Disaster Risk Reduction and Management (VCDRRM) office in providing effective responses and actions.

Parameters for Real-Time System Functionality:

Connectivity: The system is accessible 24 hours a day, seven days a week. The City Government of Valenzuela maintains a strong internet connection, using Globe as the primary service provider and PLDT as a backup, ensuring continuous operation of the web-based system. Each office and barangay have its own internet connection, allowing for updates even during inclement weather conditions.

Hardware Parameters: Similar to connectivity, the two satellites operate continuously, 24/7, with backup power supply generators to ensure uninterrupted service. Valenzuela also utilizes CCTV cameras as an alternative monitoring method for floods. However, according to the VCDRRM Office and Traffic Advisory Office, there are times when these cameras may malfunction. The system serves as an additional means of data collection, allowing for human intervention and inputs through actual observations to provide accurate information.

Liaison and Personnel: Different officers and personnel play crucial roles in this platform. Each has an account in the system for inputting and updating data. The Traffic Management Office, using CCTV cameras, can update information regarding street or road conditions, including flood levels and whether routes are passable or impassable. During the rainy season, the Barangay Councilor assigned to the Disaster Risk Management Office updates the flood levels in at-risk areas. This collected data can inform future protocols and policies created by the Flood Control Division and the Public Safety Division Office.

Access Protocol: The VCDRRM office serves as the main administrator responsible for decision-making based on the inputs and data gathered from various offices. The department head controls user accounts for different concerned offices and their respective personnel. He also updates the Geoinformatics-Flood Monitoring sections by manually changing the status (Green, Orange, or Red) in conjunction with the corresponding alert protocols and advisories. The Digital Communications Unit can utilize this information, which may be shared through various social media platforms.

To monitor and assess the weather and flood conditions in Valenzuela City and provide possible courses of action, the web application serves as an integrated system platform that collects updated inputs from assigned and authorized personnel or offices. For weather forecasting, the system predicts the percentage of rainfall from the current day up to the next three days using multiple linear regression, taking into account historical weather data collected from the two stations. The VCDRRM office uses this predicted data as one of their alternative sources for weather conditions, and the entire community, along with other officers, can also monitor the percentage chance of rainfall as it is displayed in the web application.

For Floodwater Monitoring, the web-based system includes two monitoring components on the dashboard: pumping stations and flood levels per street and barangay. Assigned engineers monitor all pumping stations and river conditions in Valenzuela, updating the status and conditions as needed by the VCDRRM. For High Tide Monitoring, the system provides information through data mining for daily and hourly updates regarding high tide and low tide conditions, including potential tide heights (source: Web Crawler).

In terms of Evacuation Centers, the Geoinformatics feature allows citizens to identify available spaces in evacuation centers, including contact numbers, status, and population capacity, along with exact locations. The administrator is responsible for adding and updating the status of these evacuation centers. Lastly, the Available Resources section displays contact numbers for various offices and rescue teams in Valenzuela, facilitating access to essential services.

To evaluate the system's performance, the ISO/IEC 25010 software standard criteria were employed. Nine evaluators manually checked the system, navigated its features, and assessed its functionality. The ISO/IEC 25010 standard includes seven criteria and twenty-two sub criteria (Yorke & Vidovich, 2016). The web application received an overall rating of 4.85 on a five-point scale, where 5 represents the highest level of satisfaction and 1 the lowest. Usability was the system's strongest attribute, earning a score of 5, indicating that evaluators were satisfied with its understandability, learnability, operability, and attractiveness. Reliability scored 4.76, the lowest among the categories, with Recoverability being the weakest subcategory, averaging 4.64. Overall, the system met the ISO/IEC 9126 software standard criteria for software development.

5 CONCLUSION

The following conclusions are drawn from the findings presented above regarding the Web-based Weather and Geoinformatics System for Valenzuela City:

To effectively provide weather forecasts and geoinformatics for Valenzuela City, certain parameters must be considered. The system requires inputs and updates from the relevant offices under established liaison, personnel, and access protocols (including user administration). According to the Head of the VCDRRM, the system is operational and accessible to both administrators and citizens 24/7.

For historical weather data, the administrator should supply this information to the software developer for direct storage in the database. However, during the implementation period approved by high officials, it will become easier to encode weather data. Currently, the system relies on manual data entry. Other offices will also contribute to updating various variables, such as flood levels, weather data, and pumping station conditions, all of which are essential for generating accurate results.

The system has successfully integrated these parameters, considering and presenting high tide and low tide status, available resources, and evacuation centers.

The web-based system delivers real-time results. As shown in Figure 4.3, using Pearson correlation, the system, which employs multiple linear regression, demonstrates an accuracy of 98.62% compared to actual forecasts. In contrast, the K-Nearest Neighbors regression model achieves an accuracy of 96.92%. Parameters such as connectivity and hardware play significant roles in this system. The City Government of Valenzuela utilizes PLDT and Globe Telecom as its main and backup providers, with average connectivity speeds of 57.99 Mbps and 57.48 Mbps, respectively (see Table 4). In terms of hardware, the two stations (Ugong and Polo) operate continuously, 24/7, with average power supplies of 12.91 V and 12.94 V, respectively (see Table 5). The system also provides accounts for different users under the liaison, personnel, and access protocol (see Figure 18).

The system facilitates flood monitoring not only for barangays but also for individual streets (see Figure 22). Through this platform, residents of Valenzuela will receive timely updates relevant to their areas, overseen by the VCDRRM. Additionally, the system provides updates for high tide and low tide schedules, which are important considerations for decision-making (see Figure 24). The platform also offers a new feature for evacuation centers (see Figure 23), enabling residents to identify the availability of all registered evacuation centers, including contact persons and numbers, availability status, capacity, and exact locations.

Using the ISO/IEC 25010 software standard to evaluate the system yielded scores of 4.84 for functionality, 4.76 for reliability, 5.00 for usability, 4.86 for efficiency, and 4.80 for maintainability and portability, resulting in an average performance score of 4.85. Therefore, the system is considered to be functioning effectively.

Acknowledgment

The author would like to express his gratitude to the editors and editorial staff of JHSSR for their assistance during publication period.

Funding

The author received no financial support for the research.

Declaration of Conflicting Interests

The author declares that he has no competing interests.

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Horizon J. Hum. & Soc. Sci. Res. 7 (S): 87 – 100 (2025)

Journal of Humanities and Social Sciences Research
www.horizon-JHSSR.com

RESEARCH ARTICLE
Peer-reviewed | Open Access

Fragile Shores: Coastal Ecosystem Vulnerability in Barangay Bacong, Babatngon, Leyte, Philippines

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ARTICLE INFO

Article history
RECEIVED: 12-Mar-25
REVISED: 7-Jun-25
ACCEPTED: 14-Jun-25
PUBLISHED: 15-Jul-25

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Citation: Julia Anne L. De Guzman, Ace Peter D. Cinco, Rica D. Moron, Elpedio I P. Cuayzon, Jhories Eve L. Capili and Ma. Elvira A. Martija (2025). Fragile Shores: Coastal Ecosystem Vulnerability in Barangay Bacong, Babatngon, Leyte, Philippines. Horizon J. Hum. Soc. Sci. Res. 7 (S), 87–100. https://doi.org/10.37534/bp.jhssr.2025.v7.nS.id1296.p87-100

ABSTRACT

Introduction: The Philippines, as an archipelagic nation, hosts a vast and dynamic coastal ecosystem that plays a critical role in the socio-economic activities of coastal communities. However, increasing development pressures, such as industrialization and population growth, contribute to the gradual degradation of these environments. This study investigates the vulnerability of the coastal ecosystem in Barangay Bacong, Babatngon, Leyte, a developing coastal barangay experiencing environmental stress amid growing industrial activities. **Methods:** The study employed the Coastal Vulnerability Index (CVI) to assess coastal geomorphology and vulnerability. Primary data were collected through a validated survey instrument adapted from Gan et al. (2022), which measured residents' perceptions of coastal resilience. Secondary spatial data were obtained from the Municipal Planning and Development Office (MPDO) and the Mines and Geosciences Bureau (MGB) in shapefile format. The spatial analysis was conducted using Quantum Geographic Information System (QGIS) version 3.28.8. The CVI was classified into three vulnerability levels—low (1–2), moderate (3–4), and high (5)—based on the scale used by Husaini et al. (2021), which reflects the observed degree of environmental damage. **Results:** The assessment revealed that Barangay Bacong's coastal areas exhibit a moderate level of vulnerability, indicating a pressing need for integrated management strategies. Interestingly, statistical analysis showed no significant correlation between demographic variables and ecological vulnerability, which may be attributed to the relatively low population density in the area. **Discussion:** The findings suggest that, despite exposure to coastal hazards, the area demonstrates a moderate level of adaptive capacity. The absence of significant demographic influence on perceived vulnerability underscores the need for ecosystem-based rather than solely population-focused approaches to coastal management. **Conclusion:** This study provides baseline data critical for future initiatives in Disaster Risk Reduction and Management (DRRM) and Climate Change Adaptation (CCA) in coastal areas. It advocates for the adoption of community-based and data-informed coastal management strategies to strengthen ecosystem resilience in the face of environmental change.

Keywords: Vulnerability Assessment, Coastal Vulnerability Index, Adaptive Capacity, Coastal Ecosystem

1. INTRODUCTION

The study on vulnerability has a significant role in gaining a better understanding on the risk of natural disasters and man-made activities. Vulnerability is defined as the extent to which a population or system is likely to suffer harm due to exposure to certain potential hazards (Prasetyo et al., 2020). Based on a recent study by Estoque et al. (2022), the Intergovernmental Panel on Climate Change (IPCC) vulnerability framework, presented in its Third and Fourth Assessment Reports, is frequently used in climate-related vulnerability assessments. Vulnerability results from exposure, sensitivity, and adaptive capacity. Following definitions given by most vulnerability studies, such as those by Robielos et al. (2020), and Jones et al. (2020), the determination of the risk source, including its magnitude, frequency of occurrence, and spatial impact, is part of the exposure assessment process. Sensitivity describes the degree to which a population or system is harmed due to exposure to natural hazards.

These studies also examine how human communities are dealing with these impacts and explore potential solutions for ecological and human adaptation (Cooley et al., 2022). The coastal zone is a delicate area that requires particular care to protect ecosystems and human activities. Coastal areas are under threat due to the effects of climate change and anthropogenic activities. As a result, analyzing their vulnerabilities and the potential for natural habitats to help preserve coastal areas and communities is critical for long-term planning, sustainability, and resilient coastal management (Ruheili & Boluwade, 2023).

This research was driven by a clear need to address a gap in studies focused on vulnerability assessments for small, rural coastal communities like Barangay Bacong in Babatngon, Leyte. While earlier research has mostly focused on coastal risks in larger cities, few studies examine how these risks impact smaller, resource-dependent areas where communities rely on fishing and have limited disaster-preparedness infrastructure. This study addresses this gap by looking at the unique challenges faced by Barangay Bacong's coastal ecosystem, where environmental changes directly affect local livelihoods and community resilience. By evaluating factors such as sea-level rise, coastal landscape, and local development, the research tackles the core problem: understanding the adaptive capacity and resilience of a rural coastal area that depends heavily on natural resources. The study contributes baseline data to support conservation and sustainable development planning for similar rural coastal areas, offering a valuable framework for future vulnerability assessments and informed coastal management strategies.

2. METHODOLOGY

2.1 Research Design

The coastal vulnerability assessment of Barangay Bacong, Babatngon Leyte, utilized a mixed-method approach, incorporating qualitative and quantitative data collection and analysis techniques. Thus, a validated survey questionnaire was provided for the local residents and the data were obtained from MPDO and MGB in the form of shape files and mainly utilized the tool Quantum Geographic Information System (QGIS) version 3.28.8 to determine the spatial data needed. The typical categories of the coastal vulnerability index were established from the research conducted by Husaini et al. (2021) and classified as low (!-2), moderate (3-4), and high (5),

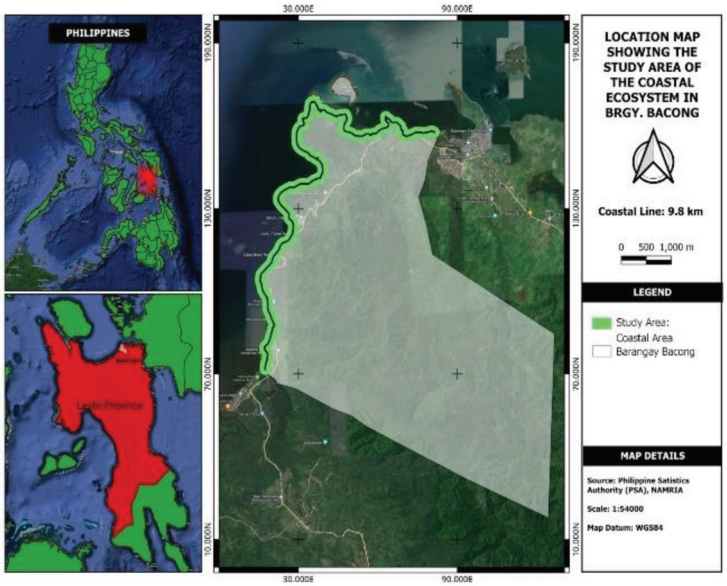

Figure 1. Location of the Study.

according to the extent of damage observed, especially in coastal regions.

2.2 Respondents of the Study

The study employed a simple random sampling method to gather data from 228 residents of Barangay Bacong, Babatngon, Leyte, out of a total population of 529. this method was chosen to ensure a representative sample, minimizing bias and allowing for generalizable findings. The Krejcie & Morgan was used as recommended by Bukhari (2021) to determine the sample size, ensuring desired level of accuracy for the study. By selecting participants randomly, the study aimed to capture the diverse characteristics of the community, making the results statistically significant and applicable to the entire barangay.

2.3 Method of Scoring and Interpretation

The following equivalents were used to record the data gathered from the questionnaire adapted from the study of Gan et al., (2022). The respondents' level of education was categorized and put into several categories. Each of the following codes designates a different level of education: 1 denotes never having attended school; 2 denotes having completed elementary school; 3 denotes having graduated from elementary School; 4 having completed High School; 5 having graduated from High School; 6 having completed some coursework; and 7 denotes having earned a postgraduate degree.

A 5-point Likert scale was used for respondents' comments in order to rate their attitudes according to what they said. The use of Likert scales in research allowed researchers to quantify community attitudes towards coastal sustainability. This was achieved through questionnaires that presented statements related to coastal sustainability, and respondents indicated their level of agreement or disagreement using a scale. This quantifiable data provided valuable insights into community perceptions and preferences, informing interventions and policies aimed at promoting sustainable practices.

The coastal vulnerability assessment of Barangay Bacong, Babatngon Leyte, utilized a mixed-method approach, incorporating qualitative and quantitative data collection and analysis techniques. Thus, the data were obtained from both primary and secondary sources.

Each parameter assigned a ranking score between 1, 2 and 3. To assess vulnerability quantitatively (Yaddav et al., 2022), the individual measurements were compared and assigned a ranking from low (1- 2), moderate (3-4), to high (5). The quantification was generally based on the definition of semi- quantitative scores according to a 1-3 scale, where 1 indicated a low contribution to coastal vulnerability of a specific key variable for the studied area, while 2 indicated a moderate level and 3 indicated a high contribution. The ranking was assigned to these values and summed for each area to provide a relative score of Coastal Vulnerability Index (CVI) based on Borruf (2005).

