VOLUME 27 NO. 2

JANUARY - DECEMBER 2023

ISSN Print: 0116-7847 ISSN Online: 2704-3703

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ISSN: 0116-7847 | ISSN Online: 2704-3703
Printed in the Philippines by: Central Mindanao University Press, Central Mindanao University
University Town, Maramag, Bukidnon 8710 Philippines

Aim & Scope

The CMU Journal of Science is a peer-reviewed multidisciplinary journal published annually by Central Mindanao University, Musuan, Maramag, Bukidnon, Philippines. This official scientific journal of the University is accredited by the Philippine Commission on Higher Education (CHED) as category B. It publishes quality research articles, perspectives, review articles, and technical notes of researchers in the fields of natural science, engineering, social science, and mathematics from local, national, and international contributors.

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The CMU Journal of Science (CMUJS) is a multidisciplinary peer-reviewed scientific journal published annually by Central Mindanao University, University Town, Musuan, Bukidnon, Philippines.

All submitted manuscripts are reviewed and evaulated by the Editorial Board to determine whether these manuscripts are publishable or not. To be accepted, articles must satisfy all of the following criteria.

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Introduction To The Issue

As we go for the extra mile in our journal, we are honored to release Issue 2 of Volume 27 (2023). To make this publication possible, I want to thank the people involved in the production, beginning with all the authors who put their trust in the CMUJS by submitting their scientific papers and the reviewers for their substantial expertise by giving their assessment of the technical aspects of the manuscript.

Vol. 27 No. 2 (2023) presents a diverse array of original articles covering various topics in research and analysis. Articles include investigations into communication styles among Mobile Legends Bang-Bang players, a proposed conceptual framework for integrating agent-based microsimulation into demand models, mining indigenous fruit trees for essential oils with antibacterial properties, geo-hazard assessment in Barangay Kiorao, adaptability of high school teachers during the pandemic, competency mapping in rural communities, Filipino soldiers' well-being, nursing knowledge development, diet and sanitation assessment in Bukangliwayway, remote sensing for tree plantation characterization, and the prevalence of zoonotic gastrointestinal parasites in cattle. This issue contributes valuable insights across multiple disciplines and domains.On behalf of the editorial team, I extend my heartfelt gratitude to all the authors, readers, and reviewers globally for their tremendous support and contribution to the journal to make this publication possible.

Thank you, and have a blessed life.

EINSTINE M. OPISO
The Editor-in-Chief

Central Mindanao University
Journal of Science
ISSN Print: 0116-7847 ISSN Online: 2704-3703

Demystifying Nursing Knowledge Development: Issues, Solutions and Future Directions

Richard Allan. R. Soliven[1], Mae Dayanne M. Soliven[1], and Ceasarlica S. Minguita[1]*

[1] Faculty, Department of Nursing, College of Nursing, Central Mindanao University
Musuan, Maramag, Bukidnon, Philippines

ABSTRACT

Nursing has evolved from its historical roots, influenced by multiple factors such as knowledge from other disciplines, methods, and processes of knowledge generation and theory utilization. Issues arise because nurses recognize the need for knowledge-based practice and envisage the focus of knowledge generation and utilization from theoretical framing guiding their practice. The borrowed or unique knowledge-based practice is grounded in philosophical and theoretical frameworks advanced through paradigmatic viewpoints within the metaparadigms of nursing. Encompassing a framework in nursing is the concept of caring. Caring in nursing uniquely contributes to appreciating nursing as a discipline of knowledge and a practice profession. Suggested processes involve knowledge-based, evidence-based, and theory-based practices within a conceptual-theoretical-empirical system. Moreover, because there is yet a continuing search for a universal theory of nursing guiding global nursing care practice, nursing must have contended with the plurality of theories dictating varying ways of practicing nursing.

Keywords: issues in theory development, borrowed theory, nursing metaparadigms

INTRODUCTION

Nursing spans the history of humankind. According to Shaw (1993), the nursing discipline has evolved from its historical roots, multiple influences of other disciplines, methods of nursing knowledge generation, and research and theory utilization. Nurses profess philosophies with respect for the autonomy and self-determination of people. We honor people's perceptions of the world and their decisions, whatever they may be. "If their perception puts them in harm's way, we are in a role to reflect them in a different way of viewing the world, but we do not discount their perceptions or make assumptions that individuals should see the world the same way we do" (Munhall, 2012, p. 526). This statement by Munhall (2012) reflects our current perspectives on developing nursing knowledge, which utilizes different paradigms and philosophical outlooks.

However, due to new theories developing each year, which add up to the nursing knowledge, there is much ambiguity about the whole effort as to the issue of definition (Theofanidis & Fountouki, 2008), interpretation, and implementation. This article will discuss the various issues regarding theory development and construction in nursing, explore solutions through contemporary and future nursing knowledge in metaparadigms, value as a practice discipline, and suggest a theory for future directions and nursing advancement.

Three Among Many Issues About Theory Development and Construction in Nursing

Ever since nursing made its roots, questions have arisen, focusing on the knowledge needed for nursing (Alligood, 2014). The focus on nursing knowledge has been the driving force for the development of professional nursing. Nursing history suggests ways that nurses addressed this question in each era of growth of the twentieth century. Moreover, different renowned nursing scholars encounter different issues from such. Now in this twenty-first century, we are in the theory utilization era where the discipline of nursing has reached quite a record in history; however, looking through the past, whenever come solution, there are more questions and more issues to solve. This article will discuss three issues related to theory development: first is the issue of borrowed versus unique theory in nursing (Hogan & DeSantis, 1991; Johnson, 1968; Levine, 1988; McEwen & Wills, 2011; Rodgers, 2005; Walker & Alligood, 2001), secondly, the issue on nursing's paradigms and metaparadigms (Hsieh & Hsu, 2008; Levine, 1988; Newman, Sime, & Corcoran-Perry, 1991; Sousa & Hayman, 2002), and third is the importance of the concept of caring in nursing (Brilowski & Wendler, 2005; Drahošová & Jarošová, 2016; Kalfoss & Owe Cand, 2016; Morse, Solberg, Neander, Bottorff, & Johnson, 1990).

Borrowed vs. Unique Theory. Since the 1960s, nurses have questioned the theoretical foundations as they borrowed knowledge from other disciplines (McEwen & Wills, 2011). Moreover, McEwen & Wills (2011) claims that two premises support the unique theory. First, is that only theories that are grounded in nursing should guide the actions of the discipline. The second premise is that any theory that evolves out of the practice arena of nursing is substantially nursing. Advocates of using borrowed theory in nursing believe that knowledge belongs to the scientific community and society and, therefore, is shared (Rodgers, 2005).

Corresponding author:
Richard Allan. R. Soliven
Email Address: rarsoliven@cmu.edu.ph
Received: Aug. 2, 2023 ; Accepted: Dec. 15, 2023

Borrowed or unique, the dilemma sets a situation where nurses must answer an important question related to the knowledge that supports their actions, as theories guide nurses in their practice. According to Rodgers (2005), the problem is the sense of "being borrowed." In a manner where "borrowing of knowledge" from other disciplines applies to Nursing. Likewise, it is borrowing a particular theory for another purpose or need. Furthermore, according to Rodgers (2005), the concepts and meanings may work contrariwise when used from the original context to another field.

The theory is expected to benefit practice. Therefore, theory development must relate to the commonalities of people who practice nursing. Nursing scholars who research and develop their arguments think differently about theory because they perceive the reality of practice (Fawcett, 2005). While Sousa and Hayman (2002) claim that borrowing or sharing of theories with other disciplines such as anthropology, education, sociology, and psychology cannot separate from nursing theory development, theories from other disciplines serve as a basis for further reflection, investigation, and refinement of a new source of knowledge. With this in mind, a working definition of borrowed theory by Johnson (1968) is considered "knowledge which is developed in the main by other disciplines and is drawn upon by nursing (p. 206)."

Nursing's Paradigms and Metaparadigms. Newman, Sime, and Corcoran Perry (1991) claimed that there was a lack of focus on nursing as a discipline, thus arguing that the central focus of the nursing discipline and its perspectives on the different paradigms involve nursing knowledge (p. 2). The four concepts central to the nursing discipline were the following: the person, environment, nursing, and health. Most authors consider that tetralogy does not focus on the discipline of nursing. Thus, the disconnection of the concepts does not raise philosophical issues or scientific questions that stimulate inquiry.

According to Fawcett (2006), "A metaparadigm is defined as the global concepts that identify the phenomena of central interest to discipline, the global propositions that describe the concepts, and the global propositions that state the relations between or among the concepts" (p.4). Metaparadigm was described by McEwen & Wills (2011) as a component of a structural hierarchy of nursing knowledge by Kuhn. The terms paradigm and metaparadigm are standard in nursing literature (Peterson & Bredow, 2013). However, Kuhn introduced the term paradigm, which was actually "borrowed" by the scientific community, not only nursing (Hsieh & Hsu, 2008; Rodgers, 2005). Rodgers (2005), further claimed that in Kuhn's work on scientific revolutions, the term "paradigm" became embedded in the vocabulary of nursing science in the 1980s. Moreover, as a result, nursing scholars compared the status of nursing to "science" in line with or instead of Kuhn's philosophy (p. 77). Later nursing scholars described and analyzed the interrelationship among nursing concepts and then recognized the nursing metaparadigm's concept as a person, environment, health, and nursing (Sousa & Hayman, 2002).

Now there is a plurality on how scholars describe metaparadigms (Cody, 1995), and this issue has become an avenue for debate and discussion that would be beneficial in tackling details of the paradigm to establish a more scholarly trajectory toward the nursing profession (Cody, 1995; McEwen & Wills, 2011). The plurality is in line with the thinking of Munhall (2012) that scholars should reflect on the perception of others, understand how to view their world, and then generate their views, opinions, and assumptions while not disregarding others. However, confusion arises since scholars have different perspectives and have different inclinations of their lenses. McCurry, Hunter Revell, and Roy (2009) made it clear that in their substantive structures, assumptions and propositions by scholars create linkages among identified concepts. Some scholars, like Wilson, Rodgers, Walker, and Avant, became valuable for their ideas for concept analysis to prevent confusion (Rodgers & Knafl, 2000). Other nurse scholars (Hagell, 1989; Grossman & Hooton, 1993) advocate the adoption of a standard paradigm to bring consensus and cohesion to the discipline, while other authors (Meleis, 2008; Timmons, Edgley, Meal, & Narayanasamy, 2016) recognized the need for diversity and plurality in nursing philosophy, science, and practice. Moreover, Fawcett's (2006) awareness of the metaparadigms brings unity to the nursing discipline by specifying the concepts of propositions in general (p. 4).

The Concept of Caring in Nursing. McEwen & Wills (2011) claims that the concept of caring has been increasingly debated because of the motivation of urgency to identify nursing's unique contribution to the healthcare discipline (p.42). The debate revolves around the qualities and roles within the practice of nursing. Authors like Thorne, Canam, Dahinten, Hall, & Henderson (1998) scrutinize the central arguments used in the nursing metaparadigms. Thorne et al. (1998) further explained logical implications by various extreme positions higher than the social mandate of nursing and health.

Notably, these views on the nature of caring are diverse, ranging from caring as a human trait, to caring as a therapeutic intervention and differ according to whether the act of caring is conceptualized as being client-centered, nurse-centered, or both. Locsin (2017) also valued the coexistence of caring with technology, thus expanding the boundaries of the concept of caring within the nursing practice as well as technological extensions of humans such as robots. Another point of debate is the terminology used in the concept of caring unique to the domain of nursing while other disciplines also share its function (McEwen & Wills, 2011; McKenna, 2005).

The caring perspective supported by Newman, Sime & Corcoran-Perry (1991) claim that other renowned authors such as Leininger, Watson, and Benner appeared in the literature explaining the logical link between caring, health, healing, and well-being. Moreover, there are two concepts relevant to the focus of nursing, health, and caring. Health is prefigured as the centerpiece of nursing knowledge while caring is positioned as the essence of nursing. Furthermore, this conceives that caring, health, and health experience has considerable evidence that these concepts are central to the discipline of nursing.

Moreover, Newman, Sime & Corcoran-Perry (1991) suggest that "nursing is the study of caring in the human health experience" (p. 3). Moreover, this focus integrates the concepts into a single statement that can be identified at the meta-paradigm level and is not associated with any particular theory. The statement conveys a focus that implies a public mandate and a service identity. Therefore, this statement will guide researchers that any body of knowledge not included in the domain of inquiry, which is caring in the human health experience, is not nursing knowledge.

While most of the nursing community accepts caring as the main essence of the nursing profession, some authors question the concept's centrality. Swanson's theory of caring proposes an elucidation of the caring manner which is practiced in nursing (Smith & Parker, 2015) while Boykin and Schoenhofer (2013) present this as the person is innately caring which are supported by assumptions of persons, entirely caring and unfolding caring possibilities from moment to moment. Moreover, caring posits the output essential for nurses to recognize the relationship with the patient demonstrated as a robust approach, attentiveness, experience, and sensitivity. It is a means where active communication takes place, which decreases apprehension and breaks barriers (Drahošová & Jarošová, 2016). The interconnectedness of the nurse and the patient becomes powerful in achieving healthy outcomes. Furthermore, Morse et al. (1990) argued that various perspectives of caring must be clarified if research advances or if caring is to be retained as the essence of nursing. Therefore, the strengths and limitations of these conceptualizations should be thoroughly examined.

Contemporary and Future Nursing Solutions to the Issues on Paradigms and Metaparadigms

Before illuminating nursing solutions to issues presented, it is essential to know contemporary and future nursing knowledge structures. Advanced nursing knowledge, according to Fawcett (2005), provides the structural holarchy of nursing knowledge that involves these components: metaparadigm, philosophies, conceptual models, theories, and empirical indicators. While the structure of future nursing knowledge is still vague, nursing scholars may offer some structures related to the future of nursing knowledge. These structures may refer to the rapidly changing healthcare needs and healthcare complexities (Allen, 1997; Linderman, 2000), which will project its focus on technology use (Locsin, 2001). It is also vital to note that aside from the healthcare needs and complexities, the rising healthcare cost is in conjunction with these changes. Therefore, this will involve socio-economic structures (Cherry & Jacob, 2014; McEwen & Wills, 2011) of future nursing knowledge.

As cited by Monti & Tingen (1999), Khun's conceptualization states that the overarching paradigm that directs scientific endeavors resulted in theoretical unification in nursing (p. 74). However, standardization suggests a convergence of paradigms rather than the dominance of one over the other. In modern-day nursing, scholars do not have a consensus to unify a single paradigm or metaparadigm to date (Fawcett, 2006). Several proposals concern dropping the idea of the metaparadigms and moving on to a much more holistic view. Scholars suggest theoretical unification has some advantages, like one paradigm has fewer concepts and relationships to be examined. Alternatively, one paradigm can have the potential for a shared vision of nursing. However, some disadvantages of theoretical unification, such as the worldview would be narrow like Kuhns's description of an "inflexible box" (Monti & Tingen, 1999, p. 75). In contrast to the theoretical unification is the multiplicity of paradigms. Every proposal is believed to have its salient points; therefore, it is tough to discredit such individual opinions about the metaparadigms. To conclude, Kim, as cited by Fawcett (2005), offered a more robust rationale for retaining the metaparadigms for public information's sake. Kim further claimed that the metaparadigms are necessary as a primary guide for developing nursing knowledge.

Nurses define concepts as representations of phenomena we perceive and experience in our healthcare environment. Levine (1988) postulated that 'concepts' are essential for any discussion in nursing practice. However, when nurses and non-nurses observe the same phenomena, they may perceive and experience them differently. Within nursing, too, perceptions may differ concerning the same clinical events; concept analysis should reduce this conceptual confusion (McKenna, 2005). The setting of the core attributes of concepts, including caring, allows nurses to determine appropriate research questions, develop theory and identify practice priorities at a time of increasing demands and constrained resources (Brilowski & Wendler, 2005). Moreover, deliberating the analysis and development of concepts and theories, nursing science is built in a dynamic process that arises from practice and is reproduced through research, mainly by analysis and development of concepts and theories (Bousso, Poles, & Da Cruz, 2014).

Research methods are inherently tied up to their philosophical frameworks as a basis for understanding and evaluating theory; thus, theorists must be aware of the discipline's philosophical bearings (Silva & Rothbart, 1984). Expansion and integration of research tradition to a multidimensional understanding of phenomena and must be aware of the changes in the philosophy of science. Nursing theory is a stage of evolution, and growth should have a common goal of solving significant problems in nursing. Furthermore, Silva and Rothbart (1984) imply that historicism may be an alternative philosophy that bridges the gaps between the views of science, nursing theory, and nursing research. While nursing standards provide strategies from which standards are identified to determine outcome measures. King (2000) claims that it is essential to have a process with a consistent basis to enable nurses to track outcomes to recognize whether or not nursing care makes a difference. King (2000) further suggested that "evidence-based nursing practice is one way to identify nursing's contributions to quality health care."

Future nursing knowledge might not just require traditional and contemporary knowledge generation techniques but because of complex clinical, management, and research responsibilities (Allen, 1997)

that may create a climate of knowledge explosion in the healthcare and educational institutions (Linderman, 2000) that nursing knowledge will involve market-driven economic policy, dramatic technology advances, and changing demographics. Fawcett (2005) proposed the comprehensive conceptual-theoretical-empirical system or C-T-E of nursing knowledge, which closes the gaps between research and practice in nursing (p. 589). Marrs & Lowry (2006), by adopting an expanded conceptual-theoretical-empirical structure of nursing knowledge, connected the dots among theory, practice, and research. The perceptions of any new technology are essential to understanding (Kaye, 2017) thus; technology advances will be based on "Meaningful Use" programs. As the term is described, knowledge generation in the nursing discipline would be linked to its meaningful use (Harrison & Lyerla, 2012).

The Value of Theory Utilization on Nursing Metaparadigms

Several authors proposed to drop the idea of metaparadigms, while others consider it necessary as a primary guide for developing nursing knowledge. Indeed, the central concepts of nursing are still evolving, and with the rapidly changing healthcare complexity, most likely, more central ideas will constantly be emerging. We need to be contented with theory utilization with the context most fit in the healthcare situation. The metaparadigms may serve as a guide for the development of theory, but an author, developing their theory may not use the metaparadigm if there is no need. One or two concepts may be added or subtracted still, depending on the situation wherein the theory is used. This is because not all theories apply to every scenario in the healthcare environment. Nor does one theory has a universal solution for all. It goes by the saying that the human person is ever dynamic and everchanging that theories and metaparadigms that guide the nursing practice would also change, together with the philosophies that are based their foundations. Therefore, the value of the plurality of theories and metaparadigms is as complicated as the human person. Depending on the person's health care needs and the complexity of the need would also reciprocate to the needed theory that guides its practice.

CONCLUSION

Among different authors, three issues related to theory development and construction were discussed. In the issue of borrowed versus unique theory in nursing, one can see that the point of borrowed theory might not be an issue; other disciplines also borrow theory from other disciplines. However, it is suggested that as modern-day nurses, we need to develop uniquely our own theories. Contemporary nursing knowledge and future nursing knowledge are essential, for they will be the foundation of our nursing discipline. Advancement in nursing theory development may suggest new metaparadigm structures so that our nurses will be ready to face the future and to adapt to advancing trends in technology as well as socio-economic decisions in health care.

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Central Mindanao University
Journal of Science
ISSN Print: 0116-7847 ISSN Online: 2704-3703

A Proposed Conceptual Framework for the Integration of Agent-based Microsimulation to Activity-Based Travel Demand Models

Ma. Bernadeth Lim[1], Hector Lim, Jr.[2], Patrick Marvin Agramon[3], Gem Vitales[4], and Joy Mae Anabo[5]

[1,3,4,5] Department of Civil Engineering, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños, Laguna, Philippines
[2] Agape Rural Program, Puerto Princesa City, Palawan, Philippines

ABSTRACT

Traffic patterns and related problems are changing due to population growth, calamities, among others. Transportation planning is crucial in finding solutions to these problems. Travel forecasting models such as activity-based demand and agent-based microsimulation ones are effective tools to simulate and evaluate transportation planning strategies. This paper aims to develop a framework in line with the advances and concepts from previous studies on transportation demand modelling. Numerous research from various countries in the past years that examine recent developments in agent-based microsimulation and activity-based travel demand models are investigated here. The integration of these models in the context of various scenario types are discussed. The findings and framework are envisaged to aid in the development of a microsimulation model that integrates both activity- and agent-based models.

Keywords: Agent-based microsimulation, Activity-based modeling, Transportation planning

INTRODUCTION

Major changes in travel patterns are brought about by recent occurrences like population growth, natural disasters, the COVID-19 pandemic, among others. These calamities have gravely affected travel activities due to socioeconomic and environmental conditions in the society (Molloy et al., 2020; Steenbruggen et al., 2012). People's decisions about whether to travel or not are affected, as to their plans to visit a specific destination (Lim et al., 2021: Chen et al., 2015). Transportation planning plays a fundamental role in these events. However, traffic engineers rely on experimentation due to the difficulty of planning, which is why traffic forecasting models are needed (Francis et al., n.d.; Palamariu and Tulbure 2021; Nor Azlan and Rohani, 2018). These scenarios highlight the necessity for models that can predict traffic patterns during the pandemic, look at potential solutions, and determine how much resource is needed to maintain economic activities (Kerr et al. 2021; Zhu et al., 2018; Jiang et al., 2014; Syed Abdul Rahman et al., 2021; Wolbertus et al, 2021; Collins et al., 2014).

Traffic forecasting models such as the activity-based travel demand and agent-based microsimulation models are used to study how potential advances in the population, economy, land usage, and transportation will affect the performance of the regional transportation network. The method of traffic simulation is frequently applied in research to plan for the development of traffic systems (Nor Azlan and Rohani, 2018). Activity-based travel demand models are designed to forecast individual tour choices through socio-demographic characteristics and behavioral factors (Ortuzar and Willumsen, 2011). This implies a behavioral approach in travel demand modeling, which provides a deeper knowledge on the factors influencing travelers, their travel, and their trip-making behaviors (Ortuzar and Willumsen, 2011; Malayath and Verma, 2012). Moreover, the significance of this method relies on its ability to predict changes in the travel choices of the corresponding household or individual, by just modifying variables that would affect their travel behavior (Horl et al., 2018). While activity-based travel demand modeling can provide alternative procedures in transport planning, it is limited by only predicting individual choices without considering factors from the transport environment itself (Chu et al., 2012; Horl et al., 2018). This means that when people encounter changes in the transportation environment, such as the incorporation of traffic management methods and increasing traffic volume as the model predicts more travelers along a given route, the basic procedure of the activity-based approach does not provide feedback (Ortuzar and Willumsen, 2011; Malayath and Verma, 2012; Chu et al., 2012; Horl et al., 2018).

There has been a developing research area in the integration of agent-based microsimulation procedures into activity-based travel demand models over the past decade. Through the development of agent-based microsimulations, researchers have explored means of providing spatiotemporal solutions for this gap within the activity-based approach. By having simulated agents adapt to the simulated transport environment, while the decision choices and transport environment parameters are constantly changing within the agent-based simulator, an equilibrated and optimized transport scenario can be achieved (Horl et al., 2018). This paper seeks to review prior works on the advancement and usage of an agent-

Corresponding author:
Ma. Bernadeth Lim
Email Address: mblim4@up.edu.ph
Received: Oct. 14, 2022 ; Accepted: Aug. 15, 2023

based microsimulation integration to activity-based travel demand models. The selected literature was analyzed using the content analysis method to elicit common findings and develop the framework for integration of models. Content analysis is a research method used wherein common patterns from the analyzed topics under the literature are looked at. In doing so, the literature selected is gathered, common topic areas are put together, and work is focused on the analysis and understanding of the details presented in the materials reviewed. Words, themes, and concepts within the texts are analyzed. Then conclusions and recommendations are drawn. The findings and proposed framework can be applied as a learning background for the future development of new traffic forecasting models. Some of the data according to past studies still needs to be adjusted but the discrepancies are getting lowered. This calls for further development of forecasting models that provide better accuracy.

Activity-based Travel Demand Modelling

Activity-based travel demand modeling is driven by the concept of modeling transportation plans through derived travel demand from performing essential activities (Ortuzar and Willumsen, 2011). Before the activity-based travel demand became recognized, the four-step method (FSM) was widely used. The FSM has four sub-models that have different functions: trip generation, trip distribution, modal split, and trip assignment (Rodrigue, 2020; Ahmed et al., 2012). Trip generation includes the number of person trips inside a zone. While trip distribution consists of the number of travels between origin and destination zones. Modal split determines the number of travels on different modes, and trip assignment involves the assignment of traffic to a transportation network (Ahmed et al., 2012).

The concept of FSM had been scrutinized during the 1970s, while the activity-based travel demand has been developed (Rasouli and Timmermans, 2014). It was criticized that the FSM only analyzed spatial interactions through zonal trips, while the activity-based model heavily accounts for an individualistic approach in analyzing travel behavior (Rasouli and Timmermans, 2014). The FSM started its development during the 1960s, wherein it is generally represented by trip-based approaches and has always been the preferred method over activity-based approaches (Ortuzar and Willumsen, 2011; McNally, 2008). It evaluates the performance of transport networks and provides means for forecasting travel demands. This is made possible by initially determining study areas or Traffic Analysis Zones (TAZs), activity systems, and transportation systems. However, limitations of the trip-based approach in travel demand modeling have been a general topic of research throughout the years (Kim, 2021). This is mainly due to the inability of FSM to recognize interactions between trips made within trip chains (Kim, 2021). Moreover, this approach tends to become tedious in terms of added travel demand sub-models, which results in biases in demographic market segmentation, temporal scales, and spatial resolutions (Kim, 2021). Hence, activity-based approaches are on the rise in the field of research, as it provides more potential for travel demand sub-model developments. This potential allows for flexible representation in terms of travel behavior which could further address a larger scope of transport policies (Kim, 2021).

General frameworks for activity-based travel demand modeling are synthesized in various research and are collated in Figure 1 (e.g., Ortuzar and Willumsen, 2011; Malayath and Verma; 2013). Econometric models are widely used in this approach and are the bases for creating these frameworks (Malayath and Verma, 2013). The primary components of the framework inputs include land use transportation data, aggregate population statistics for the initial year, and policy actions for predicted years. The population synthesizer takes the aggregated population input as a reference to build a synthetic population that would account for the disaggregated behavior of the individuals within the population in the study. The daily activity pattern model, being the core phase of activity-based travel demand modeling would then process the synthetic population data by modeling inside and outside-home activities. Within these models, collaborative activities and tours can be evaluated or represented by considering constraints and intra-household interactions. The daily pattern activity model also incorporates the activity scheduling method, which forecasts the tour time of day option, mode, destination, supplementary tours, intermediate stops, and stop locations (Malayath and Verma, 2013). After predicting these choices, an output of a household or person's day/tour trip list can be formulated. This list contains the destination, mode, and time of travel choices that would be fed into a trip aggregator. Ortuzar and Willumsen (2011) have also added special trip generators, external trips, noise trips, and commercial vehicle trips into this aggregator. Special trip generators include long-distance trips such as those from an airport or any travel station. External trips are those trips that are not included in the initial aggregated data. Noise trips are supplementary trips added into the model to consider for infrequent trip cases such as trips that do not exactly have a constant activity or final location. Examples of these are lost drivers, people who just went out for a drive, among others. Moreover, commercial vehicle trips are those trips generated by logistics mobility such as deliveries. Once these trips are collected and evaluated, origin-destination matrices can be built according to spatial, temporal, and modal choices. These are then assigned to the transport network and resulting outputs from the model can be fed back to the population synthesizer and land use transport system models for a forecast year analysis. Further, an external analysis of emissions can be made through the network performance output. It should be noted that this framework still needs further validation by using actual travel behavior data, as the models presume heavily from preference surveys. Modifications are expected to streamline the generated framework according to the characteristics of prospective study locations.

Activity-based travel demand modeling is persistent in the past using several frameworks. According to Chu and Cheng (2015), more significant theoretical and procedural developments will be made in the activity-based travel demand modeling field. The advancements in activity-based modeling are summarized in Table 1.

Model development research has focused on the

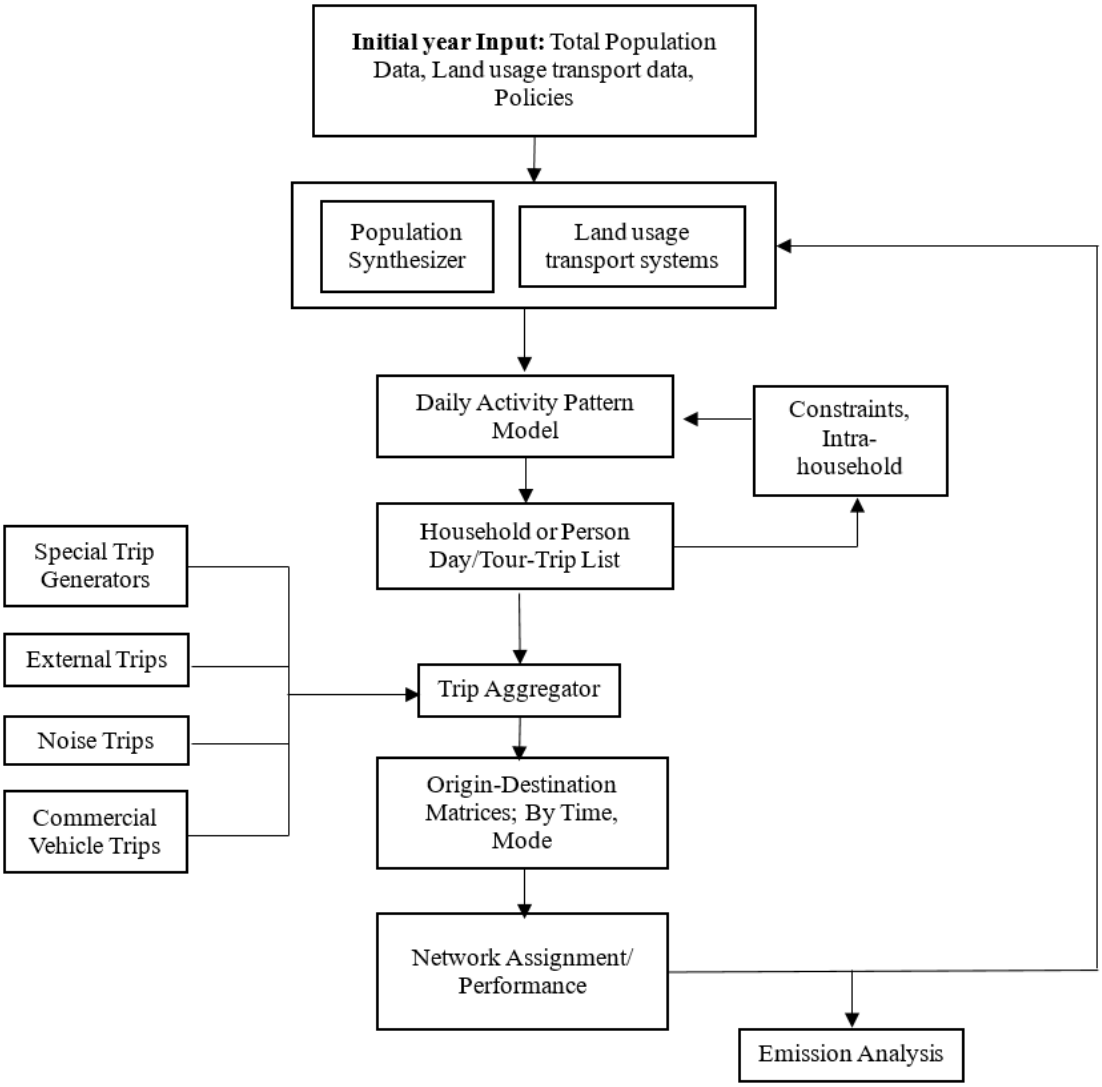

Figure 1. General Framework for Activity-based Travel Demand Modeling

Table 1. Summary of the development of activity-based travel demand modeling		
Author/s	Country	Context of Research
Pinjari et al., 2006	U.S.A.	Model development (CEMDAP-II)
Nurul Habib et al., 2012	Canada	Model development (Parking type choice model)
Malayath and Verma, 2012	India	Review of an activity-based approach
Cho et al., 2015	South Korea	Model validation using smart-card data (Validation of FEATHERS – an activity-based simulator)
Lekshmi et al., 2016	India	Model development (Single activity tour generation model)
Yasmin et al., 2016	Canada	Model validation (Validation of TASHA)
Langerudi et al., 2017	Chicago	Optimization of ADAPTS, an activity-based model
Linh et al., 2019	Vietnam	Model transferability (Transferability of FEATHERS – an agent-based simulator)
Joubert and de Waal, 2020	South Africa	Model development using Bayesian networks
Hafezi et al., 2021	Canada	Model development (Random-Forest model)
Hamad et al., 2022	U.A.E.	Model development (Dormitory model)

development of an activity-based model for predicting travel behavior (e.g., Pinjari et al., 2006; Nurul Habib et al., 2012; Lekshmi et al., 2016; Malayath and Verma, 2012; Hafezi et al., 2021; Hamad et al., 2022). With the help of disaggregate models, Pinjari et al. (2006) created the Comprehensive Econometric Micro-simulator for Daily Activity-travel Patterns II (CEMDAP-II), which simulates activity-based travel modeling. The inputs of CEMDAP-II are the demographic dynamics of the population, long-term household choice behaviors, and economic markets. Then, to research the impacts of choices on types of parking on activity scheduling behavior, Nurul Habib et al. (2012) developed a parking type choice model. It was discovered that the choice of parking type has a significant impact on the method of activity scheduling and acts as an exogenous variable for mode selections. Furthermore, Lekshmi et al. (2016) created an activity-based trip generation model for the Indian city of Thiruvananthapuram. According to this model, the factors of distance, age, income, and presence of license are relevant to the travel demand in the field of study. This finding is corroborated in a review by Malayath and Verma (2012), who identified the important factors influencing travel behavior in India. It was determined from their research that individual and household socio-demographics, lifestyle, activity-travel environment, and communication technology are significant variables in individual travel behavior. Hafezi et al. (2021) built a Random-Forest modeling framework that predicts temporal attributes for activity-based travel demand models and combines the results from a series of regression decision trees. Additionally, Hamad et al. (2022) created a tour-based travel demand model for dormitory travel at Sharjah University City (SUC). This model demonstrated that home-based education and business travel have the highest mobility rates. It was also found that dormitory-based travelers are more likely to use private cars as destination trip distance and duration increase.

Due to these developments, model validation research has also been evident to test the capability and features of developed models (e.g., Joubert and de Waal, 2020; Cho et al., 2015; Yasmin et al., 2016). Cho et al. (2015) used smart-card data in Seoul from 2012 as a validation tool for the activity-based travel demand model Forecasting Evolutionary Activity-Travel of Households and their Environmental RepercussionS (FEATHERS). FEATHERS models the activity participation and travel of individual members of the population of a study region for a whole day. It predicts activity-travel patterns by Monte-Carlo simulation, where individuals take successive decisions based on 26 decision trees (Bellemans et al. 2010). It was found that FEATHERS performs better at anticipating the global pattern of public traffic needs than local patterns (Cho et al. 2015). Particularly, FEATHERS does not predict well in terms of local areas with mixed land-use types and multi-modal trips. From another study in 2020, Joubert and de Waal (2020) have shown the applicability of Bayesian networks in synthesizing activity and trip-chain structures. The study made it possible to use expert and data-driven inputs for structural and conditional probability. This provides an opportunity in focusing on low-frequency observations that would enable expert input that is difficult to obtain from small surveys. These low-frequency observations can pose helpful inputs for policymaking, especially in the case of developing countries.

Model transferability studies, on the other hand, investigated the compatibility and applicability of an activity-based travel demand simulator to the scenarios of developing countries (Yasmin et al., 2016; Linh et al., 2019). Yasmin et al. (2016) focused on using the spatial transferability test in validating the activity-based model Travel Activity Scheduler for Household Agents (TASHA). It was discovered that TASHA performs poorly when attempting to forecast the activity features of flexible activities like shopping. However, it performs well at the macro and meso-level of simulation. And then, Linh et al. (2019) investigated the transferability of FEATHERS to the area of Ho Chi Minh City in Vietnam. As FEATHERS is trained from developed countries' travel data, the researchers found the need to determine the model's applicability to developing countries such as Vietnam. The tests concluded that FEATHERS is indeed transferable to the study area, however, recalibrations must be performed on the sub-models of the simulator due to variability in the cultural settings. Additionally, it was found that mode of transport and choice of location models were shown to be the models that are least transferable because of the factors of land use patterns and personal location preferences.

The development of these models and simulators has also called for the need for optimizations, hence, studies that improve the performance of this methodology were also apparent. There have also been review studies on the subject matter that focused on collating recent developments. This implicates heavy significance in the advancement of this methodology. Langerudi et al. (2017) optimized the Agent-based Activity Planning and Travel Scheduling (ADAPT), an activity-based model, to result in conflict because of lacking notion dynamics in the activity scheduling process. In summary, model development, model validation, model transferability, model optimizations, and model reviews have been the main topics of research studies in activity-based travel demand modeling for the past decades. To determine the factors impacting travel behavior, models were developed, and their effectiveness was evaluated. The transferability procedure was used to examine the model's ability to adapt to different contexts. Finally, the features of the models were improved in some research studies.

Development and Applications of Agent-based Microsimulations

Several applications for the potent simulation modeling technique known as agent-based modeling have emerged in past years (Bonabeau, 2002; Collins et al., 2014; Zhu et al., 2018; Abdul Rahmen et al., 2021; Francies et al., n.d.; Wolbertus et al., 2021; Yedavalli et al., 2021). Agent-based microsimulation is simulating the responses per agent, wherein each agent captures the behavioral variables obtained from modeling methods and puts these agents within a simulated transport environment (Heard et al., 2015). This would then enable feedback for spatiotemporal optimization of decision choices. Further, agent-based simulation provides a set of autonomous

Table 2. Summary of reviewed literature on agent-based microsimulation		
Authors	Simulation Software	Application
Collins et al. (2014)	Repast Simphony	Building Disaster Evacuation
Zhu et al. (2018)	MATSim	Hurricane Evacuation
Francis et al. (n.d.)	LocalSim	Traffic management
Wolbertus et al. (2021)	R Software	Optimization of Roll-out Strategies
Yedavalli et al (2021)	MANTA	Transportation planning
Kerr et al. (2021)	CovaSim	Covid-19 agent-based microsimulation
Najmi et al., (2021)	SydneyGMA	Covid-19 agent-based microsimulation
Akyildiz et al., (2022)	Aimsun	National parks evacuation

persons (agents), where interaction between agents is allowed and where agents can consider the information before performing their next action (Gilbert and Troitzsch 1999). The design of the model, its implementation, and its evaluation are the three main processes in agent-based modeling (Abdulkareem et al. 2019). Growing research on the application of these agent-based traffic simulators has then been essential throughout the years. Table 2 presents a summary of reviewed literature on agent-based microsimulation that incorporates traffic simulators.

Researchers conducted a study on developing an agent-based microsimulation for forecasting the interactions of individuals during natural disasters (e.g., Collins et al., 2014; Zhu et al., 2018; Abdul Rahmen et al., 2021). Collins et al. (2014) used the Repast Simphony Software to create an agent-based model that includes groups of people that exit for evacuation. They concluded that this method is ineffective when the desire of people for group cohesion is low and produces a zigzag pattern of simulated movement. Furthermore, in the context of hurricane evacuation using the Multi-Agent Transport Simulation Toolkit (MATSIM), Zhu et al. (2018) proposed a calibrated behavior model with a simulation of agent-based evacuation to capture the evacuation behaviors of people from Northern New Jersey. According to MATSIM results, background traffic significantly slows down evacuation times. Then, in a 3D environment, Abdul Rahman et al. (2021) replicated in the Pathfinder simulator the required timings and user evacuation mobility conditions from the Campus Infrastructure Building. It was discovered that the ideal path planning, which separates the impact of the capacity of the user and the access factor, depends on the total evacuation time. Following that, Akyildiz et al. (2022) used the Aimsun to predict traffic flow and suggest a successful alternative evacuation in a variety of scenarios in Rocky Mountain National Park. The model was able to suggest alternative evacuation routes, and the agent-based microsimulation was able to replicate the traffic flow during the evacuation, despite the microsimulation requiring a lot of data as inputs.

Studies have also been developing agent-based microsimulations for traffic management (Francis et al., n.d.; Wolbertus et al., 2021; Yedavalli et al., 2021). Francis et al. (n.d.) validated the simulator developed by the University of the Philippines (UP), Localized Traffic Simulator (LocalSim). LocalSim is the first simulator developed in the Philippines. The model choices were based on traffic-related research done by UP. It is designed to explicitly replicate the driving behavior of the Filipino road user. Additionally, using R software, Wolbertus et al. (2021) investigated the effects of alternative implementation techniques for the infrastructure supporting the wide use of electric cars. In conclusion, the model has demonstrated its ability to simulate a variety of diverse deployment scenarios and evaluate these on many fronts. This aids decision-makers in making long-term decisions on these methods and making necessary adjustments. An expanded version of the Microsimulation Analysis for Network Traffic Assignment (MANTA) for adaptable transportation planning at the metropolitan level was created by Yedavalli et al. (2021). It is highly effective and can simulate actual traffic demand on very large-scale networks with a great level of precision.

The latest COVID-19 outbreak has a significant influence on travel behavior. Most studies also focused on the development of agent-based microsimulation for the pandemic. Kerr et al. (2021) developed the COVID-19 Agent-Based Simulator (CovaSim), which replicates the dynamics and interventions made during the pandemic. CovaSim has already been utilized by many countries to assess epidemic dynamics and inform policy choices. The software is subject to the typical restrictions that apply to statistical equations, and important limitations on the amount of accuracy that may be modeled. For instance, CovaSim must use incredibly basic algorithms to simulate unfathomably intricate human touch patterns. Furthermore, Najmi et al. (2021) utilized the SydneyGMA agent-based model to forecast the travel behavior in Sydney Australia during the COVID-19 pandemic and to evaluate how far alternative control techniques can prevent COVID-19 from spreading. They revealed that it is dangerous to resume regular travel and take public transportation in Sydney GMA, and they acknowledged that the model needs a lot of data to be adjusted.

From the above reviewed works, findings have shown that agent-based microsimulation is essential to transportation planning and optimizing roll-out strategies in the case of calamities and outbreaks. It is utilized to generate probable decisions based on what is shown in simulations. Maximizing the effectiveness of the activity-based travel demand model and agent-based microsimulation could develop better transportation plans.

4. Integration of Agent-based Microsimulation to Activity-based Travel Demand Models

Model development studies have integrated agent-based simulators into the concept of activity-based travel demand to account for spatiotemporal gaps. Some studies also involve the creation of frameworks that apply one model to another or the other way around, as well as the use of activity-based data from another device for agent-based simulation. Table 3 shows the summary of studies on the Integration of Agent-based Microsimulation to Activity-based Travel Demand Models from previous studies.

Researchers have been comparing and combining the features of the activity-based model into agent-based microsimulation to cover up the spatiotemporal gaps. Bekhor et al. (2011) investigated the possibilities of MATSIM and Tel Aviv activity-based model collaboration in a paper. The representation of individual supply from MATSim and the representation of disaggregate demand from Tel Aviv are both employed for this. The combined model executes in a decent period, according to the results. Furthermore, Ziemke et al. (2015) coupled MATSIM with FEATHERS. Despite being a demand-adaptation model, MATSim does not completely take into consideration activity-based demand, which forecasts activity-travel patterns based on a fictitious population with socioeconomic characteristics. This feature is added through the coupling with FEATHERS. Therefore, the linked model can be used to simulate scenarios where the population has increased, new neighborhoods have been added, or other spatial patterns have altered and require new activity-travel schedules. Additionally, Saleem et al. (2018) integrated MATSIM with SCAPER, an activity-based travel demand model that constantly considers temporal choices, to demonstrate how it can be used for more extensive simulations. Based on the basic service level matrices produced by MATSim, SCAPER develops travel patterns that include the trip amounts, mode of transport, travel destination, time of departure, and travel purposes. The demand is then simulated by MATSim using transport patterns created by SCAPER. SCAPER and MATSim continue to iterate in concert until convergence is reached. According to the results, the difference between the observed data in a location and simulated values in converged settings is very small. To simulate traffic flow, parking behavior, and vehicle energy use in Beijing, China, Zhuge et al. (2019) created MATSIM-Beijing, a sizable activity, and agent-based simulation. The model developed a detailed traffic network, parking areas, and the utilization of filling stations.

Some research also creates an activity-based model using the framework from an agent-based microsimulation and using different devices for inputs of activity behavior into agent-based microsimulation. Auld et al. (2011) implemented a fully integrated activity-based model using the frameworks from Polaris, an agent-based simulator. It has proven to have the ability to considerably boost efficiency and organize activity-based models and traffic flow simulations using agent-based modeling techniques. Bassolas et al. (2019) used records from mobile phones to acquire data from activity diaries in Barcelona for activity-based travel demand modeling, which they then used to develop a city transport MATSim model. This method has been demonstrated to be an effective way to create models that can be used to calculate the effects of traffic demand management strategies. The results obtained by the verification and calibration approach confirmed the accuracy of the activity-travel diaries data obtained from mobile phones and provide evidence in favor of the concept that other data sources can be used to satisfy the data requirements needed for agent-based modeling strategies.

