ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181
RUN RESEARCHERS RUN

Fertility Map of Agricultural Production Areas in Barangay Sibuto and Tenonggos, Datu Odin Sinsuat, Maguindanao Del Norte

Mohamidin C. Adam[1], Prof. Muslimin S. Usop[2], Prof. Andal U. Salibo[3]*, Prof. Musa M. Dicolano[4], Prof. JN Mocktar K. Ebrahim[5]
College of Agriculture, Mindanao State University, Maguindanao Del Norte, Philippines
*Corresponding Author e-mail: *ausalibo@msumaguindanao.edu.ph*

Received: 29 September 2024 **Revised**: 19 October 2024; 30 October 2024 **Accepted**: 31 October 2024

Available Online: 31 October 2024

Volume III (2024), Issue 4, P-ISSN – 2984-7567; E-ISSN - 2945-3577

Abstract
Aim: The goal of this study was to assess the soil fertility of agricultural areas in Barangay Sibuto and Tenonggos, Datu Odin Sinsuat, Maguindanao, to increase crop output and promote sustainable farming methods.
Methodology: A descriptive mapping method was utilized. Soil samples were taken from various crop fields and analyzed for key chemical properties such as soil pH, organic matter, phosphorus, potassium, magnesium, calcium, and zinc. Geographic Information System (GIS) technology was employed to produce soil fertility maps.
Results: Major chemical properties of the soils also differed at the different sites. Organic matter, phosphate, and other necessary nutrients were present in some variable proportions, and the pH ranged from very acidic to slightly alkaline. Suitable crops that may be grown are rice (*Oryza sativa*), corn (*Zea mays*), soybeans (*Glycine max*), sweet potatoes (*Ipomoea batatas*), and tomatoes, eggplants, and peppers among others. Other crops grown are root crops, including carrots and radishes, as well as legumes, including cowpeas and mung beans. There were seven soil fertility maps with detailed indications of suitable crops for a given type of soil.
Conclusion: GIS-based soil fertility mapping is very important in soil health assessment and crop selection and management. This will be helpful in improving the productivity of agriculture in the region. Overall, it adds more knowledge to soil fertility dynamics and its implication on sustainable agricultural practices in mountainous areas of Maguindanao.

Keywords: GIS, GPS, Mapping, Production, and Soil Fertility

INTRODUCTION

Soil fertility is the capacity of soil to sustainably support plant growth. It has to do with the soil's capacity to provide vital nutrients and whether it can use its resources or requires additional assistance to yield crops. Managing soil fertility is essential to improving crop nutrition and ensuring sustainable farming practices. Fertile soil can produce healthy crops with less fertilizer because of its natural nutrient concentration. Iron, copper, boron, molybdenum, nickel, phosphorus, potassium, calcium, magnesium, sulfur, and nitrogen are some of the necessary nutrients (Berner & Brueck, 2016). Furthermore, organic matter in fertile soil improves soil structure, maintains a pH between 6 and 7, and aids in the retention of water and nutrients.

Recent studies show a worrying trend in soil fertility and crop yields in different areas. For example, soil tests in Maguindanao have shown a decrease in nutrient levels, leading to crop yields dropping by about 20% over the past ten years (Valdez, 2019; Paul, 2018). This decline is especially noticeable in Barangay Sibuto and Tenonggos in Datu Odin Sinsuat, where farmers grow corn, coconut, sugarcane, rice, and mango. Despite contributing to the large coconut area of 117,074.20 hectares in Maguindanao, farmers report a significant drop in their crop yields due to poorer soil quality.

The assessment of soil fertility and its implications for agricultural productivity is a significant area of research, especially in developing regions or localities like Datu Odin Sinsuat, Maguindanao. A growing body of literature emphasizes the importance of understanding soil characteristics to optimize crop yield and promote

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

sustainable farming practices. For instance, Abdulai et al. (2022) conducted a comprehensive review of geospatial techniques used for agricultural land suitability assessment in sub-Saharan Africa, highlighting how Geographic Information Systems (GIS) can effectively map soil properties and inform land-use decisions. This aligns well with the study, where GIS technology is employed to produce detailed soil fertility maps for the local agricultural areas.

Understanding specific soil nutrient dynamics is also vital. Beegle (2019a) discusses phosphorus management in agriculture, highlighting the need for enough nutrient management strategies to maximize crop production. This is complemented by findings from Zhang et al. (2021), which explore the spatial-temporal dynamics of soil organic matter and its effects on crop growth, providing an initial basis for recommending suitable crops based on soil characteristics.

Moreover, research by Lal (2015a) emphasizes the necessity of integrating sustainable practices in agriculture to combat soil degradation. This is particularly relevant in the context of your study, which aims to not only assess soil fertility but also provide recommendations for enhancing soil health. The incorporation of integrated nutrient management frameworks, as discussed by Fageria (2014) and Nwite et al. (2021), can guide the development of effective crop management strategies that balance organic and inorganic inputs to improve overall soil health.

Additionally, studies by Huang (2019) and Smith (2018) investigate how soil pH affects nutrient availability, especially zinc and other important micronutrients for crop growth. This shows the need for a careful approach to managing soil fertility, especially in areas where certain nutrient shortages may occur.

The literature supports a multifaceted approach to assessing and managing soil fertility, combining geospatial analysis, integrated nutrient management, and sustainable agricultural practices. By adopting these frameworks, the study can contribute to a more comprehensive understanding of soil fertility dynamics and their implications for crop productivity in Barangay Sibuto and Tenonggos.

In agriculture, the Geographic Information System (GIS) is a crucial instrument. It enables maps to be combined with information about agricultural products, land usage, soil, and surveys. This technology helps farmers manage their land more effectively by providing useful information. GIS has been widely used in agriculture, with evidence that it can boost output while preserving the environment (Oshunsanya et al., 2016). However, GIS can provide comprehensive soil maps, which are necessary for making informed farming choices.

However, the soils in Barangay Sibuto and Tenonggos have not been properly analyzed, and GIS maps have not been created. This study aimed to fill these gaps by assessing soil fertility and developing a GIS framework for the agricultural areas of Datu Odin Sinsuat.

Research Objectives

The general objective of the study is to map the soil fertility in Barangay Sibuto and Barangay Tenonggos, Datu Odin Sinsuat, Maguindanao.

Specifically, the study sought to answer the following questions:

1. What are the chemical properties of the soil in the study areas?
2. Which crops are suitable for cultivation in these areas based on soil properties?
3. How can seven soil fertility maps be generated to guide crop selection and management?

Conceptual Framework

Several frameworks are commonly utilized in soil fertility research to enhance agricultural productivity. The Descriptive Research Framework is employed to provide detailed data on soil properties, such as nutrient levels and pH, aligning with the mapping approach used in the study. The Geospatial Analysis Framework involves the use of GIS technology to visualize soil fertility patterns across regions, enabling targeted crop management. The Integrated Nutrient Management Framework emphasizes the combination of organic and inorganic fertilizers to optimize soil health, while the Sustainable Agriculture Framework focuses on practices aimed at maintaining soil quality in the long term.