The degree of vulnerability which can be seen on Table C, was then evaluated using a rating methodology.

In a similar context, the standard levels of the coastal vulnerability index were derived from Husaini et al., study (2021) and categorized as low vulnerability, moderate, and high, based on the impact of the damage observed, particularly in coastal areas. Each cell then received a vulnerability ranking in the corresponding parameter.

The data obtained from the assessment underwent various statistical treatment to address the research problem. Therefore, the study utilized the following formula of Borruf (2005):

$$CVI = \sqrt{(a * b * c * d * e)/n}$$

Where:

n = number of vulnerability variables, a = coastal geomorphology, b = type of coastal development, c = coastal slope, d = presence or absence of coastal habitats, e = sea level rise.

3. RESULTS AND DISCUSSION

3.1 Profile of the Respondents

The study considered various attributes of the participants, including their age range, educational background, occupation, and number of household members. These attributes are described in the following discussion.

3.1.1 Age

Majority of the people who answered the survey were at the middle aged which can be seen on Table

Table 1. Interpretation on the Attitude-based Actions of the Local Community

Scale	Mean Range	Interpretation
1	1.00- 1.80	Strongly Disagree
2	1.81-2.60	Disagree
3	2.61-3.40	Neutral
4	3.41-4.20	Agree
5	4.21-5.00	Strongly Agree

Source: *Authors, 2024.*

Table 2. Coastal Vulnerability Levels

(CVI)	VULNERABILITY
1-2	Low
3-4	Moderate
5	High

Source: *Authors, 2024.*

1. Followed by ages from 18-24 categorized as adults at twenty-seven-point twenty percent (27.20%). Furthermore, twenty-one-point ninety percent (21.90%) are young adults that are ages 25- 34, whereas thirteen-point ten percent (13.10%) are old adults. The least respondents were older adults that ages 55 and above having comprised of five- point eighty percent (5.80%). The finding of the study is consistent with the research conducted by Lau et al. (2019) which highlighted the importance of middle-aged individuals in coastal resource management.

3.1.2 Educational Attainment

Of the total number of respondents, twenty-three- point two percent (23.20%) have an educational attainment at a high school level as seen on table 2, whereas nineteen-point twenty percent (19.20%) have graduated in high school. Followed by eighteen-point forty percent (18.40%) were college level and seventeen-point thirty percent (17.30%) having elementary level of education. Twelve-point twenty percent (12.20%) of which graduated from elementary and eight-point thirty percent (8.30%) graduated in college, with zero-point forty percent (0.40%) being post graduate. People that have a certain degree of education are sometimes connected to being aware of environmental issues, helping them to make decisions that provides an outcome that benefits the majority. Conversely, lower levels of education can contribute to behaviors that may negatively impact coastal ecosystems, such as overfishing and pollution, due to a lack of awareness regarding their significance and vulnerability (Wang et al., 2022). The findings of this study are consistent with the research conducted by the La Support (2022), which emphasizes that education's effectiveness and significance are widely established. Engaging people in education and raising their level of awareness about the environment as a whole is an effective strategy of motivating them to take action to protect it.

3.1.3 Occupation

The data indicates which can be seen in Table 5 revealed that the most common occupation is fishing (100 respondents) making up 44.00% of the total surveyed population. Additionally, occupation listed are vendors (44 respondents) with nineteen-point twenty percent (19.20%) of those surveyed population. Followed by employees (14 respondents) with six-point ten percent (6.10%) of the total, and drivers (7 respondents) making up three-point ten percent (3.10%) of the population.

Another construction worker (3 respondents) and caretakers (3 respondents) have the same number of results with one-point thirty percent (1.30%) of the sum total. There were (2 respondents) that have pension with the percentage of zero-point ninety percent (0.90%). Farmer represents the smallest portion of the population

Table 3. Age

Age Range	Frequency	Percentage
18-24	62	27.20%
25-34	50	21.90%
35-44	73	32.00%
45-54	30	13.10%
55 above	13	5.80%
Total	**228**	**100%**

Source: *Authors, 2024.*

Table 4. Educational Attainment

Educational Attainment	Frequency	Percentage
Post Graduate	1	0.40%
College Graduate	19	8.30%
College Level	42	18.40%
High School Graduate	44	19.20%
High School Level	53	23.20%
Elementary Graduate	28	12.20%
Elementary Level	41	17.30%
Total	**228**	**100%**

Source: *Authors, 2024.*

Table 5. Occupation

Occupation	Frequency	Percentage
Caretaker	3	1.30%
Construction Worker	3	1.30%
Driver	7	3.10%
Fisherman	100	44.00%
Employee	14	6.10%
Farmer	1	0.40%
Vendor	44	19.20%
Seasonal Worker	54	23.70%
Pension	2	0.90%
Total	**228**	**100%**

Source: *Authors, 2024.*

Table 6. Number of Household Members

Number of Household Members	Frequency	Percentage
1-3	99	43.50%
4-6	111	48.70%
7-9	12	5.20%
10-12	6	2.60%
Total	**228**	**100%**

Source: *Authors, 2024.*

Table 7. Attitude-based action of the local community towards sustainability of the coastal area

Statement	Mean	Interpretation
a. I think any plastics are harmful to marine ecosystems.	4.28	Strongly Agree
b. I think marine environment pollution is currently a serious problem.	4.26	Strongly Agree
c. I think marine environment pollution negatively affects our tourism sector.	4.22	Strongly Agree
d. To reduce the amount of solid waste in the marine environment, we should reduce plastic production.	4.17	Agree
e. I think daily-life needs generate and ultimately will cause marine pollution.	4.14	Agree
f. I should be aware about the damage caused by various marine environment pollutants.	4.18	Agree
g. I should be aware about reports of marine about the reports of marine-related pollution.	4.18	Agree
h. I should support activities related to the marine environmental pollution.	4.19	Agree
i. I agree that the government should build sanitary sewers and sewage treatment plants.	4.21	Strongly Agree
j. I intend to do my part to prevent the ocean pollution.	4.13	Agree
k. I will inform the relevant Local Government institutions when I notice pollution near the coast.	4.11	Agree
l. I do not support manufacturers or companies that do not have proper waste disposal.	4.14	Agree
m. I will reduce my consumption of coastal marine species such as shrimp, crabs, fishes, etc.	3.05	Agree
n. I will reduce the use of cleaning products such as detergents that pollute the sea.	3.60	Agree
o. I will reduce my participation in leisure activities that will affect the coastal ecosystem.	4.03	Agree
p. I will discuss topics related to the sustainability of the coastal ecosystem with the community, family, and friends.	4.13	Agree
q. I will partake in beach clean-up activities.	4.08	Agree
r. When I go to the seaside, I will take my own garbage with me.	4.16	Agree
Total Mean	**4.07**	**Agree**

Source: *Authors, 2024.*

with (1 respondent) making up zero- point forty percent (0.40%) of the entire surveyed population. However, a significant number of respondents (54 respondents) which makes up twenty-three-point seven percent (23.7%) of the whole surveyed population considered as seasonal worker. In general, the data suggests that most of the respondents depend on natural resources or common work for their income. A huge part of population leans on fishing or various marine resources exploitation for their livelihood; this could be one of the contributing factors in terms of coastal vulnerability.

3.1.4 Number of Household Members

The results of the distribution revealed that majority of the respondents which can be seen in Table 7, had 4-6- or forty-eight-point seventy percent (48.70%) members in their family. Of the total respondents, ninety-nine (99) or forty-three-point fifty percent (43.50%) had 1-3 members in their family, whereas twelve (12) of them had 7-9 household members or five-point twenty percent (5.20%). And the lowest of which, 10-12 household members in their family or two-point sixty percent (2.60%). While house hold size is one of the demographic factors, it is not directly relating to the vulnerability of the coastal ecosystem in Barangay Bacong, implications including an increased population density have a higher chance of generating more waste and having more impact with regards to susceptibility.

3.1.5 Attitude-based Actions of the Local Community

Majority of the respondents' rates indicate their level of agreement with the statement concerning the sustainability of the coastal area in the barangay. This aligns with the studies of Jones & Patel (2022) which highlight the significance of community attitudes and actions in waste management and pollution control, which are the crucial aspects for maintaining the health and resilience of coastal ecosystems. In addition, the knowledge of the coastal community proves significant in mitigation and conservation efforts in promoting the sustainability of coastal environments (Hasriyanti et. al., 2024). This shows individuals of improper disposal of plastic garbage has a harmful impact to human and

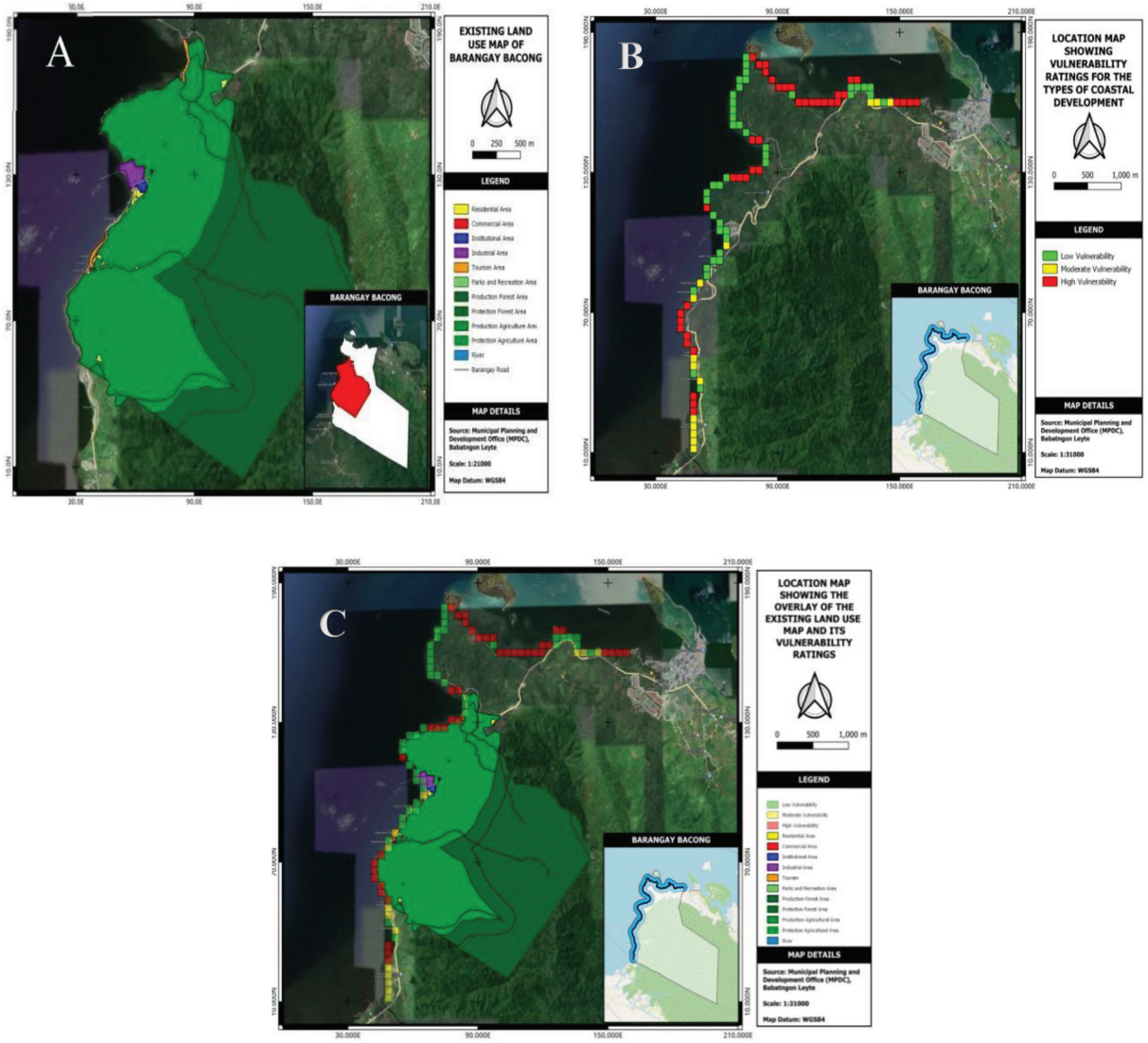

Figure 2. (A) Existing land use map (B) Vulnerability ratings for the type of coastal development (C) Location map showing the overlay of the existing land use map and its vulnerability ratings.

environmental health. The majority of respondents 51-57% agreed that properly disposing of personal waste helps to reduce beach pollution. In beaches, it is typical seen management gather PET, scale and other (Inocente et al., 2023). Additionally, Fava (2022), stated that, the most effective plan of actions, according to a number of experts, to stop plastic debris by starting from our home. They can begin implementing better policies for everybody by deepening their understanding and knowledge about the effects of marine pollution.

3.2 Type of Coastal Development

The existing map which can be seen on Figure 2 indicate that along the coast: tourism, industrial residential, and agricultural areas are commonly found. The existing land use map serves as the basis for the ratings in determining the level of vulnerability of each cell which can be seen on Figure 2B. The result of the vulnerability ratings is further visualized which is seen in Figure 2C. The type of coastal development shows that out of ninety-seven (97) cells, forty-two cells (42) of the coastal are is given the classification of low (1) mostly due to the land use type being tourism, commercial, and industrial area. Fourteen (14) of the cells are categorized as moderate (2) because of the area possessing in comparison to the low vulnerability zones, these residential infrastructure locations are more vulnerable to coastal disasters. Additionally, the classification of high (3) indicates that forty-one (41) cells of the coastline region are used for agriculture indicating that agricultural areas, especially those situated in the coastal zone, are more vulnerable to coastal dangers. The analysis of Rocha et al., (2021) stated in terms of assessing coastal vulnerability, distance is a crucial factor. The coastal area is susceptible to coastal pressures. As the distance to coastline increases, erosion and coastal vulnerability decreases. In contrast, the closer the distance of the residents near the coastline the more vulnerable the are in coastal damages.