Jafari et al. (2021) created an Activity-based and agent-based Transport model of Melbourne (AtoM). The mode choice coefficients for the different principal modes of transportation were modified to accurately reflect the mode sharing seen for actual journeys to major locations. The comparison with actual data also revealed that the model closely matches real-world peak hour car traffic volumes, public transport station utilization distributions, and realistic journey times and distances. To evaluate travel patterns of infected people during the pandemic, Shahrier and Habib (2021) integrated the

Table 3. Summary of studies of Integration of Agent-based Microsimulation to Activity-based Travel Demand Models

Author/s	Country	Context of Research
Bekhor et al., 2011	Israel	Integration of Tel Aviv and MATSIM
Auld et al., 2014	U.S.A	Implementing activity-based framework thru Polaris-an agent-based simulator
Ziemke et al., 2015	Poland	Integration of FEATHERS and MATSIM
Saleem et al., 2018	Sweden	Interfacing SCAPER, and activity-based model, to MATSIM
Bassolas et al., 2019	Spain	Mobile phone data for the activity-based demand model and MATSIM for analyzing toll policy
Zhuge et al., 2019	China	Integration of agent and activity base microsimulation (MATSIM-Beijing)_
Jafari et al., 2021	Australia	Activity-based and agent-based Transport model of Melbourne (AToM)
Shahrier, H. & Habib, M. (2021)	Canada	Coupling Epidemiological Model within an Activity-based Travel Modelling System

Shorter-term Decisions Simulator (SDS), an activity-based demand model, with the Susceptible-Infected-Recovered (SIR), an epidemiology model. The SIR model forecasts the percentages of infection and recovery as well as the amount of reproduction, whereas the SDS microsimulation model, on the other hand, makes predictions about the travel patterns in terms of several variables, including activity participation, mode preference, trip distance, route length, and vehicle allocation.

In summary of findings as discussed above, prior studies about the development of integration of activity-based demand models to agent-based microsimulation have shown the possibilities and innovations that will potentially serve as solution to the spatiotemporal gaps. The combination of these two could be applicable in different scenarios or environments and can significantly improve performance and standardize the structure of activity-based models and traffic flow simulations utilizing agent-based modeling methodologies. As the integration is being improved by different developers, it is shown that the discrepancies between the actual data and simulated data are being lowered.

Proposed General Framework for Integrating Agent-based Microsimulation and Activity-based Travel Demand Models

Based on the findings from the reviewed papers above, a general framework that describes this procedure is proposed and presented in Figure 2. The framework starts by introducing scenarios that call for evaluation, such as in the case of urban transport, pandemic, and evacuation. These examples are commonly observed in recent studies. After the provision of scenarios, variables relating to these scenarios can be modeled through different methods. Related literature has collated discrete choice, hazard duration, structural equations, rule-based simulation, and hybrid choice models as observed modeling methods in forecasting travel demand through an activity-based approach (e.g. Chu et al., 2012; Shah et al., 2022; Kim et al., 2014). These models provide significant behavioral variables as outputs, which are then used to predict or model the decisions of individuals. Destination, mode, evacuation, and activity-based output choices are the most found decision choices among previous activity-based travel demand research. Agent-based microsimulation is integrated by simulating the responses of individuals as agents. Each agent captures the behavioral variables obtained from modeling methods and puts these agents within a simulated transport environment. This would then produce outputs considering spatiotemporal optimization of decision choices.

Scenarios

The integration of agent-based microsimulation to activity-based travel demand models allows the replication of different scenarios that can proactively evaluate policy recommendations. Examples of scenarios include the application of this methodology for traffic problems, hurricane evacuation, fire disasters, building disasters, and optimization of roll-out strategies (e.g., Zhu et al., 2018; Jiang et al., 2014; Abdul Rahman et al., 2021; Wolbertus et al, 2021; Collins et al., 2014). Scenarios include the modification of variables that significantly affect the choices of respondents.

In many places across the world, traffic congestion is a serious issue (Ilahi et al., 2020). Harrou (2022) asserts that traffic congestion decreases traffic performance since it lengthens travel times and contributes to air pollution. The main issue is not traffic congestion, but rather the economic and educational systems that force individuals to commute to a job, schools, and other locations at the same time (Downs, 2014). On the other hand, fuel expenses, time, driver stress, and effects on physical and mental health are just a few of the costs that traffic congestion creates for society (Ng et al., 2021). According to a recent study, for individual drivers, the level of unhappiness with a 19% wage drop can be compared to the trip lengthening effect of 20 minutes (Chatterjee et al., 2017). Wasted output,

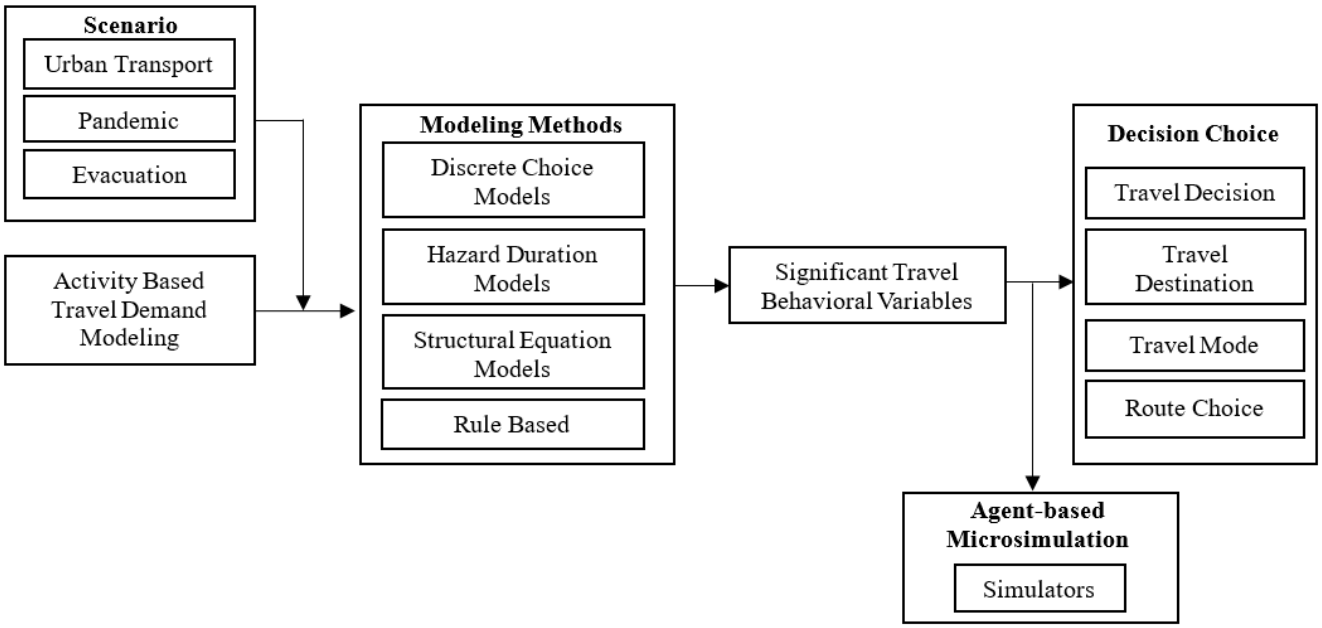

Figure 2. General Framework in Integrating Agent-based Microsimulation to Activity-based Travel Demand Models

noise, pollution, the likelihood of traffic accidents, the dangers to pedestrians, as well as the effects of emission of greenhouse gases on the environment, are some of the costs to society (Bilbao-Ubillos, 2008).

A study also found that natural disasters are one of the major accidents that affect transportation. Disaster affects traffic by having longer travel times, higher air pollution, and high risks of traffic accidents (Steenbruggen et al., 2012). The mobility of people is constrained not only by the need to pick up family members but also by the requirement to go to and from their places of employment. The interactions between family members, which are common during an evacuation, may significantly affect the evacuation process. Widespread use of activity-based modeling to predict daily traffic demand (Chen et al., 2015). According to Iida et al. (2020), the Great Hanshin-Awaji Earthquake uncovered problems with traffic management systems. Every aspect of travel behavior, including the selection of destination, frequency of travel, route selection, and mode selection, is impacted by the onset of a natural catastrophe, resulting in traffic patterns that are significantly different from typical ones. The traffic was in complete disarray after it because of the damage the earthquake caused.

Moreover, the recent COVID-19 pandemic had a huge effect on transportation because of social distancing and risk prevention. It is believed that the limits put in place by the government and people's fear of infection are the main reasons why travel preferences and behaviors alter significantly during pandemic scenarios compared to pre-pandemic situations (Abdullah et al., 2020). The closure of nearby physical companies has also resulted in a large reduction in trips made and distance traveled. With disparities between urban and rural populations, COVID-19 has resulted in a move away from multi-purpose vehicles and toward driving, walking, and biking. (Shaik and Ahmed, 2022). Hence, utilization of modeling tools considering such variables are also needed.

Modeling Methods of Activity-Based Travel Demand Approach

The various methods used in activity-based travel analysis are covered in this section, including rule-based models, hybrid models, hazard duration models, discrete choice models, and hybrid models. Discrete choice models are aimed to describe and forecast two or more choices of possible groups. Since the 1980s, it has been utilized to simulate complex trip behavior using activity-based modeling. (Chu & Cheng, 2012). It follows the premise that people are more likely to choose these observations depending on their socioeconomic status and how appealing the supplied choice is to them. (Ortuzar and Willumsen, 2011). The primary modeling method used in the activity-based approach is the discrete choice model (Chu et al., 2012; Joubert & de Waal, 2020; Hamad et al., 2022).

To include neural data in the model, hybrid choice models (HCM) are an appropriate framework. Hybrid choice models have been developed to extend discrete choice models, particularly multinomial logit models, and to include attitudinal variables. (Kim et al., 2014). Before now, HCMs have primarily been utilized to leverage measurable indicators to combine latent components, such as attitudes, views, or perceptions, with observable decisions in a single model structure (Ben-Akiva et al., 2002). The core of hybrid choice models is the estimation of an attitude formation model, which is added to the set of attributes that are frequently employed in discrete choice models, such as sociodemographic factors and attributes of the choices.

Another modeling method used is the Hazard-based duration model. Its concept is to model the probability of failures, given that the failures did not happen yet (Chu & Cheng, 2012). This model covers a class of analytical procedures that, if the duration has lasted for a predetermined period, are suitable for modeling data with a significant emphasis on an end-of-duration event (Mannering et al, 1994). The hazard-based duration is particularly helpful for activity-based travel demand analysis when simulating the length of activities and rest at home (Ettema et al., 1995; Mannering et al., 1992).

Inayat et al. (2014) created a structural equations model, a multivariate method used to evaluate theories for variable interaction. The major processes that this approach offers are factor analysis with regression to understand correlations between observed and unobserved variables. Instead of using exploratory factor analysis, it assesses relationships through confirmatory factor analysis. Several driving behavior indicators are converted into latent variables using the structural equations model, which is also utilized to investigate the relationships between crash severity, latent variables, COVID-19, and other relevant factors (Dong et al., 2002). The study of survey and clinical data, offers several benefits, including the capacity to model hidden characteristics that might not be immediately evident.

Rule-based models replicate the travel behavior of people by simulating daily travel and ordering activities using different sets of condition-action rules when creating schedules (Tajadinni et al., 2020). To comprehend or forecast a system's behavior and how it may be managed or altered, rules are modeled. Rule-based modeling assumes that the world may be viewed as a system of connected elements that behave predictably (Whitney, 2017). These models could be divided into two primary categories: switching models and activity schedule-building models (Jovicic, 2001). The switching models changed the predetermined schedule in response to proposed alterations, whereas the activity schedule building models create a schedule of activities from the beginning.

Travel Behavior Significant Determinants

Numerous studies have examined the effects of several factors on travel behavior. One factor that has been considered is the land usage pattern. Several land use attributes are highlighted in review studies (e.g., van Wee, 2002; Ewing and Cervero, 2001) from diversity and density measurements to the type of neighborhood and components of urban design. Results are often adjusted for socioeconomic characteristics, and some research also

Table 4. Significant variables that affect travel behavior according to past studies.		
Decision Choice	Authors	Significant variables
Travel decision	Chen et al. (2022), Shaikh et al. (2020), Lee et al. (2022), Wang (2022)	Security, safety, alternatives, travel risks, social media, travel-related apps, travel websites
Travel destination	Calumba et al. (2021), Lim et al. (2021), Shaer and Haghshenas (2021), Poli, (2021), Lakatos and Mandoki (2020)	purpose, reasons for the trip, socio-demographic behaviors, travel risks, distance
Travel mode	Bhaduri et al., (2020), Shakibaei et al. (2020), Arreeras et al., (2020), Harbering and Schluter (2020), Jiao and Azimian, (2021). Keyes and Brown, (2018), Arreeras et al., (2020)	Income, Vehicle ownership, safety and comfort, age, gender
Travel route	Cao et al. (2016), Anwari et al. (2021), Chen et al. (2020), Shelat et al. (2022), Marra et al. (2022)	The severity of traffic incidents, saving and delay time of alternate route, knowledge, route distance, and attitude of traveler

examines the perceptions, attitudes, and preferences of each participant (Witlox, 2009). Significant variables that affect the travel decision, travel destination, travel mode choices, and travel route choices based on past studies are summarized in Table 4.

Changes in circumstances have an impact on the decision to travel. In the Netherlands, Chen et al. (2022) investigated how the COVID-19 epidemic has affected travelers' behavior. Their findings indicate that the decision to travel is influenced by both their inclination to travel and their travel policy. Additionally, the importance of transit waiting time decreases during pandemic (Chen et al., 2022). Shaikh et al. (2022) conducted a study on the elements influencing Pakistani travelers' choices in other circumstances. The results demonstrate that tourists prioritize safety and security because of Pakistan's strict anti-terrorism laws. They utilize social media as well while making decisions. On the other hand, a study on the risk-related factors influencing travel decisions in South Korea was conducted by Lee et al. (2022). The research demonstrates that dangers associated with travel such as terrorism, natural catastrophes, and political instability, have a big impact on travel behavior. Further, with the increasing adaptability of social media applications, Wang et al. (2022) conducted research on the factors that influence the decision to travel. According to the research, social media travel websites and applications influence tourists' decisions to travel.

In terms of destination selection in various circumstances, numerous factors have also found to influence the choice. The choice of evacuation location in the case of natural disasters varies based on the socio-demographic or travel-related characteristics of the persons (Calumba et al. 2021; Lim et al. 2021). A received warning, being closer to the threat, and structural damage are statistically linked to the choice of evacuation destination after a natural catastrophe, all of which have a substantial impact on the evacuation process (Calumba et al. 2021). Lim et al. (2021) investigated the variables influencing evacuation destination decision behavior in Eastern Samar, Philippines. The findings indicate that the choice of destination is significantly influenced by gender, income, marital status, the number of evacuated family members, the position of the household leader, the mechanism and time of the evacuation, the amount of perceived risk, and the source of the information. On the other hand, for the COVID-19 context, Shaer and Haghshenas (2021) examined the impact of the outbreak on the trips of senior citizens and discovered that travel for work and groceries is more likely to influence the location of their trips. Longer travel distances may imply more tours in a trip, and thus more trips to be distributed (e.g. Poli, 2021; Lakatos and Mandoki, 2020). Poli (2021) found in his study that individuals decrease their distance traveled, so they go for destinations with lesser distance. It was supported by Lakatos and Mandoki (2020) in their study of long-distance transportation in Hungary. This could imply that people are reluctant to travel for an extended period during a pandemic. It is because there is a high chance of more prolonged exposure to many people during their travel.

For travel mode choices, respondents' age, income, and employment status are influencing factors in the context of India (Bhaduri et al., 2020). When gender and occupation characteristics are considered, the 35-44 age group is more likely to use private cars than others (Arreeras et al., 2020). It is supported by Jiao and Azimian (2021), who found that people aged 35 and up are much less inclined to utilize public transport. They also added that in terms of gender, men have a lower probability to travel by public transportation. This result is like that of Shakibaei et al. (2020) and Harbering and Schluter (2020), where it was revealed that females are more probable than males to take public transit and walk instead of driving. The negative coefficients associated with income had a significant impact on mode choice decisions. In addition, low and middle-income households show that they are more inclined to use public transit as they cannot afford to purchase a personal vehicle (Jiao and Azimian, 2021). The groups with higher income are less likely to use public transportation than low-income earners. The capacity

of high-income earners to own a private car is linked to socio-economic factors. If all other factors are considered, income and car use are correlated with greater income linked with lower probability of deciding to take public transport or active mode rather than a car (Keyes and Brown, 2018, Arreeras et al., 2020).

As for choosing a route, the variables that affect such behavior include the socio-economic characteristics of the traveler, the severity of the traffic incident, the amount of time saved by taking an alternate route, the amount of time lost on the original route, road network knowledge, and the traveler's assessment and attitude toward traffic information (Cao et al., 2016). Pedestrians and vehicles differ in their route choice because of their difference in freedom of mobility in heavily congested areas. However, pedestrians without vehicles need more physical effort to take the transportation to reach their destination faster (Chen et al. 2020). Other studies of vehicle route planning during a pandemic, found that the trip destination, travel distance, and travel time all imply vehicle route choices. People who travel a shorter distance will have a relatively short travel time, which results in taking that route. Anwari et al. (2021) corroborated this previous study. Long-distance trips are closely attributed to the road a commuter will consider taking unless a shorter route can be accessed. Marra et al. (2022) reported the same results as other studies, indicating that the significant distinction in travel patterns during this outbreak depends on how people consider travel expenses and trip duration. Also, commuters do not have a definite best route for a regular trip, but they frequently take routes that will provide cheaper alternatives. However, they have suggested that this phase of transport planning needs more attention from studies and findings to understand better the factors in choosing their route alternatives. According to the studies, the most important thing to be considered in route choice is that people will want to reach their destination via the shortest route with the minimum cost as much as possible.

SUMMARY AND CONCLUSIONS

Transportation planning is significant in finding a solution to traffic problems due to population growth, calamities among others, and uncertain events such as the COVID-19 pandemic. Travel forecasting models such as activity-based demand and agent-based microsimulation are effective tools to simulate and evaluate transportation planning strategies. Development plans can be made through the help of simulations. Activity-based travel demand models are designed to forecast and analyze individual travel choices through socio-demographic characteristics and behavioral factors while agent-based microsimulation simulates responses per agents (e.g., Ortuzar and Willumsen, 2011; Malayath and Verma, 2012; Bonabeau, 2002). The limitation of the activity-based travel demand model is that it can only forecast individual decisions without taking the transportation environment into account (Chu et al., 2012; Horl et al., 2018). This is why past researchers recommend and take efforts to integrate the activity-based travel demand model into agent-based microsimulation.

Researchers have investigated ways to fill this gap by providing spatiotemporal solutions through the development of agent-based microsimulations. This paper includes the development of forecasting models over time. The activity-based model had undergone model development, model evaluation, model transferability, and optimizations. Growing research on the application of agent-based traffic simulators has then been essential throughout the years. It is developed for evacuation planning, optimization of roll-out strategies, transportation planning, and pandemic simulation. The simulation of many scenarios that can proactively analyze policy proposals is made possible by the integration of agent-based microsimulation with activity-based travel demand models. Researchers have been comparing and combining the features of the two models to cover the gap in the activity-based demand model. Through the integration of these models, frameworks were created.

Prior studies have collated the findings about the scenario, modeling methods, and significant variables affecting travel behavior and decision choices. The findings are integrated to create a framework that will be applied for the future development of models. The framework starts by introducing scenarios that call for an evaluation. And then, variables relating to these scenarios can be modeled through different modeling methods. These models provide significant behavioral variables as outputs, which are then used to predict or model the decisions of individuals. Destination, mode, evacuation, and activity-based output choices are the most found decision choices among previous activity-based travel demand research. Agent-based microsimulation is integrated by simulating the responses of individuals as agents. Each agent captures the behavioral variables obtained from modeling methods and puts these agents within a simulated transport environment. This would then enable feedback for spatiotemporal optimization of decision choices. The proposed framework is applicable in transportation planning to solve travel problems due to traffic congestion, disasters, and pandemic. This paper integrated agent-based simulators and activity-based travel demand to test further activity-type choices that would be essential for the improvement of policy recommendations. The further development of integrated travel forecasting models to be used for more applications of various situations, such as the COVID-19 pandemic, is a suggested topic for future study.

ACKNOWLEDGEMENT

This work is part of the research project ACTS that was funded by the Department of Science and Technology – Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST-PCIEERD-2022-10350).

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Central Mindanao University
Journal of Science
ISSN Print: 0116-7847 ISSN Online: 2704-3703

Communication Styles and Interpersonal Communications Of Mobile Legends Bang-Bang (MLBB) Players

Kyla Marie O. Genson, Desty Anse A. Aboy, and Charity T. Turano

Department of Communications, Linguistics, and Literature, University of San Carlos
Talamban, Cebu City, Philippines, 6000

ABSTRACT

This study explored the Mobile Legends Bang-Bang (MLBB) players' dominant communication styles and how their participation in this online game contributed to their interpersonal communications. The researchers utilized a 5-point Likert scale questionnaire based on Bourne's (1995) Communication Styles and an open-ended questionnaire that elicited qualitative responses from the 30 respondents for the players' interpersonal communications within family interactions. Data reveal that MLBB players often utilize the Aggressive Communication Style, given the nature of the game that involves competitiveness and quick decision making in order to win. In addition, Passive-Aggressive and Assertive Communication came close as other dominant styles since players could also be subtle in their aggression and at the same time positively straightforward in their communication to support or lead team members in defeating the game opponents. Data also show as revealed by the players' siblings that the Interpersonal Communications of the MLBB players might have been strengthened in terms of displaying assertiveness, clarity and directness in communicating their thoughts and feelings to the family members. On the other hand MLBB engagements might also have weakened interpersonal communications as some of these players demonstrate aggressiveness which could include the use of harsh words in interacting with their siblings on certain occasions.

Keywords: Flashflood-resilient, frequency ratio, GIDAs, GIS, susceptibility

INTRODUCTION

Online Games are now popular not only to the youth but also among adults. According to a survey conducted in 2022, gamers aged 18 to 34 make up 36%, while gamers aged 65 and beyond make up 6% (Clement, 2022). Over 43 million players take part in the Philippine esports sector, which has been growing yearly by 12.9% since 2017 (YCP Solidiance, 2021). These esports are played through consoles which work with television, laptops or computers, and augmented reality (AR) allowing players to interact through digital elements and mobile applications. Video games are often viewed as a source of relaxation during leisure time and information (Kolek et al., 2022). According to Stockdale and Coyne (2018), most video game players view playing video games as a fun way to unwind, interact with others, and hang out with their friends.

One of the very popular online games launched in Kuala Lumpur in 2016 is the Mobile Legends Bang-Bang (MLBB) created by Shanghai Moonton Technology. MLBB is a worldwide multiplayer online battle arena also known as Multiplayer Online Battle Arena (MOBA) wherein players use heroes as characters and team up with other random players online. The online game ranks number one based on the Top 15 Popular Mobile Games in the Philippines during 2021; having 1 billion game downloads, 100 million registered users, and 25 million monthly active users in the Philippines (Mobile Legends Bang-Bang: Building the Filipino Esports Community, n.d.). Since its release, Racoma (2021) stated that the game has grown in popularity worldwide, most notably in Southeast Asia and was announced as a medal game in the inaugural esports tournament of the 2019 Southeast Asian Games or SEA Games. Given that the game is easy to access and is available for free download on both iOS and Android, there are several issues observed in players with prolonged exposure to the game. One concern that may have implications on communication is that online game addicts fail to consider their relationships to the people around them since they are deeply hooked and concentrated in playing (Kristanty and Sunarya, 2019) hence replacing social interaction with the players' family and loved ones (Chai et al., 2011). MLBB players communications with their families can be a commendable context in investigating communication styles and interpersonal communications as it is within the family setting where members of this basic unit are given opportunities to interact with each other before they relate with the members of larger communities. Also, looking into family communications can possibly help strengthen family relationships which may lead to better interpersonal communications of family members when placed in other larger settings.

Specifically, online game players' communication styles and interpersonal communications have not been widely explored in researches. Most of the related studies that talk about the interrelationship of video games and communication have been centered on how video games can help improve the communication skills, specifically

Corresponding author:
Charity T. Turano, Ph.D.
Email Address: ctturano@usc.edu.ph
Received: Aug. 7, 2023 ; Accepted: October 17, 2023

in acquiring English as a Second Language (Graham & Hardaker, 2017, p.797) of gamers. Thus, this study intends to investigate the communication styles of MLBB players as observed by their siblings and how these communication styles contribute to their interpersonal communications as manifested in their interactions within the family setting. It is important that the observations of the players' siblings are considered instead of the players themselves in order to have less biased descriptions of these communication styles and interpersonal communications that are exhibited.

Review of Related Literature and Theoretical Framework

Pradhipta (2021) as cited by Firmannandya et al. (2021) affirms that since programmers release these online games without fee leads people to have an easy access to these games, causing them to become addicted and treating cyberspace as their reality. In a study conducted by Odour et al. (2016) as cited by Firmannandya et al. (2021) in the North American Region, the researchers acknowledged that excessive smartphone use in the family members can lead to conflicts in family communication patterns. However, Costa dan Veloso (2016) as cited by Firmannandya et al. (2021), refutes the findings of the previous studies, asserting that there is an increase in social interaction in the family environment as a result of online game usage.

There are also claims that the participation of the players on different online video games can influence strategic minds and communication behavior. According to Neofitou (2014), digital game worlds provide language learning environments via collaborative and entertaining communications through text-based chats which may also assist them in knowing how such communications may or may not affect their worlds outside of the games (Bawa, 2018).

Communication Styles by Bourne, J. E. (1995)

Communication style refers to a form of verbal or nonverbal cues such gestures, use of time, space and distance (Abdullah et. al., 2018). Identifying personal communication style is necessary to effectively communicate and understand what the sender or receiver is trying to convey. According to Abidin and Mohamed (2021), communication style is a method that negotiates situations involving others. Negotiation is based on the scenarios involving others such as using words gently but still being firm and willing to consider other opinions before making any decision. Bourne (1995) recognized five (5) types of communication styles: Submissive, Aggressive, Passive-Aggressive, Manipulative, and Assertive, which are explored in the present study.

Submissive. This communication style refers to individuals exhibiting behaviors that focus on pleasing other people to avoid conflict. According to Bourne (1995), in this type of communication, the person does not express true feelings and wants. Submissive communicators treat the needs and rights of others as more important than their own and seek to play a minimal part during meetings or discussions (Yardley, 2017). Examples include "You're on your own now. It's up to you." In addition, according to Lane (2016), they are characterized as having lives directed by others and suppressing feelings of anger that can erupt at unexpected times and over insignificant events.

Aggressive. This style refers to individuals who are typically insensitive to others' rights and feelings and will attempt to obtain what they want through coercion (Bourne, 1995). In addition, aggressiveness succeeds by sheer force, creating enemies, and conflict along the way which often puts others on the defensive, leading them to withdraw or fight back rather than cooperate. Aggressive communicators behave as if their needs are the most important and their opinions are more important than everyone else (Yardley, 2017). These communicators are antagonists who most likely express a strong feeling of anger who challenge others hence get counter aggression. Aggressive communicators will cause some ill-feelings and resentment from others (Bocar, 2017). Examples include statements like "You're stupid if you think this will work!" and other statements that tend to be frank and less respectful. In addition, as expressed by Agarwal (2019), "Aggressive communicators are perceived to be poor listeners often expressing their feelings and opinions in a way that violates the rights of others, manifesting competition, criticism, interruptions, and impatience for others' perspectives" (p.5). This description is in line with the assertion of Filipeanu and Cananau (2015), that aggressive communicators impose their opinion on others, unwilling to give up their ideas for the team.

On the other hand, Passive-Aggressive according to Bourne (1995), is a style that instead of openly confronting an issue, the communicators express aggressive feelings covertly through passive resistance and seldom get what they want because they never get it across. This is the type of communication wherein individuals appear to be passive on the surface, but act out their anger indirectly or covertly (Yardley, 2017). Examples include statements like "No problem. You always seem to know everything." These communicators exhibit sarcasm and an ironic persona. With this, it can lead to a toxic and hostile work environment as evidenced through high attrition, unrealized productivity, feelings of frustration, fear, disappointment, among other adverse responses from the receiver (Brown et al., 2018).

Manipulative. According to Bourne (1995), manipulative communicators attempt to make people guilty and play the role of victim. In addition, manipulation only works as long as the target fails to recognize what is happening. These individuals exhibit shrewd and calculating behavior to achieve the outcomes they need. Their spoken words hide an underlying message, of which the other person may be totally unaware of (Yardley, 2017). Examples include statements like "This is not what I said." which may refer to the person attempting to gaslight. Manipulative communication is characterized by the preference for a backstage role, by the tendency to wait until the opportune moment comes, and the tendency to look for any hidden intentions behind others' statements (Urea, 2014).

Assertive. According to Bourne (1995), being assertive means respecting yourself and other people. It is the ability to clearly express one's thoughts and feelings through open, honest and direct communication. Yardley (2017) defined that communications are neither aggressive

nor passive, enabling them to have the confidence to communicate without resorting to games or manipulation. With this, assertiveness is considered as defending one's rights done through expression of opinions, emotions, and faiths directly, honestly and appropriately (Sherman, 2015 as cited by Abidin and Mohamed, 2021). Examples include statements like "We should choose the best option but if you have other ideas in mind, feel free to share them to the big group.".

Arif and Aditya (2022) discovered adverse effects of MLBB towards the communication styles of the players as they found that players have frequent exchange of harsh words, and hate speech often surfaces when they spend long hours in the game. This influence of the player's change of behavior was found in a study by Quwaider et al. (2019, p. 581, para. 5) wherein online games were proven to have impact on player's personality, emotions, and the ways players think and respond to various situations.

In another study conducted by Mawalia (2020), the researcher discovered that Mobile Legends created a tendency for players to be passive in socializing with others in the real world. Additionally, Mawalia (2020) stated that players of Mobile Legends are becoming more indifferent to the real world around them by being preoccupied in playing and communicating with virtual friends over interacting with people who are physically present. However, Lande et al. (2019) came to the opposite conclusion in their study titled "The effect of mobile gaming in the quality of family communication" wherein the researchers found that there is a positive correlation between how frequently an MLBB player played a mobile game to family communication. The findings of the previous studies have different claims and these conclusions may or may not be true to the respondents of the present study.

Interpersonal Communications

Chen et al. (2018) defines interpersonal relations as the degree of a person's connectedness to people around them. Lin et al. (2017) stated that interpersonal relationships are classified into two categories: those that take place in offline situations and those that take place in the online platform. According to Lin et al. (2017), online gamers can create a virtual environment and detach from the real environment. Moreover, the researcher claims that introverts or people who are not comfortable communicating with others tend to seek emotional support in the virtual environment, thus resulting in distance and barriers in interpersonal relationships. With this detachment from the real world, it may result in depression, anxiety, and loneliness, as Wang et al. (2019) found, there was a positive correlation of these variables to mobile gaming. Hence, interpersonal communication plays a vital role in shaping family resilience and strengthening the functioning of families facing increasingly severe challenges (Thariq, 2018). Olipas and Leona (2020) explored how playing mobile games affects a person's relationships with others. Dumrique et al. (2018) as cited by Olipas and Leona (2020) claimed that playing mobile games improves social conduct in individuals and may even be linked to adolescents' good academic performance. However, Ali (2018) as cited by Olipas and Leona (2020) declared that the negative impact of mobile gaming in creating a good relationship with others is that a player possesses aggressive behavior, which causes an individual to be a loner and develop incorrect values; unhealthy lifestyle, and poor academic achievement.

The opportunity for online engagement increases possible exposure to potentially risky behaviors for teens, which may have significant negative consequences (Hair et al., 2009). With this, understanding one's communication style and the communication styles of others can help the individual recognize situations in which the preferred type is not working and adapt to improve communication (Rustici, 2019) or maintain the communication style. In this connection, the present study will investigate the MLBB players' communication styles and how these styles contribute to their family interpersonal communications.

METHODOLOGY

Research Design

Quantitative and qualitative were the approaches used for the data gathering. The communication styles of the MLBB players were identified through a questionnaire with Likert scale and open-ended questions were asked to elicit descriptions of the players' interpersonal communications.

Research Participants

To avoid potentially biased responses of the MLBB players themselves, the siblings of these participants were chosen as the respondents of the study. The thirty (30) research respondents were selected through purposive-convenience sampling. The respondents of this study were determined through a researcher-made criteria which includes the following: (1) both the MLBB player and the sibling-respondents should be 18 years old and above upon answering the survey; (2) the MLBB sibling should have played the mobile game for two (2) years or more, regardless if they are an active or an inactive player at present; and (3) should not be part of the vulnerable group (e.g., senior citizens, pregnant women, PWD, mentally challenged, etc.). Individuals who willingly agreed to participate in the study were assigned a respondent code to maintain anonymity.

Research Procedures

Gathering of Data. Prior to data gathering, the researchers complied with all the protocols mandated by the Research Ethics committee.

The consent letter stated in clear terms that: (1) the respondents are participating voluntarily, (2) that their personal information will not be shared for any purpose other than this study, and that they have been made aware of their right to withdraw any time without any penalty, (3) that their names will not be asked, (4) and that the survey should be appropriately disposed of once the research is complete.

The online survey questionnaire took the

respondents at least 30-40 minutes to complete. The collected data were treated with utmost confidentiality and were automatically transferred and organized in a coding sheet using Google Sheets securely stored in a Google Drive.

Treatment of Data

For the first research objective, the responses were tallied in a coding sheet and were analyzed and interpreted using the Communication Style framework of Bourne. For the second, the answers which were mostly in narrative forms on how the MLBB players communication styles affect their interpersonal communications within family communications were transcribed and coded into themes. The narratives provided by the respondents were transferred to a coding sheet and analyzed using Glaser and Straus' (1967) Grounded Theory approach.

RESULTS AND DISCUSSION

The data gathered are presented in a tabular form that consists of numerical values and the common themes from the respondents' narratives are discussed in this section.

Results suggest that MLBB players often use Aggressive Communication Style when engaged in this game. The result somewhat confirms findings of a series of experiments, wherein researchers found video game violence elevating aggressive behavior and that more competitive games produced more significant levels of aggressive behavior than less competitive games (Adachi, 2011). In the case of MLBB's nature, participants are encouraged to be highly competitive in the game.

With this, it is evident that the players' communication style is primarily aggressive when engaged in the mobile game given that MLBB is an online battle arena where one aims to destroy the opponent and consecutively wins to rank up. Further, when a player experiences losing the battle, it increases one's urge to use hate speech to beat the opponent during the next game. Also, since the game requires quick and decisive action, players become naturally aggressive in their interactions with other players. This aggressiveness is then being carried over in their interactions with the siblings.

Passive-aggressive communication style on the one hand came close to Aggressive style as some respondents observed that their siblings also have the tendencies to be passive at times but act out anger in subtle and indirect ways. This style is manifested in their sarcastic communications on certain situations. Indirect aggression could happen during the game for several reasons such as frustration, influence of toxic gaming culture, and may also be due to anonymity among gamers. This communication style may also be carried over by players even when not playing.

While the players' siblings declared that Aggressive and Passive-Aggressive communication styles are the dominant types displayed, it is noteworthy that the Assertive communication, a style known to be more positive is almost as evident as the other two types of communication. MLBB players exhibit this communication style as they support their teammates in the game, leading to mutual success. When players actively assist and empower their teammates, it enhances the performance of the entire team. By enabling their allies to perform at their best, supportive players contribute to overall team success, which benefits everyone involved. Furthermore, in Mobile Legends, different heroes have specific roles, such as tanks, supports, marksmen, mages, and assassins. Supportive behavior is essential because support heroes are designed to assist their teammates, provide healing, crowd control, vision, and utility.

Also, among teammates, it is vital to build a healthy and supportive gaming group through courteous and constructive interactions hence resulting in the use of Assertive communication style. Being assertive communicators may have positive implications on family dynamics and relationships as these MLBB players are able to express themselves confidently within family communications.

Some players however have resorted to Manipulative communication style especially when losing in the game. Albeit in MLBB, manipulation, blaming and the likes are not usually considered productive or conducive to a fulfilling gaming experience since these produce a toxic environment and may result in a negative impact on the overall game atmosphere, inevitably a manipulative style of communication can still occur.

The Submissive communication style occurred the least as this type may not be the most suitable when engaging in MLBB especially in dealing with opponents. However, depending on some unknown factors, these gamers on few occasions may still display a yielding attitude. Also, in dealing with team members, the

Table 1.0 Dominant Communication Styles based on Bourne's (1995) Communication Styles Sibling-respondents (n=30)

Communication Styles	Mean	Percentage
Aggressive Communication Style	3.11	62.33
Assertive Communication Style	3.05	61.11
Manipulative Communication Style	2.50	50.11
Submissive Communication Style	2.32	46.44
Passive - Aggressive Communication Style	3.09	61.89

Note: 1.00 - 1.79 = Strongly Disagree; 1.80 - 2.59 = Disagree; 2.60 - 3.39 = Neutral; 3.40 - 4.19 = Agree; 4.20 - 5.00 = Strongly Agree

Submissive communication style is expected on some instances.

Interpersonal Communications

Seemingly, MLBB engagements have either weakened or strengthened the interpersonal communications of the gamers. As far as weakening interpersonal communication is concerned, the nature of the game which requires aggression might have affected the players' communications outside of the gaming context. Included are excerpts from the respondents' narratives.

MLBB Weakening Interpersonal Communications

SR-002: "... the way my siblings communicate is aggressive ... MLBBdoes affect my siblings' communication."

SR-003: "You can't really have a conversation with him when he's playing MLBB since he doesn't like to be interrupted, therefore I guess that lowers his interpersonal communication skills."

SR:004: "Whenever they lose a rank game, they become very truculent they shout and curse..."

SR-006: "My brother's communication style to the family is poor. He is often misunderstood and is usually offensive. In my opinion, MLBB negatively impacts his communication style."

SR-007: "... she would raise her voice or scream at me when she's trying to prove a point."

SR-009: "... whenever I ask them a question while they are playing, they respond aggressively."

SR-021: "... just like saying bad words, and aggressively talking, and manipulative sometimes."

SR-025: "... he tends to be harsh especially when the game is going bad."

SR-030: "...whenever we would ask for him when he is in-game, he would get angry and would not want to be bothered. Also, after a loss, my sibling would be grumpy as well."

Habibillah (2022) purported that MLBB players often use offensive language to attract attention, insult their enemies or teammates, and provoke their opponents to create an exciting match. The act of MLBB players being aggressive in communication, including shouting and cursing, shares a common theme of aggression. MLBB players display aggression in their communication in competitive games to make their opponent uneasy and not confident to play Ringo (2021). The excerpts reveal that manifestations of hostility in communication are observable among these players even when not participating in MLBB.

Interestingly, some respondents also believe that playing MLBB have strengthened the interpersonal communications of their siblings.

MLBB Strengthening Interpersonal Communications

SR-001: "after playing so much together, we actually know how to communicate non-verbal, you know, you get used to his habits and without even verbal communication"

"It actually strengthens our communication... we found our common ground as siblings..."

SR-004: "in my brothers' case it strengthened their communication skills; They now talk a lot..."

"...both my brothers are introverted and had a hard time talking and making friends, but as they started playing MLBB they learned how to mingle with people..."

SR-005: "... it somehow enhances his leadership skills as he sometimes leads the team and directs his teammates on what to do during the game."

SR-008: "... it developed his communication skills."

SR-018: "He is more expressive and straightforward about anything he is trying to convey."

SR-026: "... He's more confident in dealing with others, especially to people with different personalities."

SR-029: "... she has improved her communication skills."

MLBB for some gamers became a tool that made them expressive and confident speakers as claimed by the siblings. The reason for this outcome is probably because MLBB as mentioned earlier is a game that encourages coordination and support among same team members which most frequently requires affirmative forms of communications.

Furthermore, some respondents indicated that their siblings have honed leadership skills and that playing MLBB allowed the gamers to form new friendships. These constructive interpersonal relations may be due to the shared goals of the players which is to win, make commands, and submit to the one who is in control which develops their leadership skills, communication skills, and leading them to create friendships. This finding confirms the assertion of Mawalia (2020) that virtual communications and interactions allow friendship in cyberspace to form a community. The players' exposure to the communication dynamics of MLBB can therefore potentially make MLBB players convey thoughts and emotions with their family members more openly hence possibly creating positive bonds and relationships with their respective families.

Based on the respondents' narratives, it is interesting to note that MLBB can both strengthen and weaken the interpersonal communication skills of gamers. On the other hand, it is essential to acknowledge that while MLBB gaming can positively affect or support interpersonal communications, the potential weakening of the players' interpersonal communications should be given more attention as the later can be disadvantageous to the gamers' ability to interact with others outside of the game more affirmatively.

CONCLUSION

MLBB players use the Aggressive Communication Style considering the nature of the game. MLBB players tend to communicate aggressively by shouting, cursing, and being sarcastic while playing the game. This type of communication can still be demonstrated even when players are not playing hence weakening interpersonal communications. On the other hand, MLBB can also help one to express and communicate freely by leading the team in the game in an assertive manner. As a result, players tend to have better communication skills as they become more expressive, vocal, and straightforward.

Despite the potential for MLBB to cause aggressiveness in communication styles of its players, the data highlights that the game can improve players' interpersonal communication skills. This improvement was demonstrated by the fact that players could express themselves better, more clearly, make new friends through the game, and even develop leadership skills through leading the team. Respondents even reported instances wherein their formerly introverted siblings learned to open up more and socialize as potentially and positively affected by MLBB gaming.

Nevertheless, researches still suggest guidance for young people especially the very young players who have yet to develop further their cognitive, social, and emotional quotients so that they can maximize the positive outcomes of MLBB engagements and minimize the harmful effects of their participation.

RECOMMENDATIONS

Given the knowledge that MLBB may cause aggressiveness in players' interpersonal communication skills, the researchers emphasize the importance of responsible gaming to prevent the possibility of conflicts within the household due to players' tendency to use harsh words while immersed in the game, and promote in-person bonding and connection with family members instead of solely focusing on the virtual reality of the game. The researches stress the value of courteous and constructive offline interactions which should not be affected negatively by online gaming. With this, future researchers may also consider expanding the number of respondents and reaching out to professional Esports players to further understand the world of online gaming and its positive and negative effects on the general well-being of the gamers.

Future researchers may also use alternative methods in collecting data such as Focus Group Discussions (FGD) and Face-to-face in-depth interviews to elaborate respondents' answers to the questions asked in the questionnaire. Moreover, different communication contexts in relation to online gaming may also be considered. Conducting comparative analysis of the communication styles and interpersonal communication of MLBB players during the years before they were introduced to this online game and after they started playing the game can also be an alternative method.

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Central Mindanao University
Journal of Science
ISSN Print: 0116-7847 ISSN Online: 2704-3703

Mining the Indigenous Fruit Trees of Mindanao for Essentials Oils with Antibacterial Activity

Glenda Z. Doblas[15], Samuel S. Zamora Jr.[1], Hannah P. Lumista[1], Yuyen V. Tan[2], Ronaldo C. Balandra[3], and Reggie Y. Dela Cruz[1]

[1]Institute of Biological Sciences, College of Arts and Sciences
[2]Department of Chemistry, College of Arts and Sciences
[3]Department of Mechanical Engineering, College of Engineering
Central Mindanao University, University Town, Musuan, Maramag, Bukidnon, Philippines

ABSTRACT

Indigenous fruit trees are underutilized local resources but of great interest as potential sources of new chemical entities for drug discovery. In this work, the antimicrobial potential of essential oils (EOs) extracted from indigenous fruit trees of Mindanao was evaluated. Thirty-four (34) fruit trees were screened for the presence of EOs using the Clevenger apparatus for hydrodistillation. EOs were subjected to disk diffusion assay for antibacterial evaluation. The result showed that *Lansium domesticum* (lanzones) leaves, *L. domesticum* (lanzones) pericarp, *Psidium guajava* (bayabas) leaves, and *Citrus maxima* (pomelo) pericarp yielded a significant amount of EOs. The said EOs were shown to inhibit the growth of *B. subtilis* and *E. coli*. However, only EOs from *P. guajava* leaves inhibited the growth of three other bacteria namely *S. aureus*, *S. enteretica* and *P. pseudomonas*. The EOs from these plants may further be investigated as potential drug candidates against microbial drug resistance. Moreover, these EOs could be combined for possible synergistic action to maximize their antimicrobial potential.

Keywords: indigenous fruit trees, essential oil, antibacterial, hydrodistillation

INTRODUCTION

The Philippines, which represents 5% of the world's flora, is home to 152 indigenous fruit species that have various ecological and economic importance for food and nutrition, and are a potential source of new chemical entities for drug discovery (Magcale-Macandog et al., 2005). Several of these indigenous fruit trees are found in Mindanao such as nangka (*Artocarpus heterophyllus*), santol (*Sandoricum koetjape*), durian (*Durio zibethinus*), and marang (*Litsea perrottetti*), all of which are indigenous and endemic, with some that are locally found but are introduced from other tropical countries (Miranda et al., 2018; Alipon et al al., 2022).

Aside from various ecological and potential economic importance, these plants are sources of phytochemicals that have profound positive health benefits. They are potential sources of bioactive compounds in fighting several diseases such as cancer, diabetes and microbial disease-causing infections which are one of the prominent causes of health problems, physical disabilities, and mortalities worldwide (Adebayo et al., 2016). These phytochemicals may be obtained in concentrated amounts by extracting the essential oils (EOs) from fruit trees. Such effort not only promotes the utilization of local resources but also encourages the conservation and reproduction of these fruit trees before becoming endangered.

EOs, volatile or ethereal oils, are aromatic oily liquids obtained from plant material like flowers, buds, seeds, leaves, twigs, bark, herbs, wood, fruits and roots (Guenther, 1948). They are the highly concentrated version of the natural oils in plants and can be obtained by expression, fermentation, enfleurage, extraction, and most commonly by distillation through steam or water (Van de Braak and Leijten, 1999). Technically they are not oils because they contain no fatty acids. But they contain highly concentrated plant compounds which make plants more resistant to disease and insect invasion. This protection in plants also has a wide range of uses for humans. Essential oils have been long recognized for their bactericidal, virucidal, fungicidal, antiparasitic, insecticidal, medicinal and cosmetic applications (Bassole and Juliani, 2012). There are approximately 3000 EOs known, about 300 of which are commercially important (Van de Braak and Leijten, 1999) finding their way into the pharmaceutical, sanitary, cosmetic, agricultural and food industries. The benefits of EOs and the recent enhancement of green consumerism have renewed the scientific community's interest in providing a novel insight into the perspective use of essential oil volatile constituents to combat microbial infections and expands on the current state of knowledge on the potential efficacy of essential oils. Thus, this paper was carried out on the extraction of EOs from leaves and pericarps of indigenous fruit trees in Mindanao for screening on its antibacterial efficacy against six health and food-borne pathogens.