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

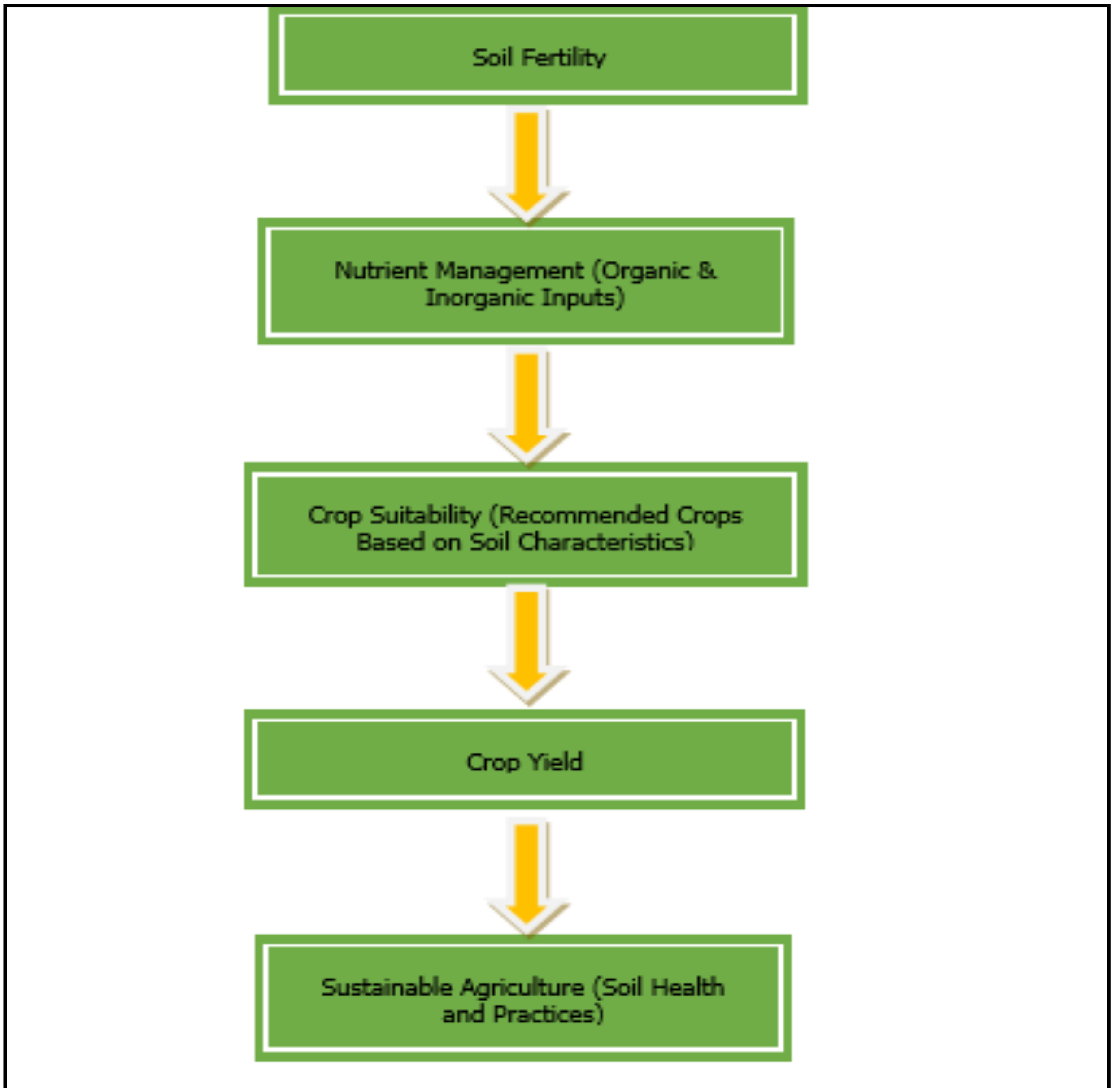


Figure 1. Conceptual Framework

Research Methodology

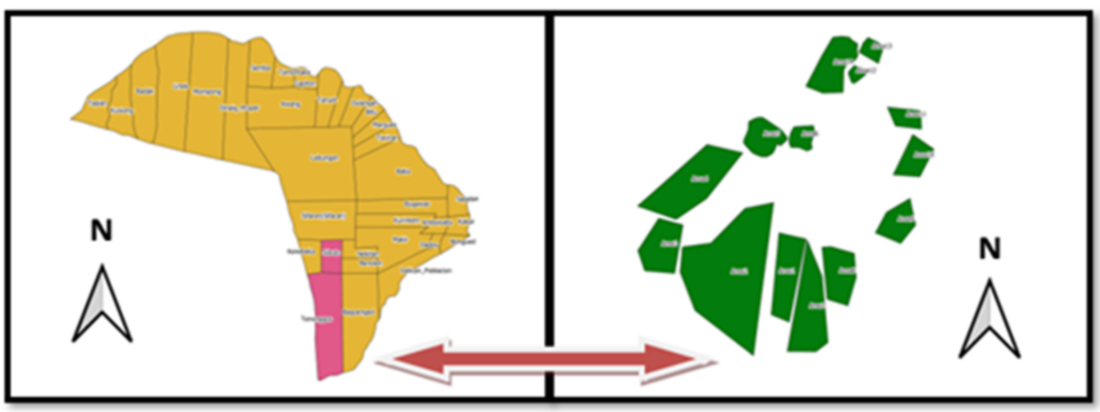
Research Design

To assess the soil fertility of crop fields, this study used a descriptive research design. Important soil chemical characteristics, including pH, organic matter, phosphorus, potassium, magnesium, calcium, and zinc, were examined using a descriptive mapping technique. To create soil fertility maps, soil samples were gathered from a variety of agricultural locations and analyzed using Geographic Information System (GIS) technology. A thorough evaluation of the soil's condition and the identification of regions that might profit from better soil management techniques were made possible by these maps, which depicted the distribution of nutrients throughout the fields.

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Scholar
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181
RUN RESEARCHERS RUN

Locale of the study

In Datu Odin Sinsuat, Maguindanao, the study was carried out in the barangays of Sibuto and Tenonggos. The study areas for Barangay Sibuto and Barangay Tenonggos are roughly located at 07°1'47.28'' N latitude 124°15'47.88'' W longitude, and 06°58'45.48'' N latitude and 124°15'39.6'' W longitude, respectively. These areas are roughly 8.67 and 5.6 miles from the municipality of Datu Odin Sinsuat, respectively, and are located at elevations of roughly 130.2 and 345.1 meters above mean sea level.



(a) (b)

Figure 2. Agricultural Areas in Barangay Sibuto and Barangay Tenonggos, Datu Odin Sinsuat, Maguindanao: (a) Sibuto and (b) Tenonggos.

Materials Used

The study used the following supplies: a shovel, a bolo, cellophane, a marker, tape, a mobile phone with a GPS app, a laptop with GIS and Google Earth apps, a ballpoint pen, sacks, a piece of wood, data sheets, a weighing scale, a sieve, and cell phone.

Data Collection Procedures

Soil sample collection involved the use of a bolo, shovel, cellophane, marker, tape, and cell phone. The number of sample units depended on the areas occupied by different crops, with each crop requiring its sample unit. Before collecting a soil sample, the researcher cleared the area using the bolo. After removing debris and other obstructions such as grass, the researcher used the shovel to dig approximately one foot into the soil to ensure that the sample was free from undesirable materials. For each crop area, five sample units were collected using an X pattern-one from each corner and one from the center of the field representing the final sample unit. The sample unit was then placed in cellophane, labeled with a marker and tape, and the coordinates and altitude of the sampling location were recorded using a GPS-enabled cell phone. These steps were repeated until the entire area of the barangay was covered from boundary to boundary.

The collected samples were air-dried, pulverized, sieved, packed, and properly labeled. The samples were then submitted to the Department of Agriculture Regional Field Office 12, Integrated Laboratory Division, Regional Soils Laboratory for testing.