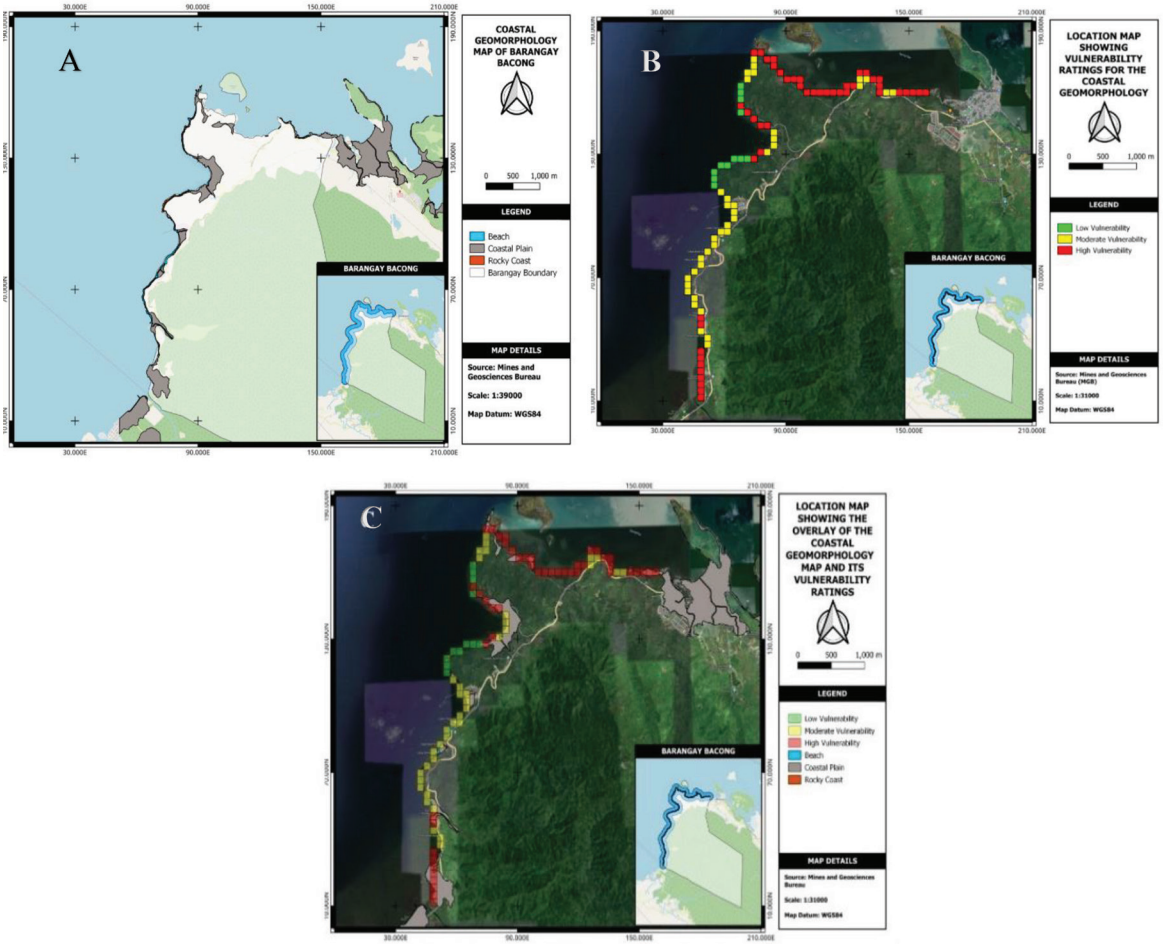

Figure 3. (A) Coastal geomorphology map (B) Vulnerability ratings for coastal geomorphology (C) Location map showing the overlay of the coastal map and its vulnerability ratings.

3.3 Coastal Geomorphology

The coastal geomorphology map which is seen in figure 3A indicate that along the coast; coastal plain, rocky coast and beach are commonly found. The coastal geomorphology map serves as the basis for the ratings in determining the level of vulnerability of each cell which can be seen on Figure 3B. The result of coastal geomorphology shows that out of ninety-seven (97) cells, thirty- eight (38) cells of the area are classified as moderate (2), it is observed that sandy beaches, such as Tulaan Beach Resort and Karisyohan Beach are located along the coast. A total of twelve (12) cells of the area classified as low (1) shows rocky coastlines that tend to be more resistant to erosion compared to sandy beaches, providing a natural protective barrier against coastal hazards, and forty- seven (47) cells are coastal plains that consists of low-lying areas classified as high (3).

The data presented suggest that the area, having varied landscape, experiences moderate levels of vulnerability. This implies that although most of the coast has sandy beaches, coastal plains and rocky coast are also evident which causes to have a high vulnerability. Furthermore, the study of Widura and Mardiatno (2022) explains that marine landforms such as rocky coastal lower erosion that formation disposition has moderate vulnerability, while marine landforms that have low vulnerability are found on the cliff coast. Moreover, the study of Koroglu (2019) indicates how the geomorphology of the coast affects how it responds to rising sea levels which some areas like cliffs, rocky coasts, are naturally more resistant to erosion than sandy beaches.

3.4 Coastal Slope

The coastal slope map as seen on Figure 4A indicate the slope degrees found. Along the coast, the values observed were only less than or equal to zero point-two degrees (≤0.2°). The coastal slope map served as the basis for the ratings in determining the level of vulnerability of each cell which can be seen on Figure 4B. The coastal slope of the coastal area was given a classification of high (3), a value of less than or equal to zero point- two degrees (≤0.2°) were observed which signify high vulnerability in terms of the inclination rate of the coastal area. According to López-Dóriga et al. (2020) human development tends to concentrate in flat coastal areas, further increasing vulnerability by intensifying exposure to coastal hazards and reducing natural buffers.

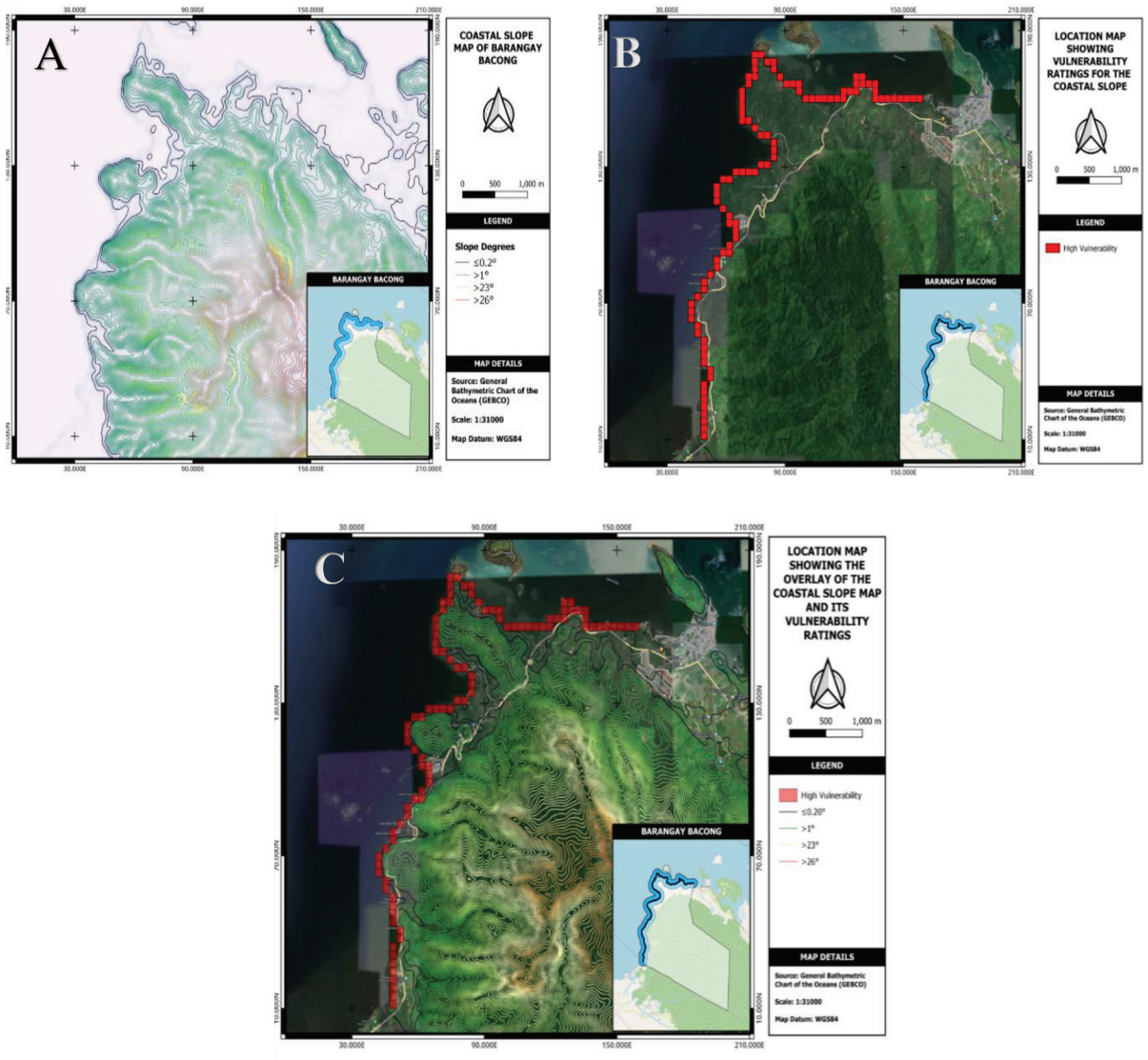

Figure 4. (A) Coastal slope map (B) Vulnerability ratings for coastal slope (C) Location map showing the overlay of the coastal map and its vulnerability ratings.

3.5 Presence or Absence of Coastal Habitats

The coastal habitat map which can be seen on Figure 5A indicate that along the coast the presence of mangroves, sea-grasses and coral reefs are observed. However, there are also some areas do not have coastal habitat present. The coastal habitat map served as the basis for the ratings in determining the level of vulnerability of each cell which can be seen on Figure 5B. The presence or absence of coastal habitat shows that out of ninety-seven (97) cells, thirty (30) cells of the coastal area consist of coral reefs and sea-grasses which is given the classification of moderate (2). A total twenty-nine (29) cells did not have any coastal habitats observed and were classified as high (3), the thirty-eight (38) cells were classified as low (1) due to the coastal area having mangroves as well as coral reefs and sea-grasses. The best ways to mitigate coastal risks ought on by sea level rise and protect coastal towns have been proposed as nature-based solutions. People at risk from these impact risks will significantly rise with the loss of current natural ecosystems (Manes et al., 2023).

3.6 Sea Level Rise

At projected 0.5 meters scenarios, which can be seen on Figure 6A indicate that along the coast that flooding at ankle deep (0.1-0.25) meters and knee deep (0.25-0.7) meters are mostly observed. The projected sea level rise served as the basis for the ratings in determining the level of vulnerability of each cell which can be seen on figure 6B. The projected sea level rise at 0.5 meters shows that the coastal area has the possibility of experiencing flooding at 0.1 meters to 0.7 meters. The projected sea level rise at 0.5 meters' scenarios shows that out of ninety-seven (97) cells, four (4) cells of the area show 0.1 meters to 0.25 meters of flooding, giving the classification of moderate (2) which suggest significant vulnerability. The inundation indicates the potential for adverse impacts such as erosion, coastal habitat loss, and infrastructure

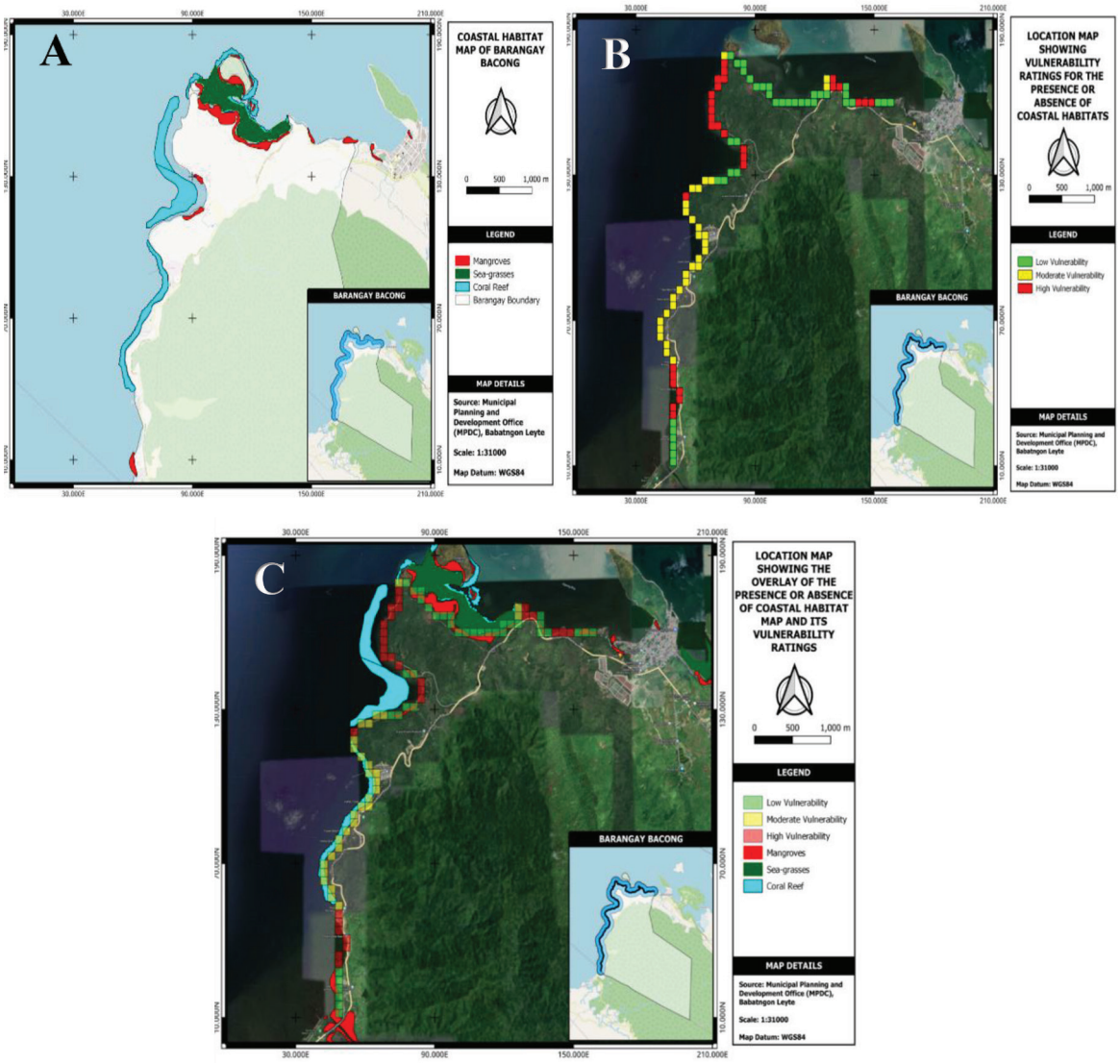

Figure 5. (A) Coastal habitat map (B) Vulnerability ratings for the presence or absence of coastal habitat (C) Location map showing the overlay of the coastal map and its vulnerability ratings.

damage, highlighting the urgent need for adaptation measures to enhance resilience. Additionally, seventeen (17) cells of the area shows that there is no flooding experienced at 0.5 meters sea-level rise scenario due to presence of natural buffers. A large portion of the area also shows that seventy-six (76) cells experienced knee deep flooding between 0.25 to 0.7 meters. Taherkhani et al., (2020) indicates that coastal floods can be disproportionately increased by even little sea level rise. Numerous oceanic phenomena, including tides, extratropical and tropical storms, climatic cycles (such as the El Niño / Southern Oscillation). As a result, there are many different time scales at which coastal flooding occurs and how severe it is. However, there is a significant interplay between the constant trend and accelerated rise in sea level and brief intense occurrences.

3.7 Coastal Vulnerability Index

The findings of this study are consistent with the research conducted by Yadav et al. (2022), who observed that coastal areas classified with moderate vulnerability often sustain their adaptive capacity through natural features like mangroves and coral reefs. Similarly, in Barangay Bacong, moderate vulnerability levels were observed, with some areas benefitting from natural barriers that provide resilience against environmental threats. The study further aligns with López-Dóriga et al. (2020), who noted that low-elevation coastal areas face heightened vulnerability to sea-level rise and erosion, as demonstrated by Barangay Bacong's exposure to significant flood risks. These similarities underscore the importance of coastal elevation and geomorphology in determining resilience.