METHODOLOGY

Collection and preparation of Plant samples

Indigenous fruit trees were collected around and nearby places in Bukidnon based on accessibility,

Corresponding author:
Glenda Z. Doblas
Email Address: gzdoblas@cmu.edu.ph
Received: Mar. 13, 2023 ; Accepted: Oct. 18, 2023

availability, and rarity. These are: *Annona muricata* L. (guyabano), *Annona squamosa* Linn. (atis), *Artocarpus odoratissimus* Blanco (marang), *Averrhoa bilimbi* L. (kamias), *Averrhoa carambola* Linn. (balimbing), *Carica papaya* L. (papaya), *Chrysophyllum caimito* L. (Caimito), *Anacardium occidentale* L. (Kasoi), *Citrus maxima* Merr. (Pomelo), *Citrus sinensis* L. (Dalandan), *Lansium domesticum* Correa (Lanzones), *Manilkara zapota* (L.) P. Royen (Chico), *Muntingia calabura* L. (Aratiles), *Nephelium lappaceum* L. (Rambutan), *Psidium guajava* L. (Bayabas), *Sandoricum koetjape* (Burm.f.) Merr. (Santol), *Syzygium cumini* (L.) Skeels. (Duhat), *Syzygium samarangense* (Blume) Merr.& L. M. Perry (Makopa), *Tamarindus indica* Linn. (Sampalok), *Persia americana* Mill. (Avocado), *Garcinia mangostana* L. (Mangosteen), *Syzygium aqueum* (Burm.f.) Alston (Tambis), *Artocarpus heterophyllus* Lam. (Nangka), *Passiflora edulis* Sims (Passion fruit), *Theobroma cacao* L. (Cacao) and *Durio zibethinus* L. (Durian). The pericarp of the fruit and the leaves were manually chopped, air-dried at room temperature, and ground.

Extraction of Essential Oils

Dried pericarp and leaves were subjected to oil extraction using the Clevenger-type steam distillation apparatus. A varying weight of both the pericarp and leaves per species were placed in the still. The boiling flask was filled with two (2) liters of distilled water and allowed to boil. Boiling was continued for six (6) hours to allow the formation of steam that heated up the plant samples inside the still. This caused the release of essential oil from the plant tissues. The EOs were evaporated and made to travel through a tube into the condensation chamber. Here, the essential oil vapors condensed with the steam and were collected in the receiving funnel forming a filmy layer. The oil produced was measured following the formula below:

$$\text{Yield of extraction} = \frac{\text{The volume of oil extract}}{\text{Weight of fresh material}}$$

For each type of essential oil, five concentrations were prepared: pure, 1:1 (50 µl essential oil + 50 µl diluent), 1:5 (20 µl essential oil + 80 µl diluent), 1:10 (10 µl essential oil + 90 µl diluent), and 1:20 (5 µl essential oil + 95 µl diluent). The diluent was prepared by adding 100 µl of 10% aqueous DMSO and 100 µl of 10% aqueous Polysorbate 20 to 800 µl distilled water.

Test Organisms

Broth culture of *Bacillus subtilis*, *Escherichi coli, Staphylococcus aureus, Salmonella enterica, Pseudomonas aeruginosa*, and *Xanthomonas campestris* were used. To ensure purity, these test organisms were re-streaked several times in NA plates. Before assay, each inoculum was standardized following these steps. An isolated colony from a 24–48-hour culture of the test organisms was inoculated in 10ml NB tubes and incubated at room temperature for 8-10 hours with continuous shaking. After incubation, the optical density of the cultured organisms was checked and adjusted to 0.08 to 0.1 at 625 nm in the microplate reader. This is equivalent to 0.5 McFarland standard. This was done by placing 100µl of the adjusted pathogens in 3 wells and 100µl of media (NB) in another 3 wells in a 96-well plate. The optical density in wells with pathogen, media and blank was read at 625 nm in a microplate reader. Blank subtraction was not done if the optical density of the empty wells was nearly close to the media wells. If the reading is beyond 0.1, the pathogen is diluted further using the formula:

$$\text{Volume of pathogen} = \frac{\text{(Desired reading) (Desired volume)}}{\text{Actual reading}}$$

Disk Diffusion Microbial Assay

Mueller Hinton Agar (MHA) was prepared according to the manufacturer's instruction. MHA plates were inoculated with the standardized test organism. Sterile filter paper disks (6 mm) were impregnated with 10 ul of the corresponding treatments as follows: five concentrations of the EOs, 2% DMSO (diluent control), water (negative control) and 15 µg Cefazolin (Phizolin) (positive control). The disks were placed on the surface of the inoculated MHA plates. All disks were distributed evenly so that they were not closer than 24 mm to the center or too close to the edge of the plate. One disk was impregnated with 10 µl 2% DMSO (negative control), another with 10 ul water (negative control) and another with 15 µg Cefazolin (Phizolin) (positive control). For the three (3) remaining disks, 10µl of each concentration (15 mg/ml, 30 mg/ml, and 50 mg/ml) was pipetted. After impregnating all the disks, the plates were upright for 5 minutes. The plates were then incubated at 37°C for 18-24 hours. This assay was done in at least (3) replicates. After incubation, the diameters of the zone of complete inhibition (ZOI) including the disk were measured in millimeters using a ruler. The ZOI was considered if the unaided eye sees no obvious visible growth surrounding the disk. The faint growth of tiny colonies at the edge of the zone of inhibition detected by the magnifying lens was ignored. The test was repeated when the zone of inhibition was shaped irregularly and only circled ZOI was considered. The test was repeated if colonies are present in the zone of inhibition.

Statistical Analysis

The results obtained were statistically analyzed using a One-way Analysis of Variance (ANOVA) at 5% level of probability ($P<0.05$). Significant differences between means were then analyzed using Tukey's post hoc test. Data were computed as mean ± SD of the three replicates.

RESULTS AND DISCUSSION

Description and Yield of Crude Essential Oil

There are thirty-four (34) fruit trees screened for the presence of essential oils. Of these, only the leaves of *L. domesticum* (lanzones) and *P. guajava* (bayabas) and

pericarp of *L. domesticum* (lanzones) and *Citrus maxima* (pomelo) yielded a significant amount of EOs.

Psidium guajava obtained the highest yield with 0.66 µl per gram of dried leaves followed by *L. domesticum* (0.62 ul) per gram of dried leaves and 2.52 ul for dried pericarp while least in *Citrus maxima* (pomelo) with 0.40 µl per gram of dried pericarp. The oils of *P. guajava* and *L. domesticum* are light yellow and produce a strong yet non-irritating aroma. The oil observed in C. maxima was cloudy yellow and produced a strong, non-irritating aroma. In *P. guajava* and *L. domesticum*, the first drop of oil was observed at 25 minutes after boiling. In contrast, in *C. maxima*, the first drop of oil was observed after 21 minutes.

This study employed the hydrodistillation method of extracting essential oil using the Clevenger apparatus. The plant material was soaked for some time in the water, after which the mixture was heated, and volatile materials were carried away in the steam, condensed, and separated. The Clevenger apparatus is the standard method for extracting EOs for quality control. However, the extraction yield using steam distillation is relatively more minor since a part of the essential oil becomes dissolved in the distillation water, making it an inefficient method for the complete extraction of essential oil from aromatic crops (Rao, et. al., 2004). Microwave and microwave-ultrasonic extractions methods were much more efficient than ultrasonic methods as well as conventional steam distillation extraction methods in terms of both the extraction time and obtained yields (Jaradat et.al., 2016). Moreover, the extraction yield of essential oil depends on different factors, such as the regulation of biosynthetic genes, climatic variation, and expression of metabolites (Bora et al., 2020). Tran et.al. (2019), using hydrodistillation to extract the essential oil from Vietnamese powdered mandarin (C. reticulata Blanco), reported that the size of the fruit peel samples, the water-to-peel ratio, the temperature extraction, and the time of extraction could affect the yield of essential oils extracted through hydrodistillation. Also, essential oil yield from natural sources depend on climate, geography, source, degree of freshness, period of harvest, and extraction method, among other factors (Lawrence,1986).

An essential oil's unique aroma and other bioactive properties depend on its chemical constituents. The chemical components of plant essential oil differ between species. This chemical difference is directly related to antimicrobial activities against various pathogenic microorganisms (Pichersky, 2006). The leaves of *Psidium ssp*. contains iso-caryophyllene (33.53%), veridiflorene (13.00%), farnesene (11.65%), dl-limonene (9.84%), δ-cadinene (1.75%), α-copaene (2.80%), α-humulene (3.74%), aromadendene (1.70%) and τ-cadinol (0.08%). The volatile oil, "pompelmus" oil, from leaves of *C. maxima* contain d-pinene (0.5-1.5%), d-limonene (90-92%), linalool (1-2%), citrate (3-5%), geraniol (1.2%), linalyl and geranylacetate, citral (25%), free alkaloid (8.61%) and ester (4.38%). The dried peel of *L. domesticum* pericarp produces a dark, semiliquid oleoresin composed of 0.17% volatile oil and 22% resin (Heyne, 1987).

Disk Diffusion Anti-bacterial Assay

Before testing, the EOs were dissolved in DMSO with polysorbate 20. Polysorbate 20 is an emulsifier choice of aroma therapists and cosmetic formulators for mixing EOs in water. At the same time, polysorbate 80 is used to mix heavier oils, such as sunflower oil, olive oil, and argan oil. Without these emulsifiers, the oils would not mix uniformly throughout the product, but would separate or not be homogenous. DMSO with polysorbate 20 acts as a surfactant for the bacterial cells to absorb the oils because of its hydrophobicity and non-polar characteristics. However, DMSO concentration above 10% becomes toxic to cells (Karande et al., 2006).

The antibacterial activity of the essential oils extracted from indigenous fruits revealed that the EO from guava leaves exhibited significant inhibition against *B. subtilis*, *E. coli*, *S. aureus*, *S. enterica*, and *P. aeruginosa*. In *B. subtilis*, inhibition was observed even at 1:5 dilution. For *E. coli*, *S. aureus*, and *P. aeruginosa*, inhibition was observed only when the oil was undiluted (Table 1).

EOs from C. maxima pericarp exhibited inhibition against B. subtilis and E. coli up to 1:5 and 1:10 dilution, respectively (Table 2).

EOs extracted from the leaves and pericarp of lanzones also showed inhibition against *B. subtilis* and *E. coli* at various concentrations but did not inhibit the growth of *S. aureus*, *S. enterica*, *P. aeruginosa* and *X. campestris* (Table 3 and 4). In this study, not all bacteria

Table 1. Mean zone of inhibition (mm) of EO from *P. guajava leaves*.

Treatment	B. subtilis	E.coli	S. aureus	S. enterica	P. aeruginosa	X. campestris
A (Pure)	13.9b	12.5b	12.7b	0.00a	12.7b	0.00a
B (1:1)	12.5b	0.00a	0.00a	12.9b	0.00a	0.00a
C (1:5)	12.7b	0.00a	0.00a	12.9b	0.00a	0.00a
D (1:10)	0.00a	0.00a	0.00a	12.7b	0.00a	0.00a
E (1:20)	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a
F (Water)	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a
G (Diluent)	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a
H (Cefazoline)	33.3c	31.3c	20.6c	18.3c	31.3c	21.6b

Column means of the same letters are not significantly different from each other (P>0.05 ANOVA).

Table 2. Mean zone of inhibition (mm) of EO from *C. maxima pericarp*.

Treatment	B. subtilis	E.coli	S. aureus	S. enterica	P. aeruginosa	X. campestris
A (Pure)	13.7[b]	14.7[c]	0.00a	0.00a	0.00a	0.00a
B (1:1)	13.5[b]	12.8[c]	0.00a	0.00a	0.00a	0.00a
C (1:5)	13.6b	12.8[b]	0.00a	0.00a	0.00a	0.00a
D (1:10)	0.00[a]	12.8[b]	0.00a	0.00a	0.00a	0.00a
E (1:20)	0.00[a]	0.00[a]	0.00a	0.00a	0.00a	0.00a
F (Water)	0.00[a]	0.00[a]	0.00a	0.00a	0.00a	0.00a
G (Diluent)	0.00[a]	0.00[a]	0.00a	0.00a	0.00a	0.00a
H (Cefazoline)	31.3[c]	34.0[d]	33.6b	24.3b	31.3b	23.0b

Column means of the same letters are not significantly different from each other (P>0.05 ANOVA).

Table 3. Mean zone of inhibition (mm) of EO from *L. domesticum leaves*.

Treatment	B. subtilis	E.coli	S. aureus	S. enterica	P. aeruginosa	X. campestris
A (Pure)	13.8b	12.9b	0.00a	0.00a	0.00a	0.00a
B (1:1)	13.7b	12.7b	0.00a	0.00a	0.00a	0.00a
C (1:5)	13.7b	12.8b	0.00a	0.00a	0.00a	0.00a
D (1:10)	12.9b	12.7b	0.00a	0.00a	0.00a	0.00a
E (1:20)	8.2a	0.00a	0.00a	0.00a	0.00a	0.00a
F (Water)	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a
G (Diluent)	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a
H (Cefazoline)	31.3c	34.0c	33.6b	34.3b	31.3b	23.0b

Column means of the same letters are not significantly different from each other (P>0.05 ANOVA).

Table 4. Mean zone of inhibition (mm) of EO from L. domesticum pericarp.

Treatment	B. subtilis	E.coli	S. aureus	S. enterica	P. aeruginosa	X. campestris
A (Pure)	13.9a	14.9c	0.00a	0.00a	12.9b	12.9a
B (1:1)	13.8a	14.7c	0.00a	0.00a	0.00a	12.8b
C (1:5)	13.4a	14.8b	0.00a	0.00a	0.00a	12.8c
D (1:10)	13.5a	12.7b	0.00a	0.00a	0.00a	0.00a
E (1:20)	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a
F (Water)	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a
G (Diluent)	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a
H (Cefazoline)	31.3c	31.3b	34.6b	33.6b	33.0c	30.6b

Column means of the same letters are not significantly different from each other (P>0.05 ANOVA).

tested were susceptible to the four EOs. The EOs extracted from *P. guajava* leaves inhibited only *B. subtilis*, *E. coli*, *S. aureus*. *S. enterica*, and *P. aeruginosa* and not X. campestris. Moreover, the EOs of *C. maxima pericarp* and *L. domesticum* leaves, and pericarp inhibited only *B. subtilis* and *E. coli*. The mode of action of EOs and/or their components is dependent on their chemical composition and may have a single target or multiple targets of their activity (Nazzaro, 2013). *P. guajava*., popularly known as guava, is a small tree belonging to the myrtle family (Myrtaceae). It is one of the plants in folklore medicine used to treat several diseases. In the Philippines, the astringent unripe fruit, the leaves, the cortex of the bark and the roots are used for washing ulcers and wounds, as an astringent, vulnerary, and for diarrhea. P. guajava leaves have been reported to contain fixed oil and volatile oil which is dominated by α-pinene, 1,8-cineole, and *β*-bisabolol (Da Silva et al., 2003) as well as 57 components including 27 terpenes, 14 alcohols and 4-esters (Joseph and Priya, 2011). These compounds may be responsible for the susceptibility of the bacteria except for *X. campestris*. Quercetin is said to be the primary antibacterial compound in guava leaves (Rattanachaikunsopon and Phumkhachorn, 2010). This compound has been shown to inhibit both Gram-positive and Gram-negative bacteria such as *S. aureus*, *S. mutans*, *P. aeruginosa*, *S. enteritidis*, *B. cereus*, *P. vulgaris*, S. *dysenteriae* and *E. coli* (Cowen, 1999). Barret et al. (1994) evaluated a range of antibiotics against Xanthomonas campestris pelargonii and showed that many antibiotics showed reduced or no activity on the latter.

Pomelo is a perennial plant belonging to the

family Rutaceae, scientifically known as *Citrus maxima* (Burm.) Merr. and locally known as lukban or suha (Libunao et al., 2013). This plant has been reported to treat fever, cough, pharyngitis, skin diseases and sore throat (Othman et al., 2016). Li et al. (2019) reported the antibacterial activity of finger citron essential oil (FCEO, *Citrus medica L. var. sarcodactylis*) and its mechanism against food-borne bacteria such as *Escherichia coli*, *Staphylococcus aureus*, *Bacillus subtilis* and *Micrococcus luteus*. They identified 28 components in the oil through gas chromatography-mass spectrometry, in which limonene (45.36%), γ-terpinene (21.23%), and dodecanoic acid (7.52%) were the three main components present in the plant. Limonene has been shown to suppress the development of both Gram-positive and Gram-negative bacteria, but with greater activity on the former than the latter, indicating that it has a broad spectrum of action which includes destroying cell walls and membranes, causing protein and bacterial nucleic acid leakage and inhibiting ATPase activity (Raspo et al., 2020). *Lansium domesticum* Corr. is a fruit tree of the Meliaceae family. It is a popular folk remedy for sore eyes and was reported for treating malaria, dysentery, and even as a mosquito repellant (Orwa et al., 2009). The aqueous extract of Lanzones seed inhibited the growth of *E. coli* and *S. aureus* at high concentrations (Alfonso et al., 2017). Shan et al. (2007) showed that as the concentrations of the fruit extracts increase, the antibacterial activities also increase. This inhibition could be due to components that attack the bacterial cell wall and cell membrane, thereby causing leakage and coagulation of cytoplasmic components. The fresh peel contains 0.2% light-yellow volatile oil, a brown resin and reducing acids while the dried peel has a dark, semi-liquid oleoresin composed of 0.17% volatile oil and 22% resin. The fruit peel also contains three new onoceranoid triterpenes, lansionic acid, 3 β -hydroxyonocera-8,14-dien-21-one, and 21α-hydroxyonocera-8 and 14-dien-3-one. The seed includes five tetranorterpenoid, domesticulide, and 11 known triterpenoids. The seed extract is rich in limonoids which includes andirobin derivates, methyl angolensates, mexicanolides an azadiradione, onoceranoids and dukunolides (Tilaar et al., 2008).

The susceptibility of a particular species to essential oil is hard to predict. Identifying the mode of action of EOs requires much study of the raw material until the singular components are identified, and the mode of action should also be studied in multiple strains and species of microorganisms (Nazzaro et al., 2013).

In this work, the extracted EOs from indigenous fruit trees such as *P. guajava*, *C. maxima* and *L. domesticum* proved to be potential sources of antimicrobials for developing health and cosmetic products. Though the inhibition exhibited by the EOs is lower than that of cefazolin, the antibiotic control. This is not surprising since the antibiotic control is of high purity compared to the crude EOs, which are a mixture of several components.

CONCLUSION

This study extracted EOs from *P. guajava leaves*, *C. maxima pericarp* and *L. domesticum* leaves and pericarp. All four EOs extracted from these plants were shown to inhibit the growth of bacteria particularly *B. subtilis* and *E. coli*, thereby, making these indigenous fruit trees as potential sources of antimicrobials for the development of various health and cosmetic products. It is recommended to develop combined formulations of the extracted EOs to determine their potential synergistic action to maximize their antimicrobial potential.

ACKNOWLEDGMENT

This study is made possible by the research grant from the Central Mindanao University. Special thanks also to the CMU-Tuklas Lunas Development Center, NSRC and the Institute of Biological Sciences.

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Central Mindanao University
Journal of Science
ISSN Print: 0116-7847 ISSN Online: 2704-3703

Geo-Hazard Assessment and Mapping In Barangay Kiorao, Kibawe, Bukidnon

Ma. Catherine Q. Arca, Cheryl F. Daleon, Eric L. Cenabre, Einstine M. Opiso, Paulino R. Reomero, Richie Catherine Supremo-Lood, Richard Namuag, Methuselah Gen R. Berame, and Jan Mavylle S. Umali

Department of Civil Engineering, College of Engineering, Central Mindanao University
Musuan, Bukidnon, Philippines, 8710

ABSTRACT

Geohazards pose a significant threat to human life and property in the Philippines, and Barangay Kiorao, Bukidnon is no exception. Predominantly expansive soils in the barangay are susceptible to swelling and shrinking with changes in moisture content, and three sampling areas were identified to be collapsible. These soil conditions, combined with the barangay's location in a seismically active region, render it vulnerable to a variety of geohazards, including landslides and earthquakes. This study aimed to generate a geohazard map of the barangay to inform land use planning and disaster risk reduction efforts. Slope stability analysis revealed that the slopes in Barangay Kiorao are stable under semi-saturated and fully saturated conditions, even with friction angles as low as 0º. This suggests that the slopes have a "high" to a "very high" stability even under extreme conditions. Despite being safe from ground rupture, liquefaction, and tsunami, Barangay Kiorao is susceptible to strong ground shaking during earthquakes. The seismic hazard assessment identified areas in the Barangay that are at risk of experiencing strong ground motions during earthquakes. The resulting geohazard map scaled at 1:200,000 integrated these findings, marking areas susceptible to landslide and earthquakes.

Keywords: factor of safety, geohazard mapping, shallow landslides, slope stability, soil thickness

INTRODUCTION

Geohazards, encompassing a wide range of natural processes, can have a significant impact on human activities around the world. Advances in geohazard mapping have improved the ability to assess and mitigate these risks. However, the rapid development of infrastructures in vulnerable areas often outpaces the creation of effective disaster preparedness strategies. A critical gap remains in accounting for the dynamic environmental and geological changes that can render existing hazard maps obsolete.

The Philippines, situated on the typhoon belt and along the Pacific Ring of Fire, is a testament to the complexity of managing geohazards (Aurelio, 2004). The country's topography and climatic conditions predispose it to a variety of hazard, with landslides frequently occurring in areas with steep slopes and high rainfall. These events are exacerbated by geological materials that are weathered and structurally weak, leading to numerous forms of slope failure (Padrones, et al., 2017). The commonly observed slope failures in the country include block slides, debris slides, and earth creep (Opiso et al., 2016). Moreover, seismic activities present additional risks. Seismic hazard is used to characterize earthquake-induced natural processes that can be harmful, such as surface rupture, ground motion, ground-motion amplification, liquefaction, or triggered landslides (Wang, 2011). The July 2023 mudflow, which triggered a flash flood, and the series of earthquakes from June to July 2023 underscore Kibawe, Bukidnon's vulnerability to a variety of geohazards. These events serve as stark reminders of the urgent need for comprehensive and effective disaster risk reduction strategies to safeguard the lives and property of Kibawe residents.

This study addresses these challenges by conducting a slope stability assessment, identifying problematic soils, identifying locations vulnerable to earthquakes, and ultimately, developing a detailed geohazard map for Barangay Kiorao in Kibawe, Bukidnon. This supports the ongoing efforts to improve mobility and connectivity in the area. By employing a deterministic quantitative approach through Infinite Slope Model, this study evaluates slope stability and identifies regions at heightened risk, incorporating soil properties, slope gradients, and saturation levels into the analysis. This model is a well-established method for calculating the Factor of Safety (FS) for shallow landslide assessment. The FS is a measure of how stable a slope is. A lower FS indicates a higher risk of landslides. Additionally, the study also considered seismic hazards. Accessible data from HazardHunterPH, a tool developed by the Philippine Institute of Volcanology and Seismology, was incorporated into the geohazard map to identify areas prone to ground shaking, liquefaction, and tsunami. Leveraging Geographic Information System (GIS) techniques in mapping provides an excellent tool for assessing potential risks. GIS is a computer-based tool that allows the creation of detailed maps by combining different types of data. This helps in visualizing and understanding the potential impact of geohazards on communities.

The resulting geohazard map is a step towards bridging the information gap for communities, policy makers, and developers. It serves as a vital tool for disaster risk management, enabling the formulation of

Corresponding author:
Ma. Catherine Q. Arca
Email Address: cathiearc1580@gmail.com
Received: Apr. 14, 2023 ; Accepted: Oct. 10, 2023

effective mitigation strategies and emergency response plans. Identifying areas at risk equips communities, local government units, and developers with the information they need to make informed decisions, steering growth towards safer zones. Ultimately, the purpose of this study is to foster development of resilient communities, safeguarding lives and property against the inevitable challenges posed by natural hazards in the Philippines.

METHODOLOGY

Study Area

The research area is in Barangay Kiorao, found in the Municipality of Kibawe, in the province of Bukidnon, in Region X, Northern Mindanao, the Philippines. Kibawe has a more significant percentage of rolling than plain areas. A rough estimate is 80% rolling hills and 20% plainlands. The important landmarks of the municipality are several mountain peaks clustered over most of the barangays. On the island of Mindanao, Barangay Kiorao is located roughly 7° 31' North and 124° 55' East. The elevation at these coordinates is estimated to be 275.1 meters, or 902.5 feet, above mean sea level. As determined by the 2020 Census, Barangay Kiorao had a population of 653, accounting for 1.56% of Kibawe's total population.

The geology of Barangay Kiorao is complex, with a mix of volcanic and sedimentary rocks. The volcanic rocks in the barangay are predominantly andesite and basalt. The sedimentary rocks in the barangay include sandstone, shale, and limestone. The soil types in Barangay Kiorao are also varied. The most common soil type is clayey soil, which is often found on steep slopes. Sandy soils are also common in the barangay, especially in areas that are prone to flooding. Loamy soils are found in areas that are well-drained and have a mix of sand, silt, and clay. The rainforest in the barangay is dominated by trees such as dipterocarps, mahogany, and narra. The grassland in the barangay is dominated by grasses such as cogon and elephant grasses.

An initial inspection of the study area was conducted to evaluate its accessibility and to account for all the industrial and agricultural establishments, road networks, and communities at high risk of a geohazard. The findings of the initial inspection suggests that Barangay Kiorao is vulnerable to a variety of geohazards, including landslides and earthquakes. The risk of geohazards is exacerbated by the barangay's complex geology, steep slopes, and varied soil types.

Generation of Slope Map

GIS exploration was conducted to obtain data on slope gradient. A 5x5 meter resolution Digital Elevation Model (DEM) was procured from the National Mapping and Resource Information Authority (NAMRIA) through

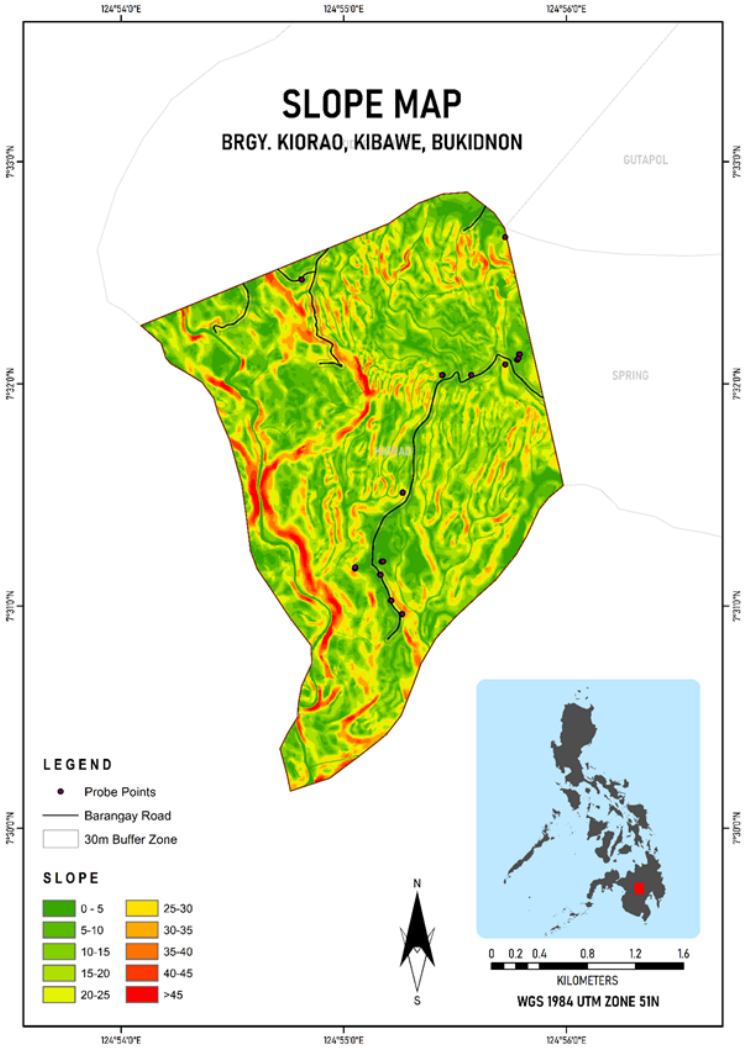

Figure 1. Slope Map of Barangay Kiorao.

the Central Mindanao University (CMU) GeoMin Center. The DEM was used to generate a slope map of the study area, which showed that slope angle was a major factor influencing slope stability. The slope variability in the study area was derived using ArcGIS software, as shown in figure 1.

Sampling points were deliberately chosen near roads to ensure the safety of the field team and expedite data collection. Some parts of the barangay were inaccessible by car, and others were too dangerous to reach during the rainy season. By focusing sampling near roads, the team was able to optimize resources and collect quality data without overspending. Despite their proximity to roads, the sampling points represented a wide range of slope angles. This was important because roads often lead to or area adjacent to population centers, which are at heightened risk of slope instability due to increased human activity and potential infrastructural developments.

Soil Sampling

Soil samples were collected from across the study area to determine the necessary geotechnical properties. The selection of sampling points was based on slope gradients, as indicated by slope map data. Different slope gradients can significantly influence soil properties, so it was important to capture samples from various slope categories. To systematically identify sampling points, the study area was stratified into distinct slope gradient ranges. Within each gradient stratum, specific locations were chosen to capture the variability of soil conditions influenced by that particular slope range. The soil was then characterized in terms of its physical, index, and mechanical properties. The soil sampling procedure adhered to ASTM D1452-09 standards. Before sampling, the chosen area was cleared of any debris and vegetation. Disturbed soil samples were collected and immediately sealed in airtight containers to preserve their moisture content. These samples were tested in the laboratory to determine index properties such as Atterberg limits, moisture content, dry density, and particle size distribution. Core samplers were used at the predetermined sampling points to obtain undisturbed soil samples, which were similarly sealed to maintain their moisture levels. These undisturbed samples were essential for determining the soil's shear strength parameters. The soil sampling method ensured that the samples collected provided a representative overview of the soil properties across different slope gradients in the study area.

Determination of the Geotechnical Properties of the Soil

To comprehensively understand the geotechnical properties of the soil samples collected from the study area, a systematic approach was adopted, targeting the determination of moisture content, particle size distribution, soil classification based on index properties, Atterberg limits, unit weight, and key parameters such as soil density, cohesion, and internal friction angle.
The moisture content of disturbed soil samples was determined in accordance with ASTM D2216 using standard oven-drying procedures. This involved heating the samples to 110°C for 24 hours in a thermoelectric oven. Sieve analysis was performed on the oven-dried soil samples to determine their particle size distribution, as per ASTM D422. The resulting particle size distribution was classified following the guidelines of ASTM D2487-11, the Unified Soil Classification System (USCS), and the American Association of State Highway and Transportation Officials (AASHTO) standard classification. The index properties of the disturbed soil samples were evaluated to facilitate soil classification. The Atterberg limits, indicative of the soil's plasticity, were determined using the fall cone method, following ASTM D4318. The total unit weight of the undisturbed soil samples was determined in accordance with ASTM D2937. This involved extruding the samples from the core samples using a soil extruder and measuring their weight and dimensions using a vernier caliper. To determine the shear strength parameters of the undisturbed soil samples, a Direct Shear Test under Consolidated Drained Conditions was performed, as per ASTM D3080. This test provided vital data on soil density, cohesion, and internal friction angle. The data amassed from these laboratory tests offered a holistic view of the geotechnical parameters of the soil samples, facilitating a robust analysis and correlation of their properties.

Slope Stability Assessment

Slope stability assessment is the process of determining and evaluating how much stress a specific slope can withstand before failing. It is a fundamental step in evaluating landslide hazards and designing safe structures. The slope stability assessment in this study was conducted using the Infinite Slope Model (ISM) through an Excel spreadsheet. The ISM is a simple but effective model for assessing slope stability. However, it is important to note that it is a deterministic model that assumes a uniform slope and infinite length. In reality, slopes are often heterogeneous and finite. This can lead to inaccuracies in the slope stability assessments produced using the ISM. Despite its limitations, the ISM was chosen for this study because it is a well-established and widely used model for slope stability analysis. Additionally, the ISM is relatively easy to use and does not require a large amount of data. The following critical input parameters were used to assess slope stability using the ISM:

Unit Weight of soil (γ): This parameter represents the density of the soil, which is a fundamental factor in calculating the gravitational forces acting on the slope.
Saturation Index (m): also known as groundwater depth to soil thickness ratio. This ratio indicates the level of soil saturation with water, where 'zw' is the height of the water table above the failure surface, and 'z' is the depth of the failure surface below the terrain surface (Mondal & Maiti, 2012).

Cohesion (c): This soil strength parameter represents the resistance to shear due to interparticle bonding.
Angle of Internal friction (ϕ): This soil strength parameter represents the resistance to shear due to interlocking of soil particles.

Terrain Surface Inclination (β): The angle of the slope with respect to the horizontal plane, which directly affects the potential for slope movement.

To establish the relationship between soil parameters and slope angle, empirical relationships from Daleon & Lorenzo (2018) were used, as direct measurements were not possible at all sampling points. This approach was necessitated by financial constraints that limited the number of direct shear tests to four sampling points. For these four points, the measured values of cohesion and angle of internal friction angle were directly used in the Factor of Safety (FS) calculations. For the remaining points, the correlations were used to estimate these parameters, allowing for a comprehensive analysis across all 13 sampling points.

The FS is defined as the ratio of resisting forces to driving forces along the potential failure surface, with FS = 1.0 indicating imminent failure (Chae et al., 2015). An FS less than 1.0 suggests an unstable slope, necessitating intervention. The factor of safety is calculated according to the following formula of Brunsden & Prior (1979):

$$FS = \frac{c' + (\gamma - m\gamma_w)zcos^2\beta tan\emptyset'}{\gamma zsin\beta cos\beta}$$

Where:

c' – is the effective cohesion
γ – unit weight of soil
γw – unit weight of water
m – zw/z
z – depth of the failure surface below the surface (m)
zw – height of water table above failure surface (m)
β – slope surface inclination
Φ' – effective angle of shearing resistance

The FS was calculated at incremental 2-degree intervals of slope inclination. This incremental approach commenced at a minimal slope angle of 2 degrees and progressed methodically to the actual slope angle observed at each sampling point. By adopting this interval-based calculation, the study was able to capture the FS for a range of potential slop inclinations, providing a nuanced understanding of how slope stability varies with changes in slope angle.

Groundwater's role in slope stability was accounted for by considering different saturation conditions: semi-saturated (m_1 = 0.5, m_2= 0.25) and fully saturated (m = 1). For the fully saturated condition, the friction angle was reduced to account for the increase in water content. This assumption was based on the inverse relationship between friction angle and moisture content, which shows that the friction angle tends to decrease with increasing moisture content (Arca & Lorenzo, 2018), see figure 2. These conditions simulate the fluctuating groundwater table, particularly during the monsoon season, when rainwater infiltration can raise water levels and increase power water pressure, thereby reducing slope stability.

ArcGIS was used to map the calculated FS values, providing a visual representation of slope stability across the study area. As shown in table 1, the FS values were categorized into different stability classes as per the Factor of Safety Classification by Arca & Lorenzo (2018), facilitating the interpretation of stability and spatial distribution risk.

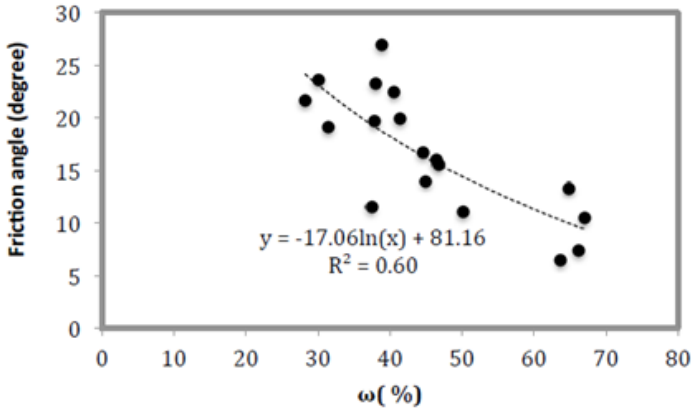

Figure 2. Logarithmic w-Φ Curve (Arca & Lorenzo, 2018).

Table 1. Factor of Safety Classification (Arca & Lorenzo, 2018).

Color Code	Factor of Safety	Stability Class
	0 - 0.50	Unstable
	0.50 - 1.00	Very Low
	1.00 - 1.25	Low
	1.25 - 1.50	Moderate
	1.50 - 2.00	High
	> 2.00	Very High

Table 2. Soil Expansivity Prediction by Liquid Limit.

Degree of expansion	w_L: %	
	Chen[6]	IS 1498[4]
Low	<30	20–35
Medium	30–40	35–50
High	40–60	50–70
Very high	>60	70–90

Table 3. Soil Expansivity Prediction by Plasticity Index.

Degree of expansion	I_p: %		
	Holtz and Gibbs[10]	Chen[6]	IS 1498[4]
Low	<20	0–15	<12
Medium	12–34	10–35	12–23
High	23–45	20–55	23–32
Very high	>32	>35	>32

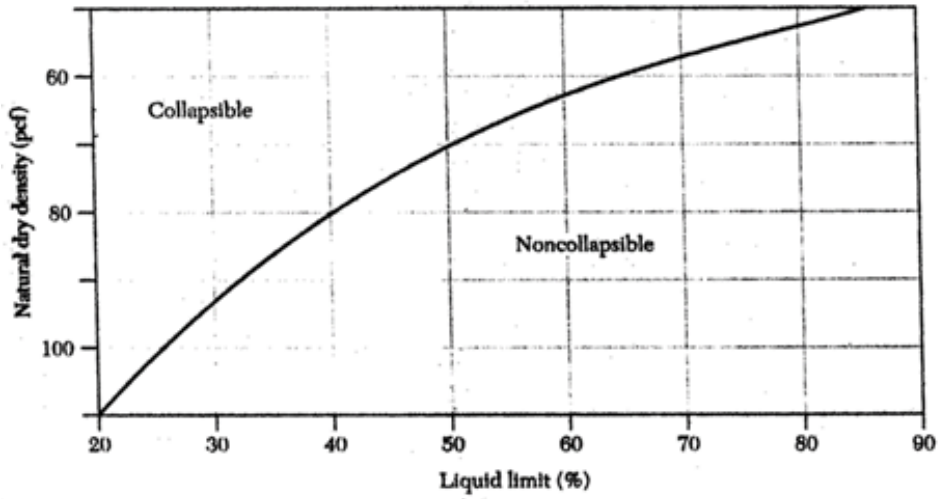

Figure 3. Criterion for Collapsibility Potential (Holtz & Gibbs, 1967).

Determination of Problematic Soil

According to Baynes (2008), expansive soils, soft clays, collapsible soils, and dispersive soils are among the most problematic soils. This study focused on identifying and characterizing expansive and collapsible soils. Expansive soils experience significant volume changes in response to moisture fluctuations. To predict soil expansivity, two key geotechnical properties were measured: the liquid limit and the plasticity index. The liquid limit is the water content at which soil transitions from a plastic to a liquid state. The liquid limit and plasticity index were cross-referenced with the soil expansivity prediction tables developed by Chen (1983) and Holtz and Gibbs (1967), respectively (see Tables 2 and 3). These tables classify expansivity potential based on the measured liquid limit and plasticity index values, enabling a quantitative assessment of the soil's expansive nature. By integrating these two predictive tables, the study leverages robust, empirically derived data to classify soil expansivity and facilitate a more informed evaluation of the risks associated with soil volume changes in the study area.

On the other hand, the primary concern with collapsible soils is the significant loss of shear strength and volume reduction that occurs when they are exposed to more water or moisture. The collapsibility of the soil in the study area was assessed using the criterion for collapsible potential provided by Holtz and Gibbs (1967), as presented in 3. This criterion entails measuring the soil's natural moisture content, dry unit weight, and degree of saturation. Collapsible soils typically have a low natural moisture content, low dry unit weight, and are frequently only partially saturated. When these soils become wet, the interparticle bonds that provide structure and strength can weaken or dissolve, resulting in a sudden and significant decrease in volume and bearing capacity. The degree of collapse is then used to classify the soil's collapsibility

potential, which can range from non-collapsible to highly collapsible.

Geohazard Mapping

The geohazard mapping was systematically conducted using ArcGIS software to integrate various datasets and to visualize the spatial variability of potential risks. Initially, a field reconnaissance survey was undertaken to gather first-hand observations of the current geohazard conditions and to document the historical geohazard events within the study area. Various data sets, including those pertaining to soil properties, slope stability, and historical geohazard events were compiled. This data served as the foundation for the subsequent analysis.

The Infinite Slope Model (ISM) was used to generate slope stability maps for the study area. Two (2) sets of FS maps were generated to represent semi-saturated conditions with saturation indices of m1 = 0.25 and m2 = 0.5. Additionally, five (5) FS maps were produced to model the slope stability under fully saturated conditions with varying friction angles (Φ1 = 2.4, Φ2 = 4.4, Φ3 = 6.4, Φ4 = 8.7, and Φ5 = 0), the latter to simulate the worst-case scenario. HazardHunterPH, a collaborative product of GeoRisk Philippines, was employed to generate the preliminary hazard assessment reports for the study area. This tool provided insights into the potential impact of geological hazards on the community.

Shapefiles indicating liquefaction susceptibility, active faults, and potentially active faults were obtained from PHIVOLCS. These shapefiles contain critical geospatial information necessary for the hazard mapping. The acquired shapefiles were then overlaid on the FS map that depicted the fully saturated condition with a friction angle of zero. This overlay process was meticulously performed to ensure that the spatial correlation between the FS data and the geohazard indicators was accurately represented. The final step involved the synthesis of the overlaid data to produce a comprehensive Geohazard Map. This map illustrates the areas of potential risk by combining the slope stability data with the geohazard indicators from the shapefiles.

RESULTS AND DISCUSSION

Geotechnical Data

The physical properties of the soil within the study area, as detailed in Table 4, provide valuable insights into the collapsibility potential of the soils encountered. The average moisture content of 46.44% is indicative of a moderate to high level of soil moisture, which is a critical determinant of soil behavior. Moisture content significantly influences soil compressibility, permeability, and strength. In the context of collapsibility, the high moisture content observed in the study area could be a precursor to increased soil compressibility and a reduction in shear strength (Ian & Chris DF, 2012). This is because water acts as a lubricant between soil particles, diminishing the interparticle friction that provide shear resistance (Bláhová et al., 2013).

The average total unit weight of the soil, recorded at 15.55 kN/m3, and the dry unit weight, at 10.63 kN/m3, are also significant in assessing the collapsibility potential. The unit weight of soil is a fundamental parameter that affects the bearing capacity and settlement characteristics of the soil. In the case of collapsible soils, the dry unit weight can be particularly telling. A low dry unit weight often corresponds to a loosely packed soil structure, which is susceptible to collapse when the soil becomes wet and capillary stresses are diminished, as described in the Soil Mechanics Designs Manual 7.01 (1986).

It is also important to note that the sample points fall within different slope categories, ranging from gentler to mid-portion slopes (6° to 41°) and steep slopes greater than 45°. This information is crucial for assessing the potential impact of slope angle on soil stability and the risk of landslides or collapse. The identification of BH8, BH11, and BH12 as collapsible soils, based on the Holtz and Gibbs criteria, underscores the importance of these physical properties. When these soils are exposed to moisture, such as during construction activities or changes in groundwater levels, the potential for rapid settlement or collapse becomes a critical consideration for land development and infrastructure design.

Table 4. Physical Properties and Collapsibility of the Soil Samples.

Sampling Code	Slope (°)	Moisture Content (%)	Density (kg/m^3)	Total Unit Weight (kN/m^3)	Dry Unit Weight (kN/m^3)	Liquid Limit (%)	Collapsibility
BH1	6	49.71	1,533.96	15.05	10.05	64.90	N
BH2	11	43.68	1,709.91	16.77	11.67	74.99	N
BH3	13	43.89	1,572.59	15.43	10.72	75.98	N
BH4	20	48.63	1,616.81	15.86	10.67	50.57	N
BH5	21	48.24	1,550.66	15.21	10.26	56.36	N
BH6	26	49.75	1,632.65	16.02	10.70	68.27	N
BH7	27	42.33	1,654.61	16.23	11.40	47.38	N
BH8	31	56.63	1,660.00	16.28	10.40	57.93	C-C
BH9	38	48.75	1,583.94	15.54	10.45	80.09	N
BH10	41	53.91	1,462.17	14.34	9.32	89.12	N
BH11	48	40.00	1,591.62	15.61	11.15	44.57	C-C
BH12	51	36.74	1,511.82	14.83	10.85	47.15	C-C
BH13	53	41.52	1,522.44	14.94	10.55	52.53	N
Average		**46.44**	**1,584.86**	**15.55**	**10.63**	**62.30**	

The measurement of Atterberg limits is an essential part of soil analysis, as it provides valuable insights into the soil's behavior and potential for problems, such as expansion, under different moisture and clay content conditions (Selby, 1993; Mugagga, et al., 2011; Bidyashwari, et al., 2017). Table 5 presents the liquid limit, plasticity index, and liquidity index of the soils within the study area. The liquid limit, a critical parameter in soil mechanics, varies from 44.57% to 89.09%. This limit represents the moisture content at which soil transitions from plastic to liquid (O'Kelly, 2021). The average liquid limit for the study area is 62.30%. According to the classification provided by IS 1498, this average falls within the 50%-70% range, indicating a high degree of expansion. This high liquid limit suggests high compressibility and a significant shrinkage or swelling potential. These characteristics can significantly influence the soil's behavior under load and its response to changes in moisture content. The plasticity index, another critical parameter, ranges from 14.11% to 71.28%. This index measures the range of water content over which the soil exhibits plastic behavior. The observed range indicates that the soils in the study area show medium to very high plasticity. Soils with a plasticity index greater than 25 are classified as expansive, as described in ASTM D4318. These soils have a high potential for volume change with changes in moisture content, which can lead to significant ground movement and potential damage to structures. Daleon (2022) corroborates these findings, identifying the majority of the soils in the study area as highly expansive with a high tendency to swell. This propensity for swelling can pose significant challenges for construction and requires careful consideration during the design and construction process. The liquidity index, which measures the natural water content of the soil relative to the liquid and plastic limits, varies from 0.26 to 0.96. This range indicates that the soil can deform like plastic under certain conditions. A high liquidity index suggests that the soil is closer to the liquid limit and is likely to exhibit significant deformation under load.