Mapping Procedures

Using the GPS on the cell phone, the researcher recorded the location while collecting soil samples. It was important to position the device in an open area with a clear view of the sky and wait for the GPS error to reduce to less than 10 meters by holding the cell phone steadily without any movement.

Digitizing

Digitizing was performed using a laptop or desktop computer with GIS software. The process began by opening QGIS and creating a new project. A vector layer was added by selecting "Add Layer" (or pressing Ctrl+Shift+V), then browsing to the QGIS files folder to open the Maguindanao base map and the Brgy_DOS_shp file. The DOS map appeared on the template. Next, Microsoft Excel was used to encode the coordinates and points of

ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingthecultureofresearch@etcor.org
Mobile Number : 0939-202-9035
Thank you for embracing the culture of research with us!

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

interest (POIs) from the datasheet. The data was saved as a CSV file. Back in QGIS, properties were set to display single labels, which revealed the names of the barangays in Datu Odin Sinsuat. To isolate a specific barangay, the researcher used the attribute layer tools to filter and export the selected features. The coordinates were then added by importing the delimited text layer from the CSV file.

To generate the fertility map, the researcher used Google Earth to place markers for easy tracing of crop areas. The images were captured and imported into GIS, where polygons were drawn over the production areas corresponding to the POIs. The polygons were labeled with the crop names and saved. The attribute table was updated with the coordinates and laboratory results using the "Joins" function. The researcher then categorized the data by chemical element, assigned color ramps, and labeled the polygons according to their areas. Finally, the map was exported as an image, and this process was repeated until all seven fertility maps were generated.

Inputting Data of Soil Analysis

To input soil analysis data, a new column was added in editing mode within the GIS software. The researcher added rows and columns as needed, input the soil data, and confirmed the entries by selecting the appropriate icon.

Ethical Consideration

This study was conducted concerning ethical guidelines, ensuring that all soil sampling and data collection were performed in a manner that did not harm the environment or disrupt local agricultural practices. Permission to access the agricultural areas in Barangay Sibuto and Tenonggos was obtained from the respective landowners and local authorities. The study aimed to benefit the local farming community by providing valuable insights into soil fertility, which could enhance crop productivity and support sustainable agricultural development. No personal or sensitive information was collected, ensuring the privacy and confidentiality of all participants involved in the study.

RESULTS and DISCUSSION

This figure presents the study's results and the fertility map layouts, followed by a detailed textual discussion.

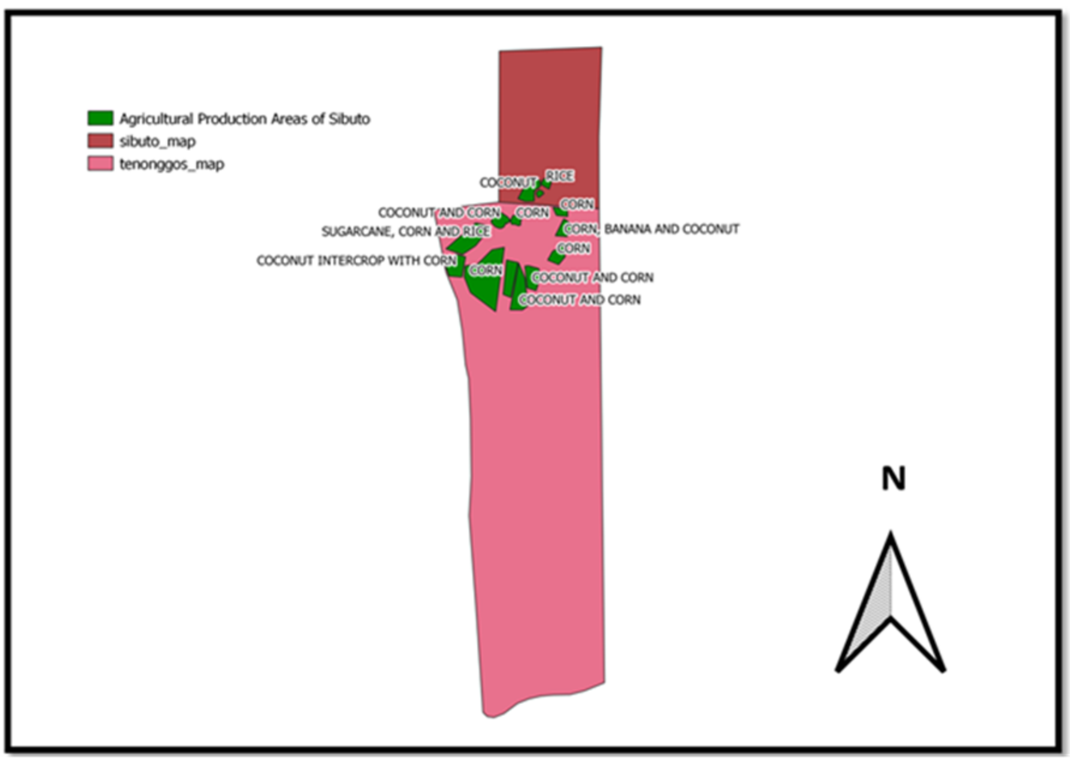


Figure 3. Agricultural Areas of Barangay Sibuto and Tenonggos, Datu Odin Sinsuat, Maguindanao

ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingthecultureofresearch@etcor.org
Mobile Number : 0939-202-9035

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

The soil analysis in Barangay Sibuto and Tenonggos, Datu Odin Sinsuat, Maguindanao highlights several key implications for improving agricultural productivity. Soil pH management is important, as acidic soils may benefit from lime applications, while alkaline soils may require adjustments to prevent micronutrient deficiencies, especially zinc. Low organic matter levels suggest the need for practices like composting to improve soil fertility. Phosphorus and potassium management should be adjusted based on specific site needs, with phosphorus fertilization changed for both high and low-phosphorus areas. Adequate magnesium and calcium levels are equally important for plant growth and soil structure, but deficiencies in these nutrients should be addressed with appropriate fertilizers. Zinc deficiencies, influenced by soil pH, can be corrected with zinc fertilization and pH management. Overall, these findings highlight the need for customized soil management practices to improve crop yields and maintain soil health (Brady & Weil, 2017; Fageria, 2014).