This research also integrates with Fedele et al. (2021), who emphasized that communities dependent on natural resources for livelihoods, particularly in tropical regions, face amplified risks from environmental degradation. The high reliance on fishing in Barangay Bacong places it in a similarly vulnerable position, indicating a need for diverse livelihood options and conservation measures to bolster

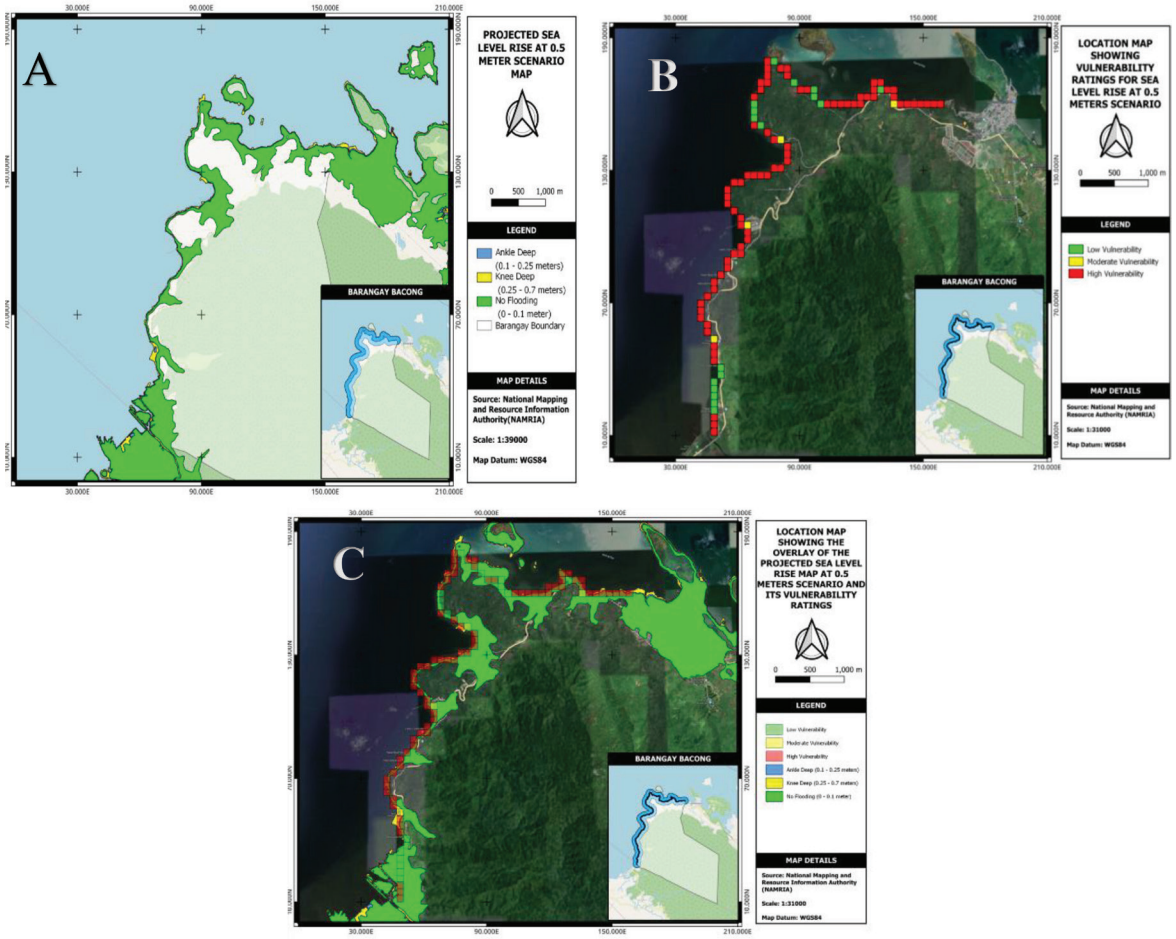

Figure 6. (A) Projected sea level rise at 0.5 meters scenarios (B) Vulnerability ratings for the sea level rise (C) Location map showing the overlay of the coastal map and its vulnerability ratings.

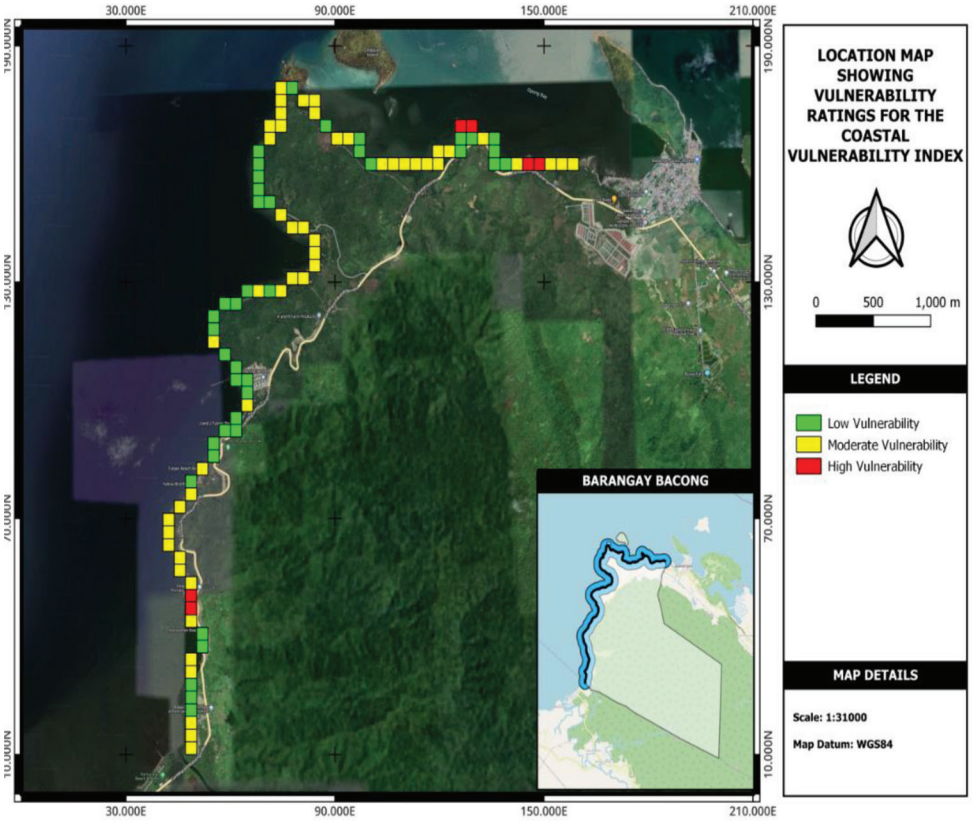

Figure 7. Ratings for the Coastal Vulnerability Index.

resilience. Additionally, the findings echo Meddah et al. (2023), who advocated for community-based adaptive strategies tailored to the unique socio-economic and environmental needs of small coastal communities. Together, these comparisons highlight the importance of integrative, community-focused approaches in managing coastal vulnerability effectively.

4. CONCLUSIONS

The study reveals that the respondents, primarily middle-aged adults (35-44 years old) and young adults (18-24 years old) with a high school education, are mainly engaged in fishing as their occupation. Despite the low population in Barangay Bacong, there is a notable awareness of marine pollution among respondents. They actively take steps to mitigate pollution by refraining from waste disposal into the sea and participating in conservation efforts by releasing immature marine species back into their natural habitat. The area shows a moderate level of vulnerability, emphasizing the need for continuous community engagement, infrastructure development, sustainable practices, and effective disaster risk reduction strategies to enhance adaptive capacity.

The coastal ecosystem exhibits a high level of integrity, with sandy beaches and diverse habitats contributing to its resilience. However, challenges like coastal slope and sea level rise pose significant risks, with a notable vulnerability flooding. This study provides valuable baseline information for future research but ongoing monitoring and management practices are essential to address the complexities of vulnerability assessment in coastal ecosystem.

Acknowledgments

The authors would like to thank the MPDO- LGU Babatngon, Leyte, MGB VIII Geosciences Division, GEBCO, EnP Julius Ken P. Badeo and the Bureau of Fisheries and Aquatic Resources RO8 for providing the constructive comments, shape files for the different maps, and guidance throughout the study.

In addition, the authors would also like to express his gratitude to the editors and editorial staff of JHSSR for their assistance during publication period.

Funding

The authors received no financial support for the research.

Declaration of Conflicting Interests

The authors declare that they have no competing interests.

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Horizon J. Hum. & Soc. Sci. Res. 7 (S): 101 – 105 (2025)

Journal of Humanities and Social Sciences Research
www.horizon-JHSSR.com

RESEARCH ARTICLE
Peer-reviewed | Open Access

Harnessing High-Performance Computing for Carbon Capture and Storage: A Strategic Pathway to Climate Change Mitigation

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ARTICLE INFO

Article history
RECEIVED: 06-Mar-25
REVISED: 07-Jun-25
ACCEPTED: 17-Jun-25
PUBLISHED: 15-Jul-25

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Citation: Nopparuj Suetrong, Pornnapa Panyadee, Natthanan Promsuk and Juggapong Natwichai (2025). Harnessing High-Performance Computing for Carbon Capture and Storage: A Strategic Pathway to Climate Change Mitigation. Horizon J. Hum. Soc. Sci. Res. 7 (S), 101–105. https://doi.org/10.37534/bp.jhssr.2025.v7.nS.id1297.p101-105

ABSTRACT

Introduction: The accelerating pace of climate change, driven primarily by rising greenhouse gas emissions, presents a critical challenge to sustainable natural resource management. Carbon Capture and Storage (CCS) is increasingly recognized as a viable mitigation strategy to reduce atmospheric CO_2 levels and support global carbon neutrality goals. **Methods:** This study explores the integration of Machine Learning (ML)—specifically Graph Convolutional Networks (GCNs)—and High-Performance Computing (HPC) to optimize CCS processes. GCNs are employed to analyze and model complex datasets for CO_2 transport, identifying optimal routes based on criteria such as distance, cost, and efficiency. Simultaneously, HPC infrastructure, including GPU acceleration, is leveraged to enhance computational speed and processing capabilities. **Results:** The combined implementation of GCNs and HPC significantly reduces computational time—by approximately 65% compared to GCNs without HPC support. This acceleration enables real-time route optimization and model recalibration based on dynamic environmental and logistical inputs, improving the operational efficiency of CO_2 capture, transport, and storage. **Conclusions:** The integration of high-performance computing with advanced ML techniques offers a transformative approach to improving CCS systems. By enabling rapid, data-driven decision-making, this strategy not only enhances the precision and efficiency of CCS but also strengthens broader efforts toward climate change mitigation and sustainable environmental management.

Keywords: Carbon Capture and Storage, Climate Change, Computational Modeling, Green Technology, High-Performance Computing, Machine Learning, Sustainability, Transportation

1. INTRODUCTION

Rapid climate and environmental changes present significant challenges for global natural resource management, primarily driven by increased greenhouse gas emissions, particularly carbon dioxide (CO_2). These changes have severely impacted ecosystems, economies, and human quality of life (Intergovernmental Panel on Climate Change [IPCC], 2021). Researchers have recently developed technologies to reduce CO_2 emissions, as they significantly contribute to global warming (Friedlingstein, et al., 2022). One key approach is Carbon Capture and Storage (CCS) technology, which is essential for lowering

CO_2 levels in the atmosphere. The primary goal of CCS is to safely and permanently store CO_2 underground, making it a crucial strategy for achieving the ambitious goals of Carbon Neutrality and Net Zero Emissions (Bui, et al., 2018). However, the large-scale CCS implementation challenges related to efficiency and cost, especially concerning the transportation of CO_2 from emission sources to storage sites. Designing efficient transportation routes is crucial for economic feasibility and widespread CCS adoption. Integrating Machine Learning (ML) and High-Performance Computing (HPC) shows great promise in revolutionizing CCS system design and operation (Wim, et al., 2013), potentially overcoming these challenges and enhancing the technology's effectiveness in combating climate change.

ML can be applied to analyze various factors related to CO_2 transportation and geoinformatics, such as distance, terrain, traffic patterns, and existing infrastructure. Given the large and complex nature of these datasets, ML techniques can be employed to optimize route selection for CO_2 transport. This optimization may involve identifying the shortest, the fastest, or the most cost-effective path from the source to the sink. Meanwhile, HPC is essential for supporting ML operations, as it can process large amounts of data quickly and accurately (Ettifouri, et al., 2024). HPC resources, including Graphics Processing Units (GPUs), enable rapid computation and modeling of complex scenarios. This capability is particularly crucial for analyzing and designing CO_2 transportation routes from multiple emission sources to storage sites (sinks) across a country or region (Yan, et al., 2021).

The integration of ML and HPC in advancing and refining CCS systems not only improves the effectiveness of reducing atmospheric CO_2 but also reduces expenses and enhances the practicality of widespread CCS implementation (Wen, et al., 2021). Thus, the objective of this research is to demonstrate the application of ML in conjunction with HPC to identify the shortest path from CO_2 emission sources to sinks. This research explains how HPC can reduce processing time, making CO_2 transportation in real-world applications more efficient.

2. MATERIALS AND METHODS

This section provides the details of the datasets and optimization algorithms, such as Dijkstra's algorithm and Graph Convolutional Networks (GCN), utilized to determine the most efficient routes for CO_2 transportation in Thailand.

2.1. Datasets

The datasets incorporate 1,956 CO_2 emission sources dispersed across Thailand and two potential sinks for CCS projects, specifically the Lampang Basin in northern Thailand and the basin in the Gulf of Thailand. Furthermore, this research necessitates the use of HPC systems to determine the optimal route among all possible paths between emission sources and sinks across the country.

2.2. Dijkstra's Algorithm

Dijkstra's algorithm is employed to determine the shortest path between nodes in a graph (Noto & Sato, 2000). In this study, the graph consists of CO_2 emission sources represented as nodes, with sinks designated as destination nodes. The edges of the graph illustrate the road network within the country, weighted by distance between each node. The algorithm constructs a tree of shortest paths from the emission sources to the destination sinks. It operates by maintaining a set of unvisited emission sources and calculating tentative distances from a source node to each destination sink. When a shorter path to a particular node is identified, the algorithm updates the corresponding distance. This problem demonstrates an optimal substructure as follows: if CO_2 emission source A (the starting node) is connected to CO_2 emission source B and CO_2 emission source B is linked to a destination sink (the destination node), such that the path from CO_2 emission source A to the destination sink must pass through CO_2 emission source B, then the shortest path from CO_2 emission source A to CO_2 emission source B, together with the shortest path from CO_2 emission source B to the destination sink, constitutes the overall shortest path from CO_2 emission source A to the destination sink. Therefore, the optimal solutions to these subproblems directly inform the overall optimal solution, facilitated by the algorithm's systematic tracking of the shortest possible path to each node.

2.3. Graph Convolutional Networks (GCN)

A GCN is a specific type of Graph Neural Network (GNN) designed to process and analyze graph-structured data. In this context, a graph consists of interconnected nodes and edges, where nodes represent entities and edges denote the relationships or connections between them. Unlike traditional Convolutional Neural Networks (CNNs), which operate on grid-like data such as images, GCNs perform convolutional operations on an adjacency matrix (Suetrong, et al., 2024) or a node feature matrix.

In this work, the nodes represent various sources and sinks, while edges represent the connections between these nodes, determined by road networks in Thailand. This approach is similar to Dijkstra's algorithm, as previously mentioned. The nodes and edges serve as inputs to the GCN model. The model utilizes graph convolutional layers to learn embeddings for the nodes

Table 1. Average training time per epoch of GCN across a total of 20 epochs

Algorithm	Average training time per epoch
GCN without HPC	~ 3.2 hours
GCN with HPC	~ 1.1 hours

Source: Authors, 2024.