Table 6 presents the grain size distribution of the soil within the study area. A notable characteristic of the soil is its high clay and silt content, which ranges from 56.5% to 98.49%. This high percentage significantly exceeds the 32% threshold, indicating an extremely high expansive potential (Mugagga, et al., 2011; Baynes, 2008; Den Merwe, 1964). Expansive soils, also known as shrink-swell soils, undergo significant volume changes with changes in moisture content (Reddy et. al, 2020; and Kabeta & Lemma, 2023). Upon saturation, these soils

Table 5. Index Properties of the Soil Samples.

Sampling Code	Slope (°)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Liquidity Index
BH1	6	64.9	36.29	28.61	0.47
BH2	11	74.99	19.67	55.32	0.43
BH3	13	75.98	28.02	47.96	0.33
BH4	20	50.57	14.56	36.01	0.95
BH5	21	56.36	36.75	19.61	0.59
BH6	26	68.27	16.59	51.68	0.64
BH7	27	47.38	31.10	16.28	0.69
BH8	31	57.93	24.78	33.15	0.96
BH9	38	80.09	20.87	59.22	0.47
BH10	41	89.12	17.84	71.28	0.51
BH11	48	44.57	26.73	17.84	0.74
BH12	51	47.15	33.04	14.11	0.26
BH13	53	52.53	25.29	27.24	0.60
Average		**62.30**	**25.50**	**36.79**	**0.59**

Table 6. Grain Size Distribution of the Soil Samples.

Sampling Code	Slope (°)	Coefficient of Uniformity, Cu	Coefficient of Concavity, Cc	Textural Composition (%)		
				Gravel	Sand	Clay and Silt
BH1	6	11.00	0.62	0.00	10.25	89.75
BH2	11	9.61	0.64	2.28	2.62	95.10
BH3	13	8.89	0.65	0.07	1.44	98.49
BH4	20	14.80	0.58	1.49	18.65	79.86
BH5	21	10.60	0.62	0.43	8.41	91.16
BH6	26	22.85	0.53	5.60	25.62	68.78
BH7	27	11.37	0.62	0.21	11.25	88.54
BH8	31	10.55	0.62	0.00	8.67	91.33
BH9	38	11.45	0.61	3.64	8.10	88.26
BH10	41	9.25	0.64	1.63	1.63	96.74
BH11	48	19.50	0.55	2.36	25.19	72.45
BH12	51	65.58	0.32	8.99	34.51	56.50
BH13	53	12.93	0.60	0.00	15.92	84.08

experience a sudden loss of strength. This loss of strength occurs as rainfall infiltration reduces soil suction and increases pore-water pressure, thereby reducing the soil's shear strength capacity. The soil's high clay and silt content significantly affects its behavior. While silt retains a large amount of water, clay tends to be very dense. Clay also has slow permeability, resulting in a substantial water-holding capacity. This capacity can lead to prolonged periods of high moisture content, influencing the soil's shrink-swell behavior and suitability for construction.

The soil also exhibits a varying Coefficient of Uniformity (Cu) value, ranging from 8.89 to 65.58. The Cu measures the range of particle sizes in a soil sample. A high Cu indicates well-graded soil with a wide range of particle sizes. At the same time, a low value suggests that the soil is poorly-graded with a narrow range of particle sizes. The Coefficient of Concavity (Cc) of the soil ranges from 0.32 to 0.65. This coefficient measures the curvature of the particle size distribution curve. It provides insights into the grading characteristics of the soil. Daleon (2022) classified the soil in the study area as gap-graded. Gap-graded soils have an excess or deficiency of specific particle sizes or may lack at least one particle size. This grading characteristic can influence the soil's compaction characteristics, permeability, and shear strength.

Table 7 presents the soil classification in the study area. The study identified three distinct types of soil in the area. The first type is MH, or elastic silt, a soil of high plasticity. Elastic silt is characterized by its ability to undergo significant deformation without cracking or breaking. This characteristic can influence the soil's response to loading and suitability for construction. High plasticity indicates that the soil can undergo significant changes in volume with changes in moisture, leading to ground movement and potential damage to structures.

The second type of soil identified in the study area is CH, or fat clay, with very high plasticity. Fat clay is known for its high water-holding capacity and ability to undergo significant volume changes with changes in moisture content. These characteristics can lead to considerable ground movement, posing challenges for construction and requiring careful engineering considerations.

The third type of soil is ML, or silt, a soil of medium plasticity. Silt is characterized by its fine particles and its ability to retain water. Medium plasticity indicates that the soil can undergo moderate volume changes with changes in moisture content. While less reactive than high plasticity soils, medium plasticity soils can still pose challenges for construction, particularly in areas with significant changes in moisture content.

Table 8 presents the results of direct shear tests conducted on soil samples from four boreholes within the study area. The test determines the soil's shear strength parameters, specifically the cohesion and friction angle. These parameters are crucial for understanding the soil's behavior under shear stress and its suitability for construction. Financial constraints limited the direct shear tests to only four (4) boreholes. Despite this limitation, the tests provided valuable insights into the shear strength characteristics of the different soil types in the study area.

The CH soil type exhibited the highest cohesion value of 19.8 kN/m2. Cohesion measures the soil's ability to stick together and resist shear stress. A high cohesion value indicates a high resistance to shear stress, which can benefit supporting structures. However, the CH soil type had the lowest friction angle value of 10.8º. The friction angle measures the soil's internal resistance to sliding along a failure plane. A low friction angle suggests a lower resistance to sliding, which can influence the soil's stability under load. The ML soil type had an average cohesion value of 19.6 kN/m2 and an average friction angle value of 11.85º. These values suggest a moderate resistance to shear stress and sliding, indicating a balance between cohesion and frictional resistance.

On the other hand, the MH soil type had the lowest cohesion value of 11.4 kN/m2 but the highest friction angle value of 16.9º. Blahova et al. (2013) noted that cohesion usually does not increase with increasing stress, except for clayey soils. In these soils, an increase in stress can lead to an increase in molecular bonds, enhancing the soil's cohesion.

Daleon & Lorenzo (2018) previously established a correlation between several vital parameters: soil thickness with slope angle, cohesion with slope angle, and friction angle with slope angle. These correlations provide a robust framework for generating the necessary soil stability parameters for calculating the FS, a critical measure of slope stability. This study adapted these correlations to analyze the soils within the study area.

Table 7. Soil Classification.

Sampling Code	Slope (°)	Soil Classification		Description	Soil Type (Budhu, 2000)	Degree of Plasticity (Venkatramaiah, 2006)
		USCS	AASHTO			
BH1	6	MH	A-7-5	Dark brown silts with few sands	Clay	High plasticity
BH2	11	CH	A-7-6	Dark brown clays with traces of sands & gravels	Clay	Very high plasticity
BH3	13	CH	A-7-6	Dark brown clays with traces of sands	Clay	Very high plasticity
BH4	20	CH	A-7-6	Dark brown clays with little sands & traces of gravels	Clay	Very high plasticity
BH5	21	MH	A-7-5	Dark yellowish brown silts with few sands	Clay	Medium plasticity
BH6	26	CH	A-7-6	Dark brown clays with little sands & traces of gravels	Clay	Very high plasticity
BH7	27	ML	A-7-5	Dark yellowish brown sandy silts	Clay	Medium plasticity
BH8	31	CH	A-7-6	Strong brown clays with few sands	Clay	High plasticity
BH9	38	CH	A-7-6	Dark brown clays with few sands and traces of gravels	Clay	Very high plasticity
BH10	41	CH	A-7-6	Dark yellowish brown clays with traces of sands and gravels	Clay	Very high plasticity
BH11	48	ML	A-7-5	Dark brown sandy silts with traces of gravels	Clay	Medium plasticity
BH12	51	ML	A-7-5	Very dark brown sandy silts with few gravels	Clay	Medium plasticity
BH13	53	CH	A-7-6	Very dark clays with little sands	Clay	High plasticity

Table 8. Cohesion and Friction Angle.

Sampling Code	Actual Slope (°)	Soil Classification (USCS)	Cohesion (kN/m2)	Friction Angle (°)
BH1	6	MH	11.4	16.9
BH3	13	CH	19.8	10.8
BH7	27	ML	16.1	15.7
BH12	51	ML	23.1	8.0

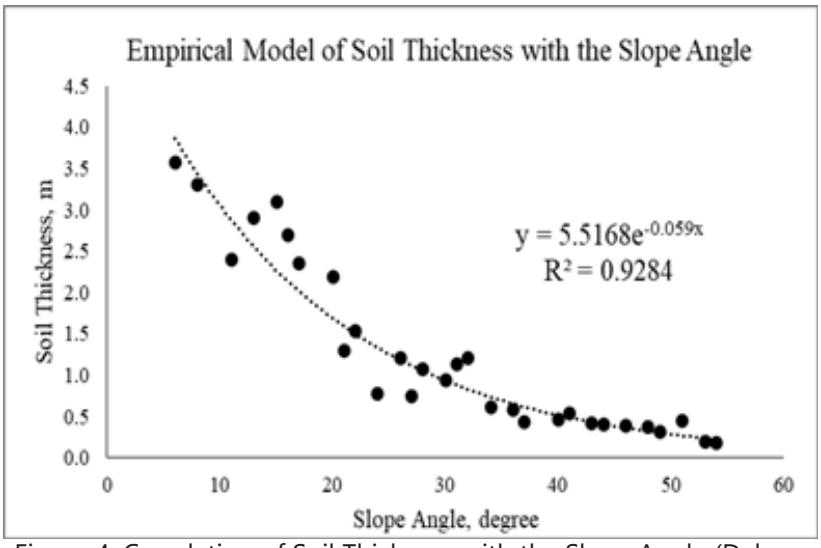

Figure 4. Correlation of Soil Thickness with the Slope Angle (Daleon & Lorenzo, 2018).

Table 9. Predicted Soil Thickness

SLOPE	ACTUAL SOIL THICKNESS	PREDICTED SOIL THICKNESS
6	2.93	3.85
11	1.77	2.83
13	2.27	2.50
20	1.02	1.59
21	0.68	1.49
26	0.44	1.07
27	0.54	1.00
31	0.82	0.76
38	0.37	0.46
41	0.41	0.37
48	0.70	0.22
51	0.46	0.17
53	0.40	0.15

Figure 4 illustrates the relationship between soil thickness and slope angle within the study area. This relationship is described by an exponential correlation, suggesting that soil thickness decreases exponentially with increasing slope angle. This trend is consistent with geomorphological principles, as steeper slopes often have thinner soil layers due to increased erosion and less accumulation of soil particles. The exponential correlation yielded a high coefficient of determination, R2 = 0.9284. A high R-squared value, close to 1, suggests that the regression line closely fits the data. The high R-squared value indicates that the exponential correlation is a good model for predicting values of the soil thickness needed in slope stability analysis. Soil thickness is a critical parameter in slope stability, influencing the weight of the soil and the potential driving forces for slope failure.

Table 9 presents the predicted soil thickness values for the study area. These values were calculated using the equation derived from the correlations established

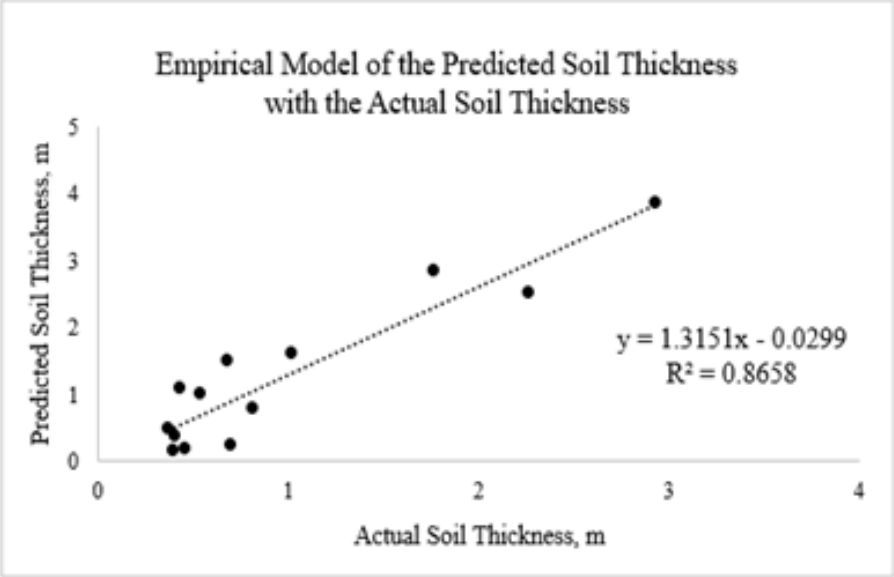

Figure 5. Correlation of Predicted Soil Thickness with the Actual Soil Thickness.

by Daleon & Lorenzo (2018). This equation allowed for a systematic and consistent estimation of soil thickness across the study area.

The validity of the predicted soil thickness was confirmed through exponential correlation, as illustrated in Figure 5. This method was chosen due to its ability to model the relationship between the predicted soil and the actual soil thickness. The exponential correlation yielded a high coefficient of determination with a value of R2 = 0.8658, thereby affirming the accuracy of the soil thickness predictions.

Slope Stability Assessment

The result of the slope stability assessment is presented in two sections. These two conditions represent a spectrum of possible scenarios, from less severe to a worst-case scenario, and provide a comprehensive understanding of the slope's response under various circumstances. This assessment uses specific parameters, which include the friction angles (Φ) and the factor of safety (FS), to understand the degree of slope stability in different circumstances. The first section discusses the FS distribution under semi-saturated conditions, where m1 = 0.25 and m2 = 0.5. The second section focuses on the fully saturated condition, with Φ of 2.6, 4.4, 6.4, 8.7, and 0.

In the semi-saturated condition, the computed FS values for m1 = 0.25 and m2 = 0.50 are all greater than two, indicating a very high level of slope stability. Figures 6 and 7 show the robustness of the slope under these conditions. Under fully saturated conditions, the FS values vary depending on the friction angle. For friction angles of 2.60, 4.40, and 6.40, the FS values range from 1.5-2 to greater than 2, indicating a high to very high slope stability, as shown in Figures 8, 9, and 10. A friction angle of 8.70 yields very high slope stability, with FS values exceeding 2, as depicted in Figure 11. Even in a potentially catastrophic scenario where the Φ is equal to zero, the FS values range from 1.5-2 to greater than 2, suggesting a high to very high slope stability, as shown in Figure 12.

Despite the generally favorable results, it is essential to remember that slope stability is not guaranteed under all circumstances. For instance, in 2014, continuous rainfall from June 1 to 10 led to numerous landslide incidents in the Municipality of Kibawe, Bukidnon. Although no casualties were reported in Barangay Kiorao, the incidents are a stark reminder of the potential dangers of unstable slopes. Several research studies emphasize the conditional stability of slopes, even those with FS greater than 1 (Mugagga et al., 2012). Both internal and external factors can influence the stability of the soil. In particular, highly plastic inorganic soils can become prone to sliding during rainfall due to reduced shear resistance (Dai et al., 2002). External variables such as high rainfall, deforestation, farming, and excavation can lead to slope instability even in previously considered stable areas (Mugagga et al., 2012).

Thus, while the current assessment provides strong indicators of slope stability, it is crucial to remember that this is not a guarantee. Given the many factors influencing slope stability, it remains a complex and nuanced issue requiring continual monitoring and assessment.

Geohazard Mapping

HazardHunterPH, a leading authority in seismic hazard assessment, has thoroughly investigated and pinpointed Kiorao Elementary School as a critical facility in Kibawe, Bukidnon. The school's location, approximately 18.4km from the South Bukidnon Fault, ensures its safety from the threat of ground rupture, a common occurrence during seismic activities along fault lines. In addition to its safety from ground ruptures, the school's geographical position also safeguards it from the risks of liquefaction and tsunamis. Liquefaction, a process where saturated soil temporarily loses strength and behaves as a fluid during intense ground shaking, is not a concern for the school due to its geographical position. Similarly,

the threat of tsunamis, often triggered by undersea earthquakes, is also negligible. However, despite these safety assurances, the school is only partially immune to the effects of seismic activity. It remains vulnerable to ground shaking, a common earthquake phenomenon that can cause significant structural damage. Updates on the vulnerability to earthquake-induced landslides are still unavailable. However, it is known to be highly susceptible to rain-induced landslides. This susceptibility is apparent by numerous old or inactive landslides in the vicinity, indicating the area's instability during periods of heavy rainfall.

Geohazards, such as those mentioned above, play a pivotal role in land development. Ignoring these hazards during the early planning stages can result in severe consequences, including structural damage, financial losses, and even loss of life. Therefore, it is crucial to incorporate geohazard considerations into the planning process from the outset. The geohazard map is a valuable tool in this regard. It provides detailed information about slope gradients vulnerable to instability based on their safety factor. This data allows planners to avoid constructing on slopes likely to fail under certain conditions. The map also indicates the potential for soil collapse, another critical consideration in land development.

Furthermore, the geohazard map pinpoints the locations of active and potentially active faults. This information is crucial for avoiding construction near these hazardous areas. Figure 13 visually represents these geohazards, making it easier for planners and developers to understand the risks involved.

A geohazard map is an indispensable tool for evaluating potential risks and creating a comprehensive picture of a community's vulnerability to geological hazards. It can be utilized for preliminary assessments and reviews of land development projects during the early planning stages. Using this tool effectively, planners and developers can mitigate risks, ensure safety, and promote sustainable development.

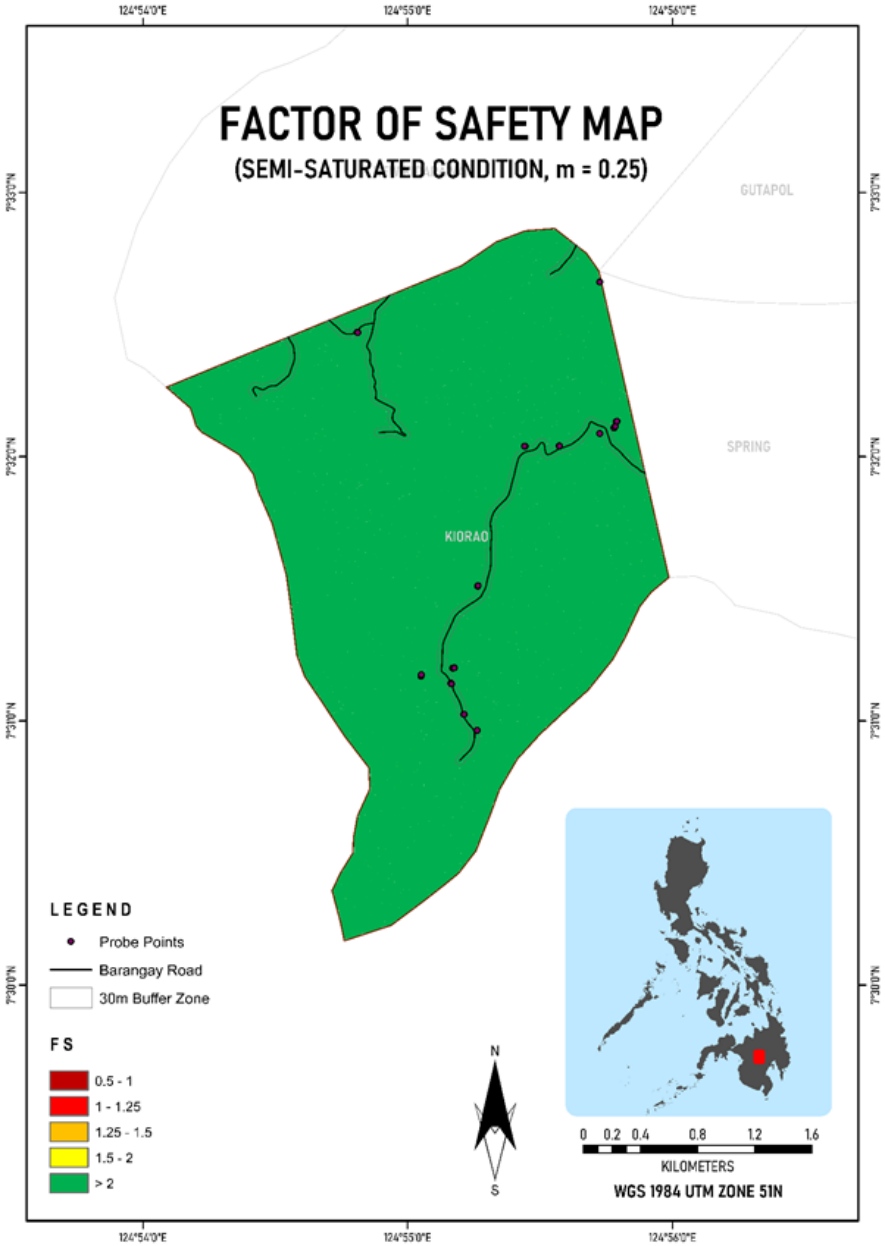

Figure 6. The Factor of Safety Map (Semi-saturated Condition, m = 0.25).

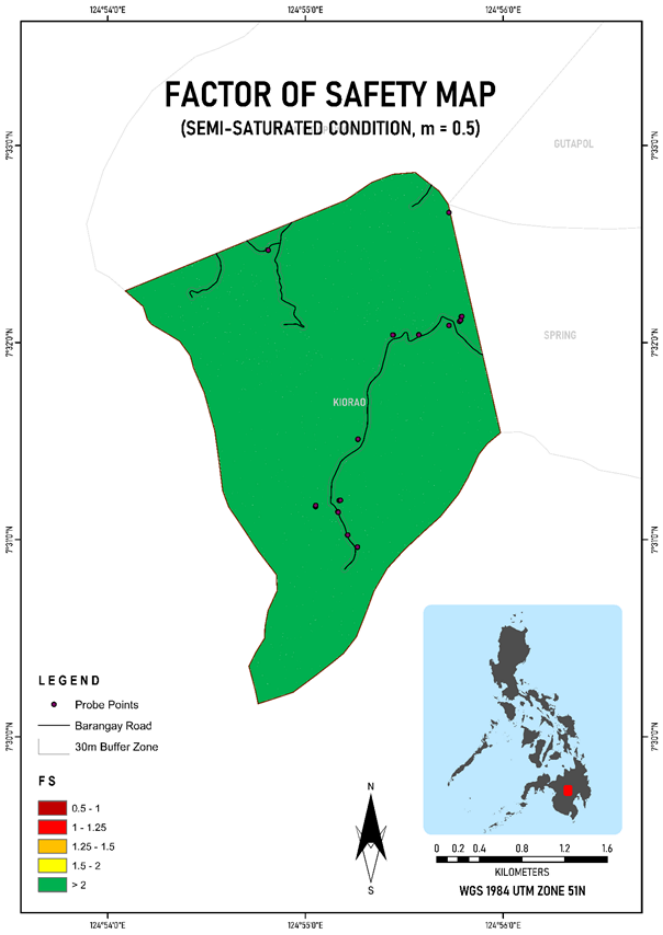

Figure 7. The Factor of Safety Map (Semi-saturated Condition, m = 0.50).

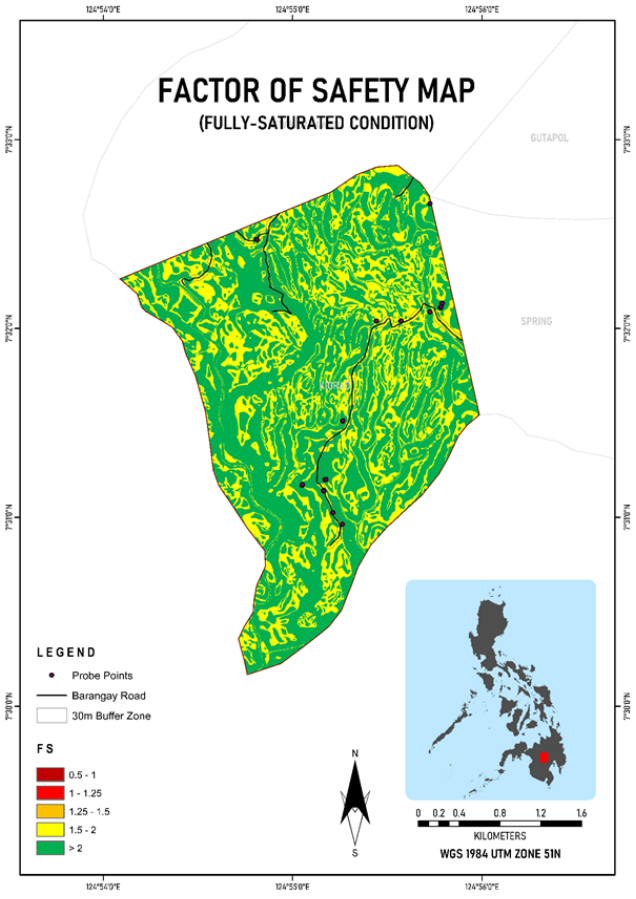

Figure 8. The Factor of Safety Map (Fully-saturated Condition, friction angle = 2.60).

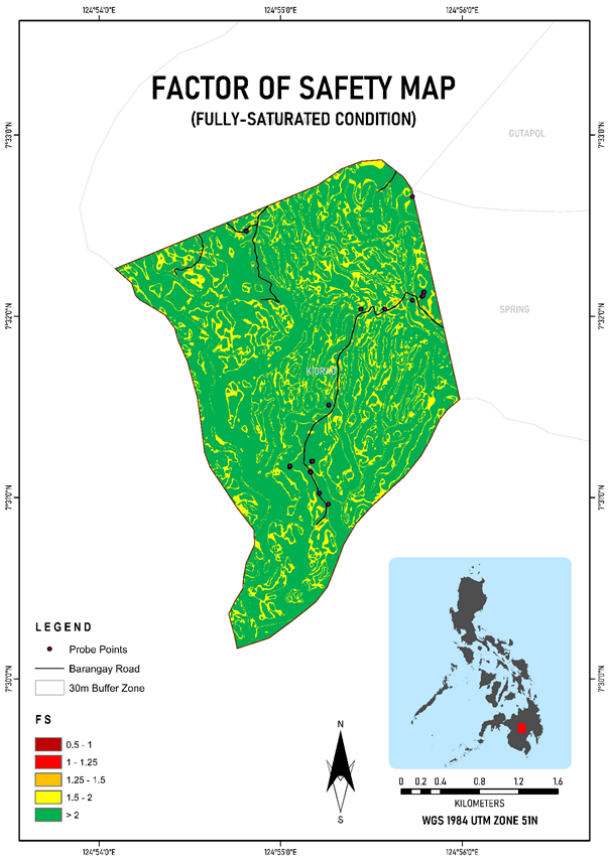

Figure 9. The Factor of Safety Map (Fully-saturated Condition, friction angle = 4.40).

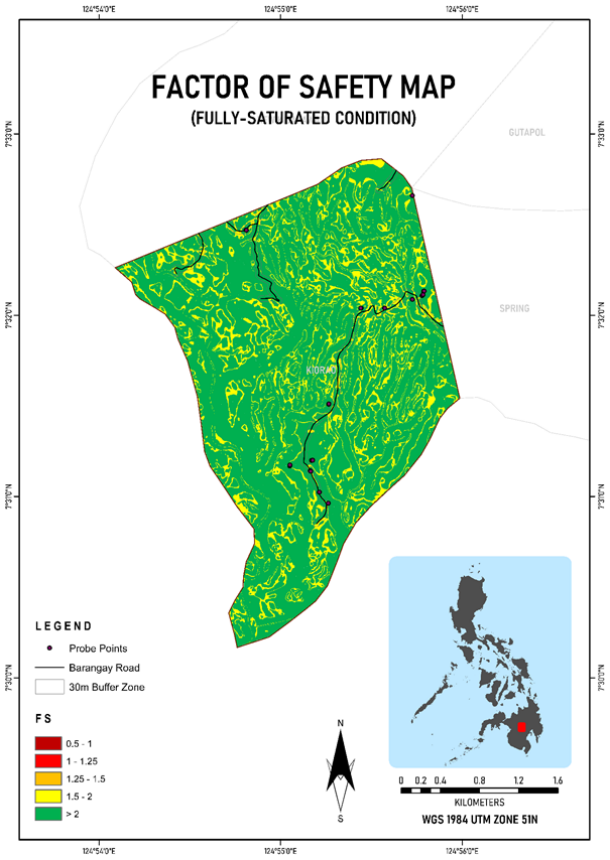

Figure 10. The Factor of Safety Map (Fully-saturated Condition, friction angle = 6.40).

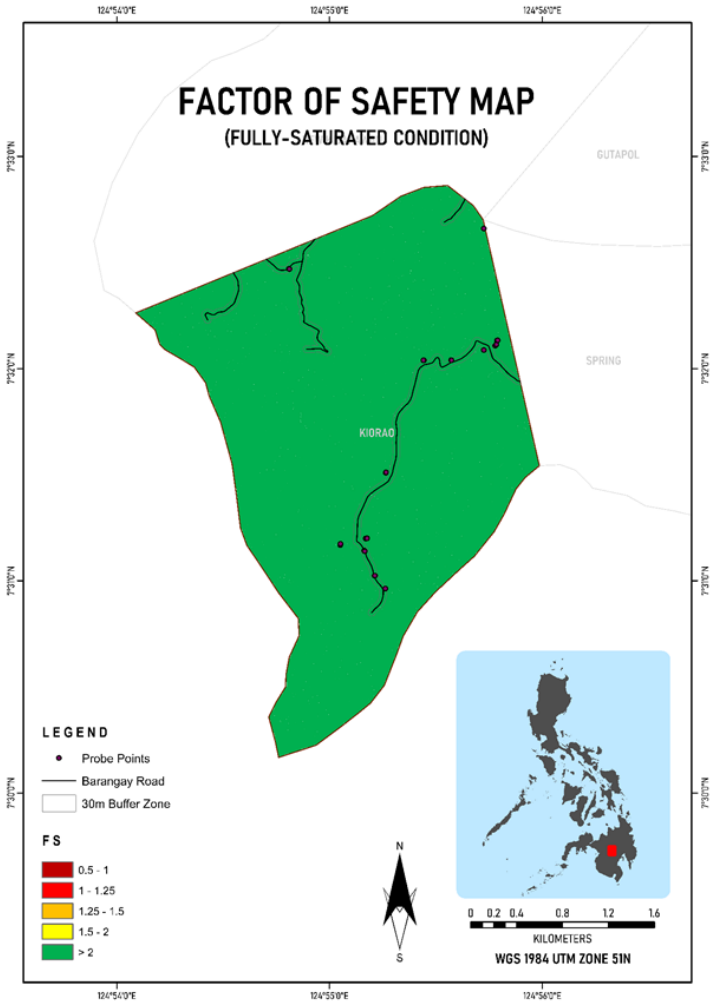

Figure 11. The Factor of Safety Map (Fully-saturated Condition, friction angle = 8.70).

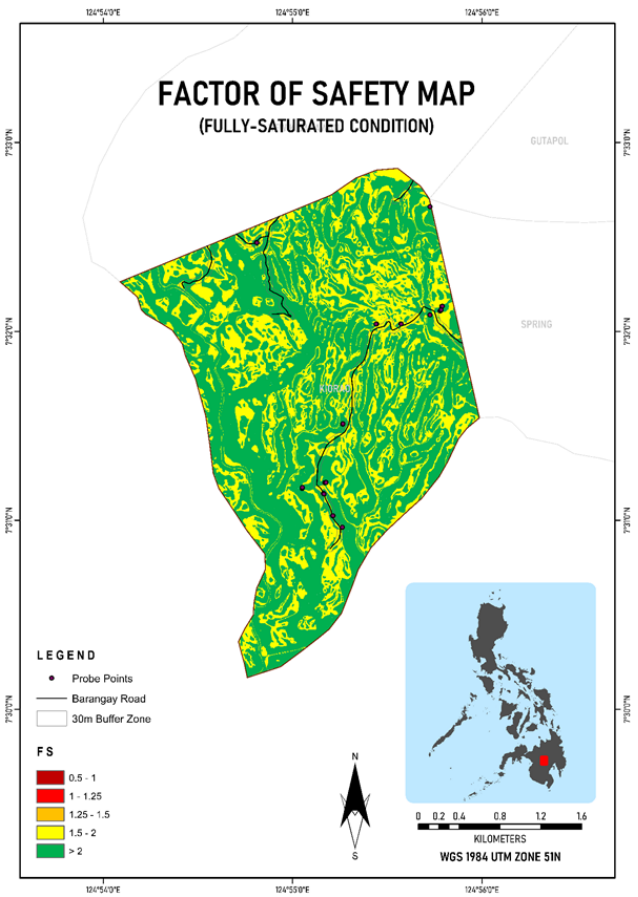

Figure 12. The Factor of Safety Map (Fully-saturated Condition, friction angle = 0).

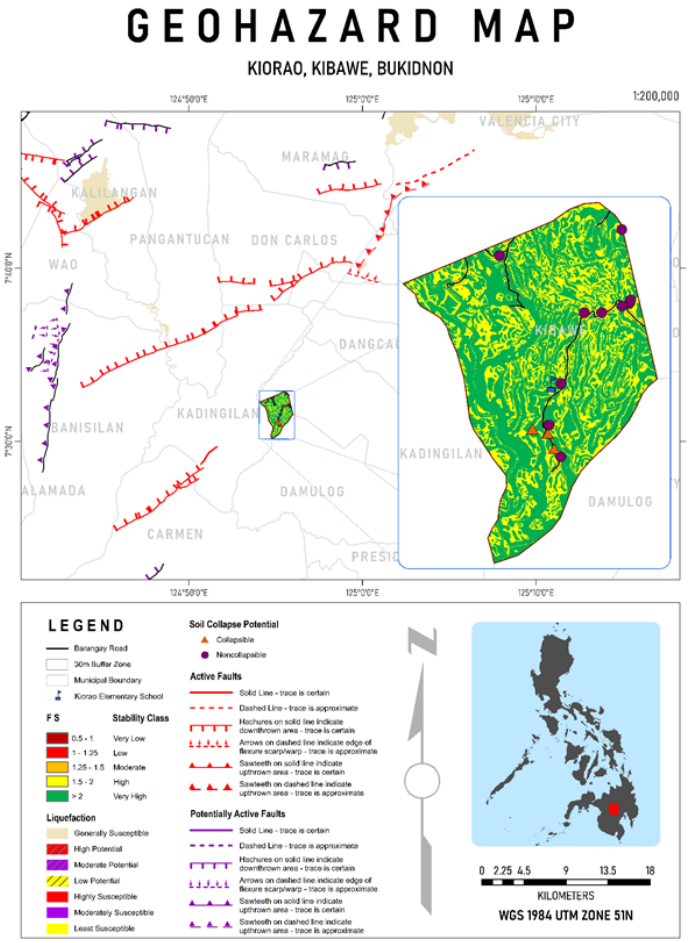

Figure 13. Geohazard Map of Barangay Kiorao, Kibawe, Bukidnon.

CONCLUSION

The study successfully assessed the geohazards of Barangay Kiorao, Kibawe, Bukidnon, providing valuable insights for land development planning and risk management. The study revealed that the FS values for the semi-saturated conditions with m1 = 0.25 and m2 = 0.50 are all greater than two, indicating very high slope stability. For the fully saturated conditions, the FS values with friction angles equal to 0, 2.60, 4.40, and 6.40 range from 1.5-2 to greater than 2, suggesting high slope stability. The FS values for the fully saturated condition with a friction angle equal to 8.70 are greater than 2.0, indicating very high slope stability.

The soil in the study area is identified as soft clay, which is highly expansive and has the propensity to swell. This could have significant implications for land development in the area. Furthermore, three locations in the study area are classified as collapsible. These areas could be at risk of sudden and dramatic settlement, which could pose a risk to any structures built on them. Land development in the area should consider the expansive and collapsible nature of the soil.

The seismic hazard assessment identified Kiorao Elementary School as one of the nearest critical facilities in Kibawe, Bukidnon. The school is safe from ground rupture, but it could still be vulnerable to ground shaking. The school should be equipped with earthquake-resistant features and earthquake drills should be conducted regularly.

Finally, the study generated a geohazard map showing information regarding the slope gradients vulnerable to instability based on their FS and the location of active and potentially active faults. This map is a valuable tool for land development planning and risk management. It identified areas at high risk of geohazards and guided decisions about where to build and avoid.

ACKNOWLEDGMENT

The author would like to acknowledge Central Mindanao University for funding this research and the local government unit of the Municipality of Kibawe, Bukidnon, headed by Hon. Reynaldo S. Ang Rabanes; the mayor, and to and to Hon. Raymundo A. Batao Jr., the vice mayor of Kibawe, Bukidnon, for their commitment and confidence in the researchers.

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Central Mindanao University
Journal of Science
ISSN Print: 0116-7847 ISSN Online: 2704-3703

Remote Sensing Technology Application for Tree Plantation Characterization and Sustainable Operation

Olpenda, A. S.[a], Paquit, J. C.[b], Tulod, A. M.[b], Polinar, K. D.[b] and R. G. Aguinsatan[a]

[a]Forest Resources Management Department
[b]Forest Biological Sciences Department
College of Forestry and Environmental Science
Central Mindanao University, Musuan, Bukidnon, Philippines 8710

ABSTRACT

In order to increase the supply of timber especially from industrial tree plantations (ITPs) and at the same time reducing the pressure on the remaining natural forests, proper planning and management must be strengthened. A plantation manager can efficiently do this if equipped with the right information using the latest but cost-efficient technology. This study was conducted to show the usefulness of remote sensing datasets in approximating the spatial distribution of the relative amount of wood materials in a *Gmelina arborea* Roxb. plantation and in identifying site parameters significant to the growth and development of the plantation. Between October 2019 and March 2020, field inventory was conducted within the *G. arborea* plantation of CMU in Bukidnon. A total of 38 randomly generated circular plots of 15-m radius were established. All tree and stand parameters inside the plots were subjected to correlation with 13 vegetation indices and 7 bands derived from Sentinel-2 (S2) multispectral image. Findings revealed that all but one of the indices were statistically correlated with the mean height, stem volume and basal area (BA) with their respective highest R values of 0.59, 0.65 and 0.66 ($p<0.01$). The Leaf Chlorophyll Index (LCI), after subjecting to curve estimation modeling, was able to explain the variation of the field data at 43% and 41% for stem volume and BA, respectively with standard errors of estimate of 0.40 and 0.34. It is suggested that more samples should be added in the analysis and use a non-parametric regression technique which may improve the model.

Keywords: *Gmelina arborea*, tree plantation, Sentinel-2, vegetation index, Bukidnon

INTRODUCTION

Tree farming is an alternative livelihood for many farmers in Mindanao and has been a significant option to meet the increasing demand for wood in the region while reducing the pressure on the remaining natural forests. However, proper planning and management must be strengthened to increase the supply of wood especially from industrial tree plantations (ITPs). A plantation manager can effectively do this if equipped with the right information using the latest but cost-efficient technology. These information includes, among others, canopy height, estimated volume, stand density or basal area that may represent harvestable woody materials. These tree parameters can be obtained from the field using the traditional inventory technique. As reliable as it may be, such technique is expensive and laborious.

The ITP of Central Mindanao University (CMU) in Bukidnon, composed chiefly of fast-growing exotic trees, has an area of 575.16 hectares (CMU CLUP, 2016) wherein the largest area is occupied by *Gmelina arborea* (about 371.15 ha or 64.5% of the total tree plantation area). This prime ITP species has been gaining popularity not only because it is used for posts, house timber or as a material for veneer and plywood, but also as a substitute for banned forest wood, particularly for use in the furniture industry (DOST-PCAARRD, 2018). The tree plantation is one the University's income-generating projects that addresses lumber demands of CMU itself, its constituents, and even nearby towns for building and house construction. In spite of its critical role, a map of the plantation with reference to the latest inventory is lacking. A visual presentation of the ITP with blocking grids based on certain stand parameters would be ideal for a more organized and systematic logging operation.

The technology of remote sensing (RS) is a powerful tool in assessing vegetation properties at different scales and objectives. This paper utilized specifically passive RS which relies on natural energy (normally from the sun) that is reflected or emitted by the Earth's surface. This technique had been used by a number of authors using optical sensors onboard satellites for forest biomass estimation (Nguyen et al, 2020), refo- and deforestation analysis (Perez et al, 2020), predicting forest structures (Gebreslasie et al, 2020) and forest fire assessment (Olpenda, 2019). Dos Reis et al (2018) were able to generate correlation values of -0.91 for basal area and -0.52 for tree volume of Eucalyptus trees using band ratios of Landsat TM with 30m spatial resolution. Benguet et al (2012) on the other hand produced better results in estimating forest structures (R2 up to 0.97) by using a very high resolution satellite images. Meanwhile, Günlü and Kadıoğulları (2018) were able to directly compare the performance of low

Corresponding author:
Olpenda, A. S.
Email Address: alecsolpenda@cmu.edu.ph
Received: Jan. 19, 2022 ; Accepted: Oct. 23, 2023

and high resolution images to predict the basal area of pine forest using vegetation indices. From their research, vegetation indices derived from Landsat and Quickbird datasets produced R2 values of 0.36 and 0.54, respectively for stand volume prediction. Meanwhile, Brown et al (2022) combined lidar, an active type of remote sensing that uses laser technology, and Sentinel-2 in estimating forest metrics of mixed stands. The results of their study suggest that the addition of multispectral imagery is not significantly useful in improving the estimates of BA and volume. Based on these literatures and similar studies, the accuracy of the model depends on the types of sensors used, spatial resolutions of the dataset as well as the conditions of the forest (e.g. age, heterogeneity, stand density).

Although there are already a number of studies conducted in CMU's tree plantation and natural forest areas (e.g., Olpenda and Tulod, 2019; Rojo and Paquit, 2018; Tulod et al, 2017), the application of RS technology is very scarce. Maps generated from satellite images, coupled with field data, are advantageous for inaccessible sites and require less resources in the long run. The primary purpose of this study therefore is to explore the usefulness of RS data in approximating the spatial distribution of the relative amount of wood materials in a tree plantation. The results are expected to have sustainable management implications especially in the use of RS technology as a tool to track the development of tree plantations in the area for adaptive management.

METHODOLOGY

Study Area

The area of the study is the plantation of *G. arborea* (local name: yemane) of CMU, located mostly at the northwestern side of its titled land along Sayre Highway, Maramag, Bukidnon. CMU lies between 125°03'03" E longitude and 7°51'34'' N latitude and is situated 4.5 kilometers south of the city of Valencia. Based on the University's Comprehensive Land Use Plan (2016), the total area of the said plantation is 371.15 ha with an elevation ranging from 305 to 669 meters above sea level. Natural forest of secondary growth and agricultural land uses mostly surround the plantation forests. Other ITP species in the area include *Swietenia macrophylla*, *Acacia mangium* and *Tectona grandis*. On the other hand, majority of CMU's land area has a slope of less than 10% and for the G. arborea plantation alone, about 80% of its area has a slope of 8 to13%. In terms of climate, the area falls under Type III based on the Modified Corona classification of PAGASA. Type III climate is characterized as having a seasonal variability that is not very well pronounced, with dry season from November to April and wet during the remaining months of the year.

Sampling Plots

Sampling plots for this study were randomly

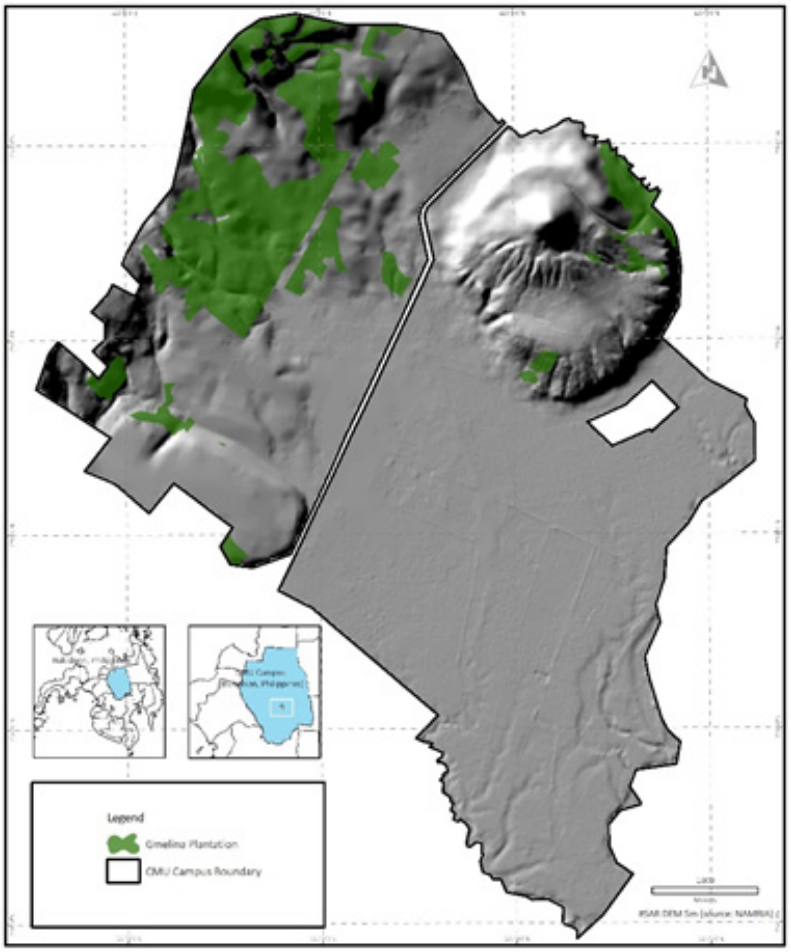

Figure 1. Location of the study area with hillshaded depiction of the terrain as basemap

generated using GIS. A total of 38 circular plots with 15 m radius and equivalent area of 0.07 ha. were established. The exact coordinates of these plots were taken from the field using survey-grade GPS equipment (up to 20cm accuracy) at the center of each individual plot. All field measurements were conducted between October 2019 and March 2020.