SOIL pH

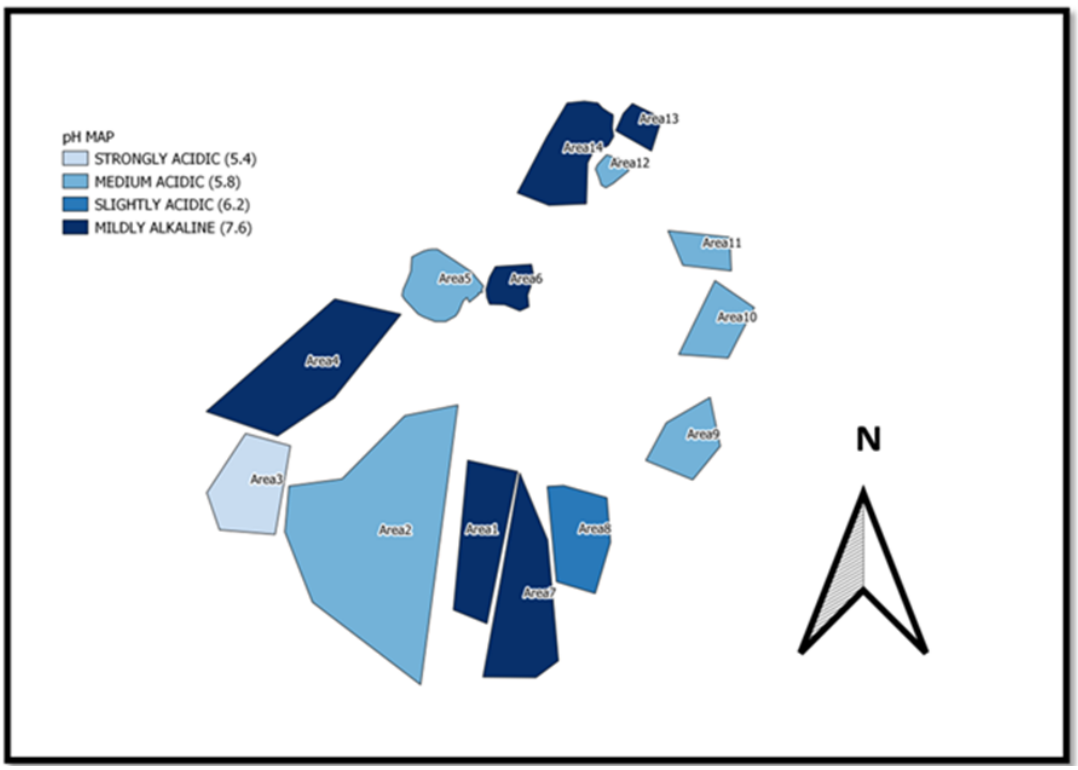


Figure 4. pH map of Agricultural Areas of Barangay Sibuto and Tenonggos, Datu Odin Sinsuat, Maguindanao

The pH levels across Barangay Sibuto and Tenonggos, as shown in Figure 4, have important implications for agricultural practices in these areas. Since soil pH affects nutrient availability, managing pH in strongly acidic and mildly alkaline areas will be crucial to optimizing plant growth. In highly acidic regions like Area 3, lime applications could help neutralize acidity, improving nutrient uptake and reducing the risk of aluminum toxicity, which is common in acidic soils. On the other hand, mildly alkaline areas (Areas 1, 4, 6, 7, 13, and 14) may need to address potential micronutrient deficiencies, particularly zinc and iron, which become less available in higher pH soils.

The observation that pH levels align with topographical and slope variations suggests that managing water runoff and erosion could be beneficial. Higher elevations may experience more leaching of basic nutrients, contributing to increased acidity in lower areas, as seen in Area 3. Rainfall, particularly in sloped regions, can exacerbate this effect, washing away nutrients like calcium and magnesium and leaving behind more acidic soils. This emphasizes the need for tailored pH management strategies that consider both the natural landscape and the specific crops grown in each area (Zhang et al., 2019; Brady & Weil, 2017).

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

ORGANIC MATTER

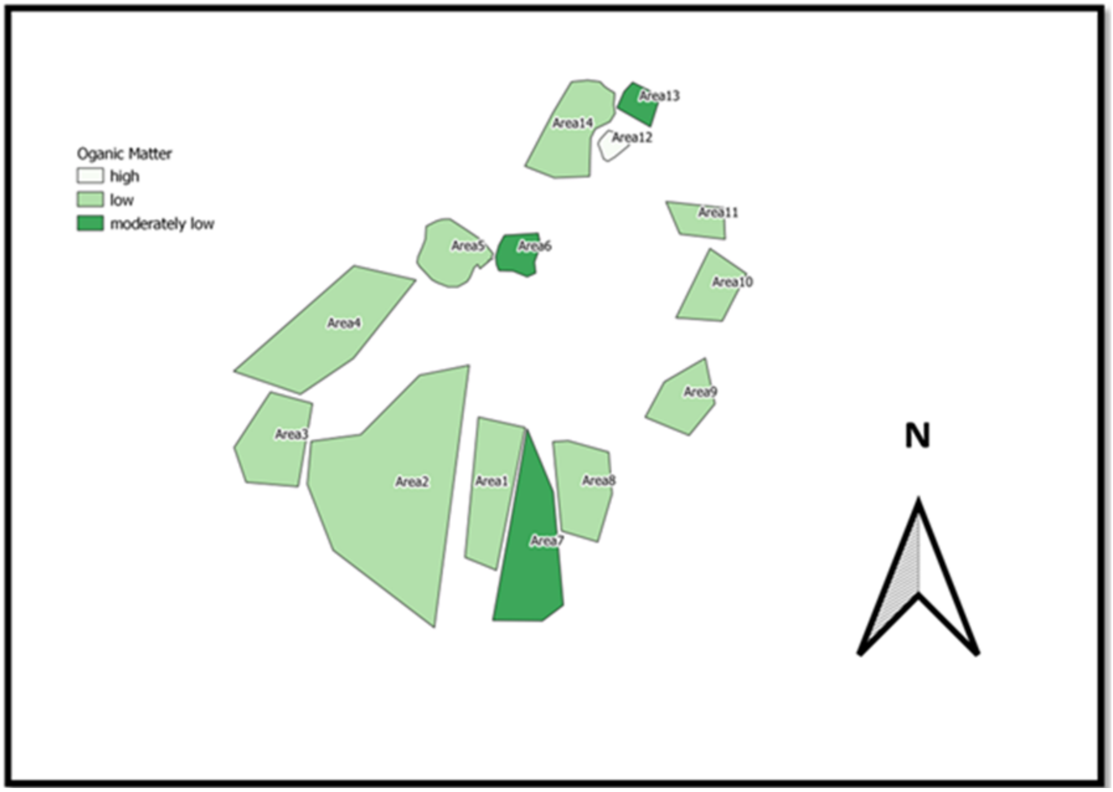


Figure 5. Organic Matter map of Agricultural Areas of Barangay Sibuto and Tenonggos, Datu Odin Sinsuat, Maguindanao

The organic matter levels across the agricultural areas of Barangay Sibuto and Tenonggos have significant implications for soil fertility and crop productivity. Areas with low organic matter (0-2%) may experience reduced water retention, nutrient availability, and microbial activity, which can negatively impact plant growth and yield. These areas may require organic amendments such as compost or manure to improve soil structure and nutrient cycling. Conversely, Area 12, which has higher organic matter content (4.6-5.5%), indicates better soil health, as organic matter acts as a reservoir for essential nutrients like nitrogen and phosphorus. This area is likely to exhibit better water retention and higher nutrient availability, promoting more robust plant growth.

The variation in organic matter content is closely linked to differences in vegetation cover and slope. Areas with dense vegetation and flatter slopes tend to accumulate more organic matter due to the decomposition of plant material, while sloped areas may experience erosion, leading to lower organic matter content. This suggests that soil conservation practices, such as terracing or cover cropping, could help maintain or increase organic matter in sloped areas, preventing erosion and nutrient loss (Lal, 2015b).

Additionally, the mineralization of organic matter has an important role in nitrogen cycling. As organic matter breaks down, nitrogen is converted into plant-available forms, such as ammonium ($NH4+$). In alkaline soils (pH above 7), ammonium can volatilize as ammonia gas, leading to nitrogen losses. Therefore, managing soil pH in areas with moderately low organic matter is critical to prevent nutrient depletion and ensure sustainable crop production (Brady & Weil, 2017).