Table 2. Average computation time for Dijkstra's algorithm

Algorithm	Average computation time (50 iterations)
Dijkstra's algorithm without HPC	~ 54.49 minutes
Dijkstra's algorithm with HPC	~ 26.74 minutes

Source: Authors, 2024.

based on their connectivity. Ultimately, the model output provides the shortest path between a source and a sink by indicating the next node in the path.

Furthermore, GCNs are a subtype of Deep Learning (DL), which is a branch of ML. GCNs require substantial amounts of data for training and may encounter challenges due to hardware limitations, especially when dealing with very large or complex graphs, such as those with nearly 2,000 nodes in this study. However, HPC resources can adequately support the computational demands associated with training these models.

3. RESULTS AND DISCUSSION

This section analyzes the performance of Dijkstra's algorithm and GCN in identifying the shortest path within a graph consisting of 1,958 nodes (1,956 nodes of sources and 2 nodes of sinks). It compares the training times with and without HPC resources. The local environment used for testing was a 2020 Mac Mini, equipped with an Apple M1 chip featuring an 8-core CPU (4 performance cores and 4 efficiency cores), an 8-core GPU, and 8 GB of memory. In contrast, the HPC environment utilized a 2-core CPU AMD EPYC 7742 @2.25 GHz and a NVIDIA HGX A100 graphics card.

The results indicate that the training time per epoch with HPC is approximately three times faster than without HPC, reducing the duration from around 3 hours to approximately 1 hour. This represents a reduction of about 65%, as shown in Table 1. Furthermore, Table 2 demonstrates that Dijkstra's algorithm runs faster with HPC compared to without, reducing the computation time by approximately 51 %.

4. CONCLUSION

In conclusion, rapid climate changes significantly contribute to global warming. Carbon Capture and Storage (CCS) is a technology aimed at mitigating rising carbon dioxide (CO_2) levels in the atmosphere. It works by capturing CO_2 from emission sources, transporting it to designated sinks, and injecting it underground. This study introduces an application of Machine Learning (ML), particularly Graph Convolutional Networks (GCNs), in conjunction with High-Performance Computing (HPC), which provides substantial computational resources for identifying the shortest path from sources to sinks. The results obtained from both GCN and Dijkstra's algorithm demonstrate that utilizing HPC reduces the training time of the GCN model by approximately 65% and decreases computation time by approximately 51%, respectively. These findings contribute to more efficient management of CO_2 transportation in real-world applications.

Acknowledgements

This work was supported by Erawan HPC Project, Information Technology Service Center (ITSC), Chiang Mai University, Chiang Mai, Thailand. The authors would also like to express their gratitude to the Chiang Mai CCS Research Group for providing valuable data and consultation throughout the research.

The authors would like to thank the MPDO- LGU Babatngon, Leyte, MGB VIII Geosciences Division, GEBCO, EnP Julius Ken P. Badeo and the Bureau of Fisheries and Aquatic Resources RO8 for providing the constructive comments, shape files for the different maps, and guidance throughout the study.

In addition, the authors would also like to express his gratitude to the editors and editorial staff of JHSSR for their assistance during publication period.

Funding

The authors received no financial support for the research.

Declaration of Conflicting Interests

The authors declare that they have no competing interests.

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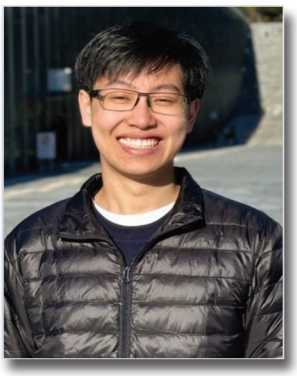

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Horizon J. Hum. & Soc. Sci. Res. 7 (S): 106 – 116 (2025)

Journal of Humanities and Social Sciences Research
www.horizon-JHSSR.com

RESEARCH ARTICLE
Peer-reviewed | Open Access

Strengthening Resilience in Schools and Communities: The Strategic Role of Universities in Climate Crisis Management

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ARTICLE INFO

Article history
RECEIVED: 10-Mar-25
REVISED: 07-Jun-25
ACCEPTED: 16-Jun-25
PUBLISHED: 15-Jul-25

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Citation: Reni Juwitasari (2025). Strengthening Resilience in Schools and Communities: The Strategic Role of Universities in Climate Crisis Management. Horizon J. Hum. Soc. Sci. Res. 7 (S), 106–116. https://doi.org/10.37534/bp.jhssr.2025.v7.nS.id1299.p106-116

ABSTRACT

Introduction: In the context of escalating climate-related disasters, building resilience in schools and surrounding communities has become a critical priority. This study explores the strategic role of universities in advancing climate crisis management, aligning with Sustainable Development Goal 13 (Climate Action), by facilitating knowledge dissemination, capacity-building, and multisectoral collaboration. **Methods:** Through a collaborative initiative led by the School of Social Innovation (DRES-ARCID), in partnership with experts from Kumamoto University and Hiroshima University, a community-based disaster resilience framework was implemented at Santikhiri Witthayakom School, located in the highland forest area of Doi Mae Salong, Chiang Rai Province. The initiative employed a mixed-method approach, beginning with a situational analysis of school capacities in three domains: institutional systems, physical infrastructure, and external stakeholder relations. Based on this assessment, targeted training sessions were delivered to 25 school administrators and teachers. **Results:** Findings revealed significant gaps in disaster preparedness, particularly in the absence of a robust early warning system and limited emergency response planning. The training enhanced the school's capabilities in emergency communication, logistical coordination, first aid, and its function as a community shelter. The participatory design and implementation process also fostered stronger community engagement, positioning the school as a focal point in local disaster resilience. **Conclusions:** The study underscores the pivotal role universities can play in bridging academic expertise with local needs by designing and delivering integrated climate crisis response programs. It recommends the institutionalization of university-led initiatives such as Community Emergency Response Teams (CERT) training and certification, to strengthen school-community partnerships and enhance resilience at the grassroots level.

Keywords: Climate Change, Community Service, SDGs, Role of Higher Education, Capacity-building, *Tsunagaru*

1. INTRODUCTION

The escalating impacts of climate change are a pressing global issue, with vulnerable communities in Southeast Asia, particularly rural and highland areas, facing disproportionate risks. The Intergovernmental Panel on Climate Change (IPCC) reports a rising frequency and severity of hydrological disasters, such as floods and droughts, due to increasing global temperatures and shifting weather patterns (IPCC, 2013). These disasters not only threaten livelihoods but also exert immense

pressure on social infrastructures, especially schools, which are pivotal for community safety and education. Schools in disaster-prone regions are expected to safeguard children and serve as shelters for the broader community (Fernandez et al., 2022). However, without adequate preparedness, these schools and their communities remain highly vulnerable (UNDP, 2020). Universities, as knowledge hubs, must actively bolster community resilience through education, training, and applied research (Virji et al., 2012).

This study addresses the critical need to improve disaster risk reduction (DRR) within educational institutions in regions vulnerable to climate-induced disasters. While universities have traditionally advanced climate science and sustainability, there is a growing need for direct engagement with local communities through capacity-building initiatives (Storms et al., 2024; Sims et al., 2020). Recent studies highlight universities' unique position to support disaster resilience by developing localized solutions that empower communities to respond to and recover from disasters (Virji et al., 2012). This shift aligns with Sustainable Development Goal (SDG) 13, which calls for urgent climate action (UN, 2015). By collaborating with local schools, universities can foster sustainable and scalable preparedness (World Bank, 2019). Educational institutions play a key role in fostering community resilience, particularly in disaster-prone areas (Virji et al., 2012; Sims et al., 2020). Schools are well-positioned to disseminate critical disaster preparedness information and serve as community hubs for resilience initiatives (UNESCO, 2015). Integrating DRR into school curricula educates students on climate risks and equips them with practical emergency response skills (UNICEF, 2016). This aligns with global calls to incorporate DRR into national education strategies, as outlined in the Sendai Framework for Disaster Risk Reduction (UNISDR, 2015). By fostering a culture of resilience in schools, communities can better prepare for and recover from climate-related disasters.

The study focuses on *Santikhiri Witthayakom* School in Doi Mae Salong, Chiang Rai, Thailand, a region particularly vulnerable to flash floods, landslides, and droughts. The school not only educates students but also serves as a potential community shelter during emergencies. However, like many rural schools, it lacks the infrastructure, training, and resources to manage disaster risks effectively. Previous research underscores the importance of school-based DRR initiatives for enhancing student safety and community resilience (UNESCO, 2014). In response, this study, in collaboration with Kumamoto and Hiroshima Universities, developed a comprehensive school safety framework tailored to *Santikhiri Witthayakom* School (Storms et al., 2024; Fernandez et al., 2022). This study aims to create a comprehensive framework for school safety and disaster preparedness at *Santikhiri Witthayakom* School, serving as a model for similar institutions in high-risk areas. It assesses the school's institutional capacities, physical conditions, and external relations with the local community and government authorities (Sims et al., 2020). Training sessions conducted with university experts emphasize participatory approaches involving the community in disaster preparedness (UNDP, 2020). The training also includes CERT certification to enhance the school's role as a community leader in disaster resilience, ensuring that both students and residents are prepared for natural disasters (UNESCO, 2015). This study contributes to the discourse on disaster resilience and higher education's role in climate crisis management. By focusing on the intersection of education, community service, and climate action, it shows how universities can act as catalysts for building resilience in vulnerable communities. The case study of *Santikhiri Witthayakom* School provides insights into transforming educational institutions into hubs of disaster preparedness, contributing to local and global efforts to mitigate climate change impacts (Virji et al., 2012; Sims et al., 2020). Through participatory approaches, capacity building, and university-community collaboration, this study offers a scalable model for integrating DRR into schools, fostering resilience in high-risk regions.

1.1. Literature Review

1.1.1 Tsunagaru: University Presence through Capacity Building for Resilience

Resilience, as defined by the UNDRR, is "the ability of a system, community, or society exposed to hazards to resist, absorb, accommodate, adapt to, transform, and recover from the effects of a hazard" (UNDRR, 2015). However, recent debates emphasize resilience as an ongoing, transformative process where systems evolve to face both current and future risks rather than merely returning to a pre-disaster state (Cutter, 2016; Manyena, 2006). In educational settings, resilience involves building adaptive capabilities that strengthen preparedness and response to future hazards, particularly in high-risk areas prone to disasters like floods, landslides, and droughts (Pelling & Dill, 2010; UNESCO, 2014).

In high-risk, rural areas, resilience requires more than physical reconstruction. It must include community preparedness, resource access, emergency plan implementation, and collective recovery efforts (Twigg, 2015). Educational resilience involves both infrastructural improvements and institutional capacity-building, with schools often serving as community centers for disaster

preparedness and recovery (Sims et al., 2020). Debates continue about balancing physical and social resilience in educational settings. Gaillard (2019) argues that disaster management frameworks focus too heavily on infrastructure, overlooking local knowledge and the role of students and teachers. In contrast, Paton and Johnston (2017) advocate for a community-based resilience approach, where schools serve as focal points for community-wide disaster risk reduction (DRR) efforts through collaborative planning and capacity-building initiatives.

Capacity building, a key pillar of resilience, involves developing the skills, knowledge, and resources necessary to manage disaster risks effectively (Virji et al., 2012). In schools, it includes emergency preparedness training, crisis communication, and recovery planning, equipping staff and students to act during emergencies and contributing to long-term community resilience (Gaillard, 2019). Universities (multisectoral collaboration or *Tsunagaru)* play a critical role in facilitating capacity-building efforts in disaster risk management by providing technical expertise, research-based solutions, and institutional support, particularly in under-resourced regions (Sims et al., 2020). However, university-led initiatives often face criticism for being short-term and project-based, which limits their long-term impact (Twigg, 2015). These programs, constrained by funding cycles, may prioritize immediate outcomes over sustainable resilience, leading to a decline in effectiveness once external support ends (Pelling & Dill, 2010).

1.1.2 Disaster Risk Reduction (DRR) in Schools and School Safety Indicators

Disaster education has been promoted internationally since the Hyogo Framework for Action (HFA) 2005–2015 established Priority for Action 3, which emphasizes the use of knowledge, innovation, and education to build a culture of safety and resilience at all levels (UNISDR, 2005). It highlights the role of "Knowledge and Education," with both formal and non-formal education and awareness-raising being crucial components of disaster risk reduction (Shaw et al., 2011).

In the context of climate change, vulnerable populations, especially children, require special attention and protection, including the need to mitigate and adapt to its impacts. Child-centered disaster risk reduction (DRR) in schools is critical for creating a culture of safety. This requires linking old and new curricula, addressing natural and social issues, and fostering participation from various stakeholders, including students, teachers, school administrators, government agencies, NGOs, private sectors, media, and the local community. The 2016 Kumamoto disaster case study illustrates Japan's promotion of disaster education through the concept of *tsunagaru*, which emphasizes the connection between different elements, disciplines, and stakeholders in fostering a culture of safety in schools. Japan has proactively developed disaster preparedness capacities, integrating multilayered institutional cooperation and community participation through *tsunagaru* in the educational process. However, Thailand, despite facing increasing climate change-related disasters, continues to implement a reactive approach to disaster management. The country's disaster risk management strategies lack integration of institutional and community participation in prevention efforts (Singkran, 2017; Hungspreug et al., 2000; Tingsanchali, 2012). Thus, tsunagaru underscores the importance of linking institutions and fostering community participation in building disaster-resilient school environments, providing valuable lessons for Thai schools in addressing the challenges posed by climate change.

Hitherto, DRR, a key component of resilience, involves proactive measures to reduce vulnerability and mitigate the impacts of natural hazards (UNISDR, 2015). In schools, DRR includes developing safety protocols, improving infrastructure, and integrating disaster preparedness into daily operations (UNESCO, 2015). A comprehensive approach combines retrofitting buildings with robust emergency preparedness plans (World Bank, 2019). The Sendai Framework for Disaster Risk Reduction highlights schools as critical hubs for community safety, especially in rural, disaster-prone areas (UNDRR, 2015). However, a gap remains between global DRR frameworks and local school-level implementation (Gaillard, 2019). Key indicators of DRR effectiveness in schools include institutional capacity, physical resilience, and community engagement from Tong et al (2016).

Institutional capacity refers to a school's ability to develop and implement disaster protocols, maintain communication systems, and train staff and students in emergency procedures (UNESCO, 2015). This includes disaster response plans, regular drills, and integrating disaster management into school operations. Physical resilience involves the ability of school buildings to withstand disasters, including durable structures, emergency shelters, and essential services like water, electricity, and medical supplies during crises (Storms et al., 2024). Resilient infrastructure not only protects students and staff but also allows schools to serve as shelters for the community. External relations or community engagement is crucial, as schools are often central to local disaster resilience efforts. In rural areas, schools frequently serve as evacuation centers

and coordination hubs during emergencies, requiring collaboration with local governments and organizations (Sims et al., 2020).

An example is *Santikhiri Witthayakom* School, located in a highland area prone to landslides and floods. The school faces challenges due to limited funding and support, hindering its ability to implement comprehensive DRR measures to protect both students and the wider community. In many rural areas, schools serve dual roles as educational institutions and community shelters. To fulfill these responsibilities, schools need adequate resources and infrastructure, such as retrofitting buildings for disaster shelter use—a costly investment that often requires external support.