Field Inventory

The following tree and stand parameters were recorded during the fieldwork: diameter at breast (DBH) using tree calipers, merchantable height (MH, from stump to the first live branch) and the total height (TH, from stump to the apical tip of the tree) using a digital hypsometer or Haga altimeter. Only trees with a DBH of 10 cm or greater were included in the inventory. From the collected data, other plot-level parameters were calculated (equations 1 – 3). Basal area (BA) was later converted to the standard unit of density (m2/hectare). BA is important in this study because it's a good indicator of the presence of trees quantitatively. Stem volume on the other hand was calculated in two ways: (1) those with only pure main stem by using the MH as the multiplier (to be called SVMH) and (2) main stem plus the crown length by using the TH where branches and leaves are present (to be called SVTH). Crown length (CL) was also included in the analysis since it signifies the condition of the crown relative to the amount of branches and leaves. Additionally, the canopy cover for each plot, defined as the percentage area above ground covered by the leaves, branches and trunks of all trees, was taken from the averaged visual estimates of three persons conducting the fieldwork.

$$Basal\ area\ (BA) = 3.1416\left(\frac{DBH}{2}\right)^2 \quad \text{Eq. (1)}$$

$$Stem\ volume\ (SV) = 3.1416\ (DBH)(MH\ or\ TH) \quad \text{Eq. (2)}$$

$$Crown\ lenght\ (CL) = TH - MH \quad \text{Eq. (3)}$$

Remote Sensing (RS) Data

Sentinel-2 (S2) from the Multi Spectral Instrument (MSI) of the European Space Agency (ESA) was used for the analysis. The full S2 mission comprises twin polar-orbiting satellites in the same orbit (Sentinel-2A and Sentinel-2B), phased at 180° to each other. The mission monitors variability in land surface conditions, and its wide swath width and high revisit time (10 days at the equator with one satellite, and 5 days with 2 satellites under cloud-free conditions which results in 2-3 days at mid-latitudes) will support monitoring of changes to vegetation within the growing season (ESA, 2015). The sensor has 13 spectral bands ranging from 443 to 2,190 nm with spatial resolutions of 10 m (3 visible and 1 near-infrared (NIR) bands), 20 m (4 red edge and 2 shortwave infrared (SWIR) bands) and 60 m (3 atmospheric correction bands) (figure 2). Red edge bands are known to be sensitive to the health and condition of any vegetation in general (Curran et al., 1990; Gitelson et al., 1996; Richardson et al., 2002).

The original 100 km2 tile of S2 imagery utilized in this study was downloaded from the Copernicus Sentinel Scientific Data Hub website (https://scihub.copernicus.eu/) and has an acquisition date of 23 December 2019. It was then sub-sampled to cover only the cloud-free area of interest for the study site (figure 3). The dataset was in L2A level format, which is already an orthorectified Bottom-of-Atmosphere (BoA) corrected reflectance product.

Generation of Vegetation Indices

Various spectral vegetation indices (VIs) were computed from the bands of the S2 image using the raster calculator in Quantum GIS software (ver. 3.16.9). These indices, generated through mathematical equations and transformations (table 1), are computationally simple and easy to implement while capturing a wide range of vegetation biophysical variables (Xie et al., 2015). A total of 9 vegetation indices were gathered from different literature excluding 4 from this study. A number of literatures had been using multiple indices (around 5 to 11) to determine

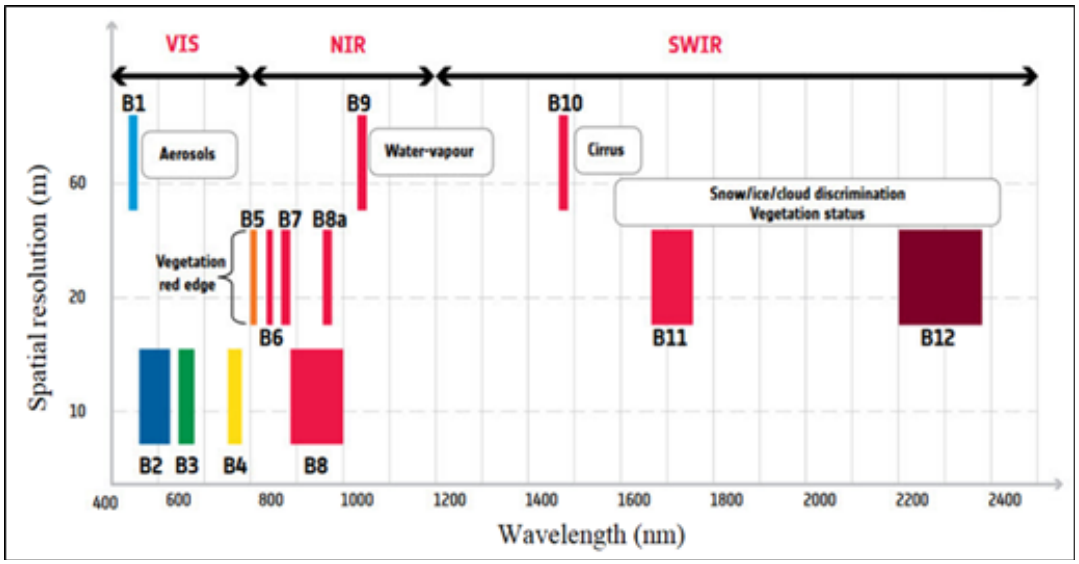

Figure 2. Sentinel-2's 13 spectral bands with corresponding bandwidth as illustrated per wavelength versus spatial resolution (Image source: https://esamultimedia.esa.int/docs/EarthObservation/Sentinel-2_ESA_Bulletin161.pdf)

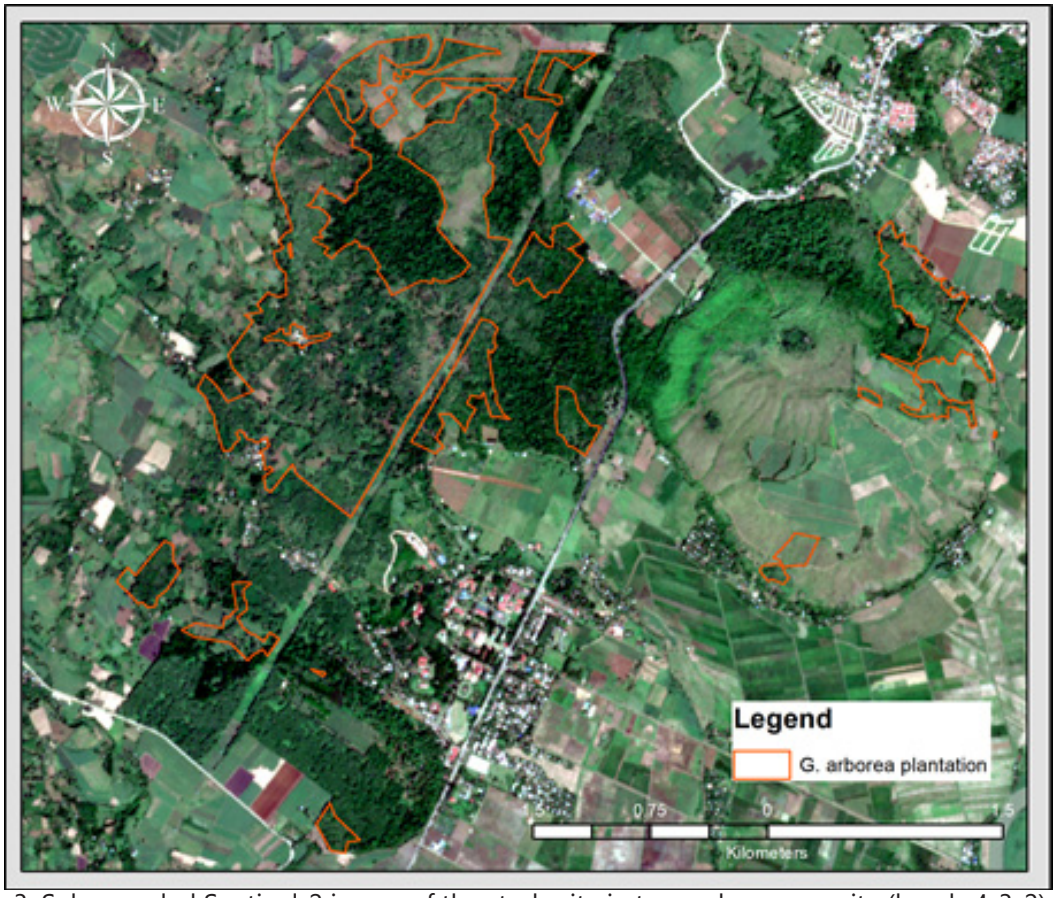

Figure 3. Sub-sampled Sentinel-2 image of the study site in true color composite (bands 4-3-2) dated December 23, 2019 to coincide with the time of the field survey

Table 1. Vegetation indices used in this study

Vegetation Index	Formula	Reference
Modified ratio vegetation index (MRVI)	(NIR/red-1)/√(NIR/red+1)	Chen and Cihlar, 1996
Enhanced vegetation index (EVI)	2.56((NIR-red)/(NIR+6(red)-7.5(blue)+1))	Liu and Huete, 1995
Normalized difference vegetation index (NDVI)	(NIR-red)/(NIR+red)	Rouse et al., 1973
Green NDVI (GNDVI)	(NIR-green)/(NIR+green)	Gitelson and Merzlyak, 1998
Soil adjusted vegetation index (SAVI)	((NIR-red)/(NIR-red+0.5))×1.5	Huete, 1988
Leaf chlorophyll index (LCI)	(NIR-VRE band 5)/(NIR+red)	Datt, 1999
Atmospherically resistant vegetation index (ARVI)	((NIR-red)-(NIR-blue))/((NIR+red)-(red-blue))	Thenkabail et al., 2002
Moisture adjusted vegetation index (MAVI)	(NIR-red)/(NIR+red+SWIR band 12)	Zhu et al, 2014
Inverted Red-edge Chlorophyll Index (IRCI)	(VRE band 7-red)/((VRE band 5)/(VRE band 6))	Frampton et al., 2013
$NDVI_{RE1}$	(VRE band 5-red)/(VRE band 5+red)	This study
$NDVI_{RE2}$	(VRE band 6-red)/(VRE band 6+red)	This study
$NDVI_{RE3}$	(VRE band 7-red)/(VRE band 7+red)	This study
$NDVI_{RE4}$	(VRE band 8a-red)/(VRE band 8a+red)	This study

Note: NIR = near infrared; VRE = vegetation red edge; SWIR = shortwave infrared

which is the best predictor of vegetation characteristics (e.g. Ali et al, 2020; Raper and Varco, 2015; Marcelli et al, 2020; Xie et al, 2015).

Data Processing and Statistical Analysis

Before any test was conducted, outliers were checked and omitted first. Plot-level correlation test, specifically Spearman's method, was performed between the various stand parameters and generated VIs to validate any relationships. Additionally, reflectance from bands 3 (green), 4 (red), 8 (NIR) and all the bands of vegetation red edge of S2 were also included in the correlation test. These bands and VIs are called S2 variables from here thereafter. In order to get the most practical values of S2 variables that best correspond to the field data, the same plot area was used for extracting their mean values. This was done by creating a circular buffer of 15 m for each geographic coordinate of all plots before overlaying them with the different S2 variables. Due to multicollinearity, the single variable with the highest correlation was further subjected to different curve estimation regression modeling with the total stem volume and BA. The model with the highest R^2 and the smallest standard error of estimate was chosen to estimate the spatial distribution of woody materials from trees.

RESULTS AND DISCUSSION

Stand Structure

The G. arborea plantation in the study has an average number of 309 ± 114.44 trees per hectare or a total number of 11,742 trees across the 38 plots sampled (Table 2). The trees were generally harvestable in size having mean DBH per plot of 0.30 ± 0.05 m and total height (TH) per plot of 15.71 ± 2.09 m. However, the average length of the usable wood portion of the trees (referred to as merchantable height, MH) was only about 60% of the TH which is equivalent to an average MH of 9.73 ± 2.64 m. The rest of the 40% was taken up by the crown cover, which had an average crown length (CL) of almost 6 m. Mean stem volume (SV) based on MH and TH respectively were estimated at 17.89 ± 9.64 m3 and 28.97 ± 2.29 m3, while the mean basal area (BA) per plot was 24.81 ± 10.19 m2/ha. The merchantable portions of trees in the area or potential yield can still be improved by 20% to 30% through regular pruning and thinning especially when the trees are still in the sapling stage. Tree plantations in the region and in the country more generally are poorly maintained resulting in a poor wood production rate of only about 632,574 m3 or 0.006 m3 per capita (FMB-DENR, 2019), which is more than 80 times lower than the world's average production rate of 0.5 m3 per capita (Bruinsma, 2002).

Vegetation Indices and Bands versus Field Data

After omitting the outliers, only 34 samples were left and subjected to statistical analysis. The result of the correlation test conducted between the S2 variables and stand parameters is summarized in Table 3. Only those with significant relationships were included in the table. Generally, all of the indices and bands involved are statistically correlated with the mean tree height, stem volume and BA of G. arborea. But the most sensitive index in terms of characterization is the LCI with coefficient of correlation ranging from moderate to slightly strong relationship ($R=0.44$ to 0.66, $p<.01$) mostly with those functions of the diameter like volume and basal area. Further, only 3 out of the 4 indices involving red edge bands proposed in this paper showed moderate correlation with only one stand parameter (mean height at 0.52 to 0.54, $p<.01$). Among the bands, the red edge bands of 7, 8 and 8a are responsive to heights and volume ($R=0.44$ to 0.55, $p<.01$). However, it was with band 5 (red edge) that registered the highest R at 0.61 with the mean diameter followed by band 3 (red). The mean tree height had the most number of correlations with the S2 variables (17 out of 20, or 85%) with NDVI registering the highest at 0.59.

Curve Estimation Models

Since the LCI recorded the highest correlation with the two important measure of wood density – the total volume and BA, these variables were subjected to both

Table 2. Descriptive statistics of stand parameters at plot level

Stand parameter	Mean	Standard deviation	Range	Minimum	Maximum
No. of trees/ha	309	114.44	538	141	679
DBH (m)	0.30	0.05	0.22	0.21	0.43
TH (m)	15.71	2.09	8.24	11.79	20.03
Maximum TH (m)	21.26	3.12	13.00	15.00	28.00
MH (m)	9.73	2.64	11.94	4.09	16.04
CL (m)	5.93	1.66	6.04	3.22	9.26
Total CL (m)	128.29	51.60	206.00	35.00	241.00
CC (%)	57.99	14.73	52.66	30.00	82.66
SVMH (m^3)	17.89	9.64	32.25	4.94	37.19
SVTH (m^3)	28.97	2.29	44.43	9.88	54.32
BA (m^2/ha)	24.81	10.19	36.55	8.82	45.37

linear and non-linear regression models. Table 4 shows that either power or exponential equations generated an adjusted R^2 of 0.43 with a standard error of less than 0.40. The paper by Günlü and Kadıoğulları (2018) in pine forest produced a lower R^2 of 0.36 with Landsat dataset using a stepwise linear regression. They were able to increased that to 0.54 by increasing the spatial resolution of the image dataset. Meanwhile, in spite of using the non-parametric random forest modeling with lidar technology to generate 3D models of trees, Brown et al (2022) still produced similar statistics for volume estimation (R^2=0.45).

Figure 4 below illustrates the curve lines based on the four equations fitted with the scatterplot of LCI-volume samples. It can be noticed that the volume only started to increased at 0.84 value of LCI, albeit quite noisy. Nevertheless, the trend of this graph is similar to the paper of Ali et al (2018) where NDVI and SAVI from Sentinel-2 were correlated with the aboveground biomass (AGB) of mixed stands. AGB of trees is typically computed from allometric equations involving the DBH.

Similarly, it was also either power or exponential equations that generated a better fit when predicting BA using the LCI (Table 5). Although its adjusted R^2 is a little lower than that of the volume, the standard error of estimate is lower at 0.34 only. Such outcome was validated by Günlü and Kadıoğulları (2018) using linear regression between the S2 variables against BA. The same authors generated an R^2 of 0.34 and 0.41 for Landsat and Quickbird, respectively. Similar results were seen from the study of Brown et al (2022) with R^2 of 0.36.

DISCUSSION

The relationships between tree structures and VIs or multispectral bands of this study is comparable with similar papers in the past. From Dos Reis et al (2018) in

Table 3. Spearman's correlation result between the VIs, bands and stand parameters

	mDBH	mTH	mMH	sCL	SVMH	SVTH	BA
MRVI	.282	.587**	.418*	.403*	.495**	.500**	.466**
EVI	.166	.546**	.461**	.371*	.484**	.487**	.413*
NDVI	.279	.594**	.425*	.398*	.500**	.499**	.466**
GNDVI	.353*	.547**	.415*	.367*	.540**	.528**	.503**
SAVI	.167	.486**	.435*	.319	.466**	.465**	.398*
LCI	.605**	.439**	.223	.368*	.630**	.650**	.659**
ARVI	.290	.587**	.389*	.410*	.468**	.479**	.450**
MAVI	.254	.530**	.428*	.326	.500**	.466**	.447**
IRCI	.343*	.571**	.424*	.415*	.540**	.543**	.516**
NDVIre1	-.308	.174	.235	.056	-.070	-.076	-.143
NDVIre2	.222	.515**	.373*	.348*	.384*	.393*	.365*
NDVIre3	.266	.545**	.400*	.354*	.421*	.419*	.398*
NDVIre4	.237	.537**	.372*	.375*	.390*	.395*	.373*
Band 3	-.549**	-.210	-.034	-.162	-.332	-.351*	-.422*
Band 4	-.317	-.387*	-.204	-.253	-.307	-.318	-.341*
Band 5	-.609**	-.272	-.055	-.161	-.360*	-.377*	-.436**
Band 6	-.010	.454**	.459**	.300	.421*	.404*	.342*
Band 7	.102	.548**	.532**	.349*	.520**	.485**	.438**
Band 8	.111	.517**	.483**	.291	.469**	.437**	.367*
Band 8a	.018	.524**	.546**	.324	.471**	.410*	.366*

*p < .05, **p<.01

Note: mDBH=mean DBH, mTH=mean total height, mMH=mean merchantable height; sCL=summation of crown length; SVMH=stem volume based on MH, SVTH=stem volume based on TH, BA=basal area

Table 4. Model summary and parameter estimates for total volume as the response variable

Equation	R^2	Adjusted R^2	Standard error of estimate	Sig	Parameter estimates		
					Constant	b1	b2
Linear	.398	.380	11.316	.000	-372.153	468.152	
Quadratic	.399	.361	11.489	.000	240.860	-969.338	842.290
Power	.445	.427	.397	.000	277.084	15.410	
Exponential	.444	.426	.398	.000	4.866E-06	18.058	

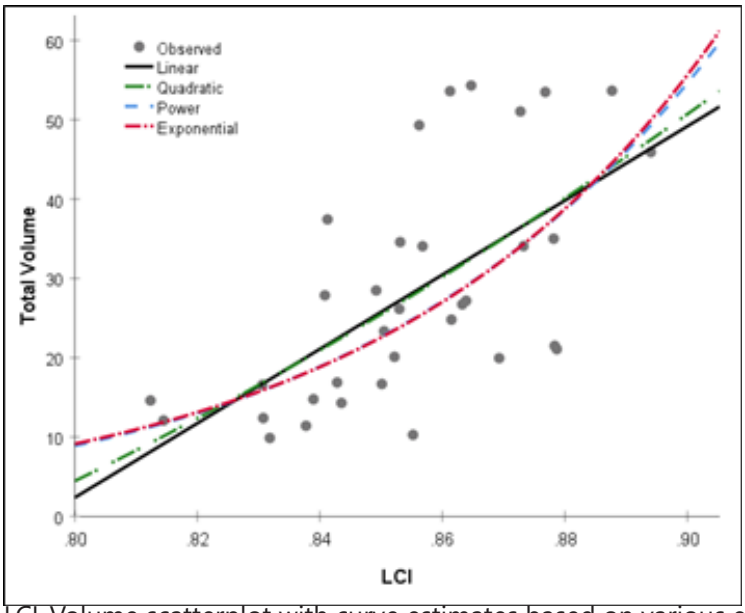

Figure 4. LCI-Volume scatterplot with curve estimates based on various equations

Table 5. Model summary and parameter estimates for BA as the response variable

Equation	R^2	Adjusted R^2	Standard error of estimate	Sig	Parameter estimates		
					Constant	b1	b2
Linear	.404	.386	8.291	.000	-272.531	347.314	
Quadratic	.407	.369	8.407	.000	508.698	-1484.635	1073.421
Power	.431	.413	.341	.000	167.430	12.865	
Exponential	.431	.413	.341	.000	5.576E-05	15.084	

Brazil, the NDVI of tree plantations from Landsat TM revealed an R values of 0.83 and 0.49 ($p<0.05$) for BA and tree volume as compared to 0.47 and 0.50 ($p<0.01$) in this study, respectively. Although their strongest correlation occurred between the normalizations of NIR and SWIR bands and BA at -0.91. In contrast, the highest R value in this paper is between LCI and BA with 0.66. Marcelli et al (2020), who also used Sentinel data in a poplar forest in Turkey, generated a correlation coefficient of 0.59 between NDVI and tree volume. Their highest correlation though was at 0.63 between tree volume and by simple ratioing of the NIR and SWIR bands.

Mutanga et al (2012) and Imran et al (2019) found a stronger relationship between AGB and NDVI if red edge bands were used compared to the broader NIR band (band 8) of S2 (R is up to 0.80). In contrast, the proposed NDVIs with red edge bands in this study had weak relationships with both volume and BA (0.36 to 0.42; $p<0.05$). Surprisingly, band 7 alone in this study had even higher correlations with the two parameters and is consistent with that of Imran et al (2019). On the other hand, Nguyen and Kappas (2020) reported that among the four spectral bands of SPOT-6 image, the red band has the strongest correlation with AGB conducted in a mixed forest including pines. Conversely, the red band in this paper is weakly correlated with only the mean height and BA. This could be attributable to the type of species being analyzed. The responses of indices and the bands involved are sometimes species-specific or restricted only to specific types of plants (Huete, 2004; Raper and Varco, 2015; Xie et al., 2015).

The LCI, developed by Datt in 1999, was originally used to determine the chlorophyll content of Eucalyptus species at leaf level. Accordingly, it was found to be a sensitive indicator of chlorophyll content in leaves and was less affected by scattering from the leaf surface and internal structure variation. Determination and analysis of chlorophyll content are crucial in studying vegetation health, forest growth or presence of stress as affected by diseases or insects (Yang et al, 2015; Gittelson et al, 2006; Sampson et al, 2003). Most of the remote sensing studies conducted in relation to chlorophyll assessment were done using airborne hyperspectral images which have narrower bands and higher resolution (e.g. Carmona et al, 2015; Zhang et al, 2008) in contrast to the one used in this paper. This is probably one of the reasons why the level of correlation between the field and RS datasets is only moderate. Moreover, stand conditions played important role in this kind of modeling as there were components captured by the satellite image but were not considered in the field data. For instance, the average canopy cover of the plots was less than 60% with a standard deviation of 15% and a minimum of 30%. Further, the average number of trees on per hectare basis from other studies (Ali et al, 2018; Günlü and Kadıoğulları, 2018) were at least doubled compared to this paper (309 versus 600 to 1000+ trees). All of these situations collectively affect the spectral characteristics as detected by the satellite sensors because soil and understories are visible through the canopy gaps. The NDVI, EVI and SAVI had been the earliest and widely

used indices for assessing vegetation growth and vigor. Hue and Su (2017) consider them as basic vegetation indices that exploit the characteristics of green vegetation having a generally low reflectance in the visible region particularly in the red portion (600-700 nm) but higher in the near-infrared (700-1100 nm). It is basically the same principle that is being followed by the other VIs in this study, although some were modified to lessen the effects of the atmosphere, soil background or both. The main issue with NDVI is that it tends to saturate as its value gets closer to 1. For instance, when the canopy cover is high and with dense vegetation, the biomass increases but the spectral index remains constant (Imran et al, 2019). This is most likely the reason why LCI in this paper is a better predictor of BA and volume than NDVI. LCI involved one of the red edge bands (Band 5) in the equation which is thought to be sensitive to the trees' structural and health condition. These findings had been corroborated by Mutanga et al (2012) where index with red edge bands had stronger correlation with the biomass compared to the conventional NDVI. The rest of the VIs were developed to investigate certain leaf pigments or to improve the estimation of specific vegetation parameters such as biomass, leaf area index (defined as the area of single leaf per area on the ground) and presence of moisture (Zheng and Moskal, 2009; Imran et al., 2020; Gao, 1996; Silleos et al., 2006).

Mapping Out Priority Areas for Harvesting

The LCI values within the G. arborea plantation were substituted to the non-linear power equation of the LCI-volume model to demonstrate the spatial distribution of the plantation's woody materials. The product was resampled to 27m to coincide with the area of the circular field plot and then reclassified into four categories based on the quantile value (figure 6). The categories pertain to the harvesting priorities where 1 and 4 in the map are the top and last priorities for cutting, respectively.

CONCLUSION

This study had just proven the usefulness of RS technology as an aid in identifying site parameters of the G. arborea plantation at landscape level significant to its growth and planning development. Since satellite images for the area are available on a regular basis (at least in the case of S2), the methodology introduced can be conducted yearly to monitor any changes in the plantation for adaptive management. As a result, plantation managers become more efficient in performing their task. Actual validation on the field, additional sampling plots and the use of non-parametric regression modeling or machine learning algorithm are recommended to further strengthen the analysis.

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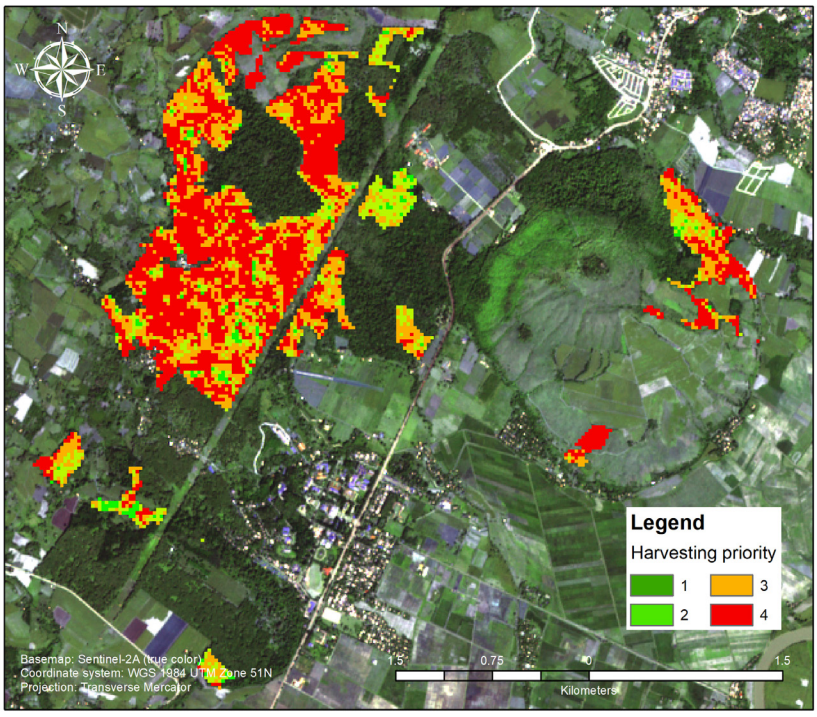

Figure 6. Resampled LCI-volume power equation model of G. arborea plantation for estimating which grids need to be harvested first where priorities 1 and 4 are the first and last to be cut (1 grid = 0.7 ha)

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ACKNOWLEDGEMENT

The authors are grateful for the support of the CMU Administration, the Forest Resources Enterprise Office (FREO), research assistants and the students who conducted their theses in line with this paper.

Central Mindanao University
Journal of Science
ISSN Print: 0116-7847 ISSN Online: 2704-3703

Competency Mapping: A Tool for Appraising Business Potentials in a Rural Community of Bukang Liwayway, Kibawe, Bukidnon

Gamaliela A. Dumancas and Hazelle M. Hibaya-Bulquerin

Department of Office Administration, College of Business and Management,
Central Mindanao University, Musuan, Bukidnon, Philippines, 8710

ABSTRACT

Competency mapping is a process that identifies existing competencies by assessing the key capabilities, knowledge, and attributes of individuals within a community. This process is crucial for identifying opportunities to build on existing human resources and provide relevant inputs for community transformation.

Recognizing the importance of competency mapping, this research project aims to assess the skills and competencies of residents in Bukang Liwayway, Kibawe, Bukidnon and develop a competency map to facilitate entrepreneurial profiles and efficient knowledge sharing among residents.

The research design employed a descriptive method with 123 respondents from households in Bukang Liwayway, Kibawe, Bukidnon. Adopting the proficiency level assessment tool developed by TESDA, results show that the highest proficiency level possessed by residents, as perceived by respondents, is in Animal Production (Ruminants, Poultry, Chicken, and Swine) with a rating of 1.82 and described as Basic. When grouped according to category, the Tourism/Hotel/Restaurant group was perceived to have the highest proficiency level of 1.51, also described as Basic. Regarding entrepreneurial opportunities, Ukay-Ukay was perceived to have the highest potential for business with a mean rating of 2.79.

Keywords: competencies, competency map, entrepreneurial opportunities

INTRODUCTION

Competency mapping is a crucial process that identifies the essential capabilities, knowledge, and attributes among employees within an organization. This process helps ensure that tasks are performed at the desired level expected by the company. Competency mapping can be conducted at various levels, including company-wide, job-specific, or individual employee assessments. This highlights the significance of human resources as a valuable asset that significantly contributes to a company's overall value (Kumar & Kumar, 2013).

At the core of any successful activity lies competence or skill (Anisha, 2012). In a business environment characterized by extended structural dimensions and organizational complexity, it can be challenging to define and identify the competencies of people involved in business processes (Russo, 2016). However, the recognition of employee competencies as intangible resources has grown increasingly, surpassing the importance of physical and financial assets in driving a company's success. Global firms have realized that their employees' competencies serve as key catalysts for navigating through business turbulence, overcoming challenges, and adapting to ever-changing market dynamics (Nagaraju & Gowda, 2012).

In today's fast-paced global marketplace, organizations need a skilled and committed workforce to maintain a competitive edge. Human resources have emerged as the most critical asset for organizations, with their abilities and competencies directly influencing organizational success. Consequently, it becomes imperative to assess the workforce's competencies and skills to evaluate a specific area's business potential.

However, a significant literature gap exists in comprehending the specific skills and competencies possessed by the residents of Barangay Bukang Liwayway, Kibawe, Bukidnon. This lack of information hampers the community's ability to fully utilize its human capital and identify potential entrepreneurial opportunities.

To address this research gap, the College of Business and Management at Central Mindanao University undertakes the task of assessing the skills and competencies of Bukang Liwayway's residents in Kibawe, Bukidnon. The primary objective is to develop a comprehensive inventory of competencies that will facilitate entrepreneurial profiles and promote efficient knowledge sharing among residents. By bridging this literature gap, this study aims to provide valuable insights into residents' existing competencies and identify potential economic contributions through entrepreneurial activities.

METHODOLOGY

This research study employed a descriptive-quantitative design to gather, analyze, and interpret

Corresponding author:
Gamaliela A. Dumancas
Email Address: gdumancas@gmail.com
Received: Aug. 26, 2023 ; Accepted: Oct. 25, 2023

data based on research instruments, document perusal, and evaluation. The study was conducted in Bukang Liwayway, Kibawe, Bukidnon, a rural community with a high poverty incidence rate. A total of 123 residents served as respondents. To adhere to health protocols during the pandemic, only one member from each household was allowed to answer the survey instrument.

To map the existing competencies of the residents, the study adapted the competency standard developed by TESDA as a tool. A pilot test was conducted in Barangay Candelaria, San Fernando, Bukidnon to test the survey instrument's reliability. The data obtained from the pilot test were analyzed using SPSS software and resulted in a Cronbach's Alpha coefficient of 0.961, indicating its validity.

The survey instrument was then administered to the respondents to solicit their self-assessment of their proficiency levels on the identified skill sets and to determine the commercial potential of existing entrepreneurial activities. The study employed descriptive statistics analysis to assess respondents' competencies as perceived by themselves, following the tool developed by TESDA. The findings of this research will provide insights into the competencies of Barangay Bukang Liwayway's residents and inform the development of strategies to improve their skills and livelihood opportunities.

In a business environment characterized by extended structural dimensions and organizational complexity, it can be challenging to define and identify the competencies of people involved in business processes (Russo, 2016). At the heart of any successful activity lies competence or skill (Anisha, 2012). Thus, this study aims to contribute to existing literature on competencies and their importance in improving livelihood opportunities, especially in underserved communities like Bukang Liwayway, Kibawe, Bukidnon.

RESULTS AND DISCUSSION

Demographic Profile

This study investigated the demographic profile of respondents in Bukang Liwayway's rural community in Kibawe, Bukidnon within the context of competency mapping as a tool for appraising business potentials. The findings provide valuable insights into respondents' characteristics and contribute to understanding prevalent competencies and skills within the community.

The sample consisted of 123 respondents who currently reside in Bukang Liwayway, Bukidnon. Table 1 presents a detailed overview of respondents' demographic profile, including age, gender, marital status, religious affiliation, household size, educational attainment, primary source of income, and monthly income.

In terms of age distribution, the majority of respondents fell within the age range of 27 to 40 years old (29.27%), followed by those aged 41 to 56 years old (22.76%). A small proportion of respondents (6.50%) did not reveal their age. These age groups are likely to represent a significant segment of the community's workforce and potential talent pool.

Regarding gender distribution, the results indicate that more than half of the respondents were female (69.11%), while the remaining 30.89% were male. This gender distribution underscores the importance of considering gender-specific competencies and skills within the context of competency mapping efforts in rural communities. This is in agreement with Petrin et al., 2011 that suggest identifying unique strengths and areas for development among females can help foster gender equality and inclusivity in competency development initiatives.

The marital status of respondents reveals that a substantial proportion (75.60%) were married. This finding suggests the potential influence of family responsibilities on individuals' competencies and skills within the community. Incorporating an understanding of marital status into competency mapping can facilitate the identification of competencies shaped by family dynamics and responsibilities. This is in agreement with Wickramasinghe & De Zoyza's study (2008) that marital status has a potential influence on individuals' competencies and skills.

Regarding religious affiliation, the majority of respondents identified as Christians (90.24%). This information highlights the potential impact of cultural and religious backgrounds on individuals' competencies and skills. Considering these factors in competency mapping efforts can lead to a more comprehensive assessment of individuals' capabilities within rural communities.

The household size of respondents varied, with the majority (45.53%) reporting having 4 to 7 members in their households. This insight provides valuable information on family dynamics and responsibilities that individuals navigate within communities. Competency mapping can take these factors into account to identify competencies related to collaboration, communication, and multitasking, which are often crucial in managing larger households.

Regarding educational attainment, the findings reveal that more than half of the respondents (56.10%) have attained an elementary level of education, while only a small number (8 respondents) have reached a college-level or graduate education. This distribution highlights potential skills and knowledge gaps within the community (International Bureau of Education, n.d.). Competency mapping efforts can focus on bridging these gaps by offering targeted training programs and educational opportunities to uplift the competencies of individuals with lower educational attainment (Vera-Toscano et al., 2017).

In terms of the primary source of income, the majority of the respondents (69.92%) derived their income from farming. Understanding this predominant income source is crucial for competency mapping, as it allows organizations to recognize and assess the competencies required for successful agricultural practices and related business potentials within the rural community. Competency mapping can further explore the specific

Table 1. Demographic profile of respondents.

INDICATOR	FREQUENCY	PERCENTAGE
Age		
18 to 26 years old	25	20.33
27 to 40 years old	41	29.27
41 to 56 years old	28	22.76
57 to 75 years old	23	18.70
76 years old and above	3	2.44
No answer	8	6.50
Total	123	100.00
Gender		
Female	85	69.11
Male	38	30.89
Total	123	100.00
Civil Status		
Single	22	17.89
Married	93	75.60
Widowed	2	1.63
Separated	1	0.81
No answer	5	4.07
Total	123	100.00
Religion		
Christian	111	90.24
Muslim	3	2.44
No Answer	9	7.32
Total	123	100.00
Members in the Household		
3 and below	45	36.59
4 to 7	56	45.53
7 and above	21	17.07
No Answer	1	0.81
Total	123	100.00
Educational Qualification		
Elementary Level/Graduate	69	56.10
High School Level/Graduate	45	36.59
College Level/Graduate	8	6.50
Post Graduate	0	0.00
No Answer	1	0.81
Total	123	100.00
Source of Income		
Government Employment	16	13.00
Private Employment	2	1.63
Farming	86	69.92
Farm Tenant	9	7.32
Business	10	8.13
Total	123	100.00
Monthly Income		
Below P9,520	100	81.30
P9,520-P19,040	10	8.13
P30,081-P66,6040	11	8.94
P66,641-P114,240	1	0.81
P114,241-P190,399	1	0.81
P190,400 and Above	0	0
Total	123	100.00

skills, knowledge, and abilities associated with farming to support the development of agricultural entrepreneurship and sustainable rural development initiatives.

Lastly, the findings indicate that a significant percentage of the respondents (81.30%) have a monthly income below P9,520.00. This income information is vital for competency mapping efforts, as it provides insights into the financial resources available to individuals for competency development activities.

Objective No. 1. To assess the competencies possessed by the residents of Bukang Liwayway, Kibawe, Bukidnon;

Competencies

Adopting the competency classification and assessment tool developed by TESDA, the respondents were requested to assess and rate their skills according to the level of proficiency using the following proficiency scale by Russo (2016) presented in Table 2.

Table 3 presents the competency skills the respondents perceived to be currently acquired. These competency skills were grouped according to a category, such as A-Tourism/Hotel/Restaurant, B-Construction, C-IT-BP, D-Transport Communication and Storage, E-Manufacturing, F-Agriculture/Fisheries/Forestry, G-Health and Wellness, and H-Other Services.

Ranked according to the level of proficiency, Table 4 presents the top competency skills perceived to be currently possessed by the residents of the Bukang Liwayway, Kibawe, Bukidnon. Results show that the competency skill with the highest proficiency level of 1.82 (Basic) is Animal Production (Ruminants-Poultry-Chicken-Swine), followed by the Domestic Work with a mean proficiency of 1.76 (Basic), and followed by Caregiving with a proficiency level of 1.73 (Basic). As can be gleaned from this table, four (4) competency skills that belong to the Category A-Tourism/ Hotel/Restaurant belong to the top ten. These are Bread and Pastry (1.62), Food Processing (1.61), and Commercial Cooking (1.60). Other competencies that have a higher level of proficiency are Hilot (1.55), Horticulture (1.52), Barangay Health Services (1.52), and Carpentry (1.49). Although these top ten competency skills have the highest mean ratings, their levels of proficiency are still considered Basic. The respondents have limited proficiency in the rest of the competency skills.

Table 2. Proficiency Scale (Russo, 2016)

PROFICIENCY LEVEL	DESCRIPTION
1. Limited	•Adunay gamay nga gipakita nga katakus. •Adunay limitado nga higayon nga magamit ang katakus. •Adunay limitado nga pagsabut sa katakus.
2. Basic	•Sukaranan nga pagsabot ug kahibalo nga gikinahaglan alang sa trabaho. •Sukaranan nga pagsabut ug kahibalo nga igoigo aron ma-kontrol ang naandan nga trabaho. •Nakasabut bahin sa mga terminolohiya ug mga konsepto nga adunay kalabutan sa katakos.
3. Proficient	•Detalyado nga kahibalo, pagsabut ug paggamit sa katakus. •Abilidad sa pagdumala sa mga dili naandan nga mga proble-ma ug sitwasyon. •Nanginahanglan ug dyutay nga paggiya. •Makanunayon nga gipakita ang kalampusan sa katakus.
4. Advance	•Naugmad nga kahibalo, pagsabut ug paggamit sa katak-us nga gikinahanglan aron magmalampuson sa trabaho ug organisasyon. •Mahimong magamit ang kahibalo sa gawas sa posisyon sa usa ka tawo. •Mahimo sa pagtudlo sa uban sa katakus
5. Expert	•Taas nga kahibalo, pagsabut ug paggamit sa katakus nga gikinahanglan aron magmalampuson sa trabaho ug organis-asyon. •Giila sa uban ingon usa ka eksperto sa katakus ug gipangita sa uban sa tibuuk nga organisasyon. •Nagtrabaho sa tibuuk nga mga kalihokan sa grupo, departa-mento, ug organisasyon •Nagpakita ug kahanas sa daghang mga proyekto o gimbu-haton •Makahimo sa pagpasabut sa mga isyu nga adunay kalabotan sa mga isyu sa organisasyon •Makahimo ug mga bag-ong proseso

Table 3. Competencies possessed by residents of Bukang Liwayway, Kibawe, Bukidnon based on self-assessment.

	COMPETENCY SKILLS	Mean	Description
A	Tourism/Hotel/Restaurant		
A1	Barista	1.39	Limited
A2	Bread and Pastry	1.62	Basic
A3	Commercial Cooking	1.60	Basic
A4	Food Processing	1.61	Basic
A5	Food Processing (Professional Cookery)	1.47	Limited
A6	Tourism Promotion Services	1.35	Limited
	Overall Mean	1.51	Basic
B	Construction		
B7	Carpentry	1.49	Basic
B8	Construction Painting	1.39	Limited
B9	Die Designing	1.42	Limited
B10	Flux-Cored Arc Welding	1.25	Limited
B11	Milling Machine Operation	1.27	Limited
B12	Plumbing	1.31	Limited
B13	Furniture Making	1.34	Limited
B14	Line Construction (Electric Power Distrib.)	1.19	Limited
B15	Masonry	1.19	Limited
B16	Mechanical Drafting	1.10	Limited
B17	Press Machine Operation	1.06	Limited
B18	Structural Erection	1.06	Limited
B19	Tool and Die Making	1.09	Limited
	Overall Mean	1.24	Limited
C	IT-BP (IT-BPM)		
C20	Contact Center Service	1.13	Limited
C21	Visual Graphics Design	1.08	Limited
C22	Audio Production	1.22	Limited
C23	Computer System Services	1.16	Limited
C24	Web Development	1.09	Limited
	Overall Mean	1.14	Limited
D	Transport Communication and Storage		
D25	Automotive Body Repair	1.09	Limited
D26	Marine Electricity	1.11	Limited
D27	Motorcycle/Small Vehicle Servicing	1.23	Limited
D28	On Highway Dump Truck	1.06	Limited
D29	Transmission Line Installation and Maintenance	1.10	Limited
	Overall Mean	1.12	Limited
E	Manufacturing		
E30	Cable TV Station	1.17	Limited
E31	Chemical Process Installation	1.13	Limited
E32	Consumer Electronics	1.17	Limited
E33	Electrical Installation and Maintenance	1.10	Limited
E34	Metal Stamping	1.12	Limited
E35	Plant Maintenance	1.33	Limited
	Overall Mean	1.17	Limited

F	Agriculture/Fisheries/Forestry		
F36	Agricultural Machinery Servicing (4-wheel tractor)	1.18	Limited
F37	Animal Production (Ruminants-Poultry-Chicken-Swine)	1.82	Basic
F38	Aquaculture (Hatchery Operation-Tilapia Culture)	1.32	Limited
F39	Bamboo Production	1.16	Limited
F40	Beekeeping	1.06	Limited
F41	Fishing Gear Repair	1.16	Limited
F42	Grains Production	1.44	Limited
F43	Horticulture	1.52	Basic
F44	Milking Operation	1.08	Limited
F45	Organic Agriculture Production	1.29	Limited
F46	Rice Machinery Operation	1.25	Limited
F47	Rubber Processing	1.06	Limited
F48	Rubber Production	1.17	Limited
F49	Seaweed Production	1.17	Limited
F50	Sugarcane Production	1.30	Limited
	Overall Mean	1.26	Limited
G	Health and Wellness		
G51	Barangay Health Services	1.52	Basic
G52	Barbering	1.32	Limited
G53	Beauty Care	1.38	Limited
G54	Beauty Care(skincare)	1.29	Limited
G55	Biomedical Equipment Services	1.20	Limited
G56	Caregiving (Clients with Special needs, Elderly, Grade Scholar to Adolescent, Newborn to Preschool)	1.73	Basic
G57	Dental Hygiene	1.47	Limited
G58	Hilot (Wellness)	1.55	Basic
G59	Massage Therapy	1.27	Limited
	Overall Mean	1.33	Limited
H	Other Services		
H60	Domestic Work	1.76	Basic
H61	Fashion Design	1.23	Limited
H62	Footwear Making	1.11	Limited
H63	Garbage Collection	1.44	Limited
H64	Hairdressing	1.28	Limited
H65	Pharmacy Services	1.11	Limited
H66	Real Estate Services	1.12	Limited
H67	Security Services	1.10	Limited
H68	Travel Services	1.13	Limited
H69	Tailoring (Casual)	1.35	Limited
H70	Warehousing	1.15	Limited
	Overall Mean	1.25	Limited

Legend:	Rating	Scale	Qualitative Interpretation
	5	4.5 - 5.0	Expert
	4	3.5 - 4.49	Advance
	3	2.5 - 3.49	Proficient
	2	1.5 - 2.49	Basic
	1	1.0 – 1.49	Limited

Objective No. 2. To determine which of the existing entrepreneurial activities have potential economic contributions to the community.

Business Opportunities

Using the classification of business opportunities that TESDA identified as income generators, the respondents were requested to assess the business potential of these entrepreneurial activities, according to the following scale: 3 for High Potential (Dako og potensyal nga mahimong usa ka negosyo), 2 for Moderate Potential (Kasarangang potensyal nga mahimong usa ka negosyo), and 1 for No Potential (Walay potensyal nga mahimong usa ka negosyo). Table 5 presents the level of the business potential of these business opportunities in the area of Bukang Liwayway, Kibawe, Bukidnon as perceived by the respondents.