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

PHOSPHORUS

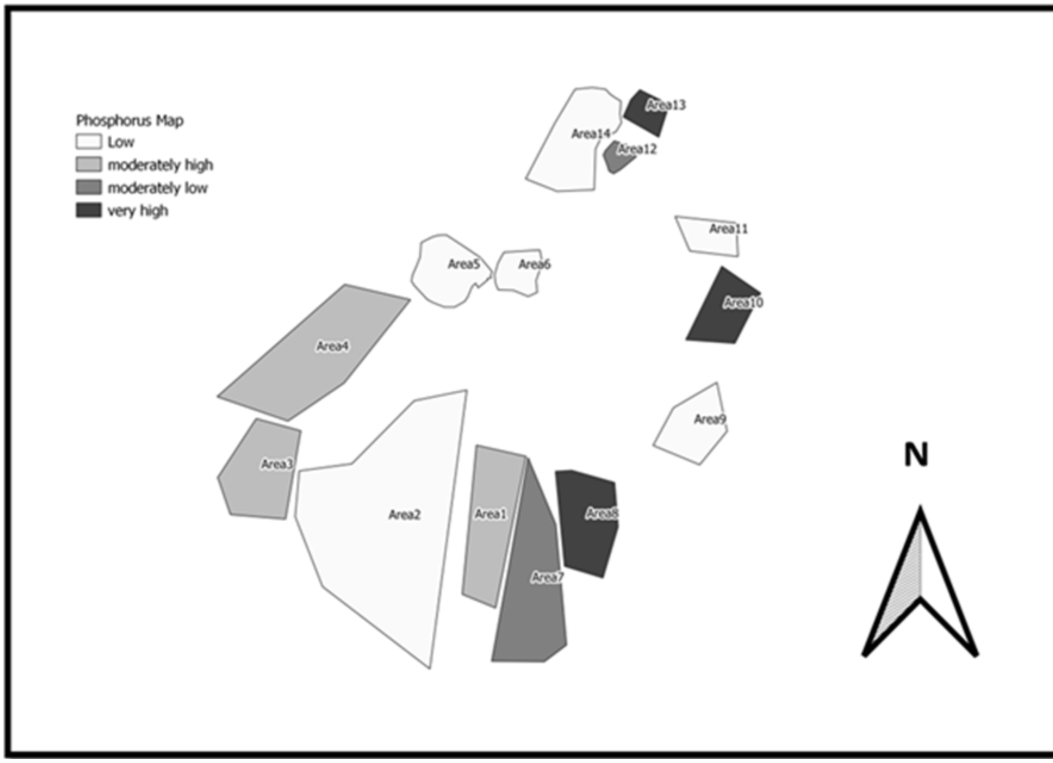


Figure 6. Phosphorus map of Agricultural Areas of Barangay Sibuto and Tenonggos, Datu Odin Sinsuat, Maguindanao

The varying levels of phosphorus across the agricultural areas of Barangay Sibuto and Tenonggos have important implications for soil fertility and crop production. Areas with low phosphorus levels (0-6%)—such as Areas 2, 5, 6, 9, 11, and 14—are likely to experience nutrient deficiencies, which can hinder plant growth and crop yields. Phosphorus is essential for key plant processes, including energy transfer and photosynthesis; thus, low availability can severely limit agricultural productivity. To address this deficiency, soil amendments such as phosphate fertilizers may be necessary to enhance phosphorus availability in these areas (Beegle, 2019b).

In contrast, the moderately high phosphorus levels (10.1-15%) found in Areas 1, 3, and 4 suggest a more favorable environment for crop growth, as these levels can adequately support plant development. However, areas with very high phosphorus levels (>20%)—such as Areas 8, 10, and 13—should be managed carefully to avoid nutrient runoff and potential environmental impacts, such as eutrophication of nearby water bodies. The application of phosphorus fertilizers should be done judiciously in these regions to prevent excessive accumulation that could harm water quality (Sharpley, 2018).

The influence of soil pH and organic matter content on phosphorus availability cannot be overlooked. As indicated by the USDA, maintaining optimal pH levels is crucial, as phosphorus solubility decreases in highly acidic or alkaline conditions (Beegle, 2019b). Organic matter also plays a role in enhancing phosphorus availability through improved soil structure and increased microbial activity, which can facilitate phosphorus release from soil reserves (Rochette et al., 2013). Therefore, targeted soil management practices that consider the specific phosphorus levels and associated factors in each area can help optimize nutrient availability and promote sustainable agricultural practices.

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
RUN RESEARCHERS RUN
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

POTASSIUM

Figure 7. Potassium map of Agricultural Areas of Barangay Sibuto and Tenonggos, Datu Odin Sinsuat, Maguindanao

The variation in potassium levels across the agricultural areas of Barangay Sibuto and Tenonggos has significant implications for plant health and crop productivity. Areas 1, 2, and 10, which have sufficient potassium levels (36-55 ppm), may support the growth of many crops, although potassium uptake can be influenced by other soil factors such as pH and the presence of competing cations (Kang et al., 2020). In contrast, the higher potassium levels found in Areas 4, 6, 8, 11, 13, and 14 (56-75 ppm) indicate an even more favorable environment for plant growth, potentially enhancing drought resistance and overall yield.

The exceptionally high potassium levels (>100 ppm) observed in Areas 3, 7, and 9 suggest that these regions are particularly well-suited for potassium-demanding crops, such as bananas and potatoes. These crops require adequate potassium for enzyme function and water regulation; thus, the elevated levels may lead to improved growth and fruit quality (Kumar et al., 2021). However, care must be taken to monitor potassium levels to avoid excess, which can lead to nutrient imbalances that may inhibit the uptake of other essential nutrients like magnesium and calcium.

The variation in potassium levels can be attributed to differences in soil parent materials and weathering processes. Potassium is primarily derived from minerals such as feldspar and micas, which release potassium ions as they weather (Martins et al., 2023). This underscores the importance of understanding local geology when managing soil fertility, as it can inform decisions about nutrient amendments and crop selection to optimize agricultural productivity.