1.2. Conceptual Framework

The conceptual framework of this study positions universities as central actors in climate crisis management, focusing on three core areas: capacity building, disaster risk reduction (DRR), and community engagement. Through capacity building, universities play a critical role in transferring knowledge to local schools and communities, equipping them with the necessary tools and expertise to address climate-induced challenges (Virji et al., 2012). This includes initiatives such as Community Emergency Response Teams (CERT) training, which provides practical skills in emergency response, first aid, and logistical coordination, ensuring that schools can act as effective response units during disasters (World Bank, 2019). In the realm of DRR, the development of a comprehensive school safety framework is crucial. This framework focuses on enhancing physical infrastructure and institutional resilience alongside the implementation of early warning systems that enable real-time monitoring and communication, thus improving preparedness and response capacities (Fernandez et al., 2022). Moreover, community engagement emerges as a vital component, with universities fostering a participatory approach that actively involves local stakeholders in the planning and execution of disaster management strategies (Sims et al., 2020). Schools are also positioned as community shelters, providing safe spaces for vulnerable populations during emergencies, thereby reinforcing their role as hubs of disaster preparedness and recovery (Storms et al., 2024). By integrating these elements, the framework underscores the multifaceted role of universities in building resilience at the intersection of education, community service, and climate action. Figure 1. addresses the conceptual framework of the study.

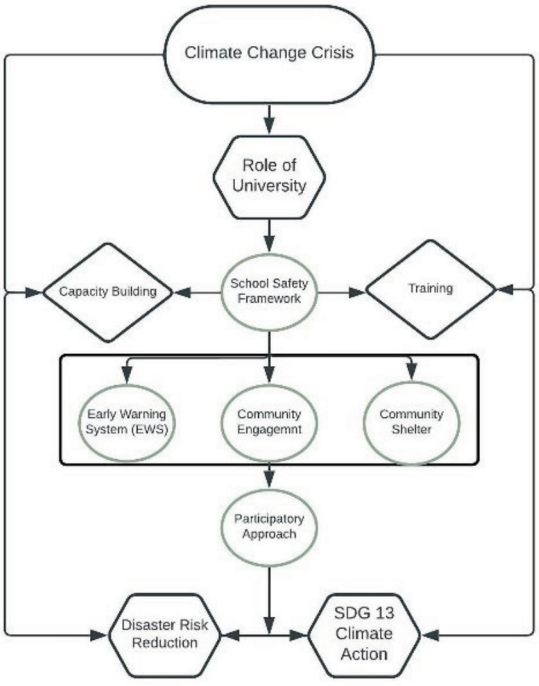

Figure 1. Conceptual Framework.

2. MATERIALS AND METHODS

2.1 Research Design

This study adopts a mixed-method approach to assess the effectiveness of DRR strategies and resilience-building efforts at *Santikhiri Witthayakom* School in Thailand. The methodology combines both quantitative and qualitative methods to provide a comprehensive understanding of the school's current institutional capacity, physical infrastructure, and external relations, as well as the outcomes of capacity-building training provided to the school administrators. This approach ensures that the study captures not only the structural and procedural aspects of DRR but also the social dimensions of resilience (Creswell & Plano Clark, 2011). The study followed the action research model, which implemented a training program in order to improve the school's disaster preparedness and address gaps identified during the capacity assessment. The training was provided to the 25 school administrators and teachers and focused on the following keywords: institutional capacity, physical conditions, and external relations. Participants were encouraged to apply the knowledge gained during the training to develop specific action plans for improving disaster preparedness at the school. It allows participants to engage actively in the identification of problems and the co-creation of solutions (Reason & Bradbury, 2001).

2.2 Sample and Data Collection

The study sample consists of 25 participants, including school administrators, executive board members, and teachers from *Santikhiri Witthayakom* School. These participants were selected through purposive sampling, as they are directly involved in the decision-making processes related to disaster

management and school operations. The sample size was deemed appropriate for generating in-depth qualitative data while also allowing for a quantitative analysis of institutional and infrastructural capacities (Palinkas et al., 2015). The quantitative phase of the study involved conducting a capacity assessment of the school's institutional preparedness and physical resilience before and after training. This assessment was based on the Institutional Capacity and Resilience Framework (ICRF), adapted from previous DRR studies (Twigg, 2015). Data was collected through structured questionnaires administered to school administrators. The questionnaires included both closed-ended and Likert-scale items designed to measure the presence and effectiveness of institutional DRR strategies, infrastructural resilience, and community partnerships.

In addition, the qualitative phase involved conducting semi-structured interviews and focus group discussions with the 25 participants to gain insights into their experiences and perceptions of disaster preparedness at *Santikhiri Witthayakom* School. The interviews focused on understanding the school's disaster response practices, the effectiveness of the training programs, and the challenges faced in implementing DRR strategies.

The semi-structured interviews allowed for flexibility in exploring individual perspectives. At the same time, focus group discussions facilitated the exchange of ideas among school staff, providing a deeper understanding of the collective experience of disaster management (Kitzinger, 1995). Participants were asked to reflect on their level of confidence in responding to disasters, the clarity of existing disaster plans, and the school's collaboration with local government and community organizations.

2.3 Data Analysis

The quantitative data collected from the structured questionnaires were analyzed using descriptive statistics to provide a snapshot of the school's current disaster management capacities. Mean scores and standard deviations were calculated for each component of the capacity assessment (institutional capacity, physical resilience, and external relations), allowing for a detailed comparison of strengths and weaknesses across different areas of disaster preparedness (Creswell, 2014). The Likert Scale questions were analyzed by using the criteria from Çelik and Oral in 2016, addressed in Table 1.

Continuously, the qualitative data from interviews and focus groups were analyzed using thematic analysis, which involved coding the data and identifying key themes related to disaster preparedness, institutional challenges, and external relations (Braun & Clarke, 2006). The coding process was iterative, with initial themes being refined as additional data were analyzed. This approach allowed for the identification of recurring patterns in participants' experiences and provided deeper insights into the barriers and opportunities for enhancing the school's disaster resilience.

3. RESULTS

3.1 Training Program Established by Three University Networks

The training program, a collaboration between Kumamoto University, Hiroshima University, and Mae Fah Luang University, aimed to build institutional capacity, enhance physical resilience, and strengthen external relations at *Santikhiri Witthayakom* School. It focused on empowering school administrators, teachers, and community leaders to lead disaster risk reduction (DRR) and climate crisis management, integrating the school's resources with broader community efforts.

The first area, institutional capacity, involved training on disaster preparedness protocols, emergency response planning, and crisis communication. Participants learned to create comprehensive disaster management frameworks, with a focus on coordination and role clarity during emergencies. Practical tools like scenario-based simulations and emergency drills were used to ensure staff preparedness and swift responses to natural disasters. Trainees were also equipped to train others, institutionalizing disaster preparedness throughout the school.

For physical resilience, the program focused on strengthening school buildings to withstand hazards like floods and landslides common in Doi Mae Salong, Chiang Rai. It provided guidance standards and improving structural integrity, retrofitting buildings to safety standards, and preparing the school to serve as a community shelter during emergencies. Participants were also trained in managing emergency supplies such as water, medical kits, and food, fostering a culture of resilience to protect students and the community.

The third focus, external relations, emphasized collaboration with local authorities and community organizations to ensure a coordinated disaster response.

Table 1. Likert Scale Evaluation Criteria by Çelik and Oral in 2016

Score Interval (Mean)	Evaluation Criteria
1.00 – 1.79	Very Low
1.80 – 2.59	Low
2.60 – 3.39	Moderate
3.40 – 4.19	High
4.20 – 5.00	Very High

Table 2. Training Program for School Safety of Disaster Risk Reduction (DRR) Adopted from Tong et al (2016)

Key Following Thematic	Key Focus Areas Aligning with Institutional Capacity and Resilience (Framework)
Strengthening Institutional Capacity for Disaster Preparedness and Disaster Risk Reduction	1. Disaster preparedness protocols 2. Emergency response planning 3. Crisis Communication 4. Disaster Training Drills
Enhancing Physical Resilience of School Infrastructure	1. School resource management 2. School as a community shelter 3. Retrofitting
Building Effective External Relations and Community Engagement	1. Building partnerships 2. Community engagement 3. Early Warning Systems

Trainees were taught to build partnerships with local disaster management agencies, aligning efforts in disaster preparedness, including early warning systems. This collaboration positioned the school as a key player in the local disaster management network, enhancing community-wide resilience. The training module is addressed in Table 2.

In conclusion, the program took a holistic approach to DRR, addressing institutional, infrastructural, and external needs. By building capacity, enhancing resilience, and fostering partnerships, the collaboration ensured that *Santikhiri Witthayakom* School is well-prepared to protect students and serve as a community hub for climate action (SDG 13), ensuring long-term resilience for both the school and the region.

3.2 Understanding of Improvement Capacity from the Training Program Implementation

This section highlights the school's capacity to implement disaster preparedness protocols, maintain communication systems, and ensure personnel are trained for emergencies. Clear, structured protocols that define roles during disasters are essential. Before training, participants rated their awareness of disaster management protocols at a low 2.5, indicating a significant gap. Post-training, confidence in understanding and implementing these protocols rose to 4.5, reflecting improved disaster management capacity. Before training, participants rated the school's emergency response plan at 2.4, citing outdated or unknown plans. One participant remarked, "We had no clear procedures, and communication was chaotic during emergencies." After training, participants confirmed the existence of a clear, updated response plan, raising the score to 4.1, signaling a proactive shift in disaster management.

Effective communication during crises is critical. Pre-training, participants rated their communication system at 2.0, citing inadequate channels and potential delays. Post-training, modernized communication systems increased the score to 4.7, significantly improving the school's real-time communication during emergencies and coordination with external responders. The effectiveness of disaster drills was also assessed. Pre-training, participants rated drill frequency at 2.3, showing a lack of practical preparedness. Post-training, regular drills were implemented, raising the score to 4.6, emphasizing the school's focus on practical disaster readiness, as recommended by Twigg (2015). Participants expressed that the training provided essential tools and knowledge. One teacher noted, "The training gave us structure. We now know who to contact, how to communicate with students, and how to coordinate with external responders."

The physical resilience component assessed *Santikhiri Witthayakom* School's infrastructure, emergency supplies, and capacity to serve as a community shelter during disasters. These factors are crucial for ensuring the safety of students, staff, and the community during natural hazards. Participants highlighted the vulnerability of the school's infrastructure, noting that most buildings had not been retrofitted to withstand floods and landslides. One administrator mentioned, "Our buildings are old, and some classrooms have visible cracks. We worry about student safety in a major disaster." Pre-training, the school's structural integrity scored 2.0 on a Likert scale, reflecting the lack of retrofitting and outdated infrastructure. Post-training, the score slightly improved to 2.3, but participants still emphasized the need for significant upgrades (World Bank, 2019; Gaillard, 2019).

The school's ability to function as a community shelter was also a concern. Before the training, participants rated the school's shelter capacity at 2.4, citing inadequate infrastructure to accommodate the community during extended disasters. Post-training, this perception improved to 3.2, but participants acknowledged that substantial retrofitting and resource investments were still needed to make the school a reliable shelter (Gaillard, 2019). Despite the desire to help the community, participants stressed that the school was not equipped to serve as a disaster shelter. A teacher

remarked, "We want to help, but we are not equipped." The need for retrofitting was widely recognized, with a very low pre-training score of 1.7. Although awareness of these needs increased during the training, no physical improvements were made, and the post-training score remained at 2.0, underscoring the urgent need for infrastructure upgrades to enhance disaster resilience.

The External Relations and Community Engagement component assessed *Santikhiri Witthayakom* School's ability to collaborate with local authorities, engage the community in disaster preparedness, and participate in Community Emergency Response Teams (CERT) training. Before the training, formal partnerships with local authorities were limited, reflected by a low Likert score of 2.4. Post-training, active collaboration significantly improved, raising the score to 4.1, demonstrating the success of the program in establishing disaster response protocols (Sims et al., 2020). Community engagement in disaster preparedness, initially weak with a score of 2.5, improved to 4.3 after the training. This participatory approach empowered the community to play an active role in disaster management, aligning with the importance of community involvement in resilience (Virji et al., 2012). The Early Warning System (EWS) also saw improvement. Pre-training, the system was inadequate, scoring 2.1. After the training, a more effective EWS integrating local knowledge and technology raised the score to 4.5, ensuring timely alerts and coordinated responses to potential disasters, consistent with UNISDR (2015) guidelines.

The study's results were examined using both quantitative and qualitative analysis. The explanation of the results is addressed below in accordance with three key factors: institutional capacity, physical resilience and external relations. In addition, Table 3 describes a summary of the improvement capacity.

4. DISCUSSION

A key outcome of the training was the successful implementation of an Early Warning System (EWS) that engages the community in monitoring climate-related hazards like floods and landslides. Pre-training, participants rated the EWS at a low 2.1, indicating a significant gap in preparedness. Post-training, the score rose to 4.5, reflecting a comprehensive, effective system tailored to local needs (UNISDR, 2015). The EWS combines local knowledge with technology, such as mobile alerts and radio communication, ensuring timely warnings for the school and community. This aligns with SDG 13's goal of enhancing resilience to climate hazards. Community involvement in the system's design and monitoring fostered ownership, critical for its sustainability and effectiveness, reflecting best practices in disaster risk reduction (Virji et al., 2012). The training significantly enhanced *Santikhiri Witthayakom* School's role in emergency response, focusing on first aid, crisis communication, and logistical coordination—critical for building climate resilience in disaster-prone areas. Pre-training, participants rated their disaster management confidence at a low 2.0. Post-training, this score rose to 4.0, reflecting improved preparedness.

Crisis communication systems also saw major improvements. Before training, communication delays and confusion were common, with a low score of 2.0. After training, robust protocols boosted the score to 4.7, ensuring quick, effective information dissemination within the school and to external stakeholders, aligning with SDG 13 goals (Cutter, 2016). The school's ability to

Table 3. Summary of Capacity Improvement from School Safety of Disaster Risk Reduction (DRR).

Indicator	Pre-Training	Value	Post-Training	Value
Institutional Capacity				
Confidence in Preparedness	2.5	Low	4.5	Very High
Emergency Planning Response	2.4	Low	4.1	High
Crisis Communication	2.0	Low	4.7	Very High
Disaster Training Drills	2.3	Low	4.6	Very High
Physical Resilience				
School Resource Management	2.0	Low	2.3	Low
School as a community shelter	2.4	Low	3.2	Moderate
Retrofitting	1.7	Very Low	2.0	Low
External Relations				
Building partnerships	2.4	Low	4.1	High
Community engagement	2.5	Low	4.3	Very High
Early warning systems	2.1	Low	4.5	Very High

serve as a community shelter improved slightly, from 2.4 to 3.2, highlighting the need for further retrofitting to ensure safety during disasters, as supported by research on disaster-resilient schools (Gaillard, 2019). The absence of a formal Community Emergency Response Team (CERT) at *Santikhiri Witthayakom* School before the training represented a major gap in disaster preparedness. Interviews with administrators and community leaders revealed that only 25% of respondents were familiar with CERT, with many uncertain about their roles during emergencies. As one administrator noted, "We knew we had to respond, but there was no formal structure guiding us." This lack of coordination heightened the school and community's vulnerability to climate-induced disasters.

Without CERT, the school was not seen as a reliable community hub during disasters. A local leader stated, "The school was not prepared to help the wider community." However, after CERT was established, the school became a key resource in local disaster management, improving coordination with local authorities and organizations. CERT's importance in schools, especially in disaster-prone areas, is critical. Schools often serve as community centers during emergencies, and having an organized, trained team ensures quicker and more effective disaster response. The training at *Santikhiri Witthayakom* School showed how CERT can transform schools from vulnerable institutions into resilient community hubs, supporting disaster risk reduction (DRR) efforts at the local level (Twigg, 2015).