When these business opportunities were ranked according to their level of potential, Table 6 shows the TESDA identified business opportunities with their level of potential for business as perceived by respondents, arranged in descending order.

As can be gleaned from the table, results show that the lone business opportunity with the highest mean rating of 2.79 is Ukay-Ukay and it is perceived to have High business potential. It can also be noted that the next higher business opportunities are Plant Selling with a mean rating of 1.71, followed by Buy and Sell with a mean rating of 1.54, and Sari-Sari Store with a mean rating of 1.53. These three (3) business opportunities, however, are perceived to have "Low Potential" for business. It is also noted that the four (4) business opportunities with the highest mean belong to one category, the Retail Business. The rest of the identified business opportunities are perceived to have "Low Potential" for business.

Objective No. 3. To establish a competency map that facilitates entrepreneurial profiles for efficient knowledge sharing.

Based on the competency classification and assessment tool developed by TESDA, the competency maps of Bukang Liwayway, Kibawe, Bukidnon are shown in

Table 4. The competency skills of respondents are arranged according to the level of proficiency.

	COMPETENCY SKILLS	Mean	Description
F37	Animal Production (Ruminants-Poultry-Chicken-Swine)	1.82	Basic
H60	Domestic Work	1.76	Basic
G56	Caregiving	1.73	Basic
A2	Bread and Pastry	1.62	Basic
A4	Food Processing	1.61	Basic
A3	Commercial Cooking	1.60	Basic
G58	Hilot (Wellness)	1.55	Basic
F43	Horticulture	1.52	Basic
G51	Barangay Health Services	1.52	Basic
B7	Carpentry	1.49	Basic
A5	Food Processing (Professional Cookery)	1.47	Limited
G57	Dental Hygiene	1.47	Limited
F42	Grains Production	1.44	Limited
H63	Garbage Collection	1.44	Limited
B9	Die Designing	1.42	Limited
A1	Barista	1.39	Limited
B8	Construction Painting	1.39	Limited
G53	Beauty Care	1.38	Limited
A6	Tourism Promotion Services	1.35	Limited
H69	Tailoring (Casual)	1.35	Limited
B13	Furniture Making	1.34	Limited
E35	Plant Maintenance	1.33	Limited
F38	Aquaculture (Hatchery Operation-Tilapia Culture)	1.32	Limited
G52	Barbering	1.32	Limited
B12	Plumbing	1.31	Limited
F50	Sugarcane Production	1.30	Limited
F45	Organic Agriculture Production	1.29	Limited

G54	Beauty Care(skincare)	1.29	Limited
H64	Hairdressing	1.28	Limited
B11	Milling Machine Operation	1.27	Limited
G59	Massage Therapy	1.27	Limited
710	Flux-Cored Arc Welding	1.25	Limited
F46	Rice Machinery Operation	1.25	Limited
D27	Motorcycle/Small Vehicle Servicing	1.23	Limited
H61	Fashion Design	1.23	Limited
C22	Audio Production	1.22	Limited
G55	Biomedical Equipment Services	1.20	Limited
B14	Line Construction (Electric Power Distribution)	1.19	Limited
B15	Masonry	1.19	Limited
F36	Agricultural Machinery Servicing (4-wheel tractor)	1.18	Limited
E30	Cable TV Station	1.17	Limited
E32	Consumer Electronics	1.17	Limited
F48	Rubber Production	1.17	Limited
F49	Seaweed Production	1.17	Limited
C23	Computer System Services	1.16	Limited
F39	Bamboo Production	1.16	Limited
F41	Fishing Gear Repair	1.16	Limited
H70	Warehousing	1.15	Limited
C20	Contact Center Service	1.13	Limited
E31	Chemical Process Installation	1.13	Limited
H68	Travel Services	1.13	Limited
E34	Metal Stamping	1.12	Limited
H66	Real Estate Services	1.12	Limited
D26	Marine Electricity	1.11	Limited
H62	Footwear Making	1.11	Limited
H65	Pharmacy Services	1.11	Limited
B16	Mechanical Drafting	1.10	Limited
D29	Transmission Line Installation and Maintenance	1.10	Limited
E33	Electrical Installation and Maintenance	1.10	Limited
H67	Security Services	1.10	Limited
B19	Tool and Die Making	1.09	Limited
C24	Web Development	1.09	Limited
D25	Automotive Body Repair	1.09	Limited
C21	Visual Graphics Design	1.08	Limited
F44	Milking Operation	1.08	Limited
B17	Press Machine Operation	1.06	Limited
B18	Structural Erection	1.06	Limited
D28	On Highway Dump Truck	1.06	Limited
F40	Beekeeping	1.06	Limited
F47	Rubber Processing	1.06	Limited

Legend: Rating	Scale	Qualitative Interpretation
5	4.5 - 5.0	Expert
4	3.5 - 4.49	Advance
3	2.5 - 3.49	Proficient
2	1.5 - 2.49	Basic
1	1.0 – 1.49	Limited

Table 5. Business opportunities are available at Bukang Liwayway, Kibawe, Bukidnon and their level of potential as perceived by the respondents.

Business Opportunities	Mean	Description
1. FRELANCING BUSINESS		
1A. Hair & Make-up	1.29	Low Potential
1B. Videography/ Photography	1.25	Low Potential
1C. Tutorial Services	1.26	Low Potential
Total Mean	1.27	Low Potential
2. FOOD AND BEVERAGES		
2A. Cake Making/Baking	1.40	Low Potential
2B. Food Delivery	1.24	Low Potential
2C. Tutorial Services	1.24	Low Potential
2D. Destaurant/Canteen/Carenderia	1.44	Low Potential
Total Mean	1.33	Low Potential
3. RETAIL BUSINESS		
3A. Buy and Sell	1.54	Low Potential
3B. Plant Selling	1.71	Low Potential
3C. Sari-sari Store	1.53	Low Potential
3D. Ukay-Ukay	2.79	High Potential
Total Mean	1.51	Low Potential
4. PERSONAL SERVICES		
4A. Auto Repair & Maintenance	1.35	Low Potential
4B. Barbershop	1.11	Low Potential
4C. Carwash Business	1.11	Low Potential
4D. Coin Laundry	1.15	Low Potential
4E. Computer Repair	1.23	Low Potential
4F. Home Massage	1.20	Low Potential
4G. Tailoring Services	1.20	Low Potential
Total Mean	1.22	Low Potential
5. RENTAL SERVICES		
5A. Clothing Rentals	1.22	Low Potential
5B. Internet Café	1.20	Low Potential
5C. Photo/video Equipment Rental	1.35	Low Potential
5D. Pisonet	1.25	Low Potential
5E. Land Transportation Service	1.27	Low Potential
Total Mean	1.26	Low Potential
6. PRINTING SERVICES		
6A. Business cards, flyers, invitations, brochure Printing	1.39	Low Potential
6B. Photocopy Business	1.31	Low Potential
6C. Tarpaulin Printing	1.28	Low Potential
6D. T-shirt Printing	1.30	Low Potential
Total Mean	1.32	Low Potential
7. HOME REPAIR & IMPROVEMENTS		
7A. Electronic & phone Repair	1.31	Low Potential
7B. Shoe Repair	1.51	Low Potential
Total Mean	1.41	Low Potential

8. ECONOMY & PROOF BUSINESS		
8A. Fishing Business	1.39	Low Potential
8B. Poultry Business	1.26	Low Potential
8C. Upholstery	1.29	Low Potential
Total Mean	1.31	Low Potential
9. EVENT PLANNING SERVICES		
9A. Floral Supplier	1.29	Low Potential
9B. Party Planner	1.17	Low Potential
Total Mean	1.23	Low Potential

Legend:	Rating	Scale	Qualitative Interpretation
	3	2.25 - 3.00	High Potential
	2	1.75 - 2.24	Moderate Potential
	1	1.0 – 1.74	Low Potential

Table 6. Business opportunities at Bukang Liwayway, Kibawe, Bukidnon ranked according to the level of potential for business as perceived by respondents.

BUSINESS OPPORTUNITIES	MEAN	DESCRIPTION
3D. Ukay-Ukay	2.79	High Potential
3B. Plant Selling	1.71	Low Potential
3A. Buy and Sell	1.54	Low Potential
3C. Sari-sari Store	1.53	Low Potential
7B. Shoe Repair	1.51	Low Potential
2D. Restaurant/Canteen/Carenderia	1.44	Low Potential
2A. Cake Making/Baking	1.40	Low Potential
6A. Business cards, flyers, invitations, brochure Printing	1.39	Low Potential
8A. Fishing Business	1.39	Low Potential
4A. Auto Repair & Maintenance	1.35	Low Potential
5C. Photo/video Equipment Rental	1.35	Low Potential
6B. Photocopy Business	1.31	Low Potential
7A. Electronic & phone Repair	1.31	Low Potential
6D. T-shirt Printing	1.30	Low Potential
1A. Hair & Make-up	1.29	Low Potential
8C. Upholstery	1.29	Low Potential
9A. Floral Supplier	1.29	Low Potential
6C. Tarpaulin Printing	1.28	Low Potential
5E. Land Transportation Service	1.27	Low Potential
1C. Tutorial Services	1.26	Low Potential
8B. Poultry Business	1.26	Low Potential
1B. Videography/ Photography	1.25	Low Potential
5D. Pisonet	1.25	Low Potential
2B. Food Delivery	1.24	Low Potential
2C. Tutorial Services	1.24	Low Potential
4E. Computer Repair	1.23	Low Potential
5A. Clothing Rentals	1.22	Low Potential
4F. Home Massage	1.20	Low Potential
4G. Tailoring Services	1.20	Low Potential
5B. Internet Café	1.20	Low Potential
9B. Party Planner	1.17	Low Potential
4D. Coin Laundry	1.15	Low Potential
4B. Barbershop	1.11	Low Potential
4C. Carwash Business	1.11	Low Potential

5B. Internet Café	1.20	Low Potential
9B. Party Planner	1.17	Low Potential
4D. Coin Laundry	1.15	Low Potential
4B. Barbershop	1.11	Low Potential
4C. Carwash Business	1.11	Low Potential

Legend:	Rating	Scale	Qualitative Interpretation
	3	2.25 - 3.00	High Potential
	2	1.75 - 2.24	Moderate Potential
	1	1.0 – 1.74	Low Potential

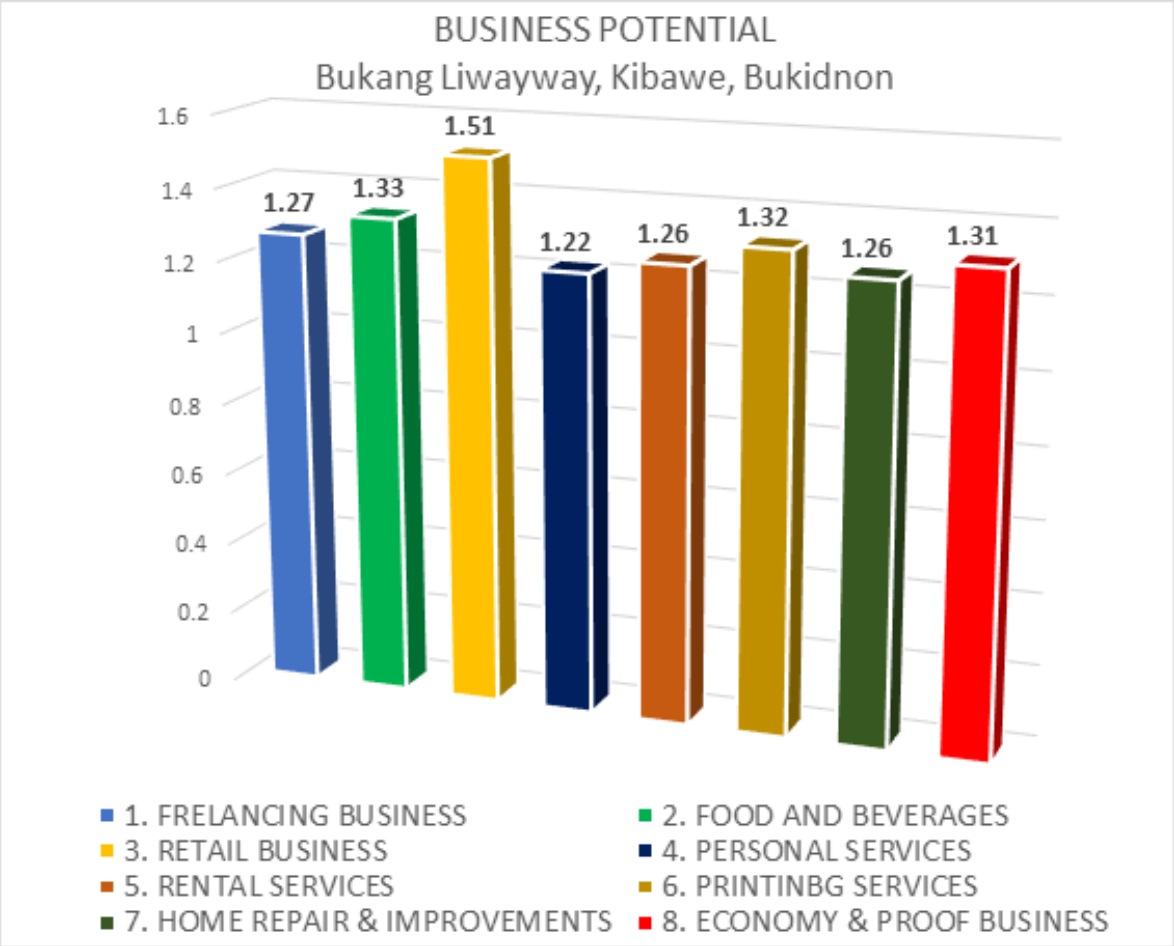


Fig. 2. Business Opportunities of Bukang Liwayway, Kibawe, Bukidnon

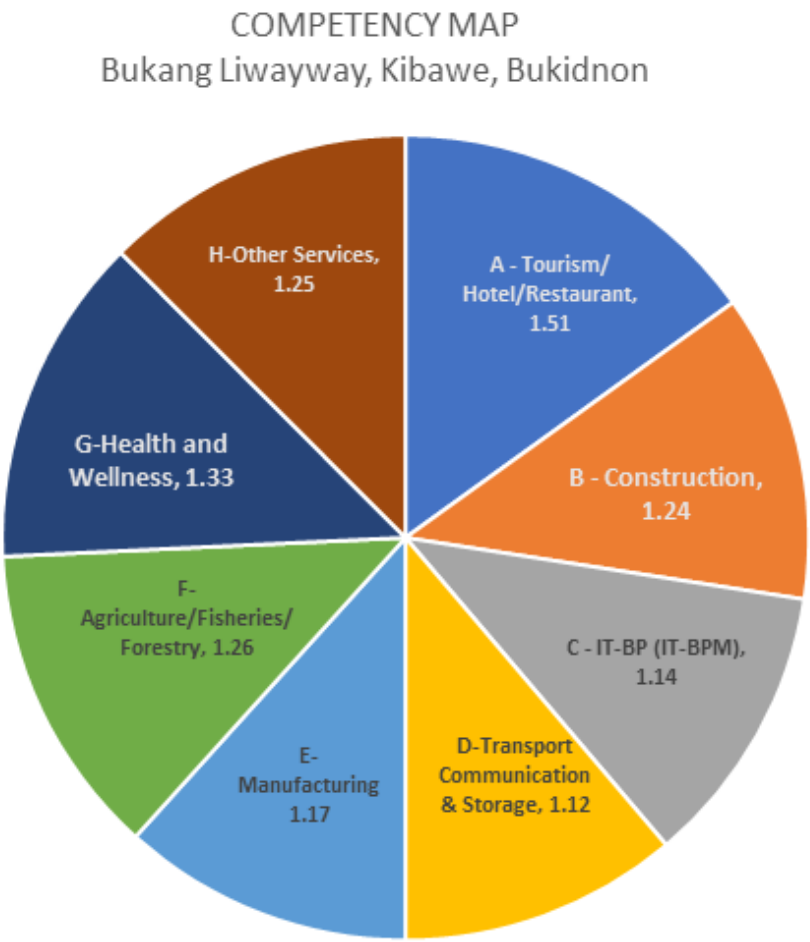
Figures 3 and 4.

CONCLUSIONS

Based on the data gathered, the following conclusions were drawn:

1. Among the identified competency skills, Animal Production (Ruminants-Poultry-Chicken-Swine) had the highest level of proficiency among the residents of Bukangliwayway, Kibawe, Bukidnon. However, it is important to note that the proficiency level in this area is still classified as basic, indicating a need for additional learning and insights to enhance their skills in animal production.
2. When the competency skills are grouped by category, the Tourism/Hotel/Restaurant category displayed the highest level of proficiency. This suggests that more residents of Bukangliwayway possess skills in Bread and Pastry, Commercial Cooking, and Food Processing. Nonetheless, the proficiency level in these skills remains categorized as basic, indicating room for further development.
3. The business opportunity with the highest potential in Bukangliwayway, Kibawe, Bukidnon is the Ukay-Ukay business. Among the identified opportunities, Ukay-Ukay received a high potential rating for a business venture.
4. When the business opportunities were grouped by category, Retail Business emerged as the category with the highest potential. However, it is important to note that the overall potential for business in Bukangliwayway, Kibawe, Bukidnon is still categorized as "low potential".

These conclusions highlight the existing competencies and potential business opportunities in Bukangliwayway, Kibawe, Bukidnon. They provide insights



Legend:	Rating	Scale	Qualitative Interpretation
	5	4.5 - 5.0	Expert
	4	3.5 - 4.49	Advance
	3	2.5 - 3.49	Proficient
	2	1.5 - 2.49	Basic
	1	1.0 – 1.49	Limited

Fig. 3. Competency Map of Bukang Liwayway, Kibawe, Bukidnon, according to skills category

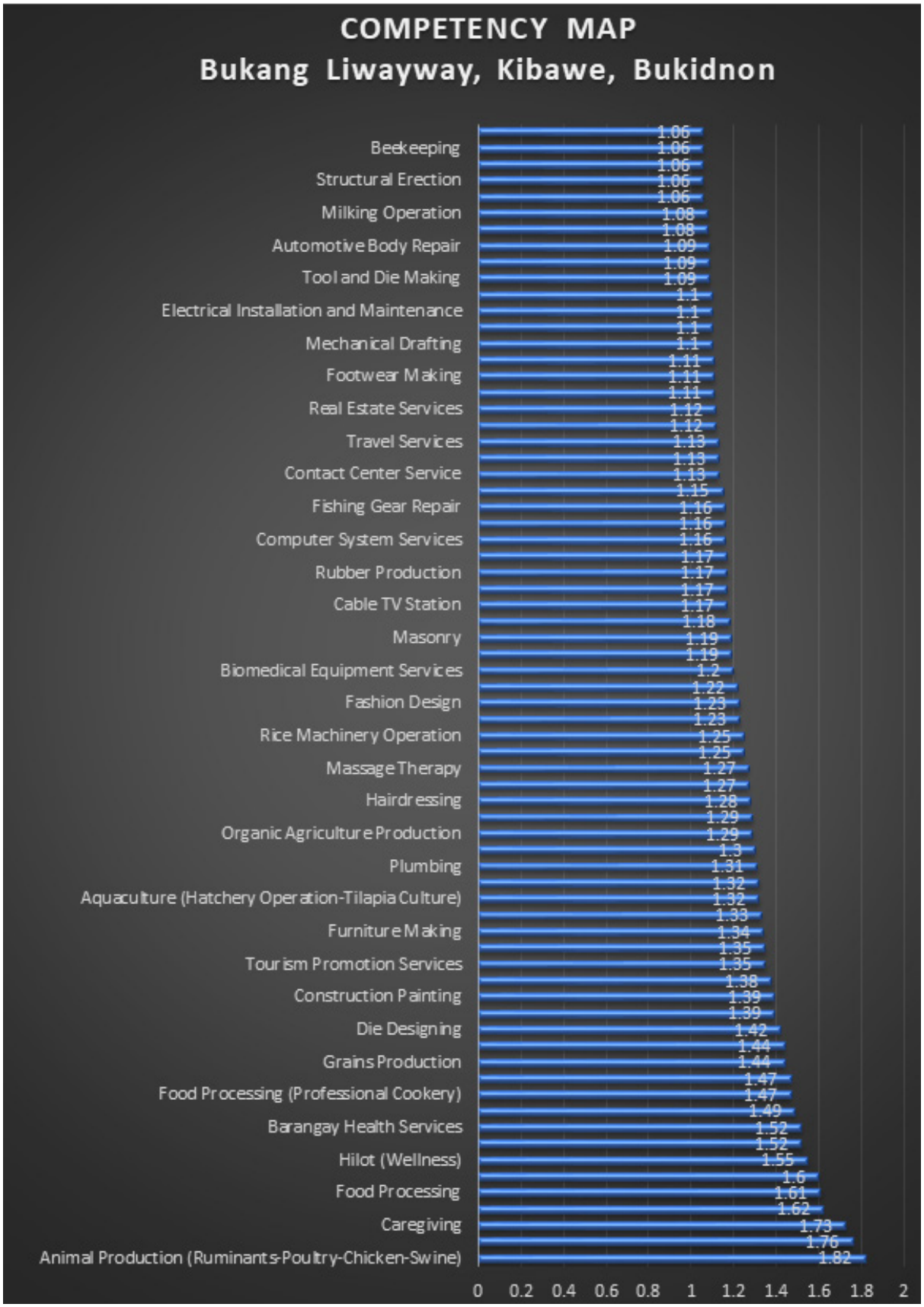


Fig. 4. Competency Map of Bukang Liwayway, Kibawe, Bukidnon, according to specific skills.

into areas that require further development and underscore the potential for economic growth through enhanced skills and targeted entrepreneurship in the community.

RECOMMENDATIONS

Given the foregoing conclusions, the following recommendations are drawn:

1. Enhance the competency skills of residents of Bukangliwayway, Kibawe, Bukidnon on Animal Production (Ruminants-Poultry-Chicken-Swine) by providing training coming from the experts of animal production.
2. Provide training and enhance their skills on Bread and Pastry, Commercial Cooking, and Food Processing.
3. Extend financial assistance to Ukay-Ukay business to obtain sustainability of the business.
4. Enhance the skills of residents who are engaged in Retail Business by providing them the training on simple bookkeeping, entrepreneurial skills, and records keeping.

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Central Mindanao University
Journal of Science
ISSN Print: 0116-7847 ISSN Online: 2704-3703

Prevalence of Zoonotic Gastrointestinal Parasites in Cattle Slaughtered at Gwadabawa Abattoir of Sokoto State, Nigeria

Gobir, S. S. [1, 2], Suleiman, M. [1], Yusuf Sarkingobir [3], Sabui, Muhammad[4]*

[1]Department of Biology, Umaru Musa Yar'adua University, Katsina, Nigeria
[2] Ummaru Ali Shinkafi Polytechnic Sokoto, Sokoto State, Nigeria
[3] Department of Environmental Education, Shehu Shagari University of Education Sokoto,Sokoto state, Nigeria
[4] Sultan Abdurrahman College of Health Technology Gwadabawa, Sokoto state, Nigeria

ABSTRACT

The current study was hatched out of the desire to strengthen the bond between veterinary and medical workers, a relationship adjudged to be non-existent or at best very weak. This study investigated the prevalence of zoonotic helminthes in cattle slaughtered at Gwadabawa abattoir of Sokoto State, Nigeria. About 5g of fecal samples were collected from 108 cattle and examined for presence of the parasites. Helminthes eggs and oocysts were detected using formal-ether concentration techniques. The results revealed an overall prevalence of 10.2% (11/108) for zoonotic parasites, from two genera Fasciola 7.4% (8/108) and Taenia 2.8% (3/108). Males had the higher prevalence 12% (6/50) of helminths infection than females 8.6% (5/58). Older cattle appeared to be more infected with 12.5% (5/48) of the infection compared to younger ones 8.3% (5/60). There were no significant ($p<0.05$) differences between infection and sex or ages of the cattle. Significantly ($P<0.05$), the prevalence based on breed showed that mixed breed cattle had the highest prevalence 17.1% (6/35) followed by Red Fulani 8.3% (4/48) and Sokoto Gudali 5.3% (1/19). Therefore, it is imperative to advocate for the provision of sanitary facilities at the abattoir, and among vendors; and the public should subject meat to proper preparation methods to minimize helminthes infections.

Keywords: Abattoir, Cattle, Helminths, Parasites, Zoonotic

INTRODUCTION

Cattle meat remain an important food that provides both micro- and macro-elements. Some of the meat components of importance include, water, protein, fat (saturated and unsaturated fatty acids), iron, zinc, selenium, vitamin D, vitamin B1, vitamin B2, vitamin B3, vitamin V5, vitamin B6, and vitamin B12 (Cabrera and Saadoun, 2014; Li, 2017). All of which serve valuable roles in the biological system for healthy life, and supplementation of nutritional deficiencies. It has a distinctive property function of producing nutritional compositions that are bio-available for healthy diet to all people across different age groups. More specifically, in the developing regions like Nigeria, the beef serves as part of the consumed balanced diet that promote food security, and cattle production is essential in sustaining the livelihood of the rural dwellers as well (Cabrera and Saadoun, 2014; Shehzad et al., 2014). Ideally, the beef meat is an important thing in health, and on the other hand can affect health due some issues, such as the presence of microorganisms that can affect human health negatively (Pighin et al., 2016). Additionally, cattle are important in producing hides, skins, manure, transportation, farming, medicine, and other socioeconomic activities benefitting the country and the entire region (Sarkingobir, 2021).

Zoonoses are infections involves in the transmission of the etiologic agent to humans from an ongoing reservoir in animals or arthropods, without the permanent establishment of a new life cycle in humans (Jones et al., 2008; Kubkomawa, 2017). Zoonotic gastrointestinal (GI) parasites are mainly protozoan and helminths. Helminths refer to a group of complex multicellular eukaryotic parasites which are infective to animals and humans (Karshima, et al., 2018). People with greater exposure to cattle and cattle products have increased risk of contracting bovine zoonotic infections. These group of people include livestock handlers, veterinarians, abattoir workers, meat inspectors, laboratory staff handling biological samples from infected cattle, and persons consuming unpasteurized milk or other dairy products and improperly prepared meats (McMichael et al., 2002). About 75% of the new diseases affecting humans over the past 10 years were attributed to pathogens from animal or their products (Coleman, 2002; Eversole, et al., 2009; Magaji et al., 2011; Lorossu et al., 2016).

A systematic review done by McDaniel, et al. (2015) identified forty-five bovine zoonotic pathogens, evenly dispersed around the world though majority (69%) have a worldwide distribution. Bacteria represent the largest taxonomic group (42%) of the pathogens, followed by parasitic pathogens (29%), viruses (22%), fungi (5%), and prions (2%). One of the major concern was that, some bovine zoonoses are among pathogens listed as emerging or re-emerging diseases of interest (EIDs), by National

Corresponding author:
Gobir, S.S
Email Address: shehuzayyan02@gmail.com
Received: Dec. 09, 2022 ; Accepted: Nov. 17, 2023

Institute of Allergy Infectious Diseases. National Institute of Allergy Infectious Diseases recognizes 25 (56%) of them as emerging or re-emerging diseases of interest (Lorossu et al., 2016). Therewith, 13 (52%) of them are bacteria, six (24%) are viruses, four (16%) are parasites, one (4%) is fungal, and one (4%) is a prion. These pathogens pose ongoing health problems and have the potential to create a significant impact on the overall health of the community. As they have the potential to be used as biological weapons based on their ability to create human disease and public fear (Markos and Abdurrahman, 2018; Muhammad et al., 2019). This research is carved out of a desire to gather more information on the occurrence of zoonotic infections in Sokoto state and Nigeria, a framework needed to cement the link between veterinary and medical workers. It was also with a view to help in protecting public health. This study investigated the prevalence of zoonotic helminthes in cattle slaughtered at Gwadabawa abattoir of Sokoto State, Nigeria

MATERIALS AND METHODS

Study Area

The study was conducted in Gwadabawa local government of Sokoto state, Nigeria. Gwadabawa is located between Kware, Illela, Tangaza, Gada, and Wurno local government areas, with a total land area of Gwadabawa is about 991kmsqm and a total population of 231,358 based on 2006 census report. The major inhabitants of the area are Hausa/Fulani, Muslims. The major occupations are farming, trading, and livestock keeping, whereas some residents are civil servants (Sarkingobir et al., 2019).

Age determination

Age of the cattle was determined using their dentition, as described by Pace and Wakeman, (2003) as follows:

Calf are born with or without teeth, usually at the end of first month after birth all eight temporary incisors appeared also called baby teeth.

Cattle of 1 year appears to have all four pair of teeth are temporary and firmly in place, the tooth appears short, broad, usually bright ivory color.

Cattle of 2 years were characterized by the appearance of first permanent incisors, both temporary incisors may or may not be present when the permanent appears.

By 3 years second pair of permanent incisors are positioned and began to wear.

Fourth pair erupted as the animal approach four years (corner incisors) and are in full wear seven months later or a year a latter.

It is difficult to estimate the age beyond 5 years, accuracy of this method is however challenged by what animals graze often on, for instance animal feeding under rough feeding conditions such as desert range land have their teeth worn at much faster rate than the one feeding on soft feed for their entire life. For this study cattle from 0 to 35 months were consider as young, while 36 months above as old.

Collection of Fecal Sample

About five grams (5g) of the fecal samples were obtained directly from the rectum of cattle with the aid of a spatula and transferred into a clean sample bottle, in accordance with the technique described by Cringoli, et al., (2010). The samples were taken to medical laboratory, School of Health Technology Gwadabawa for investigation. Each fecal sample was tested using formal ether concentration technique as suggested by Ballweber (2001).

Sample Preparation

Fecal samples were processed using formal ether concentration technique that require "about 5g of feces thoroughly mixed in 10ml of water and strained through two layers of gauze in a funnel, the filtrates are centrifuged at 2000 r.p.m. for two minutes, the supernatant were then discarded and the sediment suspended in 10ml of physiological or normal saline. Again, it was subjected to centrifugation and supernatant was discarded; then sediment was re-suspended in 7ml of formalin saline and allowed to stand for 10 minutes or longer for fixation. Then, 3ml of ether were added and shaken vigorously to form a mixture, then the stopper was removed and the tube was centrifuged at 2000 r.p.m. for two minutes; the tube was allowed to rest in a stand. Four layers become visible, the top layer consists of ether, the second was a plug of debris, third was a clear layer of formalin saline, and the fourth was a sediment. The plug of debris was then detached from the side of the tube with the aid of a glass rod, then liquid was poured off leaving a small amount of formalin saline for suspension of the sediment; which was poured on a clean glass slide covered with cover slip and then examined under a microscope (Cheesbrough, 2006).

Storage of Fecal sample

10% Formalin was adopted for this study as was an all-purpose fixative appropriate for used for preservation of protozoan cysts; therewith, it was also recommended for helminth egg and larvae. Most commercial manufacturers recommended utilization of 10% formalin, which is more likely to kill all helminth eggs to help maintain organism morphology. This solution could preserve cysts and eggs for some months (Ali, 2019).

Determination of Prevalence

Prevalence was calculated for all data as a number of infected individuals divided by number of individuals examined, and expressed in percentage as follows (Thrusfield, 2005):

$P = n/d \times 100$

Where:

p = prevalence,

d = number of individuals having diseases at a particular point in time,

Table 1: Prevalence of helminths zoonotic parasites in cattle examined based on some demographic characteristics.

Characteristic of cattle		Cattle examined (n = 108)	Cattle infected No. (%)	χ^2
Sex of cattle	Male	50	6(12)	0.339
	Femal	58	5(8.6))	
Age of cattle	Young	60	5(8.3)	0.250
	Old	48	6(12.5)	
Breed of cattle	Red Fulani	48	4(8.3)	
	Sokoto Gudali	19	1(5.3)	
	Mixed breed	35	6(17.1)	
	Muturu	6		

n = number of individuals in the population at risk at that point in time

Statistical analysis

The data obtained were subjected to descriptive statistical analysis using percentages (prevalence rates) in the different breed, sex, age and BCS of cattle. Prevalence of the parasite in relation to sex and age was analyzed using Chi-square statistical test, the level of significance was set at $P<0.05$.

RESULTS AND DISCUSSION

The results for this work are shown in Table 1, and Figure 1 of this section.

Prevalence of zoonotic helminths in relation to gender revealed that 6(12%) of males and 5(8.6%) of the females were infected (Table 1). Prevalence of helminths in relation to age revealed that old cattle had slightly higher prevalence of 6(12.5%) than young with 5(8.3%) (Table 1). However, there exist no significant differences in the distribution of the infection by sex or age of the cattle ($P<0.05$). In respect to cattle breed, mixed breed type has the higher infection rate 6(17.1%) than Red Fulani and Sokoto Gudali with 4(8.3%) and 1(5.3%) respectively.

The present study reveals that, male cattle were more infected with zoonotic gastrointestinal parasites (helminths) (Table 1), which is contrary to the findings of Singh and Bello, (2017) whom reported a prevalence of 65.0% for males and 76.0% for the females. Higher infection in males could be attributed to the aggressive nature of male animals (cattle) when feeding, which may introduce them to helminth eggs on the pasture, making them more susceptible to helminths. Furthermore, the growth and spread of parasites in male guts is more rapid than in females; an observation believed to be enhanced by factors such as hormones, and debilitating immune functions. These factors tend to make them more susceptible to infections with gastrointestinal tract parasites (Magaji et al., 2011; Abdullahi, 2019).

In this study, higher prevalence of helminth infections in adult compared to young cattle reported appears to be in opposition to what was documented by Muhammad et al., (2019) in Ilorin metropolis; and still goes contrary to the findings of Aliyu, et al. (2014) in Zaria, who documented the different finding revealing that, young cattle are more infected than adult ones. It also contradicts the notion that development of acquired immunity in the older animals may results in resistance, as opined by earlier investigators (Edosomwan and Shoyem, 2012). Higher infection in the older cattle could be due to the fact that older livestock may have been exposed more frequently to infective stages as they are mostly brought up through an extensive grazing practice of the nomadic cattle herders before the animal is sold and bought for slaughter (Sarkingobir, 2021). However, low prevalence of helminth parasites recorded in young cattle could possibly be because they are usually homestead thus, reducing the possibility of infection in the field (Dogo et al., 2017).

Meanwhile, the Sokoto Gudali, Red Fulani, and Mixed breed examined in this work are infected with the zoonotic helminths at different level of prevalence (Table 1). Whereas, this work found that, the Muturu breed was not infected by the zoonotic helminths. However, the prevalence of the found parasites in this work was far below 70.0% and 72,0% obtained for Red Bororo and Sokoto Gudali at Sokoto abattoir (Singh and Bello, 2017). The higher prevalence obtained for the local breed could be due to the fact that, cattle of this breed is the most predominant in the study area and very often, the extensive system of management under which they are reared, coupled with the dwindling grazing lands owing to increased food crops farming, compels them to graze in areas that could be heavily infested with the intermediate hosts, just as speculated by (Aliyu et al., 2014). The prevalence of helminth infections in relation to different cattle breeds is multifactorial: the frequency of and type of anthelmintic used, and the physiological and nutritional status of the cattle (Dogo et al., 217).

Nevertheless, in total, 108 fecal specimens were collected. Two zoonotic helminths eggs, Fasciola and Taenia were identified at prevalence rate of 10.2%, 7.4% for Fasciola and 2.8% for Taenia.

This study identified two genera of zoonotic parasites (helminths) capable of infecting humans at prevalence rate of 10.2% (Figure 1). Which appears slightly higher than 4.30% obtained from Phiri, et al. (2005) in Port Harcourt and much lower than the findings of Biu, et al. (2009) who reported an overall prevalence estimate of gastrointestinal parasites in the University of Maiduguri

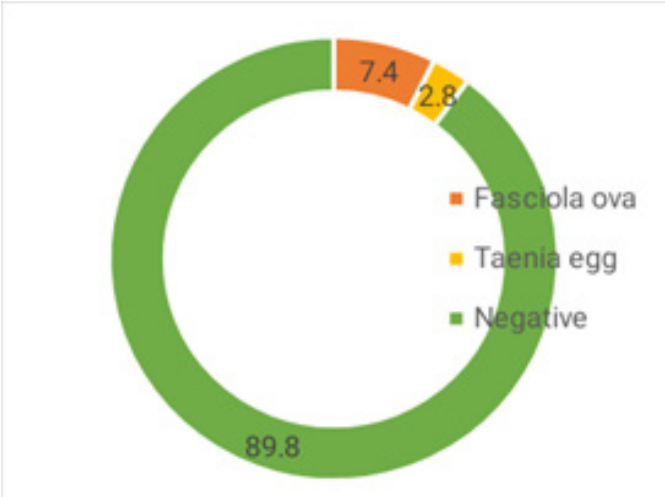

Figure 1: Occurrence of Zoonotics Parasites in cattle slaughtered at Gwadabawa Abattoir.

Research Farm at 51.3%. Our result was greatly lower than the 71.1% obtain from Singh and Bello, (2017) in cattle slaughtered at Sokoto abattoir, also dissimilar with reports from Ali, (2019) who reports 71% prevalence of F. hepatica and 18% T. saginata in cows in Mbale, Uganda. The abundant nature of these parasites could be irked by factors including grazing habits, nutritional status, husbandry, production systems, host immunological status and availability of intermediate hosts as well as the number of viable infective larvae and eggs in the environment (Karshima, et al. 2018). High immunity developed by cattle, good sanitation, and good grazing practice could yield low prevalence of zoonotic helminths (Yuguda et al., 2018).

From the health perspectives, the presence of Taenia and fasciola parasites in some samples analyzed is a public health concern, as these microbes can traverse to harm the humans by causing infection in consumers. Taenia causes a disease known as Taeniasis, an infection characterized with seizures (Gilman et al., 2012). It can traverse to reach the brain to instigate neurocysticercosis (the principal situation that can led to epilepsy), and people can feel economic burden due the disease. Thus, it is an issue to worry about (Mwangonde et al., 2014). Fasciola is among the microbes that are affecting humans, cattle, livestock and the likes. This parasite can be able to affect the liver and result in its damage entirely. Sometimes, the parasite can live in the lungs, wall of the intestine, kidney, subcutaneous tissue, and diaphragm, and lead to inflammation after tissue damages (Engdaw and Gebrie, 2015). Therefore, there is need for education and awareness among the public to elicit the public to take up healthy behaviors such as personal hygiene and environmental hygiene and chemotherapy (Engdaw and Gebrie, 2015).

CONCLUSION

Infectious diseases and malnutrition are some of the issues in Sokoto, Nigeria. Cattle is an important animal in the region that helps economically and provide food nutrients in Sokoto. However, zoonotic diseases are affecting both the cattle and human population in the state. Thus, this study objective was to determine the prevalence of zoonotic helminthes in cattle slaughtered at Gwadabawa abattoir of Sokoto State, Nigeria. Meanwhile, the prevalence of the two zoonotic helminths reported in this study are 7.4%, and 2.8% for Fasciola and Taenia respectively. This indicates a low prevalence, but considering the public health and economic importance of the parasites, measures shall be taken to bring the prevalence to a down level. Sanitary facilities are needed in the abattoir and at meat vendors' places to avoid fecal-meat contact. Other methods are needed to scuttle the chain of transmission of infections through the meat cattle.

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Central Mindanao University
Journal of Science
ISSN Print: 0116-7847 ISSN Online: 2704-3703

Filipino Soldiers' Personal Resilience, Loneliness, Stress, Sleep Quality, and Perceived Health

Joel A. Valencia, RM, RN, RGC, MAN, Charlie C. Falguera, RN, RM, MAN, and 1Lt. Stewart A. Cerbo (AGS) PA

School of Health Sciences Baler Extension Campus, University of the Philippines Manila, Barangay Reserva, Baler, Aurora 3200
School of Health Sciences (Palo, Main Campus), University of the Philippines Manila, Barangay Luntad, Palo, Leyte 6501
91st Infantry Battalion, 7th Infantry Division, Philippine Army, Barangay Reserva, Baler, Aurora 3200

ABSTRACT

The aim of this study was to determine the level of personal resilience and its relationship with loneliness, stress, sleep quality, and perceived health among Filipino military personnel during the COVID-19 pandemic. This cross-sectional study involved 259 Filipino soldiers selected through simple random sampling in the Aurora province. Five self-report questionnaires were used to gather the data, and multiple linear regression was used for the data analysis. Data were gathered in October to November 2021. The Filipino soldiers reported normal resilience levels, moderate loneliness, and good quality of sleep and perceived health, and they also reported experiencing stress fairly often. We observed that loneliness and stress were significant negative predictors of resilience and that sleep quality and perceived health were significant positive predictors of resilience. Filipino soldiers reported normal resilience levels during the COVID-19 pandemic. Soldiers who reported high levels of loneliness and stress were less likely to be resilient, and those who reported good quality of sleep and perceived health were more likely to be resilient.

Keywords: COVID-19 pandemic, personal resilience, loneliness, sleep quality, Filipino soldiers

INTRODUCTION

It has been more than two years since coronavirus disease 2019 (COVID-19) emerged in Wuhan, China in December 2019. Following its emergence, the confirmed cases increased exponentially, and COVID-19 was eventually declared a Public Health Emergency of International Concern (Sohrabi et al., 2020) and a pandemic (Mahase, 2020). In the Philippines, the first confirmed case of COVID-19 was reported on January 20, 2020 (WHO, 2020). Like other nations, the increasing number of cases of COVID-19 in the country prompted the government to impose policies, guidelines, and procedures to prevent its spread, such as travel and mobility restrictions, the avoidance of mass gatherings, individual social distancing, the use of face masks and face shields, frequent hand hygiene practices, and other quarantine measures. However, despite these measures, the number of confirmed cases continuously increased. As of December 23, 2022, there were over 4 million confirmed cases and 65,172 deaths reported in the country (DOH, 2022).

The COVID-19 pandemic affected both the physical health and the psychosocial health of individuals. Specifically, one study found that adults who perceived high levels of stress from the pandemic and had negative coping styles tended to report higher levels of emotional distress (Yan et al., 2021). In addition, reports of insomnia and other sleep disruptions became more common during the pandemic, and these disruptions made it necessary for health authorities to formulate and provide effective therapeutic interventions to prevent negative consequences (Becker, 2021).

A systematic review of quantitative studies involving Western frontline health workers demonstrated the existence of psychological problems such as stress, anxiety, depressive symptoms, sleep disturbances, and burnout in this population. However, more positively, these health workers demonstrated interest in positive coping and psychological support measures to counteract their psychological problems (Danet, 2021). In a sample of nursing students, sleep quality was reported to be poor, but their perceived health was high. Their perceived health was also positively associated with their psychological well-being, which was demonstrated by their strength and resilience and supported by their connectedness and support systems (Falguera et al., 2020). Furthermore, studies with quarantine hotel employees (Teng et al., 2020) and university teachers (Rosaldo et al., 2020) during the pandemic also indicated that these individuals experienced symptoms of anxiety, depression, and stress.

Another common negative psychological experience during the pandemic was loneliness. Importantly, the subjective experience of loneliness has been linked to the development of depression and anxiety (McQuaid et al., 2021). Additionally, Wang et al. (2022) claimed that loneliness reduces individuals' resilience. Protective measures against loneliness have been identified, such as social support, coping behaviors, resilience (Labrague et al., 2021), self-efficacy, knowledge

Corresponding author:
Joel A. Valencia, RM, RN, RGC, MAN
Email Address: javalencia4@up.edu.ph
Received: Feb. 13, 2022 ; Accepted: Oct. 25, 2023

of the risk of COVID-19, and preparedness for COVID-19 (Padmanabhanunni et al., 2021). A comparative study conducted between the Philippines and China revealed that Filipino respondents were more likely to report higher levels of depression, stress, and anxiety than the Chinese respondents. Moreover, the Filipinos were more likely to report physical health concerns, such as physical symptoms indicative of COVID-19, low confidence in the use of medical services, dissatisfaction with the country's health information, and concerns regarding contact with COVID-19 (Tee et al., 2021).

During the pandemic, maintaining domestic order in society is integral. This role has been assumed by groups of people who have the authority to defend and protect the citizenry, such as the military (also known as soldiers). The military are placed on the front line to protect the people from crimes, terrorism, and violence, and military personnel also respond to health threats (Agulto, 2020) by filling the gaps in public health capabilities. For example, the military help to monitor public health programs, facilitate and guide health workers in mobilizing the flow of health information, and remind people to follow the protocols and community quarantine measures for preventing the spread of the disease. On the borders, the military are involved in checking passengers' body temperatures and the presence of other COVID-19 symptoms, as well as authorizing people or transactions to proceed across the borders (Alconel, 2020). Furthermore, the military provide logistical support, such as transporting food or essential supplies or increasing hospital capacities. During humanitarian emergencies, military forces assume their public health responsibilities to support people who are inadequately provided for by civilian health programs. During the COVID-19 pandemic, the military have been called to their duties and have risked their lives to ensure the security and safety of the Filipino people who are affected by or at risk of this serious disease.

The presence of COVID-19 is new to everyone, and the COVID-19 pandemic has caused many unprecedented challenges for the general population across the globe. Military personnel are committed and dedicated to their sworn duty even during health crises such as the COVID-19 pandemic, and they are known to be brave and highly trained. Given these responsibilities and characteristics of military personnel, the researchers aim to investigate the psychosocial well-being of military personnel during the COVID-19 pandemic. Indeed, as human beings, military personnel have vulnerabilities. Like all other frontline personnel, they are at risk of the consequences of COVID-19 and the community lockdown measures. The findings of this study will guide high-ranking military officials and health authorities to design and implement strategies, programs, and policies for promoting the mental health of military personnel. Specifically, the findings of this study may help in designing a comprehensive mental health program, mental health and resilience activities, mental health seminars and workshops, and the like that will prevent development of mental health issues brought by any crisis like the COVID-19 pandemic while working as front liners and protectors of the civilian people. Likewise, this empirical evidence may provide insights to other soldiers that, as they are also human beings, they should not be consumed on the stigma or inhibitions associated with having mental health problems because such problems are a reality that needs proper behavioral management. Moreover, this study is one of the first preliminary studies to be conducted to investigate the psychosocial characteristics of military personnel in the Philippines.