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

MAGNESIUM

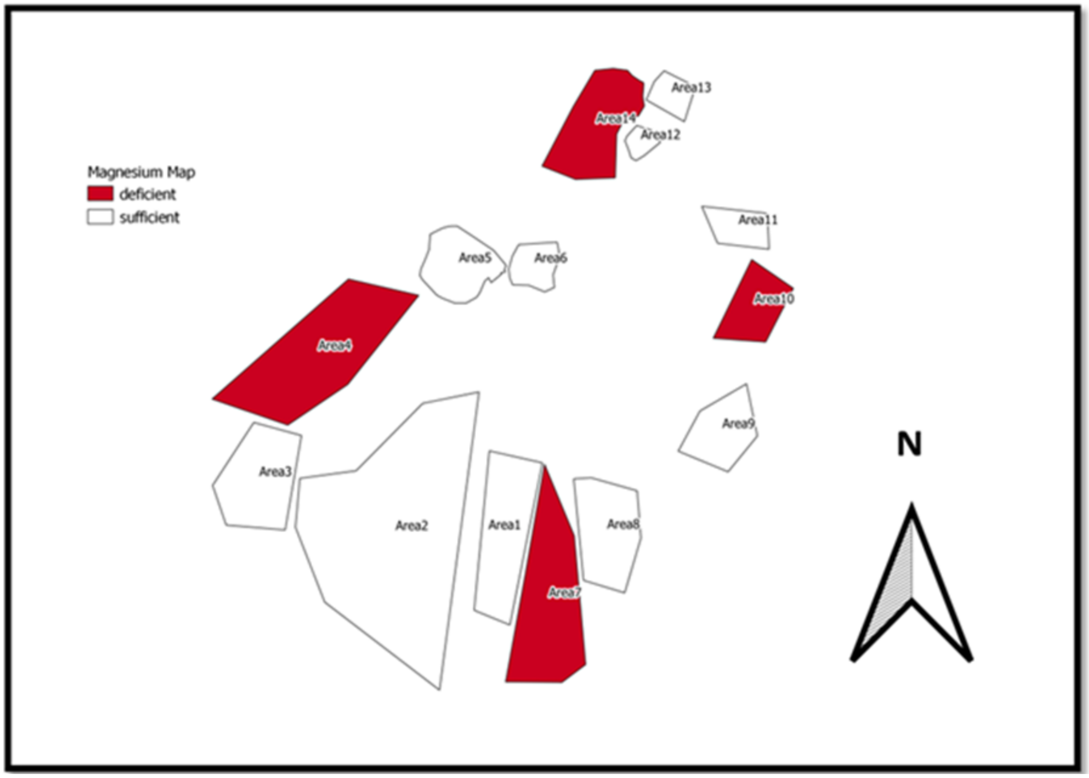


Figure 8. Magnesium map of Agricultural Areas of Barangay Sibuto and Tenonggos, Datu Odin Sinsuat, Maguindanao

The distribution of magnesium levels across the agricultural areas of Barangay Sibuto and Tenonggos has important implications for soil fertility management and crop productivity. Areas 1, 2, 3, 5, 6, 8, 9, 11, 12, and 13, which demonstrate sufficient magnesium levels, are likely to support healthy plant growth and development. Magnesium plays a critical role in photosynthesis as it is a central component of chlorophyll and is also involved in various enzymatic reactions (Hepperly, 2015). This highlights the potential for these areas to produce high-yielding crops that require adequate magnesium for optimal performance.

In contrast, areas with magnesium deficiency can experience reduced crop productivity and quality. Magnesium deficiency may lead to symptoms such as interveinal chlorosis, where leaves turn yellow between the veins, ultimately affecting the overall health of the plants (Xie et al., 2022; Zhang et al., 2022). Therefore, addressing magnesium deficiencies is crucial for enhancing crop resilience and maximizing yield potential (Mao et al., 2021).

The observed variation in magnesium content across the study areas is largely influenced by soil pH. Research from Cornell University indicates that magnesium levels are most available to plants in soils with a pH ranging from medium alkaline to medium acidic (Cornell University, 2020). Consequently, areas exhibiting higher acidity or alkalinity may face challenges in magnesium availability, necessitating targeted soil amendments to correct pH levels and enhance nutrient accessibility. Additionally, environmental factors such as low temperatures and dry conditions, along with high levels of competing cations like potassium and calcium, can further exacerbate magnesium deficiencies (Hepperly, 2015).

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
RUN RESEARCHERS RUN
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

CALCIUM

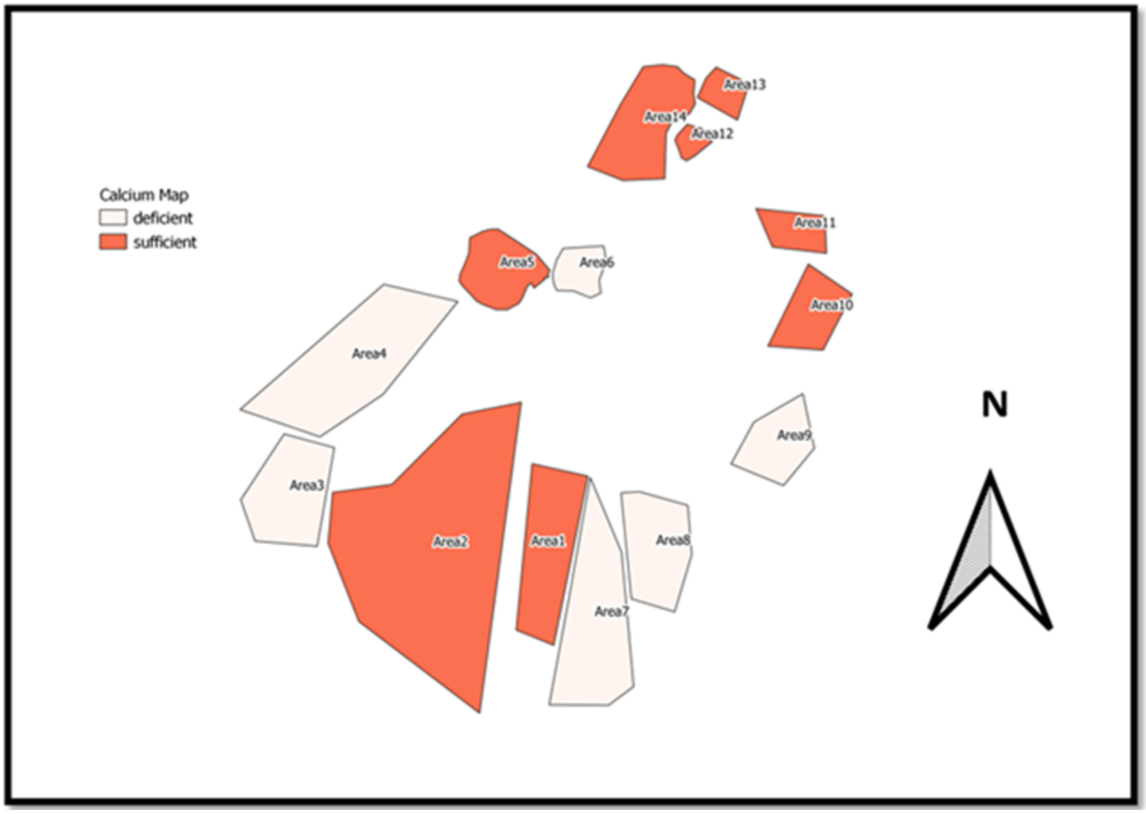


Figure 9. Calcium map of Agricultural Areas of Barangay Sibuto and Tenonggos, Datu Odin Sinsuat, Maguindanao

The analysis of calcium levels across the agricultural areas of Barangay Sibuto and Tenonggos reveals significant implications for soil management practices and agricultural productivity. Areas 1, 2, 5, 10, 11, 12, 13, and 14, which exhibit sufficient calcium levels, are likely to support better soil structure and fertility, enhancing crop yields. Calcium plays a vital role in maintaining flocculated clay, which improves aeration and promotes better water infiltration and retention in the soil (Feng et al., 2021). This is crucial for optimizing root development and nutrient uptake, especially in regions with variable rainfall patterns.

Conversely, the areas deficient in calcium may face challenges in crop growth and productivity. Low calcium levels are often associated with acidic soils, which can hinder plant growth by limiting nutrient availability and affecting soil structure. As soil pH increases beyond 7.2 due to the addition of calcium, excess free calcium can react with phosphorus, forming nearly insoluble compounds that make phosphorus less available for plant uptake (Spectrum Analytic, 2023). This interaction highlights the need for balanced soil amendments to maintain optimal nutrient availability and prevent nutrient lock-up.

Calcium's role in cation exchange dynamics further emphasizes its importance in soil fertility. By displacing sodium, which can be detrimental to soil structure when present in excess, calcium enhances the aggregation of negatively charged clay particles, resulting in improved soil structure and stability (Feng et al., 2020). A well-structured soil not only enhances aeration and water retention but also supports the overall health of crops, making it essential for sustainable agricultural practices.