This study highlights the essential role universities (multisectoral collaboration or *Tsunagaru*) play in advancing SDG 13: Climate Action by facilitating capacity-building initiatives that strengthen local resilience to climate-related disasters. Universities like Kumamoto, Hiroshima, and Mae Fah Luang bridge the gap between academic research and practical disaster management, translating climate science into actionable community-level solutions. Their involvement is crucial for both climate mitigation and adaptation, helping communities better prepare for increasing natural disasters. The participatory model used in this study shows how universities can engage local stakeholders—school administrators, community members, and governments—by integrating local knowledge with technical expertise. This collaboration fosters community ownership of disaster management systems and ensures sustainable, culturally appropriate interventions. It aligns with SDG 13's goals to strengthen adaptive capacity to climate hazards.

Universities also advance climate education, a pillar of SDG 13.3, by improving institutional preparedness through training programs. This study demonstrates how universities can lead capacity-building efforts, improving the disaster resilience of *Santikhiri Witthayakom* School and setting a model for other vulnerable regions. By providing training in crisis communication, early warning systems (EWS), and logistical coordination, universities equip communities to respond effectively to climate disasters. Beyond technical expertise, universities strengthened local institutional capacity by empowering the school and community to take ownership of disaster preparedness. This localized approach enhances long-term sustainability and builds community independence in future crises, as supported by research from Virji et al. (2012).

In addition, Lotz-Sisitka et al. mentioned in 2012 that universities and schools are important partners in implementing Education for Sustainable Development (ESD), which addresses SDG 4 Quality Education, particularly SDG 4.7 of Global Citizenship Education as a foundation for lifelong learning. That said, reforming the curricula, which include important practical training for climate change adaptation, encompassing equally critical perspectives of climate justice (Roemhild & Gaudelli, 2021), is necessary.

The collaborative model presented here offers a replicable framework for educational institutions in disaster-prone areas, showing how universities can drive climate action by combining research with practical applications. By integrating local knowledge, technical solutions, and institutional support, universities under *Tsunagaru* contribute to both immediate and long-term disaster risk reduction (DRR). These university-led initiatives extend beyond the local community, contributing to national and global climate resilience. By enhancing local capacities, universities support global efforts to reduce vulnerability to climate disasters, aligning with frameworks like the Sendai Framework and the Paris Agreement. Their work at *Santikhiri Witthayakom* School exemplifies how higher education institutions can advance global climate governance and sustainability goals.

5. CONCLUSION AND RECOMMENDATIONS

This study highlights the transformative impact of the capacity-building training at *Santikhiri Witthayakom* School, showcasing significant improvements in disaster preparedness and resilience through a participatory approach. By aligning with SDG 13: Climate Action, the training led by Kumamoto, Hiroshima, and Mae Fah Luang Universities (multisectoral collaboration or *Tsunagaru)* addressed key gaps in the school's disaster management, including the establishment of an Early Warning System (EWS), enhanced crisis communication, and the introduction of a Community Emergency Response Team (CERT). Key improvements include better

coordination with local authorities, stronger community engagement, and the school's enhanced role as a disaster response leader. The EWS became a crucial tool for proactive disaster response, and the CERT program equipped school personnel and community members with essential skills in search and rescue, first aid, and crisis management. This participatory approach, aligning with global DRR best practices, highlights the importance of community-driven solutions for climate resilience. In conclusion, this study demonstrates the pivotal role universities can play in advancing climate resilience and disaster risk reduction by integrating local knowledge, technical expertise, and community engagement. The success at *Santikhiri Witthayakom* School offers a replicable model for other educational institutions in disaster-prone regions, emphasizing the importance of participatory approaches and institutional support in addressing climate challenges. Continued investment in education, infrastructure, and collaboration will enable schools to become central to sustainable disaster management and achieving SDG 13.

In addition, the study provides the recommendations as follows:

1) Institutionalize CERT Training: Regular refresher courses for staff and community members should be conducted to sustain the knowledge and skills acquired and adapt to emerging challenges.
2) Strengthen Physical Infrastructure: Invest in retrofitting school buildings to improve their resilience to floods and landslides, enabling the school to serve as a reliable community shelter.
3) Expand Early Warning Systems (EWS): Continuously update and enhance the EWS with new technology, such as geospatial monitoring and real-time data analysis, to improve hazard detection and response.
4) Develop a Comprehensive Disaster Management Plan: Create a plan that includes regular drills, resource management, and clear roles for school personnel and community members. Update it annually with input from local authorities and disaster experts.
5) Strengthen Partnerships with External Organizations: Build stronger relationships with NGOs and international relief agencies to access additional resources, technical expertise, and funding to enhance disaster resilience further.

Acknowledgements

The author would also like to express her gratitude to the editors and editorial staff of JHSSR for their assistance during publication period.

Funding

I am very grateful to all the professors from Hiroshima University, Kumamoto University and Mae Fah Luang University for supporting the training program and research under Sumitomo Grant Japan-Related Research 2022 No. 22802026.

Declaration of Conflicting Interests

The author declares that they she has no competing interests.

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Horizon J. Hum. & Soc. Sci. Res. 7 (S): 117 – 124 (2025)

Journal of Humanities and Social Sciences Research
www.horizon-JHSSR.com

CASE STUDY
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Curriculum Maturity for Sustainable Development: A Case Study from Airlangga University's Industrial Engineering Program

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ARTICLE INFO

Article history

RECEIVED: 11-Mar-25
REVISED: 07-Jun-25
ACCEPTED: 16-Jun-25
PUBLISHED: 15-Jul-25

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Citation: Muniroh, Kartika Nur 'Anisa' and Laras Swandayani (2025). Curriculum Maturity for Sustainable Development: A Case Study from Airlangga University's Industrial Engineering Program. Horizon J. Hum. Soc. Sci. Res. 7 (S), 117–124. https://doi.org/10.37534/bp.jhssr.2025.v7.nS.id1298.p117-124

ABSTRACT

Introduction: In recent years, Indonesia has made notable progress in integrating Education for Sustainable Development (ESD) across all levels of education, including higher education. Universitas Airlangga (UNAIR) demonstrates institutional support for the Sustainable Development Goals (SDGs), particularly SDGs 6, 7, 9, and 17, through various initiatives. However, the actual implementation of ESD within academic curricula—specifically in the Industrial Engineering study program—remains limited and insufficiently documented. **Methods:** This study adopts a qualitative approach supported by quantitative data to evaluate the maturity of ESD integration within the Industrial Engineering curriculum at UNAIR. Data collection focused on course assessments, student academic performance in green technology subjects, and student engagement with SDG-related topics on public knowledge-sharing platforms such as *Jurnal* Post, *Kompasiana,* and the FTMM UNAIR website. **Results:** Findings reveal that approximately 70% of Industrial Engineering students received an AB grade in green technology-related courses. However, subject evaluation indicators, including teaching methodology, yielded an average excellence score of only 69.9%. Content analysis of student-authored articles shows that SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 6 (Clean Water and Sanitation) were the most frequently addressed topics. Collectively, these articles attracted significant engagement: 1,395 views, 9 likes, and thousands of shares across social media platforms such as Facebook (1,732), X/Twitter (1,081), and LinkedIn (207). **Conclusions:** Although student participation and awareness of SDGs are evident, the current curriculum demonstrates only moderate maturity in supporting ESD. There is a clear need for curriculum enhancement, particularly in integrating SDG-specific content, pedagogical innovation, and measurable learning outcomes. Strengthening these areas will ensure that higher education institutions like UNAIR contribute more effectively to achieving sustainable development through lifelong learning.

Keywords: Curriculum Assessment, Education for Sustainable Development, Higher Education, Industrial Engineering, SDGs Integration, Student Engagement

1. INTRODUCTION

In order to implement the SDGs in Indonesia, regulations are needed to ensure that the SDGs run in accordance with the rules and agreements made in Indonesia. One of which supports SDGs 4 on education, aiming to "ensure inclusive and equitable quality

education and promote lifelong learning opportunities for all" (United Nation, 2022). The UN General Assembly proposed Education for Sustainable Development (ESD) as a 2030 goal (UNESCO, 2017). Despite financial constraints in achieving SDs 4, Indonesia has consistently made progress in its SDGs index, showing changes in both scores and global rankings (Halimatussadiah, et al., 2022). This demonstrates the Indonesian government's commitment to mobilizing nationwide support for SDG implementation, driving efforts across all sectors to ensure sustainable development for the nation. Indonesia currently holds the 6th position in Southeast Asia and ranks 97th globally in achieving the SDGs (Halimatussadiah, et al., 2022). This ranking reflects Indonesia's ongoing efforts and dedication toward sustainable development, even as it works to improve its standing both regionally and on the world stage.

Indonesia has improved access to supporting ESD in each level of education degree, such as in university level (Hawa N. N., et al., 2021). Some universities support SDGs through various research centers, such as Universitas Indonesia (UI) established SDGs Hub which works across various faculties to integrate SDGs-related topics into the curriculum, especially in public health, environmental studies, and social sciences (SDGs Hub Universitas Indonesia, 2019); Institut Teknologi Bandung (ITB) established various research centers, such as the Center for Energy Studies and the Center for Environmental Studies which are involved in academic programs and research aligned with SDGs, particularly in renewable energy and sustainable urban planning (ITB SDGs NETWORK, 2016); Universitas Gadjah Mada (UGM) also has various centers focused on sustainable development, which offer courses related to the SDGs across different faculties, including Geography, Engineering, and Public Health (SDGs Center Universitas Gadjah Mada, 2018). More universities should follow this approach, as increased contributions can lead to significantly higher outcomes. Greater involvement from academic institutions will enhance progress toward achieving these targets, amplifying impact and paving the way for measurable advancements.

One key indicator for monitoring educational quality is student performance on assessments (O. Gladushyna and R. Strietholt, 2023). Other issues which are also related to student assessments, such as teacher quality, curriculum relevance, and infrastructure, also play essential roles and require targeted improvements to support better assessment outcomes (R. Siagian and B. Artha, 2023).

Universitas Airlangga (UNAIR) also supports SDGs through Decree of the Chancellor of Universitas Airlangga Number 253/UN3/2022 which concerning Establishment of the Sustainable Development Goals (SDGs) Center (SDGs Center Universitas Airlangga, 2022). Universitas Airlangga has implemented several SDGs in its university environment such as in Faculty of Advanced Technology and Multidiscipline (FTMM), they supported SDGs 6, where they developed clean water treatment after the earthquake in Turkey. FTMM Universitas Airlangga also supports SDGs 7 by conducting various activities such as analyzing renewable energy potential, talk shows to increase awareness of renewable technology, designing electric bicycles, electric motorbikes, and charging stations (FTMM, 2024). Unfortunately, although Universitas Airlangga fully supports SDGs, the implementation of ESD in UNAIR itself is not very prominent.

The lack of studies that identify whether Universitas Airlangga, specifically Industrial Engineering study program, have supported ESD encourages researchers to conduct research analysis. This research can help both universities and government in making decisions whether the implementation of ESD has been carried out as expected or not. It can also indicate whether students have actively participated in simple research and projects to improve their understanding, attitudes and behavior towards the success of ESD (Karyanto, 2019). The researchers aimed to gain a better understanding of ESD implementation at Universitas Airlangga.

ESD is also implemented through Green Technology subject, which involves student's active participation to propagate 17SDGs by publishing articles through several media. The effectiveness of this strategy should be measured to know how to enhance the contribution of students to broaden Indonesian knowledge about SDGs. Measurement can be conducted by evaluating the score proportions, the media influence rate and also the fidelity of the topic chosen for the task.

2. MATERIALS AND METHODS

2.1. Data Collection

The data for this research is gathered from the curriculum of the green technology subject offered in the years 2022 and 2023. This data includes both the academic performance of students and the teaching performance of instructors. Student performance data, including final grades and assessments, will be collected and organized using Ms. Excel. Similarly, teaching performance will be recorded and stored in Ms. Excel for further analysis. Ms. Excel will be used to create tables and charts to visually represent the data and simplify the analysis process.

2.2. Descriptive Statistics

In this section, a descriptive analysis is performed on the data collected from the green technology subject. The analysis includes the distribution of student grades, which will be presented in terms of means to highlight general

trends in academic performance. Furthermore, teaching performance will be analyzed based on evaluation reports. The data will be summarized using frequency distributions and visualized through charts to provide a clear overview (Triola, 2021) of both student outcomes and teaching effectiveness across the 2022 and 2023 academic years. Ms. Excel will be used to create tables and charts to visually represent the data and simplify the analysis process.

2.3. Mapping Analysis

This subject learns about technology efficiency and management, planning and design of environmentally friendly technology, utilization of sustainable technology, environmental impacts concerning biological, physical and socio-cultural aspects that may occur in relation to technological engineering activities. Soft skill attributes which must be received from this subject include integrity, professionalism, responsibility, work ethic, and critical thinking.

The final assessment for students in the green technology subject was based on their ability to produce a journal article related to topics covered during the semester. This journal article served as a capstone project, requiring students to apply theoretical knowledge to practical problems within the realm of sustainable engineering. The mapping of these final assignments involves identifying the key topics addressed in the student journals, such as renewable energy, waste management, and sustainable manufacturing processes.

These topics will then be analyzed to assess how well students integrated subject material into their final work and to measure the depth of understanding demonstrated in their submissions. Ms. Excel will be used to map and categorize these journal submissions. Each journal will be tagged according to its primary topic (e.g., renewable energy, waste management, sustainable manufacturing) and entered into Ms. Excel sheet for tracking. Ms. Excel will then be used to create visual representations, such as pie charts and tables, to show the distribution of topics and assess the alignment of student work with subject objectives.

3. RESULTS

This chapter presents the findings from the analysis of data collected in the green technology subject during 2022 and 2023. The results are divided into three main sections: student performance, teaching effectiveness, and the mapping of final assignments. The goal of this chapter is to provide a clear and structured overview of the key outcomes of the study.

The distribution of grades in the green technology subject over the past three years reveals a notable trend. A majority of students, approximately 70%, received a grade of AB, indicating that while they performed well, they did not achieve the highest level of mastery. In contrast, fewer students attained the maximum grade of A, suggesting that while many students are grasping the core concepts, only a smaller portion are excelling to the fullest extent. This pattern could point to challenges in mastering certain advanced topics or variations in assessment methods. Figure 1 provides a visual representation of this distribution, highlighting the gap between those achieving an AB versus those earning an A.

Evaluating indicators: Explaining of learning contract at the beginning of lectures; Explaining of library information used in learning (reference books/ teaching materials/ handouts/ modules); Implementation of learning in accordance with the study contract; Suitability of the material delivery method with the Course Learning Outcomes; The assessment weight is in accordance with

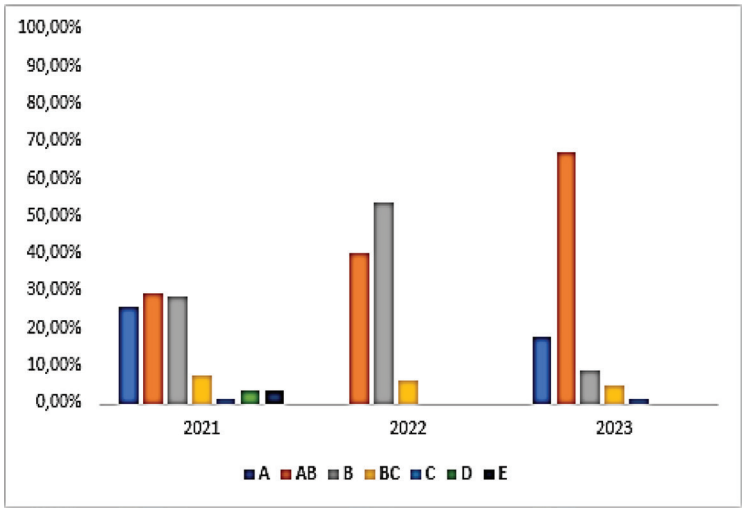

Figure 1. Grades Distribution of Green Technology Subject.