Aims

This study aims to determine the perceived level of personal resilience and its relationship to loneliness, stress, sleep quality, and perceived health among Filipino military personnel during the COVID-19 pandemic. Specifically, the researchers propose the following hypotheses:

1. There is a significant negative relationship between Filipino military personnel's level of personal resilience and their perceived stress and loneliness.
2. There is a significant positive relationship between Filipino military personnel's level of personal resilience and their sleep quality and perceived health.

METHODOLOGY

Research Design

This was a cross-sectional study that used data collected through personal surveys from October 2021 to November 2021.

Respondents and Study Setting

The study population included military personnel from the 91st Infantry (Sinagtala) Battalion, 7th Infantry (Kaugnay) Division of the Philippine Army. The headquarters are in Barangay Calabuanan, Baler, Aurora. The battalion has four (4) line companies situated across the Aurora Province (Alpha Company in Dingalan, Bravo Company in Dinalungan, Charlie Company in San Luis, and Delta Company in Baler). For inclusion in the study, the military personnel had to have worked in the military for at least one year during the pandemic, and they had to provide consent to participate in this study. Military personnel who had signs and symptoms of COVID-19 and those who were on leave during the survey period were excluded.

Sampling Technique and Sample Size Determination

There are a total of 418 military personnel, including 19 military officers, in the 91st Infantry (Sinagtala) Battalion. Because of the constraints in terms of financial resources, availability of the respondents, and time, the researchers intended to determine the sample size. Initially, the researchers used the Slovin's formula in calculating the sample size as the researchers have no idea about the population's behavior. With this formula, the sample size needed for this study is 201. However, the researchers intended to go beyond the target sample size to have a better representative of the population and thus will provide more accurate results. One of the researchers is a member of military personnel in this battalion and, thus, was excluded from the study population. The respondents were selected through the simple random technique. Specifically, a sample frame was prepared within the

battalion, including the line companies, all the population elements were numbered from 1 to 417, and random numbers generated through Excel were used to determine the simple random sample. Those selected respondents who refused to participate in this study were replaced by respondents identified using the same procedure who had not been selected in the prior sampling procedure. This technique continued until the desired number of respondents was achieved.

Research Instruments

A self-report questionnaire was used to gather the data. The demographic characteristics of the respondents were assessed using a checklist, including their age, sex, work position, net monthly income, and the presence of communication with family and loved ones.

To assess the respondents' personal resilience, the six-item Brief Resilience Scale was used (Smith et al., 2008). The items were rated on a five-point Likert scale ranging from 1 = "almost never" to 5 = "almost always". The Cronbach's alpha reliability score of this scale in a previous study was 0.91 (Labrague & De los Santos, 2020), and the Cronbach's alpha of this scale in the current study was 0.95.

The overall loneliness of the respondents was assessed using the six-item Loneliness Scale (Gierveld & Tilburg, 2006). The respondents answered the items on the questionnaire by choosing between three options: "yes", "more or less", or "no". A score of 1 was given when respondents answered "yes" or "more or less", and a score of 0 was given when respondents answered "no". The overall scores ranged from 0 to 6 and were categorized into three groups: 0–1 = "not lonely", 2–4 = "moderately lonely", and 5–6 = "severely lonely". A previous study using this scale demonstrated good internal consistency, with a Cronbach's alpha reliability value of 0.87 (Labrague et al., 2021), and the Cronbach's alpha of this scale in the current study was 0.72.

Perceived stress was measured using the four-item Perceived Stress Scale (Cohen et al., 1983). The items were rated on a five-point Likert scale ranging from 0 = "never" to 4 = "very often". The internal consistency and reliability of this scale were demonstrated by Figalova and Charvat (2021) who reported a Cronbach's alpha of 0.83. The Cronbach's alpha of this scale in the current study was 0.90.

A single-item questionnaire was used to measure the respondent's perceived health during the COVID-19 pandemic. The respondents were asked the following question: "Taking everything into consideration, how would you rate your health in general these days?". The response options were from 1 = "poor" to 5 = "excellent". The use of a single-item scale provides a valid, holistic measure. Given that responses for this measure are provided on a Likert scale, the analysis of this measure is statistically robust on the item level (Atroszko et al., 2015; Carifio & Perla, 2007)

Similarly, a single-item measure was used to assess the sleep quality of the respondents. This measure was developed by Snyder et al. (2018) and involves a single question: "During the past 7 days, how would you rate your sleep quality overall?". The response options for this question ranged from 0 = "terrible" to 10 = "excellent". The scores were interpreted according to five categories: 0 = terrible, 1–3 = poor, 4–6 = fair, 7–9 = good, and 10 = excellent. In a previous study, the tool provided favorable measurement characteristics, with a test-retest reliability score of 0.62 and an intraclass correlation coefficient of 0.74 (Snyder et al., 2018)

Data Collection Process

An administrative approval letter was secured from the Commanding Officer of the 91st Infantry Battalion, 7th Infantry Division of the Philippine Army to conduct the study with their personnel. Upon approval, the researchers coordinated with the line company heads and headquarters in charge to contact the potential respondents selected through simple random sampling. The researchers also secured a letter of approval and consent from each respondent indicating that they thoroughly understood the study in terms of its purposes, benefits, and possible risks. Participation in the study was voluntary, and the respondents could withdraw their participation at any time.

The target respondents were invited to an isolated, well-light, private area with open-air circulation within the quarters. These were performed to ensure privacy of the respondents in answering the survey questionnaire as well as in maintaining confidentiality of the responses. The survey, although was conducted in an private area, the respodents were still within the premises of their workplace. Moreover, the surveys were ensured that it followed the health protocols in preventing the spread of COVID-19. Only one respondent was present per survey session. The respondents were given 3 to 5 minutes to ask questions and seek clarification before participating in the study. Additionally, allowing them to ask questions and clarifications facilitate building rapport and ease in participating the study. The survey questionnaire lasted for 15–20 minutes. One of the researchers is a registered guidance counselor, and two of the researchers have basic training in mental health first aid. Those researchers were available to provide further assessment, counseling or psychological intervention, or a referral if the respondents experienced discomfort when answering the survey questionnaire. Fortunately, throughout the data gathering period, no respondents reported to have discomforts while answering the survey questionnaire. All the questionnaires collected were inspected as to the completeness and adequacy of the information provided. The questionnaires were given in English. At the end of the questionnaire, the respondents were given a message of gratitude for their participation.

Data Analysis

After completing the data collection, the information gathered was automatically tallied in a Google spreadsheet. The data were then entered into SPSS version 23 software (IBM Corp., Armonk, NY, USA) for statistical analysis. The descriptive statistics included frequency counts, percentages, weighted arithmetic mean,

and standard deviation. The inferential statistics applied to answer the research questions included the Pearson's R moment correlation coefficient and multiple linear regression analysis. The level of significance was set at $p < 0.05$.

Ethical Considerations of the Study

Approval from the commanding officer was obtained through a communication letter. Written consent was secured from every respondent before the data collection. The confidentiality and anonymity of the respondents were ensured throughout the study, and their names were not collected in the personal survey. Possible risks during this study included breaches of confidentiality and the associated consequences. The respondents were not paid for their participation. They were informed that they could withdraw their participation in the study at any time during the data collection period. Moreover, the researchers declared no conflicts of interest regarding this study. The data collected were utilized only for the purpose of this work. There was no available review ethics board within or near the research locale, but the study was conducted within the ethical principles of medical research involving human respondents as stipulated in the World Medical Association Declaration of Helsinki. Moreover, this study was approved by the research ethics committee of the college in following the technicalities and research ethics principles involving human respondents.

RESULTS AND DISCUSSION

A total of 259 military personnel participated in the study. The vast majority of the respondents were male (n = 252 or 97.29%), and the mean age was 31.64 years (SD = 5.98). The majority were working in a military enlisted rank (n = 241 or 93.1%), and the most common net monthly income in the sample was P30,000 to P39,000 (n = 112 or 43.24%). Table 1 shows the summary of the socio-demographic profile of the respondents.

Table 2 presents the descriptive results of the variables of interest. The mean score on the resilience scale was 3.41 (SD = 1.11). The overall mean score on the loneliness scale was 1.83 (SD = 0.36); specifically, the mean score on the social loneliness subscale was 1.81 (SD = 0.64), while the mean composite score on the emotional subscale was 1.86 (SD = 0.56). The mean score on the

Table 1. Descriptive statistics of the soldiers' demographic characteristics (n = 259)

Characteristic	Frequency	%
Age		
Mean = 31.64 years		
SD = 5.98 years		
Sex		
Male	252	97.29
Female	7	2.71
Work Position		
Military Enlisted Rank	241	93.05
Military Officer Rank	18	6.95
Net Monthly Income		
Less than P10,000	11	4.24
P10,000 to P19,000	40	15.44
P20,000 to P29,000	58	22.39
P30,000 to P39,000	112	43.24
P40,000 to P49,000	25	9.65
P50,000 to P59,000	9	3.50
P60,000 to P69,000	4	1.54

Table 2. Descriptive statistics of the key variables

Variable	Mean	SD
Resilience	3.41	1.11
Loneliness	1.83	0.36
Emotional Loneliness	1.86	0.56
Social Loneliness	1.81	0.64
Perceived Stress	3.01	0.28
Sleep Quality	7.82	2.11
Perceived Health	4.48	0.79

Table 3. Correlations between resilience and psychological responses

Variables	1	2	3	4	5
1. Resilience	1				
2. Loneliness	−.195**	1			
3. Perceived Stress	−.150*	.060	1		
4. Sleep Quality	.195**	.001	.134	1	
5. Perceived Health	.268**	−.194**	.010	.399*	1

Table 4. Regression analysis on the influence of resilience on psychological responses

Independent Variables	B	SE	β	t	p-values	95% CI
Constant	4.461	.870		5.127	<.001	2.747 to 6.174
Loneliness	-.456	.182	-.150	-2.500	.013	-.815 to -.097
Stress	-.647	.235	-.163	-2.750	.006	-1.111 to -.184
Sleep Quality	.076	.034	.145	2.236	.026	.009 to .142
Perceived Health	.256	.091	.183	2.800	.005	.076 to .435

perceived stress scale was 2.01 (SD = 0.28). Finally, the mean composite scores on the sleep quality and perceived health scales were 7.82 (SD = 2.11) and 4.48 (SD = 0.79), respectively.

Table 3 presents the correlations between resilience and psychological responses among the military personnel. There was a significant negative relationship between resilience and the respondents' overall loneliness levels ($r = -0.195$, $p < 0.01$) and perceived stress levels ($r = -0.150$, $p < 0.05$). Furthermore, there was a significant positive relationship between the respondents' resilience and their sleep quality ($r = 0.195$, $p < 0.01$) and perceived health ($r = 0.268$, $p < 0.01$). Notably, there was also a significant negative relationship between respondents' overall loneliness and perceived health ($r = -0.194$, $p < 0.01$) and a significant positive relationship between perceived health and sleep quality ($r = 0.399$, $p < 0.05$).

Table 4 depicts the results of the multiple linear regression analysis to determine the predictors of resilience. The regression model was statistically significant ($F = 9.567$, $p < 0.001$) and accounted for 13.1% of the variance in personal resilience. Overall loneliness and perceived stress were statistically significant negative predictors of resilience ($\beta = -0.150$, $p = 0.013$ and $\beta = -0.163$, $p = 0.006$, respectively). This finding indicates that the military personnel with high levels of loneliness and perceived stress were more likely to report low personal resilience, thus supporting hypothesis 1. On the contrary, sleep quality and perceived health were statistically significant positive predictors of resilience ($\beta = 0.145$, $p = 0.026$ and $\beta = 0.183$, $p = 0.005$, respectively). This result indicates that military personnel with high scores on sleep quality and perceived health were more likely to report high personal resilience levels, thus supporting hypothesis 2.

DISCUSSION

The purpose of our study was to determine the resilience levels of military personnel and their association with loneliness, stress, sleep quality, and perceived health. The results of our study showed that the military personnel demonstrated considerable personal resilience during the COVID-19 pandemic. Personal resilience is the ability of an individual to recover, adapt, or adjust in response to adversity, misfortune, threats, trauma, and other kinds of pressure or stressors (Garcia-Dia et al., 2013). The previous literature shows that these stressors and adversities are antecedent factors that are required for the development of resilience.

Indeed, it is clear that the COVID-19 pandemic has been the major stressor and health threat in the past 2 years for the global population. Depending on an individual's perception and response to the stressor, they may be able to develop certain protective factors, which may ultimately reduce the negative effects of the stress, risk, or threat (Garcia-Dia et al., 2013).However, personal resilience does not rely only on external factors (i.e., the COVID-19 pandemic and other situational or environmental particularities) but also on internal factors such as the individual's abilities and traits (Chiu et al., 2021). In addition, the majority of our respondents were relatively young, and previous studies have shown that, in the military field, younger age is one of the basic determinants of resilience (Fogle et al., 2020; Valladares-Garrido et al., 2022).

Overall, the soldiers in this study reported themselves to have been "moderately lonely", including in terms of both the emotional and social loneliness sub-scales, during the COVID-19 pandemic. Additionally, the soldiers reported experiencing stress "fairly often". Individuals working in the military or security fields are generally exposed to various stressful conditions as part of their daily routines and duties (Goodwin et al., 2015). Indeed, military personnel are known to experience long periods of isolation and fears for their safety when in operation. Furthermore, military personnel also carry the burden of responsibility for the safety and security of the citizenry and assume other roles and military tasks that could aggravate their perceived stress (Schaubroeck et al., 2011), especially during a health threat such as the COVID-19 pandemic.

Interestingly, despite the COVID-19 pandemic, the military personnel reported having good sleep quality and perceived health. This finding regarding sleep quality

contrasts with a previous study that reported that soldiers on active duty and with an enlisted rank were more likely to have poor sleep than those in the reserve section or with an officer rank (Lentino et al., 2013). A more recent study revealed similar finding indicating a good sleep quality and a lower insomnia prevalence among soldiers working during th COVID-19 pandemic. It claimed that having a good quality of sleep among soldiers was partially attributable to changes within the military operations such as working within the health protocols in preventing the spread of COVID-19 (Markwald et al., 2021). The report of good perceived health by the military personnel in this study is similar to the results of previous studies, which emphasized the need to support soldiers to engage in aerobic and strength exercises (Warr et al., 2013) as well as good dietary habits (Hollerbach et al., 2022) during deployment. Perceived health, otherwise known as self-rated health, is an individual's cognitive interpretation of their physiological and psycho-social status, and the metric of perceived health is widely known and useful for assessing an individual's health (Golenbock et al., 2017). Our study further demonstrated the positive relationship between sleep quality and perceived health. This finding is consistent with a previous study that linked sleep quality with physical performance, nutritional habits, and emotional, social, and family health (Warr et al., 2013). Moreover, short sleep duration and low sleep quality have been associated with adverse mental health outcomes such as depression and substance abuse (Kim et al., 2016).

The first and second hypotheses were confirmed by the results of the present study. Indeed, the results demonstrated the negative influence of loneliness and stress on personal resilience. Previous studies have associated both loneliness (Grossman et al., 2021) and stress (Liu et al., 2016) with low resilience. Paradoxically, stress is also regarded as an important factor in developing psychological resilience. Therefore, it is important to carefully consider the timing of research studies in relation to events such as health crises and the number or severity of stressful life events experienced by an individual, which, instead of developing resilience, may lead to mental health vulnerabilities (Arora et al., 2022). Nevertheless, resilience has been identified as a protective factor against various stressors, and those individuals who report high resilience are less likely to report mental health problems (Chen et al., 2018).

Furthermore, our study also showed that sleep quality and perceived health positively influenced resilience in the military personnel. This finding supports a more recent systematic review and meta-analysis that reported that healthy individuals who achieve enough sleep and good quality sleep are less likely to have chronic diseases and more likely to have better hormone regulation. Accordingly to that study, those individuals may have better coping mechanisms against various stressors and, thus, may ultimately develop higher levels of resilience (Arora et al., 2022). Similarly, a study among police officers showed that those who had better perceived health were more resilient during the COVID-19 pandemic (Talavera-Velasco et al., 2021).

To date, there has been limited research on personal resilience, loneliness, stress, sleep quality, and perceived health in the Filipino military population. The results of our study may guide the government leaders, military officials, and mental health agencies and advocates in designing and strengthening mental health and resilience programs and services for the military personnel who are always on duty to protect the Filipino people even during health crises. During health crises such as the COVID-19 pandemic, fostering resilience is key to reducing the negative psychological consequences of the crisis and improving the overall health of the military personnel.

CONCLUSIONS

This study provides information about personal resilience and psychological responses among Filipino military personnel during the COVID-19 pandemic. Overall, Filipino soldiers are resilient even when experiencing moderate stress and loneliness. The military personnel reported having good sleep quality and perceived health status. Furthermore, the results highlight the negative influence of loneliness and stress and the positive influence of sleep quality and perceived health on the soldiers' personal resilience.

Limitations of the Study

This study acknowledges some limitations. Firstly, the data were obtained through self-reports and, thus, may not truly reflect the actual psychological responses and resilience levels of the soldiers. Secondly, the cross-sectional design used in this study means that causal relationships cannot be inferred between the variables of interest. Thirdly, the respondents were recruited only from the 91st Infantry (Sinagtala) Battalion, 7th Infantry (Kaugnay) Division of the Philippine Army, and the results may not be applicable to other soldiers from various infantry battalions across the Philippine archipelago. Therefore, further related studies must be conducted, such as a longitudinal study, that can clearly determine the causal relationships between the variables of interest and provide results that are generalizable to the entire military personnel population of the country.

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Central Mindanao University
Journal of Science
ISSN Print: 0116-7847 ISSN Online: 2704-3703

Assessment of Diet, Breastfeeding and Sanitation in Brgy. Bukang Liwayway Kibawe, Bukidnon: A Cross-Sectional Study

Wilmar Jun O. Elopre, Marivic B. Lazar and Frank Clint L. Tamayo*

Department of Nutrition and Dietetics, College of Human Ecology, Central Mindanao University
University Town, Musuan, Maramag, Bukidnon, 8714 Philippines

ABSTRACT

In the Philippines, especially in far-flung areas where poverty is still common, malnutrition remains a significant problem. Factors contributing to malnutrition and their interplay with poverty in impoverished areas of the Philippines are not thoroughly investigated. An assessment of the different nutritional, health, and social factors are needed to address poverty-linked malnutrition in Brgy. Bukang Liwayway and similar contexts. One hundred forty-five (145) households that served as sampling units were randomly selected. Two (2) 24-hour food recalls were conducted to capture the usual dietary intakes and diet diversity. Questionnaires were adapted, pre-tested, and used to assess the breastfeeding knowledge, attitudes, and practices (KAP) and the Water, Sanitation, and Hygiene (WaSH) situation. Multiple nutrients were found to be inadequate in the usual diet of the participants compared with the dietary reference intakes, namely: fat (56.27%), fiber (51.24%), vitamin A (66.90%), iron (44.94%), vitamin C (70.90%), thiamin (25.56%), and riboflavin (56.67%). The mean SD diversity score of the households was 5 ± 1.25, which indicates that the typical diet was not particularly diversified. There were alarming knowledge deficits on crucial aspects of breastfeeding, such as only a few mothers/caregivers knew the meaning (20.69%) and the physical benefits of exclusive breastfeeding to a mother (17.24%). There were also sanitary and hygiene issues needed to be addressed, such as open defecation, poor toilet facilities, a lack of soap, and occasional handwashing. The study showed that there were significant inadequacies in dietary intake, breastfeeding, and sanitation practices that need to be addressed and developed into evidence-based strategies aimed at effectively combating poverty-linked malnutrition in the region.

Keywords: Nutrition-supportive interventions, malnutrition, diet diversity, breastfeeding, Water, Sanitation, and Hygiene (WaSH)

INTRODUCTION

Poverty remains one of the world's most severe problems and the most significant impediment to development. It has many faces, and the most threatening among them are hunger and malnutrition (Peña & Bacallao, 2002). Malnutrition is a lack, surplus, or imbalance of calories and nutrients (Soeters et al., 2017). It is characterized by various forms of under- or overnutrition, which results in alterations in body composition and bodily function and deterioration of health. Malnutrition has been linked to poverty, since places with chronic poverty have higher malnutrition rates (Setboonsarng, 2005). Poverty causes hunger, which in turn leads to malnutrition. It creates a loop from which individuals are unable to break free. Malnourished people tend to be sickly and less productive, leading to continued poverty and hunger. In this premise, a two-way relationship is noted between poverty and malnutrition, in which they are both the cause and the result of one another (Siddiqui et al., 2020).

Despite social and economic progress, the global burden of malnutrition remains unreasonable. According to recent data, 800 million people are suffering from malnutrition, with 98% living in low- to middle-income nations, mainly in Sub-Saharan Africa and South Asia (Webb et al., 2018). In the Philippines where poverty is still common, different forms of malnutrition remain a significant problem. According to the recent National Nutrition Survey results, the prevalence rates for underweight, wasting, and stunting among children under five years old were 19%, 5.7%, and 29.5%, respectively, which can all be interpreted as a public health problem of magnitude or severity ranging from medium to high (DOST-FNRI, 2022). The prevalence rates of undernutrition were highest among children under five who belonged to the poorest wealth quintile. The same pattern was observed among adults, as the prevalence rate of Chronic Energy Deficiency (CED) was highest among those who belonged to the poorest quintile (10.9%) (DOST-FNRI, 2022). Iodine deficiency and anemia rates were highest among pregnant women, while vitamin A deficiency (VAD) was highest among children under five years old (DOST-FNRI, 2022). Across all these micronutrient deficiencies, the rates have been recorded to be highest among those under the poorest wealth quintile.

Aside from poverty, there are other factors considered closely related to malnutrition. According to Ulep (2021), undernutrition during pregnancy, child nutritional deficiencies, and recurrent illness are three stressors that can lead to malnutrition in the early stages of life. These proximal pressures in the route for

Corresponding author:
Wilmar Jun O. Elopre
Email Address: wilmarjun.elopre@cmu.edu.ph
Received: Feb. 28, 2022 ; Accepted: Sept. 27, 2023

undernutrition are strengthened by distal variables such environment, mother and child health behaviors, and food security. Optimal child feeding refers to following the guidelines for infant and young child feeding (IYCF) practices, which include age-appropriate supplementary feeding and exclusive breastfeeding for the first six months of a child's life. Improper IYCF practices lead to malnutrition and/or infant death (Reinbott & Jordan, 2016). On the other hand, poor Water, Sanitation, and Hygiene (WaSH) can lead to the rise of infections in communities (Hutton and Chase, 2017). Constant infection exposure has a deleterious impact on children's linear development. Infective diseases reduce food intake, affects nutrition absorption, and hinders nutrient delivery to target organs (Dewey and Mayers, 2011). Malnutrition has a multi-level and wide-ranging cause, necessitating a multi-factorial strategy to eradicate it (Reinhardt & Fanzo). However, the investigation in the existing literature on the diverse factors contributing to malnutrition and a clearer understanding of the complex interplay between poverty and malnutrition is still scant. Therefore, an assessment of various factors linked with malnutrition is warranted to bridge this gap and contribute to the development of evidence-based strategies to address poverty-linked malnutrition in Brgy. Bukang Liwayway and similar contexts. This study is aimed to assess the nutrition, breastfeeding knowledge, attitudes, and practices (KAP), and WaSH condition in Barangay Bukang Liwayway, Kibawe, Bukidnon.

METHODOLOGY

Research Design and Sampling

The study employed a cross-sectional descriptive research design that gathered survey data from select households of Barangay Bukang Liwayway, Kibawe, Bukidnon, which is a certified Geographically Isolated and Disadvantaged Area (GIDA). Using Cochran's formula at 95% confidence interval, the minimum number of households served as sampling units was computed to be one hundred forty-five (n=145). Stratified random sampling was employed to select the identified number of sampling units out of the two hundred thirty-two (232) households living in the area at the time of the survey across all puroks. One adult (>18 years) participant from each sampling unit/household present at the time of the survey visit was randomly chosen through the lottery method to be interviewed for individual nutrient intakes, household food consumption and diet diversity, and WaSH assessment. Twenty-nine (29) mothers/caretakers with at least one (1) <6-month-old infant within the identified sampling units were then interviewed for their IYCF knowledge, attitudes, and practices. The survey started in March and ended in June 2021, which took four (4) months to complete.

Ethical Considerations

The researcher complied all the relevant international/national protocols and regulations to maintain ethical standards. An ethical clearance/permit was secured from the Institutional Ethics Review Committee of Central Mindanao University (IERC Control Number: 0273 s. 2021).

Research Instruments

The questionnaires used were based on pre-existing and validated questionnaires. The questionnaire utilized for breastfeeding KAP was adapted from a WHO's infant and young child feeding module, which tackled the indicators used in the assessment of IYCF (WHO, 2010). The adapted questionnaire only comprised knowledge, attitudes, and practices on breastfeeding, while the other indicators of IYCF, such as complementary feeding, were not included. On the other hand, the questionnaire employed for the WaSH assessment was based on the WaSH KAP tool of the United Nations High Commissioner for Refugees (UNHCR, 2020). The indicators included in the final questionnaires were the following: water quantity, water quality, water access, sanitation, hygiene, and health (incidence of diarrhea). The questionnaires were then pre-tested for validity and reliability. A panel comprised of two (2) barangay health workers, two (2) registered nutritionist-dietitians, and one (1) public health nurse reviewed the content validity of the items. To determine whether the questionnaires were reliable, Cronbach alphas were computed using statistical software. According to the results of the reliability analyses, the Cronbach alphas of the data entered were 0.842 for breastfeeding KAP and 0.856 for WaSH, indicating good reliability. The items with weakest correlations with the other items were removed and the final versions were translated into local language.

Data Collection Procedure

The data collection started from the beginning of April 2021 to the end of June 2021 for a total duration of three (3) months. Two (2) non-consecutive 24-hour food recalls were conducted to capture the nutrient intakes. The respondents for the food recall were interviewed for the first time on a Sunday and the second time on a Wednesday. The administration of survey questionnaires for diet diversity, breastfeeding KAP, and WaSH was conducted on the same respondents but on different days. The data collection was conducted during the COVID-19 pandemic, so strict public health protocols were implemented during the interview.

Data Analysis

To assess the intake of the participants, the Dietary Reference Intakes (DRIs) of the Philippine Dietary Reference Intakes (PDRI) were used as the benchmark of adequacy. Most of the participants were middle-aged (i.e., 30-49 years) (see Table 1), thus this age group was used as the point of comparison. The DRIs for energy, fiber, and sodium are based on the Recommended Energy-Nutrient Intakes (RENIs, F 30-49 y/o). The DRIs for fat and simple sugars are computed based on the minimum Acceptable Macronutrient Distribution Range (AMDR, adults >19 y/o), the DRIs for saturated fatty acid and cholesterol are based on the standards set in the Therapeutic Lifestyle Change (TLC) dietary approach, and the rest are based on the Estimated Average Requirement (EAR, F 30-49 y/o) of the PDRI. The study is purely descriptive, so only descriptive statistics (i.e., frequency, mean, percentages, and standard

Table 1. Socio-demographic profile of adults (n=145) in Brgy. Bukang Liwayway, Kibawe, Bukidnon

Socio-Demographic Factor	Frequency (n)	Percentage (%)
Sex		
Male	33	22.76
Female	32	77.24
Age		
19-29 y/o	29	20
30-49 y/o	83	57.24
50-59 y/o	21	14.48
60-69 y/o	12	8.28
Civil Status		
Single	16	11.03
Married	101	69.66
Separated	5	3.45
Cohabitating	23	15.86
Educational Attainment		
Elementary Level	41	28.28
Elementary Graduate	18	12.41
High School Level	50	34.48
High School Graduate	18	12.41
College Level	13	8.97
College Graduate	5	3.45

deviation) were utilized to answer research objectives. The processed data were then presented through graphs and tables.

RESULTS AND DISCUSSION

Socio-Demographic Profile

The socio-demographic characteristics of participants from the selected household sampling units (n = 145) are shown in Table 1. The mean age was 40.52 years (SD = 11.59). Regarding gender, the respondents were predominantly female (77.24%). The civil status of the participants was mostly married (69.66%). The educational attainment of most respondents includes high school level (34.48%), followed by the elementary level at 28.28%, with college level as the least frequent educational attainment (8.97%).

Nutrient Intakes

The usual energy and nutrient intakes per day of the respondents are shown in Table 2. The mean energy intake of 1053.54 kcal/day only met 56.34% of the Recommended Energy Intake (RE) of 1870 kcal/day for females aged 30-49 years. This is considered an inadequate intake. The means for macronutrients are as follows: protein (44.60 g/d), total fat (17.54 g/d), and dietary fiber (11.53 g/day). All these intakes were assessed to be inadequate, except for protein which met 91.02% of the Estimated Average Requirement (EAR) of 49 g for females aged 30-49 years.

A similar pattern in these findings was noted from the results of the 8th National Nutrition Survey conducted by the Food and Nutrition Research Institute in 2013, wherein the intakes for energy, fat and dietary fiber were found to be inadequate, except for protein which was determined to be adequate (Patalen et al., 2020). From the results of the more recent Expanded National Nutrition Surveys conducted in 2018 and 2019, the mean individual energy intake was computed to be lower than the Dietary Reference Intake (DRI), with protein intake met adequately by a significant number of individuals in the adult age group, a pattern still similar to the findings of this study (DOST-FNRI, 2022). Meeting the recommended levels of energy intake is significant to prevent unhealthy weight loss, chronic energy deficiency (CED), and excessive accumulation of body fat (overweight and obesity), which were found to affect health and productivity outcomes adversely (Bishwajit, 2017). It is also important to have balanced intake of fat and dietary fiber to reduce the risk of non-communicable diseases (NCDs) like cardiovascular diseases (McRae, 2017).

The means for micronutrient intakes are as follows: calcium (637.36 g/d), phosphorus (488 mg/day), iron (11.82 g/day), vitamin A (289.67 mcg RE), thiamin (0.23 mg/day), riboflavin (0.51 mg/day), niacin (11.06 mg/day) and vitamin C (36.87 mg/day). Compared to their EARs, only their calcium, phosphorus, and niacin intakes were considered adequate. The results of the NNS and ENNS have consistently shown inadequate iron and vitamin C intakes and adequate niacin intake among Filipinos (Patalen et al., 2020). In the more recent results, high prevalence rates of inadequate vitamin A, thiamin, and riboflavin intakes have been observed across age groups

Table 2. Mean ± SD energy and nutrient intakes among adults (n=145) in Brgy. Bukang Liway-way, Kibawe, Bukidnon

Nutrient	Mean ± SD Intake	DRI	%DRI	Interpretation
Energy (kcal)	1053.54 ± 379.70	1870	56.34	INADEQUATE
Protein (g)	44.60 ± 19.23	49	91.02	ADEQUATE
Fat (g)	17.54 ± 15.76	31.17	56.27	INADEQUATE
Fiber (g)	11.53 ± 6.54	22.50	51.24	INADEQUATE
Calcium (mg)	637.36 ± 423.90	600	106.23	ADEQUATE
Phosphorus (mg)	488.00 ± 233.93	580	84.14	ADEQUATE
Iron (mg)	11.82 ± 4.14	26.30	44.94	INADEQUATE
Vitamin A (mcg RE)	289.67 ± 308.65	433	66.90	INADEQUATE
Thiamin (mg)	0.23 ± 0.11	0.90	25.56	INADEQUATE
Riboflavin (mg)	0.51 ± 0.32	0.90	56.67	INADEQUATE
Niacin (mg)	11.06 ± 5.11	11	100.55	ADEQUATE
Vitamin C (mg)	36.87 ± 32.12	52	70.90	INADEQUATE
Simple sugars (g)	29.68 ± 22.51	<46.30	64.13	GOOD
Sodium (g)	2.58 g ± 2.35	<2	129.65	EXCESSIVE
Saturated fatty acid (g)	6.80 g ± 8.04	<14.35	47.42	GOOD
Cholesterol (mg)	64.72 ±107.97	<300	21.57	GOOD

(DOST-FNRI, 2022). The notable deviation from that of the results of NNS/ENNS is the adequate intakes of calcium and phosphorus found in this study, which is attributed to a high intake of calcium- and phosphate-rich dried fish observed in this particular sub-population. Although micronutrient deficiencies are still a significant public health problem in the Philippines, prevalence of inadequate micronutrient intake has declined in Southeast Asia over the past 50 years (Beal et al., 2017). Consistent with the national government's efforts against micronutrient deficiencies, the provision of nutrition-supportive activities that increase micronutrient intakes (e.g., supplementary feeding, micronutrient supplementation, conditional cash transfers, improved farm-to-market roads) must be strengthened to further reduce the problem, especially in geographically isolated and disadvantaged areas (GIDAs). Micronutrients have a plethora of indispensable biological functions in the human body, notably being important in bone health (e.g., calcium and phosphorus), in the maintenance of immunocompetence and high reductive capacity against oxidative damage (e.g., vitamins A and C), in the maintenance of healthy blood production (e.g., iron) and energy metabolism (e.g., thiamin, riboflavin and niacin) (Shergill-Bonner, 2017).

The usual intakes per day for nutrients linked with the incidence of non-communicable diseases (NCDs) are also shown in Table 2. The intakes for simple sugars (29.68 g/day), saturated fatty acid (6.8 g/day), and cholesterol (64.72 mg/day) met the criteria for good/healthy intakes as per the PDRI. However, sodium intake (2.58 g/day) was found to be excessive, and this was due to a high intake of dried fish observed in the area. One of the main dietary risks for mortality and morbidity is high sodium (Na) consumption (Naser et al., 2020). Thus, it is suggested to reduce the intake of dried fish and increase the intake of other calcium- and phosphate-rich foods (e.g., dairy products) to bring about changes in the sodium intake and consequently reduce the risk of NCDs (Lari et al., 2021).

Diet Diversity

The percentages of households (n = 145) getting each of the dietary diversity scores (DDs) are given in Figure 1. Dietary diversity scores represent how well people obtain all the nutrients they require, since the more food groups consumed, the better their diet. If their diet is monotonous, the opposite is true. In other words, DDS is intended to demonstrate nutritional sufficiency. Increased nutritional adequacy of the diet is linked to an increase in individual DDS (FAO, 2010). The mean dietary diversity score of the participants was 5, which is interpreted as "moderate" dietary diversity on the scale. Most households (26.6%) had a dietary diversity score of 4, which is also interpreted as "moderate" dietary diversity in the lower range of the scale. A "high" dietary diversity was received by 28.3 percent of the households (those who had, 6, 7, or 8 DDS), while 5.5% of the households had "low" dietary diversity (DDS = 3). Studies have consistently shown that diverse diets promote optimal health, prevent malnutrition, and guard against a wide range of chronic illnesses and morbidity (Bi et al., 2019; Afshin et al., 2019; Hatloy et al., 1998).

Food Consumption

The percentages of households (n = 145) consuming each food group included in the dietary diversity analysis are shown in Figure 2. This complements the analysis of nutrient intakes and dietary diversity scores presented previously. The top 3 food groups consumed by the respondents were starchy staples (100%), fish, shellfish, and products (100%), and dark-green leafy vegetables (85.71%), while the three food groups that were the least eaten were flesh meats and products (14.26%), organ meats (5.71%) and eggs (5.71%). The low prevalence of

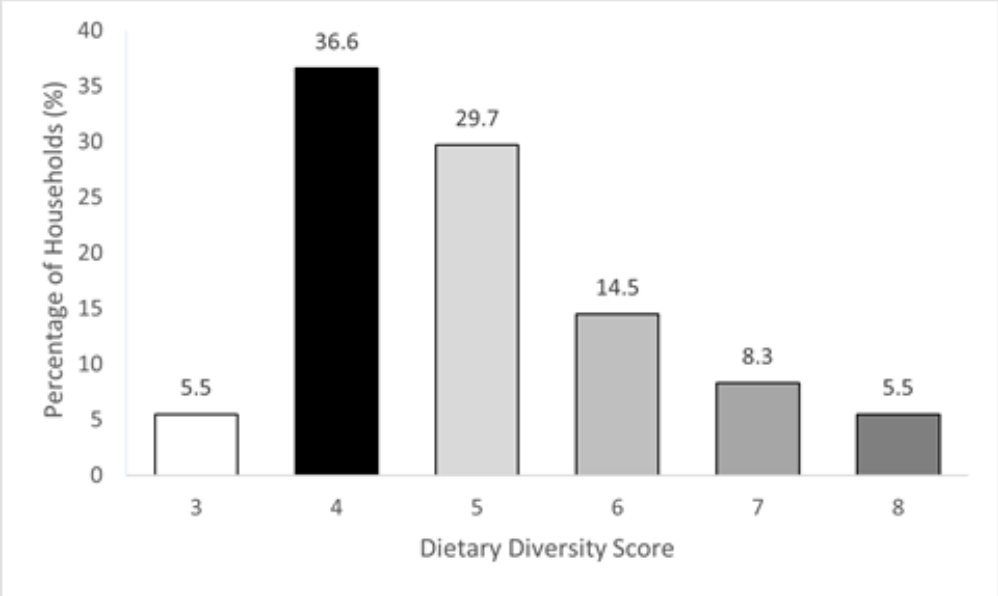

Figure 1. The results of the dietary diversity survey (n = 145)

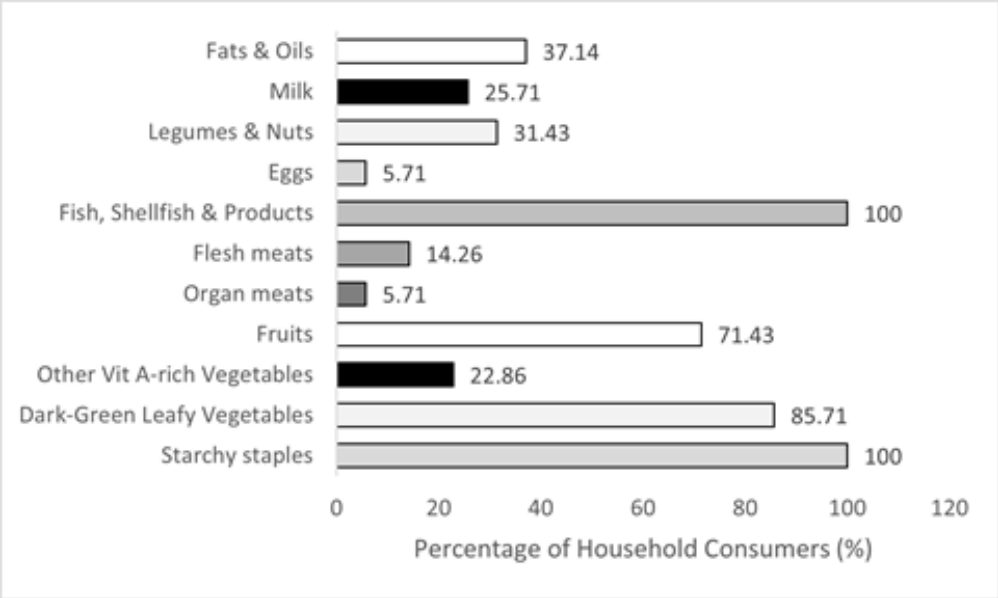

Figure 2. Percentages of households consuming food groups (n = 145)

consumption of vitamin A-rich vegetables, along with low consumption of eggs and flesh meats, contributed to the inadequate intake of vitamin A. Fats and oils were only consumed by ⅓ of the respondents (37.14%), which would explain the low caloric intake in the area is not a good finding because fat is important not only in meeting calorie needs but also in the absorption of fat-soluble micronutrients like vitamin A (Albahrani & Greaves, 2016). Additionally, the main reason why inadequate iron intake was found in their area was the low consumption of flesh meats and organ meats. Low iron intake leads to iron deficiency anemia, which impairs cognitive and physical performance and subsequently reduces productivity (Coutinho & Goloni-Bertollo, 2005). Since the main reason why most of these foods are lacking in their diet is low purchasing power, nutrition-supportive strategies to make them more accessible is warranted. Furthermore, enhancing agricultural outputs would also help. A study conducted by Gonder (2011) revealed that increasing farm biodiversity had led to an increase in dietary diversity in Bukidnon.

As shown in Figure 3, corn (Zea mays) grits (also known locally "mais-kan-on") was the most common staple food consumed in the area, as rice was only consumed by those who had higher purchasing power. This is in contrast with the results of the ENNS (2018-2019), wherein rice is the most consumed, and corn grits only ranked 4th. Corn has lower calories, calcium, iron, and folate than rice but is higher in proteins, fats, dietary fiber, vitamin A, B vitamins, and other minerals (Siyuan et al., 2018). Thus, continued consumption of corn grits is warranted, but rice can be mixed with it to complement each other's limiting nutrients. Malunggay (Moringa oleifera) represents the 2nd most eaten food by the respondents. Malunggay is one of the most nutritionally dense vegetables (Peter, 2008) in the Filipino diet, so this is one promising finding. The consumption of dried fish (also known locally as "bulad") ranks 3rd on the list. Dried fish consumed in the area belong to various species. Dried fish is a cheap source of high-quality proteins, healthy fats, and key essential minerals, including iodine, zinc, copper, selenium, and calcium (Siddhnath, 2020). Dried fish eating helped residents in the area achieve their protein, calcium, and phosphate

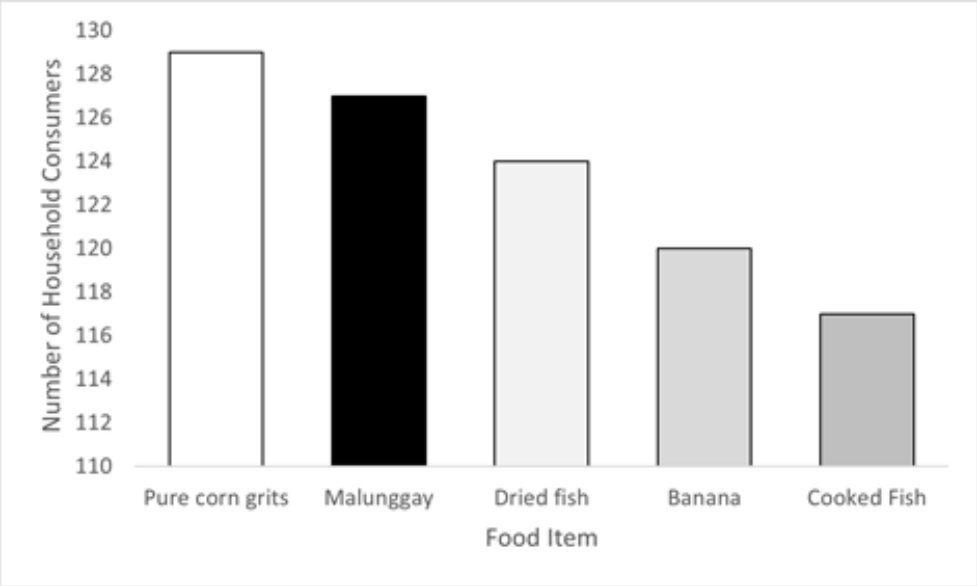

Figure 3. Percentages of households consuming food items (n = 145)

requirements, but it also contributed significantly to their high sodium intake. Although banana (Musa acuminata × balbisiana) consumption ranks 4th, this is almost exclusively the fruit eaten in the area, with other fruits being consumed only when they are in season, so interventions to diversify fruit intake are recommended. This monotony would explain their inadequate vitamin C intake. Low fruit consumption is similarly found nationwide, as shown in the recent results of ENNS (DOST-FNRI, 2022). Lastly, the 5th most frequent food eaten in the area was carp (Cyprinus carpio), which help provides a lot of nutrients in the area.

Brestfeeding Practices

The results of the breastfeeding survey from households with <6-month-old infants (n = 29) are given in Table 3. Most of the respondents (caregivers) were mothers (96.55%), had 3-4 children (44.83%), and had a high school level of education (37.93%).

For the knowledge part of the survey, most respondents were found to have the correct knowledge in four (4) out of the eight (8) questions asked. Only breastmilk should be the first food given to a newborn infant, according to 96.55 percent of respondents. A baby younger than six months should be nursed or provided breastmilk on demand, according to 75.86 percent of respondents, and 82.76 percent agreed that one benefit of exclusive breastfeeding is that the infant thrives. When asked about several methods a woman may keep up her milk production, 51.72 percent of respondents chose breastfeeding exclusively on demand. However, because these bits of information were founded on their experiences and were a part of their culture and tradition, they were expected to be well-known in communities. On the other hand, most of the caregivers did not know about the correct answers for the rest of the questions asked, which are considered technical questions. When asked about the meaning of exclusive breastfeeding, 51.72% gave an incorrect answer, and 27.59% of them simply said that they did not know it. Majority also of the respondents either did not know (27.59%) or provided an incorrect answer (41.28%) to the question, "How long should a baby receive nothing more than breastmilk?" To the questions, "Why do you think breastmilk is the only food recommended for infants up to six months old?" and "What are the physical or health benefits for a mother if she exclusively breastfeeds her baby?" most of the caregivers said that they did not know about it. This is a worrisome problem because caregivers in the area might not be practicing exclusive breastfeeding because of this knowledge deficit. Exclusive breastfeeding is defined as the practice whereby, for the first six months of life, a newborn receives breastmilk alone (Labbok, 2000). Breastfeeding an infant exclusively for the first six months of life has several advantages, including a lower risk of pneumonia, gastrointestinal infection, urinary tract infection, and otitis media in the infant, as well as a faster return to pre-pregnancy weight and a lower risk of Type 2 diabetes in the mother (Motee & Jeewon, 2014). Nutrition-supportive interventions to increase the caregivers' knowledge in these aspects of breastfeeding are needed.

Generally, caregivers in Brgy. Bukang Liwayway had good attitude toward breastfeeding. All of them said that exclusive breastfeeding is good for infants, while 96.55% thought that breastfeeding a baby on demand is good. Thus, they also thought of exclusive breastfeeding and breastfeeding on demand as not complex. Most of them also felt confident (62.07%) in breastfeeding their child. However, the majority did not feel confident expressing and storing their breast milk.

For the practices part, when asked whether they fed their baby with liquid other than breast milk the previous day, 37.93% of the participants responded yes. This means that they were not already practicing exclusive breastfeeding during that time. This is similar with the finding of the ENNS 2019 using only the data from Bukidnon, which revealed that only 66.2% of the young infants were exclusively breastfed (DOST-FNRI, 2022).