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

ZINC

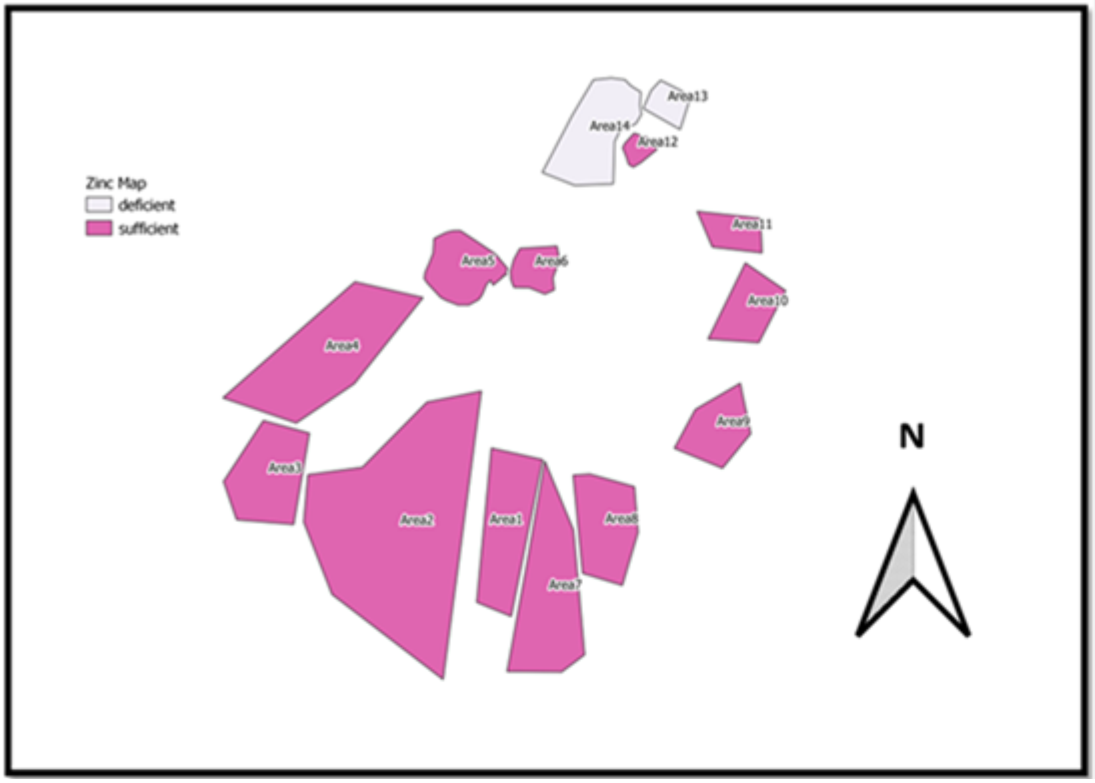


Figure 10. Zinc map of Agricultural Areas of Barangay Sibuto and Tenonggos, Datu Odin Sinsuat, Maguindanao

The assessment of zinc levels in the agricultural areas of Barangay Sibuto and Tenonggos highlights important implications for crop nutrition and soil management practices. Most areas demonstrate sufficient zinc levels, crucial for optimal plant growth, as zinc plays a significant role in various physiological processes, including enzyme function, protein synthesis, and chlorophyll formation (Smith, 2018). The presence of adequate zinc in most of the studied areas suggests that crops are likely to benefit from improved growth and yield potential, which is vital for enhancing food security in the region.

However, the observed deficiencies in Areas 13 and 14 raise concerns regarding potential crop performance in these locations. Zinc deficiency can lead to several physiological symptoms in plants, including stunted growth, chlorosis, and poor fruit development, which can significantly affect overall agricultural productivity (Alloway, 2021). Therefore, targeted soil management practices are essential in these areas to address zinc deficiencies and optimize crop yields.

Interestingly, the relationship between zinc availability and soil pH indicates that most areas with adequate zinc levels span a range from slightly alkaline to strongly acidic. This suggests that soil pH can significantly influence zinc solubility and availability to plants. In general, zinc becomes more available in slightly acidic to neutral pH conditions (Huang, 2019). Therefore, maintaining an optimal pH level is crucial for ensuring the availability of essential micronutrients, including zinc.

Furthermore, zinc levels are also influenced by soil type. Regions with sodic or calcareous soils may inherently have adequate zinc availability due to the natural mineral composition of these soils (Smith, 2018). This emphasizes the importance of understanding the soil composition and type in managing nutrient availability and optimizing crop production.

ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingthecultureofresearch@etcor.org
Mobile Number : 0939-202-9035

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Conclusion

Finding the chemical characteristics of the soil was the initial goal of this study, and it was addressed by the soil analysis carried out at Barangay Sibuto and Tenonggos. The investigation shows notable differences in nutrient levels between various agricultural areas, especially in pH, potassium, phosphorus, and zinc. Strategies for managing soil and crop yield are significantly impacted by these nutrient levels.

The low levels of certain chemical elements, such as zinc and phosphorus, point to possible nutrient deficiencies that could be causing local farmers' crop yields to decline. Sufficient potassium levels suggest a good environment for crops that require potassium, such as corn (*Zea mays*) and rice (Oryza sativa). Because of their capacity to fix nitrogen and enhance soil fertility, soybeans (*Glycine max*) may be suggested in regions with somewhat elevated phosphorus levels. Meanwhile, when organic amendments are added, crops like sweet potatoes (*Ipomoea batatas*) may adapt to low phosphorus environments.

Given these findings, a table summarizing the suitable crops based on soil pH and nutrient levels is presented below, providing a clearer connection between the soil analysis and crop recommendations.

Soil pH Range	Crop Category	Crop Examples
5.5 - 6.5	Cereals	Rice (*Oryza sativa*), Corn (*Zea mays*)
5.8 - 7.0	Legumes	Soybeans (*Glycine max*), Mung beans (*Vigna radiata*), Cowpeas (*Vigna unguiculata*)
5.2 - 6.8	Root Crops	Sweet Potatoes (*Ipomoea batatas*), Carrots (*Daucus carota*), Radishes (*Raphanus sativus*)
6.0 - 6.8	Vegetables (Fruiting)	Tomatoes (*Solanum lycopersicum*), Eggplants (*Solanum melongena*), Peppers (*Capsicum annuum*)
6.0 - 7.5	Brassicas	Cabbage (*Brassica oleracea*)

Recommendations

To address the nutrient deficiencies identified in this study and optimize agricultural productivity, specific soil management practices are recommended. In areas with low phosphorus levels, the application of phosphorus-rich fertilizers like solophos is important to enhance soil fertility. Zinc deficiencies, particularly in Areas 13 and 14, require targeted zinc fertilization and pH adjustments to improve nutrient availability.

To boost organic matter and enhance soil structure, organic amendments such as compost or vermicompost should also be spread throughout agricultural areas. Careful fertilizer management is required in areas with high phosphorus levels to limit environmental effects and stop runoff. It is also advised to use soil conservation techniques like cover crops and terracing to preserve organic matter levels and stop soil erosion in sloping terrain.

To assist farmers in putting these soil management techniques into practice, local government units (LGUs) and legislators should offer them financial and technical support. To promote the community's adoption of sustainable farming practices and spread best practices, extension programs ought to be created. In addition, to guarantee the areas' long-term sustainability and food security, politicians had to revise or establish new regulations centered on managing soil fertility, choosing the right crops, and lowering farmer costs. Farmer productivity, soil health, and sustainable agricultural growth can all be improved by Barangay Sibuto and Tenonggos farmers implementing these suggestions.