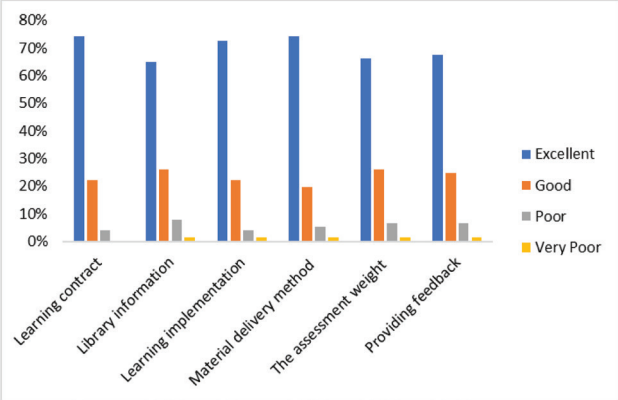

Figure 2. Lecturer Performance in Teaching Green Technology Subject.

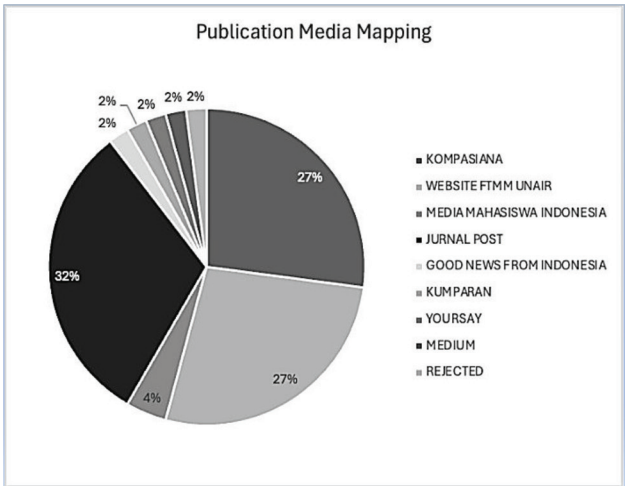

Figure 3. Mapping of the Publication Media Type.

the workload given (assignment/ quiz/ exam (midterm exam/ final exam)); Providing feedback on student learning outcomes (assignment/ quiz/ exam). The average scores of excellent, good, poor, and very poor are 69,9%, 23,4%, 5,6% and 1,1%, respectively (refer to Figure 2).

Based on the mapping (refer to Figure 3), Jurnal Post is the most popular platform among students for sharing knowledge about the SDGs. Other frequently used platforms include Kompasiana and the Website of FTMM UNAIR (the faculty's media). In addition, students have access to five other national-level platforms. This development is a positive step toward expanding their market reach for sharing knowledge about the SDGs. About 2 percent of the student's articles are rejected to be published.

Not all students explicitly mention the SDGs key topics their articles support, but some do. The most commonly chosen key topic is SDG 7, which focuses on affordable and clean energy. The second most popular topic is SDG 9, which covers industry, innovation and infrastructure, followed by SDG 6, which addresses clean water and sanitation. Other key topics that attract student interest include SDG 2 (zero hunger), SDG 11 (sustainable

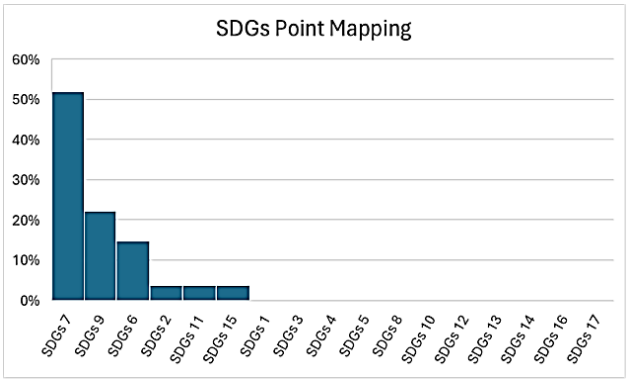

Figure 4. Mapping of the SDGs Key Topics.

cities and communities), and SDG 15 (life on land). The remaining key topics are not clearly identified as being supported by students in their articles.

About 23% of the students' published articles actively track their social engagement with the public, gauged through views, likes, and shares across various platforms such as Facebook, X (formerly Twitter), and LinkedIn. However, the majority of the articles have yet to be evaluated for their social media reach and impact (refer to Table 1).

The published articles have garnered a total of 1,395 views, received 9 likes, and have been shared 1,732 times on Facebook, 1,081 times on X, and 207 times on LinkedIn (refer to Table 2). While these numbers signal a positive impact in spreading SDG knowledge, there's a clear opportunity to amplify this influence even further.

4. DISCUSSION

Not all publication platforms track their influence on audiences, yet this metric is crucial for evaluating the subject's success in expanding knowledge to a broader public, particularly those not pursuing higher education but actively engaged with social media. This gap can be addressed by opting for platforms that provide detailed audience engagement metrics, such as views, likes, and shares. However, platform reputation and familiarity must also be considered. For instance, FTMM UNAIR's website, as the faculty's official media, should enhance its capabilities to track at least views and likes, enabling a more accurate assessment of the impact of published articles. This data driven approach could also serve as the foundation for content improvement strategies, providing insights for better content management.

The data suggests that one student assignment can reach around 1,395 viewers, demonstrating that increasing the number of publications or assignments could significantly expand reach. This strategy proves effective for disseminating SDGs knowledge, and it's vital to raise public awareness of the 17 SDG topics before 2030. Ideally, this awareness will inspire individuals

Table 1. Comparative Social Engagement Measurement

SOCIAL ENGAGEMENT						
	VIEWS	LIKE	SHARE FB	SHARE X	SHARE LINKEDIN	Average
BLANK	75%	83%	73%	73%	81%	77%
RECORDED	25%	17%	27%	27%	19%	23%

Source: *Authors, 2024.*

Table 2. Engagement Footprint of Social Platforms.

SOCIAL ENGAGEMENT				
VIEWS	LIKE	SHARE FB	SHARE X	SHARE LINKEDIN
1395	9	1732	1081	207

Source: *Authors, 2024.*

to contribute to achieving the goals by the 2030 deadline, as SDG success hinges on widespread global participation. With an average of approximately 1,395 viewers per assignment, these publications demonstrate a tangible impact on public engagement with sustainability issues. ESD emphasizes the importance of active learning, where students are not just consumers of information but also contributors to wider societal discourse on sustainability (J. Boeve-de, et. al., 2015) The outreach achieved through student publications exemplifies this active engagement, bridging academic achievement with real-world impact.

One potential strategy is to revise the subject curriculum, either by increasing the weight of publication assignments or the volume of required publications. This aligns with recent study in Education for Sustainable Development (ESD), which emphasizes the integration of practical, outcome-based learning into academic programs (Therese F., et al., 2022). By raising the assignment weight from 30% to 50%, as is being implemented this semester, the curriculum is shifting towards a model that encourages deeper student engagement with sustainability topics, not only through academic evaluation but also by enhancing their role as active contributors to societal knowledge on Sustainable Development Goals (SDGs) (Dario C. et al., 2019). ESD's advocates for more experiential learning and real-world application, and publication-based assignments serve as an effective vehicle for this by extending the reach of student outputs beyond the classroom. While the results of this curriculum revision are yet to be seen, it reflects the broader ESD goal of fostering skills that allow students to communicate sustainability issues effectively, both within and beyond academic circles (Jagneet K. and Raino B., 2023).

The mapping indicates that SDG 7 (affordable and clean energy), SDG 9 (industry, innovation, and infrastructure), and SDG 6 (clean water and sanitation) are the most discussed topics, likely due to their relevance to the students' focus on Industrial Engineering. Although the curriculum doesn't mandate specific SDGs for discussion, allowing students to freely select the topics, it is essential to recognize that the other 14 SDG topics are equally relevant and should be explored to broaden public understanding. To ensure comprehensive coverage, the subject curriculum could be designed to encourage a more balanced distribution of SDG topics for publication.

Another issue is that not all student publications explicitly state their support for specific SDG key topics. Addressing this would enable readers to easily identify and connect with the different SDG goals. A curriculum redesign could prompt students to explicitly link their ideas to relevant SDG topics, fostering a clearer understanding of how their work supports global sustainability goals. To effectively address key Sustainable Development Goals (SDGs), one approach could be directly assigning specific SDG topics to students, ensuring a broader range of important issues are discussed and published.

Currently, green technology courses are mandatory for at least 5 study programs, making it essential to evaluate how each program's body of knowledge aligns with the relevant SDG topics. For example, topics related to SDG 7 (Affordable and Clean Energy) are well-suited for the electrical engineering curriculum. Mapping more SDG topics to corresponding study programs can be further refined through curriculum meetings, helping ensure that the quality of students' work aligns with global sustainability efforts. This strategy would not only enhance learning outcomes, but also contribute to meaningful academic discourse on sustainability.

In crafting an article aimed at solving real-world challenges outlined by the UN's Sustainable Development Goals (SDGs), it's crucial to not only discuss each goal in a general sense, but also provide actionable strategies for achieving them. For example, SDG 9, emphasizes building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation. To address the global decline in manufacturing growth, students of industrial engineering can analyze trends, identify bottlenecks and propose solutions to revitalize industries. This could include strategies for increasing industry share in GDP through investments

in high-tech sectors while simultaneously reducing emissions. Furthermore, expanding mobile broadband access is another critical factor in fostering innovation and industrial growth. Industrial engineers can also explore innovative ways to balance technological advancement with environmental sustainability, ensuring that industrial development not only benefits the economy, but also protects the planet. By integrating these specific approaches, students can contribute to impactful, evidence-based discussions aligned with the ADGs, positioning themselves as problem solvers on a global scale.

5. CONCLUSION

In summary, this study highlights the critical role of publication metrics in assessing the effectiveness of the green technology subject in disseminating knowledge about Sustainable Development Goals (SDGs). The data demonstrates that while a significant proportion of students received high grades (AB), the majority of their publications have substantial outreach potential, reaching approximately 1,395 viewers per assignment. This aligns with previous studies that emerge the importance of engaging broader audiences, particularly those outside of formal education, in sustainability discussions (Filho, W. L., et al., 2024). It also emphasizes the ESD as active learning, where students are not just consumers of information but also contributors to wider societal discourse on sustainability (J. Boeve-de, et. al., 2015) The outreach achieved through student publications exemplifies this active engagement, bridging academic achievement with real-world impact.

The findings suggest that enhancing audience engagement metrics on platforms such as the FTMM UNAIR website could provide valuable insights for improving content strategies. This approach echoes the recommendations of prior research, which advocates for data-driven methodologies to enhance the impact of educational initiatives (Volkov, A., et al., 2023). Moreover, revising the subject curriculum to increase the weight of publication assignments and encourage a balanced distribution of SDG topics can further enrich the learning experience, ensuring that all 17 SDGs are adequately represented.

Furthermore, the mapping of student publications revealed a focus on SDG 7, SDG 9, and SDG 6, reflecting students' academic interests in Industrial Engineering. While this concentration is valuable, it is essential to broaden the scope of discussion to include all SDGs, as previous studies have shown that active involvement with a range of sustainability issues deepens understanding and strengthens commitment to global initiatives (Filho, W. L., et al., 2024).

In conclusion, this research underscores the importance of a comprehensive approach to curriculum design that not only promotes academic achievement but also actively contributes to public awareness of the SDGs. By incorporating publication metrics as a key tool for assessing the effectiveness of student work, the study highlights the potential for academic programs to extend their impact beyond the classroom and engage wider audiences in sustainability efforts. Revising the curriculum, such as by increasing the weight of publication assignments from 30% to 50%, aligns with ESD's goal of fostering deeper student engagement and ensuring that their work contributes meaningfully to public understanding of sustainability issues. By establishing strong connections between student work and SDG topics, educators can enhance both the relevance and impact of their programs, driving greater participation in sustainability efforts by 2030, in line with the broader aims of ESD.

Acknowledgements

The authors would like to express their gratitude to the editors and editorial staff of JHSSR for their assistance during publication period.

Funding

The authors received no financial support for the research.

Declaration of Conflicting Interests

The authors declare that they have no competing interests.

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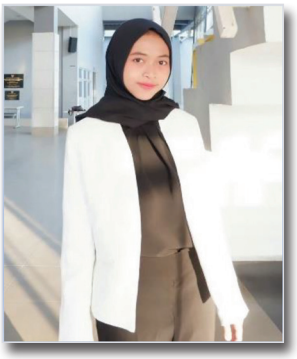

Laras Swandayai, born in 1996, possesses a keen interest in Human Factors and Occupational Health & Safety. She has developed a strong foundation in Industrial Engineering, holding a Bachelor of Engineering in Industrial Engineering from *Institut Teknologi Sepuluh Nopember*, Indonesia (2019).

She furthered her education with dual master's degree: one in Industrial Engineering from *Institut Teknologi Sepuluh Nopember*, Indonesia *(Magister Teknik)*, and another in Industrial Management from National Taiwan University of Science and Technology, Taiwan (Master of Business Administration) (2021). Currently, she is pursuing a Ph.D. in Industrial Management at National Taiwan University of Science and Technology, Taiwan, aiming to gain valuable insights in the same field.

Alongside her academic pursuits, Laras participated in bridge sports and engaged in various communities to find balance and inspiration in her life. Proudly serving as an Industrial Engineering Lecturer at the Faculty of Advanced Technology and Multidiscipline, Airlangga University, Surabaya, Indonesia.

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Acknowledgement of

REFEREES FOR THE HORIZON JOURNAL OF HUMANITIES & SOCIAL SCIENCES RESEARCH (JHSSR)

December 2024 – August 2025

The Editorial Board of the HORIZON Journal of Humanities and Social Sciences Research wish to gracefully thank the following for acting as referees for manuscripts submitted to JHSSR between December 2024 and August 2025.

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This issue of the JHSSR has been reviewed by experts in Climate Change & Environmental Studies, Disaster Risk Reduction (DRR), Education & Curriculum Development, Public Engagement & Community Participation, Scholarly Publishing & Ethics, Sustainability & Development Studies, Technology & Data Science.

These experts provided candid and critical comments, which helped our editorial team pinpoint the specific comments and improved the papers' quality. The JHSSR editorial board is very grateful for the invaluable contributions from all reviewers listed above *(sorted by alphabetical order by first name)*.

While every effort has been made to include a complete list of referees for the period stated above, however if any name(s) have been omitted unintentionally, please notify The Chief Executive Editor, *Horizon* Journals at CEE.horizon@gmail.com

 DOI: https://doi.org/10.37534/bp.jhssr.2025.v7.nS.idR.0017.p125

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Horizon Journal of Humanities & Social Sciences Research
Vol. 7 (S) Aug. 2025

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E-mail: CEE@horizon-jhssr.com
URL: www.horizon-jhssr.com

eISSN 2682-9096

PUBLISHER
B.P. Services
Masreca19, Persiaran Rimba Permai
Cyber 10, 63200 Cyberjaya, MALAYSIA

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6121 W. J. Voaz Road, Fort Worth
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