Water, Sanitation, and Hygiene

The results of the Water, Sanitation, and Hygiene

Table 3. Breastfeeding indicators in Brgy. Bukang Liwayway, Kibawe, Bukidnon (n=29)

Breastfeeding Indicators	Choices	Frequency	Percentages
Sex of the caregiver	M	1	3.45
	F	28	96.55
Relationship with the child	Mother	28	96.55
	Father	1	3.45
Parity (number of children; for women	1-2	8	27.59
	3-4	13	44.83
	5 and more	7	21.14
Educational level	Elementary	8	27.59
	Elementary Graduate	3	10.34
	High School	11	37.93
	High School Graduate	4	13.79
	College Level	3	10.34
Child's sex	Male	12	41.38
	Female	17	58.62
Child's age	Below 3 m/o	13	44.83
	3 m/o and above	16	55.17
Practices Q1: Was the baby breastfed yesterday during the day or at night?	Yes	29	100
	No	0	0
Practices Q2: Did the baby consume breastmilk in other ways yesterday during the day or night?	Yes	3	10.34
	Bottle	2	6.90
	Cup	1	3.45
	No	26	89.66
Practices Q3: Did the baby have any of the following liquids yesterday during the day or at night?	Yes	11	37.93
	Plain water	8	27.59
	Powdered milk	1	3.45
	Thin porridge	1	3.45
	Rice washing	1	3.45
	No	18	62.07
Knowledge Q1: What is the first food a newborn baby should receive?	Only breastmilk	28	96.55
	Others (infant formula)	1	3.45
Knowledge Q2: Do you know the meaning of exclusive breastfeeding?	Don't know	8	27.59
	Correct answer	6	20.69
	Incorrect answer	15	51.72
Knowledge Q3: How long should a baby receive nothing more than breastmilk?	From 0 - 6 months	9	31.03
	Other	12	41.38
	Don't know	8	27.59
Knowledge Q4: Why do you think breastmilk is the only food recommended for infants up to six months old?	Because breastmilk provides all the nutrients and liquids a baby needs in its first six months	7	21.14
	Because babies cannot digest other foods before they are six months old	5	17.29
	Other	10	34.48
	Don't know	12	41.38
Knowledge Q5: How often should a baby younger than six months be breastfed or fed with breastmilk?	On demand	22	75.86
	Other	1	3.45
	Don't know	5	17.29

Knowledge Q6: What are the benefits for a baby if he or she receives only breast-milk during the first six months of life?	He/she grows healthily	24	82.76
	Protection from diarrhea and other infections	5	17.29
	Other	1	3.45
	Don't know	4	13.79
Knowledge Q7: What are the physical or health benefits for a mother if she exclusively breastfeeds her baby?	Helps her lose the weight she gained during pregnancy	2	6.90
	Delays fertility	3	10.34
	Other	2	6.90
	Don't know	22	75.86
Knowledge Q8: Please tell me different ways a mother can keep up her milk supply	Breastfeeding exclusively on demand	15	51.72
	Manually expressing breastmilk	2	6.90
	Having a good nutrition/eating well/having a healthy or diversified diet	7	21.14
	Drink enough liquids during the day	16	55.17
	Other	2	3.90
	Don't know	6	20.69
Attitudes Q1: [Perceived benefits] How good do you think it is to breastfeed your baby exclusively for six months?	Not good	0	0
	Not sure	0	0
	Good	29	100
Attitudes Q2: [Perceived barriers] How difficult is it for you to breastfeed your baby exclusively for six months?	Not difficult	21	72.41
	Slightly difficult	7	21.14
	Difficult	1	3.45
Attitudes Q3: [Perceived benefits] How good do you think it is to breastfeed your baby on demand, that is when the baby wants to feed?	Not good	0	0
	Not sure	1	3.45
	Good	28	96.55
Attitudes Q4: [Perceived barriers] How difficult is it for you to breastfeed your child on demand?	Not difficult	19	65.52
	Slightly difficult	9	31.03
	Difficult	1	3.45
Attitudes Q5: How confident do you feel in breastfeeding your child?	Not confident	1	3.45
	Slightly confident	8	27.59
	Confident	18	62.07
Attitudes Q6: How confident do you feel in expressing and storing breastmilk so that someone else can feed your baby?	Not confident	10	34.48
	Slightly confident	9	31.03
	Confident	10	34.48

(WaSH) survey from the randomly selected household sampling units (n = 145) are given in Table 4. The primary source of water used by many households for different purposes in the area is the barangay-wide water network, which is ultimately sourced from Brgy. Kagawasan. Most respondents (93.10%) were connected to the water source for more than 12 hours per day. Most of the households liked the taste of their drinking water (51.72%) and believed that the available water met their needs as well (92.41%). These findings indicate that most people in the area have no problems with water. When it comes to sanitation, most of the households had toilets with water flush of either the sit down- (39.31%) or squat-type (28.97%). However, a significant proportion of the households still have pit latrines (28.97%). The use of pit latrines is still considered a poor sanitation facility and a poor indicator of health (Njuguna, 2019). It's especially concerning that four (4) of them were discovered to have no toilet facilities at all. Additionally, there were also nine (9) respondents who said that they sometimes defecate in an open area, a behavior that can lead to contamination of drinking water and outbreak of waterborne diseases (Montgomery & Elimelech, 2007).

Open defecation is also widespread among children, with feces being collected and disposed of by burying (33.10 %), disposal in the toilet (29.97%), or disposal elsewhere (e.g., a body of water, trash pit) (31.03%). This practice has

WaSH Indicator: Water	Choices	Frequency	Percentages
What is the primary source of drinking water for your household?	Brgy network	119	2.07
	Water vender/Delivery	16	11.03
	Private/communal well	10	6.90
What is the primary source of water for domestic use in your household?	Brgy network	73	50.34
	Private/communal well	52	35.86
	Nearby body of water	20	13.79
What is the water source for cooking?	Brgy network	115	79.31
	Water vender/Delivery	15	10.34
	Private/communal well	15	10.34
How often does your household have running water from the network?	Not connected	0	0
	Less than 4 hours per day	1	0.69
	5 to 12 hours per day	9	6.21
	More than 12 hours per day	135	93.10
Is the water you are receiving enough to satisfy your needs?	Yes	134	92.41
	No	11	7.59
How does your drinking water taste?	Excellent	20	13.79
	Good	75	51.72
	Acceptable	48	33.10
	Unacceptable	2	1.38
WASH Indicator: Sanitation & Hygiene			
What sort of toilet do you have?	Sit down toilet with water flush	57	39.31
	Squat toilet with water flush	42	28.97
	Pit latrine	42	28.97
	None	4	2.76
Where do you and another adult household members (excluding children under 5) usually go to defecate?	Single household latrine	141	97.24
	Shared household latrine	2	1.38
	Communal/public latrine	1	0.69
	Open defecation	1	0.69
Do adults from your household sometimes defecate in the open?	Yes	136	93.79
	No	9	6.21
Where do children under 5 from this household usually go to defecate?	Collected and disposed in latrine	42	28.97
	Collected and disposed elsewhere	45	31.03
	Nothing is done with it	6	4.14
	Buried it	48	33.10
	Other	4	2.76
How often do your family member bath/shower?	Everyday	126	86.90
	4 times or more per week	16	11.03
	At least once a week	3	2.07

When do you usually wash your hands with soap? (More than one answer is possible)	Before mealtimes	84	57.93
	After mealtimes	28	19.31
	Before bed	23	15.86
	Before cooking	78	53.79
	After using the toilet	112	77.24
Does the latrine most often used have handwashing facilities with soap?	Yes, with soap and water	94	64.83
	Sometimes	39	26.90
	No	12	8.28
Where does your household dispose of domestic waste?	Household pit	25	17.24
	Communal pit	17	11.72
	Designated open area	10	6.90
	Undesignated open area	7	4.83
	Bury it	38	26.21
	Burned	33	22.76
	Other	15	10.34
WaSH Indicator: Health			
Has anyone in your household <5 years of age had unusual diarrheal symptoms (watery/bloody diarrhea for a few days) in the past four weeks?	Yes	139	95.86
	No	6	4.14
Has anyone in your household >5 years of age had unusual diarrheal symptoms (watery/bloody diarrhea for a few days) in the past four weeks?	Yes	144	99.31
	No	1	0.69

been consistently linked with child malnutrition through mechanisms such as malabsorption of nutrients owing to parasitic infection and persistent diarrhea (Rahman et al., 2020). The most frequent disposal methods of solid waste were burying (26.21 percent) and burning (22.76 percent). In terms of personal hygiene, most participants bathe everyday (86.90%). Washing of hands with soap was commonly practiced after using the toilet but not really before mealtimes (57.93%), before cooking (53.79%), after mealtimes (19.31%), or before bed (15.86%). Soap was only available sometimes in 26.90% of the households and not available at all in 8.28% of the households. Sanitation these days has become important not only in the maintenance of good nutritional status but also in the prevention of COVID-19 (WHO, 2020). The incidence of diarrheal symptoms was also rare in the past four (4) weeks before the time the data were collected. However, this number was likely a result of underreporting. Studies have shown that communicable diseases like diarrheal diseases are frequently underreported in communities (CDC, 2012). Causes of underreporting include a lack of knowledge of reporting requirements and a belief that unrecognized diarrheas are a part of the normal development of infants and children (Pradhipasen, 1997).

The findings of the study in Barangay Bukang Liwayway, Kibawe, Bukidnon, a Geographically Isolated and Disadvantaged Area (GIDA) with a high rate of poverty, indicate that the identified dietary deficiencies, suboptimal breastfeeding practices, and sanitation issues have direct links to poverty within the community. Firstly, the observed imbalances in dietary and nutrient intakes can be attributed to the limited access and affordability of diverse and nutrient-rich foods. Poverty often restricts individuals' purchasing power, resulting in a higher reliance on inexpensive, energy-dense but nutrient-poor food options (Siddiqui et al., 2020). The observed knowledge deficits and suboptimal breastfeeding practices in the community can also be influenced by poverty. Limited access to healthcare services, including prenatal and postnatal care, can hinder the dissemination of accurate and comprehensive information about breastfeeding practices (Olanade et al., 2019). Furthermore, economic constraints can prevent mothers from exclusively breastfeeding due to the need to return to work early or lack of support systems, affecting optimal infant feeding practices (Lesorogol et al., 2018). The identified sanitation issues, such as open defecation and poor toilet facilities, are often associated with inadequate infrastructure and limited access to basic amenities, which can be prevalent in poor communities (Njuguna & Muruka, 2017). Poverty can hinder the provision of proper sanitation facilities, clean water supply, and hygiene education, contributing to unsanitary conditions and increased risk of food-/ waterborne diseases.

CONCLUSION AND RECOMMENDATIONS

The study showed that the usual diet of people in Barangay Bukang Liwayway, Kibawe, Bukidnon was adequate in proteins, calcium, phosphorus, and niacin but inadequate in calories, fats, fiber, vitamin A, iron, vitamin C, thiamin, and riboflavin. The usual diet has also been

found to be excessive in sodium. The typical diet was not particularly diversified. While the attitudes towards breastfeeding were generally good, there were significant knowledge deficits on the key aspects, such as the meaning and advantages of exclusive breastfeeding. It has also been found that at least one-third of the infants were not exclusively breastfed. There were no major perceived issues with water supply; however, there were sanitary problems to be addressed, such as open defecation and poor toilet facilities. In addition, there were issues with personal hygiene, such as a lack of soap and occasional handwashing. These gaps are intertwined with malnutrition faced by individuals and families living in poverty.

To correct the dietary deficiencies found, more orange-yellow-colored vegetables, fruits, nuts, seeds, and legumes, as well as animal-based food items, including flesh meats, milk and dairy products, and eggs, must be consumed. It is crucial to enhance knowledge, attitudes, and practices of exclusive breastfeeding among caregivers to ensure optimal infant nutrition. Additionally, efforts should be made to improve sanitation conditions, including access to clean and safe toilet facilities, promoting proper hygiene practices, and addressing issues related to open defecation. Thus, it is recommended to develop and implement nutrition-supportive activities, such as improving access to nutritious food, enhancing healthcare services, promoting income-generating opportunities, and investing in sanitation infrastructure to help alleviate poverty-linked malnutrition.

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ACKNOWLEDGEMENT

The authors would like to acknowledge the funding support (R-0281) of Central Mindanao University (CMU) in the conduct of this assessment and the people of Bukang Liwayway, Kibawe, Bukidnon for their invaluable participation and support.

Central Mindanao University
Journal of Science
ISSN Print: 0116-7847 ISSN Online: 2704-3703

Adaptability and Teaching Performance of Gulod and Mamatid National High School Teachers During the Pandemic

Noel P. Munda

Department of Education, Gulod National High School,
City of Cabuyao, Laguna, Philippines 4025

ABSTRACT

Adaptability is a skill needed in the performance of teachers' duties. This study aimed to assess teachers' performance and adaptability at two public schools in Cabuyao, Laguna, Philippines, in 2021-2022. It attempted to determine the level of adaptability skills, such as self-awareness, personal management, problem-solving and decision-making, attitude, and competence grasp, and teaching performance that teachers need to deal with the fast-changing academic environment. This study aimed to determine how teachers were able to respond to changes and student needs and provide potential solutions. This study also investigated whether the adaptability of teachers varies based on their profiles. It intended to bridge the gap by examining how teachers' adaptation skills relate to their performance. This research utilized the comparative and descriptive-correlational approach, and 118 high school teacher answers were collected. Female teachers between the ages of 31 and 40 with less than six years of teaching experience made up most of the study. The statistical tools used were frequency, percentage, mean, standard deviation, z-test for independent samples, one-way ANOVA, and Pearson's product-moment correlation. The findings revealed that teachers scored well in areas linked to training. It was also discovered that teachers could swiftly adapt to any characteristic of the modern learning environment. When they were categorized based on their profiles and campus, their levels of adaptability did not alter much. The capacity to adjust and teaching performance had no significant correlation. Future studies may be conducted to elucidate other variables and encourage institutional management for programs and initiatives.

Keywords: Adaptability, Teachers' Adaptability, Performance, Pandemic

INTRODUCTION

The education sector is one of the major industries being impacted by the COVID-19 pandemic. In this setting, online learning demonstrated a pedagogical movement from the traditional technique toward a more technological teaching style. Teachers' motivation and performance might deteriorate due to the educational sector's catastrophic upheaval and the pandemic's disruptive effects, which may linger longer in the educational community (Onyema et al., 2020). Educators were expected to overcome their obstacles with online learning as part of this adaptation process (Safta-Zecheria et al., 2020). Therefore, teachers must analyze their level of flexibility since it might affect their student's long-term development.

Koc and Fidan (2022) argued that complex tasks for public and private school teachers include managing online classrooms, providing materials and activities, adapting curricula for distance learning, making important themes concrete for students studying social sciences, and providing materials and activities. This argued that educators must be prepared to adapt to the environmental changes caused by the pandemic. Therefore, teachers may adapt in various ways depending on their profiles and abilities. A teacher's flexibility and performance may be associated with their profile factors, including age, gender, position, and educational attainment.

Teachers must adapt to these changes to provide high-quality education and maintain good performance in the face of this pandemic, which may impact students' knowledge and learning. According to Dhanush et al. (2023), instructors employed various coping techniques to deal with the stress and uncertainty generated by the pandemic, including seeking social support, maintaining a positive attitude, and prioritizing their own needs. Thus, instructors could fulfill their tasks efficiently because of their optimism and resilience under duress (Lagat, 2021). Understanding how flexibility impacts a teacher's effectiveness in the classroom is critical. It was also examined to discover whether adaptability varies in response to potentially affecting events.

In this manner, the study aimed to discover how teachers managed the shift to online learning in the face of pandemic concerns. The goal was to determine how teachers' effectiveness in their roles is connected to their adaptation skills, which include self-awareness, personal management, problem-solving and decision-making, attitude, and competence knowledge. It demonstrated how educators may meet the needs of children while overcoming their obstacles. The study tried to reduce the gap by investigating whether teachers' degrees of adaption alter depending on their profiles. It also aimed to close the knowledge and skill gap between students' knowledge and skills and the outcomes of their changes.

Corresponding author:
Noel P. Munda
Email Address: noel.munda@deped.gov.ph
Received: Mar. 22, 2023 ; Accepted: Dec. 11, 2023

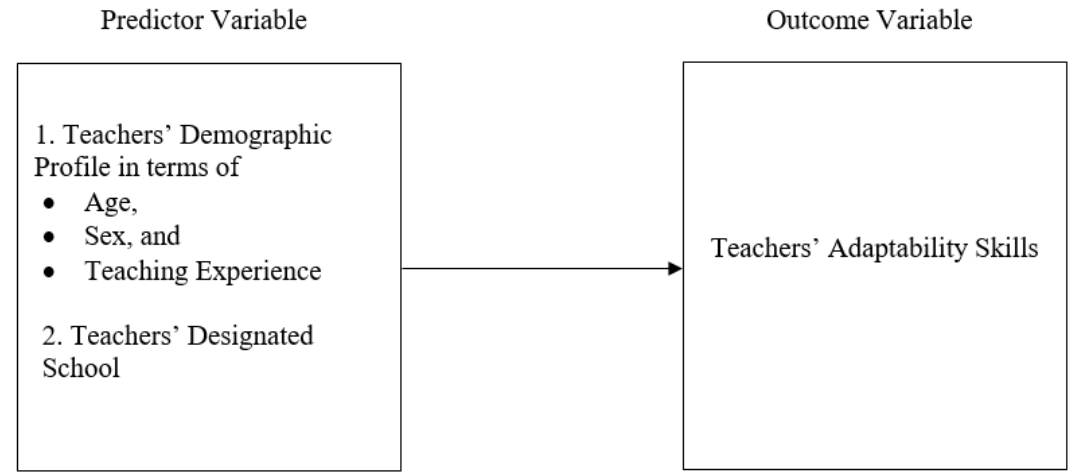

Figure 1. The Conceptual Framework of the Study as to the Difference of Teachers' Adaptability Skills when grouped according to Profile

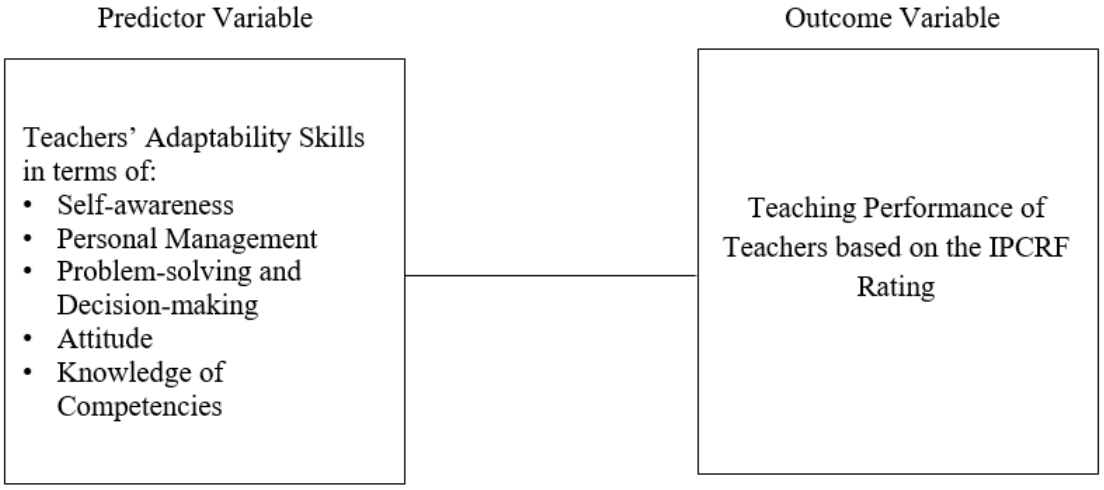

Figure 2. The Conceptual Framework of the Study as to the Relationship between Teachers' Adaptability Skills and Teaching Performance

The correlation of teaching performance and adaptability of teachers at Gulod National High School [GNHS] and Mamatid National High School [MNHS] in 2021-2022 were evaluated. This study also compared the adaptability skills of the respondents according to their profiles and designated school.

Conceptual Framework

The first framework shows the predictor variable, teachers' demographic profile in terms of age, sex, teaching experience, and designated school; and outcome variable, teachers' adaptability skills. The arrow that connects between them implies a test whether the teachers' adaptability skills differ according to their age, sex, teaching experience, and designated school.

The second framework includes the predictor variable, teachers' adaptability skills in terms of self-awareness, personal management, problem-solving and decision-making, attitude, and knowledge of competencies; and the outcome variable, teaching performance of teachers based on the IPCRF rating. The line that connects them signifies a test whether teachers' adaptability skills have association with the teaching performance of teachers.

Hypotheses

Ho1: There is no significant difference in the level of adaptability skills of the teachers when grouped according to their profiles and school.
Ho2: There is no significant relationship between the teachers' level of adaptability skills and their teaching performance.

Literature Review and Framework

This study is based on the adaptation theory, which contends that organisms may adapt to and react to environmental changes throughout time (King, 2018). Cherry described adaptation as becoming used to new information and experiences. Learning includes adapting to a changing environment. Cherry highlighted Jean Piaget's theory that adaptability is required for cognitive growth. Assimilation or accommodation may lead to adaptability.

People initially absorb information from their surroundings into their thoughts and ideas. The second is to alter mental representations of newly acquired knowledge (Cherry, 2021).

This study is also supported by the career creation theory, which helps people choose and use jobs. The theory examines occupational behavior across the life cycle and provides career counselors with tools to help clients choose occupations and thrive at work. Three views on vocational behavior are used to assure its thoroughness: differential, developmental, and dynamic. Counselors and researchers can use the three techniques to investigate how individuals use life themes to integrate personality self-organization and career adaptability into a self-defining totality that animates work, directs occupational choice, and determines vocational adjustment (Savickas, 1997).

Individuals adapt in various settings owing to change, novelty, and changes by modifying their ideas, behaviors, and emotions by adapting to examine the possibilities in the new environment, which is consistent with an individual's adaptability to changes in their environment (Collie et al., 2018). Therefore, the position of teachers in the new online learning environment has been described as transitional or ambiguous. In response to these changes, instructors adopt a new approach to their work performance, instructional strategies, and learning style.

COVID-19 greatly influences everyone, most especially the education sector. Adaptability is critical for teachers because it will necessitate adjusting thinking and attitudes about how students learn online and how technology can be harnessed in novel ways in teaching, adjusting behaviors by seeking technical support for remote teaching, and adjusting emotions by reining in potential anxiety or frustration as new technologies are navigated, and different students engage with remote learning in unique ways (Collie & Martin, 2020).

Thus, instructors must adapt to students' needs, such as coping with unexpected classroom settings or scheduling changes, communicating with new colleagues, students, and parents, and integrating new and changing professional education into teaching (Collie et al., 2018). Instructors' adaptability to their new surroundings permits them to adjust to new difficulties. This will also help pupils avoid barriers and substantial impediments in their new surroundings or learning style.

Given the need for adaptability, it is hard to deny that there have been instances of work disengagement since not all educators can adjust to changes that occur. However, job disengagement happens when teachers work but then leave (Collie & Martin, 2018). Hence, initiatives and attempts to help teachers adapt to their new conditions are required. Focusing only on teachers' flexibility may be easier for them if there is aid or cooperation from the school system to help them overcome these problems. Teachers' flexibility should be developed in collaboration with everyone in the education sector to help them in their job performance.

Castillo (2021) examines the class observation experiences of junior high school teachers during COVID-19 in a specific scenario. He noticed that instructors observe classes for two reasons: improving teachers' service competency and guaranteeing that policy standard are followed despite field modifications. There have also been instances when instructors showed amazing patience and commitment in dealing with difficulties during an online discussion due to inadequate internet signal and other technicalities. Cooperation in education is crucial since instructors find adapting to the current environment challenging if educational administration agencies or organizations need to help with this issue. Leaders and teachers must collaborate closely to adapt to the present situation.

Despite the challenges posed by the pandemic and changes in the learning environment, some studies have found that instructors have a strong sense of adaptability to the current situation. Munda (2021) observed that teachers were highly adaptable regarding self-awareness, personal management, problem-solving and decision-making, attitude, and competent knowledge. Meanwhile, female teachers were found to be less adaptable, although those above 50 were very adaptable. Similarly, Andres et al. (2021) argued that instructors are flexible teachers in a fast-changing academic environment.

Adapting to the usage of technological components is as important as adapting to skills and performance. According to Mardiana (2020), most instructors embrace online education and new methods to equip them for 21st-century online learning. Similarly, teacher competency in ICT tools is essential because it allows them to be adaptable to the transition to online education (Konig, Jager-Biela, & Glutch, 2020).

With the given circumstances, the instructors' abilities included adaptation. The research revealed the importance of teachers' adaption skills and how they may be managed and used. It highlighted how teachers might use adaptation skills to react to changes in the school environment caused by the outbreak. The study aims to fill a knowledge gap on how adaptability relates to teachers' job performance. It will evaluate the association of their adaptability skills on their work performance, particularly self-awareness, personal management, problem-solving and decision-making, Attitude, and Knowledge of Competencies.

Furthermore, the study intends to discover the gap by determining if teachers' adaption capacities differ depending on their profiles. It also aims to close the gap between the outcomes of their adaptation to their student's learning and skills. Therefore, the study will underline the need for flexibility in reacting to changes in the new environment.

METHODOLOGY

Research Design

This study used the comparative and descriptive-correlational design. The descriptive design includes

the profile of the teachers as to age, sex, and teaching experience, teachers' performance based on the latest Individual Performance Commitment and Review Form [IPCRF] rating, and level of adaptability skills of the teachers. The researcher also got the difference in the adaptability skills of the teachers when grouped according to their profiles. Meanwhile, the correlational design includes the test if there is a relationship between the level of adaptability skills of the teachers and their teaching performance.

Population and Sampling

The target participants were 118 out of 169 teachers. The researcher used multi-stage cluster sampling to select the participants of the study, where samples were drawn from a population using smaller groups at each stage. The sample size was determined by using the Raosoft online calculator, with 56 out of 80 and 62 out of 89 teacher-respondents at GNHS and MNHS, respectively.

Instrumentation

Demographics, teaching performance rating, and adaptability were used in a survey questionnaire. The researcher employed Morgan's (2011) adaptation survey. Subject matter experts evaluated the instrument's content validity. The questionnaire's Cronbach's alpha (a= 0.90) showed "Excellent reliability" (Munda and Tamban, 2019). Before survey, the researcher needs ethical clearance. The researcher asked for the Superintendent and schools heads' permission. Following research ethics, ethical committee criteria were followed. Data collection requires ethics committee approval. Confidentiality, anonymity, and voluntary participation are required. Thus, researcher provided informed consent to the respondents.

Statistical Analysis

The researcher employed frequency and percentage to determine the demographic profile of the respondents in terms of sex, age, and teaching experience. Weighted mean and standard deviation were used to describe the teaching performance and adaptability of the respondents. Regarding the significance of the difference between two and more than two groups, the z-test for independent samples and one-way analysis of variance were respectively employed. Lastly, Pearson r was utilized to examine the link between the level of adaptation skills and teachers' performance ratings.

RESULTS AND DISCUSSION

This part of the research shows how the findings were presented and discussed following the topic. Among the results were teacher profiles, performance levels, adaption levels, significant difference tests, and correlations between instructors based on profile and performance.

Table 1 presents the profile of the teachers in terms of age, sex, and teaching experience. The respondents with an age range of 31 to 40 are dominant in this study (49 or 41.5%). On the other hand, the least of the age group belongs to those 51 years old and above (7.9% or 5.9%). It also shows that female teachers (85, or 72%) are more dominant in this study than male teachers (33, or 28.0%). Concerning years of teaching experience, most participants have less than six years of experience (54 or 45.8%), while the least belong to 21 years and above (2 or 1.7%). Women outnumbered males in the teacher profile findings because women are substantially overrepresented in the teaching profession (Tani, 2019). In a similar situation, there were more instructors in their middle years than in other age groups and more professors with less than six years of

Table 1. The Profile of Teachers in terms of Age, Sex, and Teaching Experience

Profile	Frequency	Percent
Age		
21 – 30 years old	38	32.2
31 – 40 years old	49	41.5
41 – 50 years old	24	20.3
51 years old and above	7	5.9
Total	118	100.0
Sex		
Male	33	28.0
Female	85	72.0
Total	118	100.0
Teaching Experience		
Less than 6 years	54	45.8
6 - 10 years	39	33.1
11 – 15 years	19	16.1
16 – 20 years	4	3.4
21 years and above	2	1.7
Total	118	100.0

Table 2. The Teachers' Teaching Performance Level

Rating	Frequency	Percent	Mean	Std Dev	Interpretation
1.500 – 2.499	2	1.7			
2.500 – 3.499	9	7.6			
3.500 – 4.499	96	81.4	4.11	0.43	Very Satisfactory
4.500 – 5.000	11	9.3			
Total	118	100.0			

Legend: 4.500-5.000 Outstanding; 3.500-4.499 Very Satisfactory; 2.500-3.499 Satisfactory; 1.500-2.499 Unsatisfactory; Below 1.499 Poor

classroom experience.

Table 2 depicts the profile of the teachers in terms of years of the teachers' performance based on the latest IPCRF rating. The table shows that most of the participants have a performance rating from 3.500 to 4.499 (96 or 81.4%), while there are only 2 or 1.7% of participants who have a rating between 1.500 and 2.499. Further, there are no participants with ratings below 1.499. The overall mean of participants in terms of their performance rating is 4.11 (SD = 0.43), with an interpretation of "very satisfactory". It signifies that the respondents to this study have a very satisfactory level of performance.

Given the instructors' performance level, it became evident that, despite the online learning environment, teachers can adjust to it and work magnificently. It revealed that teachers are competent in handling a diverse range of students in this new manner of learning, paying attention to student's needs, and working efficiently. It revealed how effective teachers were at adapting to changing circumstances while maintaining a high level of performance that pleased the students.

Table 3 displays the level of adaptability skills of the teachers at GNHS and MNHS. In terms of self-awareness, the statements with the highest means are "I have a vision for my life that gives it meaning and purpose" (x = 4.47, SD = 0.58), and "I know what is important to me and use this knowledge in making decisions" (x = 4.47, SD = 0.55), with shared interpretation "High level". On the other hand, the statement with the least mean is "I have a strong sense of self-esteem and generally feel good about myself" (x = 3.95, SD = 0.67), with an interpretation "High level". The respondents' overall mean on self-awareness is 4.18 (SD = 0.46). Concerning the respondents' personal management, the statement with the highest mean is "I take responsibility for managing my studies" (x = 4.60, SD = 0.53), with an interpretation "Very high level". In contrast, the statement with the least mean is "I have a personal financial plan which I evaluate regularly based on my current situation" (x = 4.07, SD = 0.71), with an interpretation "High level". The respondents' overall mean on personal management is 4.26 (SD = 0.50). In terms of the respondents' problem-solving and decision-making, the statement with the highest mean is "I have emerged stronger and have learned personal strategies to deal with change because of the changes in my life" (x = 4.24, SD = 0.57), with an interpretation "High level". Conversely, the statement with the least mean is "When experiencing stress in one area of life, I can contain it within that area" (x = 4.02, SD = 0.68), with an interpretation "High level". The respondents' overall mean on problem-solving and decision-making is 4.13 (SD = 0.52). Regarding the respondents' attitude, the statement with the highest mean is "I expect life to have ups and downs and not always go as I would like it to" (x = 4.68, SD = 0.49), with an interpretation "Very high level". Alternatively, the statement with the least mean is "I don't spend time worrying about things that are out of my control" (x = 4.09, SD = 0.76), with an interpretation "High level". The respondents' overall mean on attitude is 4.40 (SD = 0.45). Concerning the respondents' knowledge of competencies, the statement with the highest mean is "I would describe myself as a continuous learner" (X = 4.55, SD = 0.58), with an interpretation "Very high level". In contrast, the statement with the least mean is "I know what others in our school expect of me" (x = 3.95, SD = 0.69), with an interpretation "High level". The respondents' overall mean on knowledge of competencies is 4.20 (SD = 0.48). Lastly, the respondents have the highest mean value on attitude (x = 4.40, SD = 0.45), while they have got a least mean value on problem-solving and decision-making. The respondents' have high level of adaptability (x=4.24, SD = 0.40).

Findings showed a high level of adaptability in terms of self-awareness, personal management, problem-solving and decision-making skills, competency comprehension, and attitude in the face of a pandemic. It also underlines how adaptability and flexibility in a new kind of learning environment might assist educators in overcoming the epidemic's challenges. Teachers have changed their course designs and teaching practices to meet the problem of the learning environment.

Table 4 presents the test of significant difference in teachers' level of adaptability skills in terms of age, which shows that teachers with ages 51 years and older obtained the highest mean level (4.42) compared to other age groups. Though all age groups obtained high levels of adaptability, teachers between 21 and 30 years old have the lowest mean (4.18) among the respondents. However, the results of the one-way ANOVA show no significant difference in the level of adaptability skills of the teachers in terms of age (F = 1.84, p = 0.14). It also shows that, though both groups fall into high-level interpretation, male teachers have a greater mean score (4.30) than females (4.20). Nevertheless, the results of independent samples z-test show no significant difference in teachers' level of adaptability skills in terms of sex (z = 1.19, p = 0.23). Munda's (2021) study also had relatively similar results; male (4.28) respondents appeared to have a higher mean value on adaptability than female

Table 3. The Level of Adaptability Skills of Teachers

	Statement	Mean	SD	Interpretation
1	I can articulate my special abilities, talents, and skills.	4.04	0.65	High level
2	I know what I must do to regain my confidence when I temporarily lose it.	4.10	0.65	High level
3	I have a strong sense of self-esteem and generally feel good about myself.	3.95	0.67	High level
4	I can identify and communicate my weaknesses and the ways that I work with or around them.	4.03	0.69	High level
5	I have a vision for my life that gives it meaning and purpose.	4.47	0.58	High level
6	I know what is important to me and use this knowledge in making decisions.	4.47	0.55	High level
	Self-awareness	4.18	0.46	High level
7	I take responsibility for managing my (graduate) studies.	4.60	0.53	Very high level
8	I can see how my study fits into the bigger picture of my life plans.	4.33	0.65	High level
9	I have a personal financial plan which I evaluate regularly based on my current situation.	4.07	0.71	High level
10	I have contingency plans, a second option if my first plan doesn't work out.	4.15	0.68	High level
11	I assess my strengths and weaknesses, outline ways to grow, and establish short- and long-range goals for my (graduate) studies.	4.16	0.67	High level
	Personal Management	4.26	0.50	High level
12	I have emerged stronger and have learned personal strategies to deal with change because of the changes in my life.	4.24	0.57	High level
13	I can organize my surroundings and prioritize tasks, even in stressful times.	4.14	0.61	High level
14	I can find and mobilize necessary resources in a crisis or new situation.	4.16	0.64	High level
15	I can usually think of several alternatives to solving a problem.	4.11	0.62	High level
16	When experiencing stress in one area of life, I can contain it within that area.	4.02	0.68	High level
	Problem-solving and Decision-making	4.13	0.52	High level
17	I believe that I always have options and choices, even in difficult situations.	4.47	0.60	High level
18	I generally approach life as an optimist.	4.36	0.61	High level
19	I have a sense of humor. I can find things to laugh about even in dark times.	4.21	0.73	High level
20	I understand there is growth in new experiences and enjoy learning from them.	4.58	0.54	Very high level
21	I expect life to have ups and downs and not always go as I would like it to.	4.68	0.49	Very high level
22	I don't spend time worrying about things that are out of my control.	4.09	0.76	High level
	Attitude	4.40	0.45	High level
23	I would describe myself as a continuous learner.	4.55	0.58	Very high level
24	I regularly spend time keeping my knowledge and skills current.	4.23	0.61	High level
25	I know the skills that will be required in my studies in the next several years.	4.25	0.60	High level
26	I know what others in our school expect of me.	3.95	0.69	High level
27	I know how my current skills are viewed by my co-teachers.	4.03	0.77	High level
28	I know which behaviors and attitudes are rewarded in our school.	4.21	0.64	High level

Knowledge of Competencies	4.20	0.48	High level
Overall Level of Adaptability	4.24	0.40	High level

Legend: 4.50 – 5.00 Very high level; 3.50 – 4.49 High level; 2.50 – 3.49 Average level; 1.50 – 2.49 Fair level; 1.00 – 1.49 Poor level of Adaptability

Table 4. Test of Difference in the Level of Adaptability Skills of the Teachers when grouped according to their Profiles and School

Profile	Mean	SD	VI	CV	P-value	Interpretation
Age						
21 – 30 years old	4.18	0.37	High level			
31 – 40 years old	4.19	0.38	High level	1.84	0.14	Not significant
41 – 50 years old	4.36	0.42	High level			
51 years old and above	4.42	0.54	High level			
Sex						
Male	4.30	0.37	High level	1.19	0.23	Not significant
Female	4.20	0.41	High level			
Teaching Experience (Years)						
Less than 6 years	4.15	0.37	High level			
6 - 10 years	4.32	0.39	High level	2.08	0.09	Not significant
11 – 15 years	4.24	0.44	High level			
16 – 20 years	4.24	0.51	High level			
21 years and above	4.82	0.26	Very high level			
Designated School						
Gulod NHS	4.21	0.38	High level	-1.12	0.26	Not significant
Mamatid NHS	4.29	0.44	High level			

Legend: SD=Standard Deviation, CV=Computed Value; 4.50 – 5.00 Very high level; 3.50 – 4.49 High level; 2.50 – 3.49 Average level; 1.50 – 2.49 Fair level; 1.00 – 1.49 Poor level of Adaptability; Significant if p-value is < 0.05

teachers (4.21). In terms of teaching experience, the results show that teachers with teaching experience of 21 years and above have the highest mean (4.82), while those with less than 6 years of teaching experience have the lowest mean (4.15). Further, the results of the one-way ANOVA show no significant difference in the teachers' level of adaptability in terms of years of teaching experience (F = 2.08, p = 0.09). Lastly, the teachers at MNHS got a higher mean score (4.29) than the GNHS teachers (4.21). The test of difference further revealed that there was no statistically significant difference in the adaptability of the teachers as to their designated school (z=-1.12, p=0.26).

Table 5 displays the test of the relationship between the level of teaching adaptability skills of the teachers and their job performance based on their individual performance commitment and review form rating. Using Pearson r, the correlation values range from 0.21 to 0.81, which are all greater than the significance level (0.05). It signifies that the null hypotheses were retained. Thus, there was no significant relationship between the level of adaptability skills of the teachers and their performance based on the IPCRF rating.

DISCUSSION

Based on the findings, most instructors who participated in this survey were women between 31 and 40 who had taught for less than 6 years. Munda's (2021) study on the adaptability of public-school teachers during the pandemic found that most of his respondents were 31 to 35 years old, while Asio's (2021) study featured teacher respondents who were 21 to 30 years old. Furthermore, the mean age of the Andres et al. (2021) research is 37, with instructors aged 20 to 30 having the greatest mean. Furthermore, most respondents in Munda's study were female teachers, whereas male teachers predominated in Asio's study. Most respondents in Munda's and Asio's studies had 1 to 5 years of teaching experience.

Teachers are doing well regarding teaching-related performance, even amid the COVID-19 epidemic. Having ratings between 3.500 and 4.499 necessitates instructors working hard even while working from home or in a face-to-face setting. It was supported by the study of Andres et al. (2021), which found that 63% of their respondents performed very satisfactorily, while 36% performed outstandingly. It also implies that the instructors are doing better.

A high level of performance also demonstrated that they have a feeling of importance and direction in their self-awareness. Instructors' self-awareness is generally reflected in their favorable attitude toward themselves. Personal management has also been a good component for the instructors, as they were able to establish preparations

Table 5. Test of Relationship between Teachers' Level of Adaptability Skills and their Performance based on the IPCRF Rating

Independent Variable	r value	p-value	Decision	Interpretation
Self-awareness	-0.10	0.28	Failed to reject Ho	Not significant
Personal Management	-0.12	0.21	Failed to reject Ho	Not significant
Problem-solving and Decision-making	-0.09	0.33	Failed to reject Ho	Not significant
Attitude	-0.02	0.81	Failed to reject Ho	Not significant
Knowledge of Competencies	-0.09	0.33	Failed to reject Ho	Not significant
Overall Adaptability	-0.10	0.27	Failed to reject Ho	Not significant

Legend: Significant if $p<0.05$

for their graduate courses and examine personal financial goals, and personal growth, demonstrating their high level of productivity. Also, problem-solving and decision-making revealed that teachers could become more resilient and develop unique coping mechanisms that allow them to manage changes in their lives better. It shows that teachers have strong decision-making abilities and problem-solving management skills, which help them more efficiently manage their lives. One of the components to examine is attitude, which shows that instructors anticipate the possibilities and repercussions. Regarding adaptability, attitude is a crucial component to understand since it will assist them in minimizing negativity and offer a positive view of the changes occurring. Finally, teachers believed that a strong knowledge of competencies would be achieved by being aware of the expectations that others in their school have of them. Findings showed that instructors strongly expressed all the components in determining their degree of adaptability, which aids them in overcoming the changes that occur in the new learning environment.

In a similar case, Munda (2021) demonstrated that teachers are adaptable by transitioning from face-to-face instruction to blended and modular distance instruction, distributing modules and weekly home learning plans, retrieving students' answer sheets, maintaining virtual communication with students, parents, and guardians, and attending virtual seminars. Despite increasing non-job-related obligations, instructors remained dependable and adaptive (Andres et al., 2021). Teachers were competent to educate and adapt to the changing academic environment as new instructional approaches emerged.

Teachers' adjustment and adaptation abilities also involve being flexible in the online style of education. Teachers were strengthening their online teaching and abilities via ICT technologies, competence, and the opportunity to gain digital skills critical to their transition due to school closures (Mardiana, 2020). Further, adherence to service competence and school policy compliance is also essential when developing their adaptability skills (Castillo, 2021). Teachers were able to become more adaptable with the help and participation of leaders and school heads. Collie and Martin (2018) discovered that instructors who get greater assistance from their bosses are more adaptive.

The researcher also discovered that the campus and all the profiles evaluated in the study, including age, gender, and years of teaching experience, revealed no significant variations in the degree of adaptation abilities of teachers. Munda (2021) supported this which found that teachers over 50 had a very high adaptability level compared to other age groups. Furthermore, there was no significant difference in the level of adaptability skills of the teachers based on gender, implying that both male and female teachers have equal levels because they all have the same interpretation. Finally, there was no significant difference in the teachers' adaptability skills based on years of teaching experience; all teachers with different years of teaching experience have equal levels because they all have the same interpretation. Teachers with 16-20 years of teaching experience and more than 30 years of experience showed extremely high levels of adaptability. Teachers with more than 30 years of experience and those with 26-30 years of experience showed extremely high levels of flexibility, whereas those with 1-5 years of teaching experience had the lowest mean. Furthermore, teachers at MNHS got higher mean score than GNHS teachers. It demonstrated that there was no disparity in the teachers' adaptability as to their school. In other words, the two groups of respondents were both highly adaptable.

Finally, the study found no link between teachers' adaptation skills and performance. The variables were not connected linearly. It contradicted the findings of Andres et al. (2021), who discovered that teachers' adaptation skills influence their teaching performance.

CONCLUSIONS

Most of the teachers in the study are women between the ages of 31 and 40 who have been teaching for less than 6 years. It was determined that more female teachers participated in the survey. It also revealed a relationship between instructors' ages and years of teaching experience. Older and experienced teacher-respondents had highest mean scores that the rest of the categories. While MNHS teachers got higher mean score than GNHS teachers, the respondents were both highly adaptable.

Despite the pandemic, the study also found that teacher-respondents do quite well in teaching-related performance. Having ratings between 3.500 and 4.499 necessitates instructors working hard even in all kinds of setting.

The research discovered that teachers had high self-awareness, personal management, problem-solving and decision-making, competency knowledge, and general flexibility. In conclusion, instructors demonstrate high flexibility in the current learning environment in all aspects.

The hypothesis that there was no significant difference in the degree of adaptation abilities of the instructors based on age, gender, and years of teaching experience was maintained, indicating no difference. It was found that the teachers' profiles and school have nothing to do with their ability to adjust to the new way of learning. The hypothesis suggesting no significant relationship between instructors' adaptability abilities and performance was kept as variables were not linearly connected. The study determined that teachers' performance and adaptation abilities were unrelated; hence, their performance cannot be judged based on how they can change in their environment.

The researcher focused on the profile, flexibility in self-awareness, personal management, problem-solving and decision-making, attitude, understanding of skills, and instructor performance throughout the epidemic. In 2021-2022, the survey was administered to teachers at GNHS and MNHS in the Division of Cabuyao, Laguna. The researcher explored gathering the most recent teacher performance ratings. The study contributed to the literature by demonstrating that instructors' adaptation abilities and performance were unrelated. It demonstrated that these two variables were distinct from one another.

RECOMMENDATIONS

The following recommendations are suggested:

1. Addressing the needs of the other sectors, which had a low participation rate in the study, should be highlighted for future studies to provide an equal representation in adjusting to the learning environment.
2. School principals, supervisors, and higher-ups in the Department of Education are encouraged to collaborate and coordinate to assist instructors in maintaining their outstanding performance in this new mode of learning. Education sector members must work together to help each other adjust to the current setting.
3. It is critical to pursue programs and initiatives that will assist teachers in maintaining their high level of adaptation abilities to keep them engaged and empowered. Teachers must be constantly equipped with the strategic abilities required to perform better.
4. The researcher suggests that other variables related to teachers' adaptability skills be investigated for them to have productive and efficient work performance. Future research may focus on other variables that have a relationship with the study's variables.
5. Future scholars may do research on instructors' adaptation and performance using a larger sample size. They may consider doing district- or division-wide research on the variables. The flexibility of instructors can also be related to other aspects.

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CENTRAL MINDANAO UNIVERSITY
University Town, Musuan, Maramag, Bukidnon, Philippines
journalofscience@cmu.edu.ph

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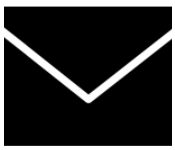

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