Acknowledgment

Above all, the researchers extend their deepest gratitude to the ALMIGHTY ALLAH, whose guidance and blessings made this research possible.

Our heartfelt appreciation goes to our beloved parents for their prayers, unwavering support, and endless love and care.

The researchers express their deepest gratitude to their adviser, Engr. Jeanneflor Salva-Atong, for her unwavering support, insightful ideas, and invaluable guidance. Her patience in reading and reviewing this study, along with the encouragement and inspiration she provided, were instrumental in achieving the successful outcome of this research.

The researchers also wish to express their sincerest gratitude to the following individuals, whose valuable time and efforts contributed to the completion of this study. Their support is deeply appreciated, and the researchers are truly indebted to them.

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Engr. Allen Julius Christ Declaro, for his untiring teachings and instructions for the digitizing and encoding of spatial data that led to the completion of this study, encouragement, and contributions to this study.

They also want to express their deepest thank to their friends, classmates, and relatives for their never-ending moral support and efforts that helped the researchers complete this study.

Finally, to their parents, brothers, and sisters for their moral and financial support and their unconditional concerns that motivate the researchers to work even more.

REFERENCES

Abdulai, M. S., Oppong, K. A., & Anning, A. K. (2022). Geospatial techniques for agricultural land suitability assessment in sub-Saharan Africa: A review. *Journal of Agriculture and Food Research*, 8, 100300. https://doi.org/10.1016/j.jafr.2022.100300

Alloway, B. J. (2021). Zinc in soils and crop nutrition: A review of its importance in agricultural systems. *Plant and Soil*, 467(1-2), 59-70. https://doi.org/10.1007/s11104-021-05055-y

Beegle, D. B. (2019). *Phosphorus management in agriculture*. Penn State Extension. https://extension.psu.edu/phosphorus-management-in-agriculture

Beegle, D. B. (2019). Soil phosphorus. In *Soil fertility management in agroecosystems* (pp. 39-60). CRC Press. https://doi.org/10.1201/9780429258094-4

Berner, A., & Brueck, H. (2016). Importance of organic matter for soil fertility and crop yield: A review. *Plant and Soil*, 408(1-2), 1-14. https://doi.org/10.1007/s11104-016-2855-2

Brady, N. C., & Weil, R. R. (2017). *The nature and properties of soils* (15th ed.). Pearson. https://doi.org/10.1080/00489600.2018.1460578

Cornell University. (2020). Nutrient management: Magnesium. Retrieved from Cornell University Nutrient Management. https://nm.cals.cornell.edu/magnesium

Fageria, N. K. (2014). *Nutrient management for sustainable crop production*. CRC Press. https://doi.org/10.1201/b17341

Feng, Y., Xu, Y., & Zhang, Y. (2021). The impact of calcium on soil structure and agricultural productivity: A review. *Soil Science*, 186(3), 135-143. https://doi.org/10.1097/SS.0000000000000547

Feng, Y., Sun, Y., & Huang, C. (2020). The role of calcium in soil structure and its implications for sustainable agriculture. *Agricultural Sciences*, 11(4), 355-367. https://doi.org/10.4236/as.2020.114025

Hepperly, P. R. (2015). The role of magnesium in plant nutrition. In *Nutrient management in sustainable agriculture*. CRC Press. https://doi.org/10.1201/b17341

Huang, J. (2019). Zinc availability and soil pH: Implications for soil fertility management. *Journal of Soil Science and Plant Nutrition*, 19(1), 1-12. https://doi.org/10.1007/s42729-019-00001-6

Kang, J., Zhang, J., Zhang, H., & Li, J. (2020). Effects of potassium management on crop yield and soil properties in different regions. *Agronomy*, 10(2), 123. https://doi.org/10.3390/agronomy10020123

Kumar, A., Singh, R., & Ghosh, S. (2021). Potassium nutrition in horticultural crops: Importance and management. *Journal of Plant Nutrition*, 44(4), 554-577. https://doi.org/10.1080/01904167.2021.1894325

Lal, R. (2015). Soil erosion and carbon dynamics. *Soil Research*, 53(5), 569-582. https://doi.org/10.1071/SR15070

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Lal, R. (2015). Restoring soil quality to mitigate soil degradation. *Sustainable Agriculture Reviews*, 15, 177-205. https://doi.org/10.1007/978-3-319-16529-4_7

Mao, L., Zeng, J., Yang, Y., & Zhu, Y. (2021). Magnesium deficiency enhances susceptibility to drought stress in rice plants. *Frontiers in Plant Science*, 12, 709678. https://doi.org/10.3389/fpls.2021.709678

Martins, A. D., Santos, R. D., & Ferreira, J. A. (2023). Soil mineralogy and its impact on potassium availability. *Soil Science Society of America Journal*, 87(1), 54-67. https://doi.org/10.1002/saj2.20643

Nwite, J. N., Iwuanyanwu, U. P., & Nweke, I. A. (2021). Soil fertility dynamics under integrated management practices in degraded Ultisols of Southeastern Nigeria. *Heliyon*, 7(4), e06744. https://doi.org/10.1016/j.heliyon.2021.e06744

Oshunsanya, S. O., Olaniyan, A. F., & Oluwaseun, O. A. (2016). Geographic Information System (GIS) applications in agriculture: A review. *Journal of Geographic Information System*, 8(2), 213-229. https://doi.org/10.4236/jgis.2016.82018

Paul, R. (2018). *The role of geospatial technologies in improving agricultural production and management*. *Agronomy for Sustainable Development*, 38(3), 21. https://doi.org/10.1007/s13593-018-0500-4

Sharpley, A. N. (2018). Managing phosphorus for environmental quality. *Journal of Soil and Water Conservation*, 73(5), 135A-139A. https://doi.org/10.2489/jswc.73.5.135A

Smith, M. (2018). Soil zinc availability: Impacts and management strategies. *Soil and Plant Nutrition Review*, 32(4), 289-299. https://doi.org/10.1016/j.soilpr.2018.01.004

Zhang, H., Wang, D., & Liu, X. (2019). The impact of soil pH on nutrient availability and crop growth. *Agronomy for Sustainable Development*, 39(3), 26. https://doi.org/10.1007/s13593-019-0582-4

Zhang, Z., Xu, D., Li, L., Zhang, C., & Liu, Y. (2021). Spatial-temporal dynamics and driving forces of soil organic matter in arable land at different scales: A case study in Hebei Province, China. *Land*, 10(11), 1150. https://doi.org/10.3390/land10111150

Spectrum Analytic. (2023). Calcium basics: The role of calcium in soil fertility. Retrieved from Spectrum Analytic.

Valdez, L. (2019). *The impact of soil nutrient decline on agricultural productivity in Maguindanao, Philippines*. *Philippine Journal of Soil Science*, 1(2), 1-12. https://doi.org/10.1016/j.phjss.2019.03.001

Xie, Z., Wu, L., Zhang, Y., Zhang, Z., & Ma, W. (2022). Magnesium deficiency reduces the yield and quality of sweet corn by altering the photosynthetic capacity and enzyme activity. *Agronomy*, 12(5), 1145. https://doi.org/10.3390/agronomy12051145

Zhang, L., Zhang, S., Liu, X., & Wang, G. (2022). The effect of magnesium deficiency on plant growth and quality in spinach (Spinacia oleracea L.). *Journal of Plant Nutrition*, 45(6), 873-883. https://doi.org/10.1080/01904167.2022.2043557