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GIS-Based Spatial Assessment of Preliminary Soil Bearing Capacity in Gapan City Using DPWH Geotechnical Data

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ABSTRACT: This study evaluates the soil characteristics and spatial distribution of shallow soil bearing capacity in Gapan City, Nueva Ecija, to support preliminary geotechnical assessment and planning. Using secondary DPWH borehole records and QGIS-based Inverse Distance Weighted (IDW) interpolation, the research analyzes soil types and Safe Bearing Capacity (SBC) at 1.5m and 3.0m embedment depths. Findings show that soil bearing capacity improves by 15% to 40% as depth increases from 1.5m to 3.0m. At 1.5m, values range from 66.98 kPa to 110.214 kPa, whereas at 3.0m, values reach up to 127.68 kPa. The northern sector, including Gapan City barangays such as Pambuan and San Lorenzo, exhibits the lowest capacities at shallow depths. The resulting thematic maps classify Gapan City into low (65–74 kPa), moderate (74–92.9 kPa), and high (above 92.9 kPa) bearing capacity zones. The study concludes that deeper strata generally exhibited higher estimated bearing capacity values. These maps serve as a preliminary screening tool for engineers and planners, though the researchers emphasize that they do not replace the requirement for site-specific geotechnical testing for multi-storey or heavy infrastructure projects.

KEYWORDS: Soil Bearing Capacity, GIS Interpolation, IDW, Geotechnical Mapping, Shallow Foundation, Gapan City

I. INTRODUCTION

The structural integrity and long-term stability of civil engineering projects are fundamentally dependent on the geotechnical characteristics of the ground. In the field of land development and urban planning, soil strength and bearing capacity serve as the primary metrics for determining whether a specific site can safely support residential structures. Bearing capacity represents the maximum load a soil mass can sustain without experiencing shear failure or excessive settlement. As Gapan City, Nueva Ecija, undergoes rapid urban expansion, the systematic evaluation of localized soil data becomes important for ensuring that residential developments are built on a foundation of engineering assessment.

A critical component of this investigation is the analysis of soil strength and bearing capacity based on different soil types and varying depths. This study emphasizes how soil classification influences the ability of the ground to support structural loads. Rather than performing manual calculations, this evaluation utilizes established geotechnical data and computed values from the Department of Public Works and Highways (DPWH), which are derived using Meyerhof's Bearing Capacity Theory. By analyzing these Safe Bearing Capacity (SBC) profiles, the research aims to classify the soil's suitability for supporting structures based on existing geotechnical records.

In the Philippine context, particularly within the alluvial plains of Central Luzon, soil conditions may vary significantly due to local geological history. According to localized geotechnical studies, mapping these properties is essential for providing engineers with a reliable baseline for foundation design. In Gapan City, utilizing geotechnical records managed by the DPWH allows for an efficient and data-driven way to assess ground conditions. By synthesizing these existing datasets, it is possible to categorize the soil's stability into low, moderate, or high bearing capacity zones before any development begins.

The primary objective of this research is to evaluate the soil characteristics in Gapan City through the analysis and interpretation of secondary data obtained from the DPWH Borehole Logs. The study focuses on identifying different soil types and assessing their corresponding bearing capacity values at two specific levels: 1.5 meters and 3.0 meters embedment depths. By integrating the acquired geotechnical data into a Geographic Information System (QGIS), the research aims to produce two detailed thematic maps representing the spatial distribution of soil bearing capacity at each respective depth. These maps will categorize areas based on their relative strength, providing a preliminary assessment of shallow foundation suitability. Ultimately, the results of this investigation may provide a practical reference for engineers and local government units, supporting informed decisions and promoting safe development in Gapan City.

1.1 Background of the Study

Gapan City is recognized as the Footwear Capital of the North and stands as one of the oldest and most rapidly developing urban centers in the province of Nueva Ecija. According to official data from PhilAtlas (2024) which incorporates figures from the Philippine Statistics Authority, the city has seen its population grow to 122,968 as of the 2020 Census. This represents a significant annualized growth rate of 2.31 percent from 2015, highlighting the city’s steady transition from a primarily agricultural landscape into a rising hub for commerce and residential development. Due to its strategic location along the Pan-Philippine Highway and its proximity to Metro Manila and other parts of Central Luzon, the demand for housing and infrastructure has increased substantially. This trend leads to the conversion of vast land areas into residential subdivisions and commercial zones, where areas previously used for farming are now being prepared to support residential and commercial structures.

However, this fast-paced urbanization brings significant engineering challenges, particularly regarding the suitability of the land for heavy construction. In civil engineering, the safety of any structure depends on the soil strength and bearing capacity of the site. These technical factors determine if the ground can support a building without sinking or cracking over time. Locally, a study by Giducos et al. (2017) regarding soil bearing capacity mapping in the Philippines highlights that creating reference maps is crucial for engineers to understand the interaction between foundations and the underground soil layers. Understanding these specific characteristics is no longer just an option, but important for construction planning and geotechnical assessment as the city continues to expand.

Because of these factors, there is a clear need for a more detailed way to analyze soil conditions in Gapan City. This is where the mapping of soil bearing capacity becomes a vital tool. Such maps provide a visual representation of the strength and distribution of different soil types across the area, allowing engineers and planners to identify zones that are suitable for construction and areas that may require caution. Rather than relying on general assumptions, this approach offers a data driven method for assessing soil performance, using secondary datasets from the DPWH integrated into QGIS for spatial analysis and visualization.

This study focuses on the analysis and interpretation of existing geotechnical data sourced from official DPWH borehole records. By utilizing available information on soil classifications and extracting bearing capacity values at embedment depths of 1.5 meters and 3.0 meters, the researchers aim to provide a comparative technical overview of the city’s soil strength profile. This approach allows for a preliminary assessment based on available data. Ultimately, this research is intended to serve as a preliminary guide for residents, local engineers, and developers of Gapan City by illustrating the soil stability at these specific embedment depths, ensuring that construction planning is informed by reliable geotechnical data.

1.3 Statement of the Problem

This study aims to evaluate and map the spatial distribution of shallow soil bearing capacity at 1.5 m and 3.0 m depths. in Gapan City using available geotechnical data from selected barangays and GIS-based interpolation techniques. Specifically, the study seeks to answer the following questions:

1. What are the available soil characteristics and soil bearing capacity values at 1.5 m and 3.0 m depth from selected DPWH records in Gapan City?
2. What soil types are present in the selected barangays based on available records?
3. How can the available bearing capacity values from the 16 barangays be spatially interpolated to estimate shallow soil bearing capacity in the remaining barangays of Gapan City?
4. What is the resulting citywide spatial distribution of estimated shallow soil bearing capacity at 1.5 m and 3.0 m depth?
5. Which areas of Gapan City may be classified as relatively low, moderate, or high bearing capacity zones for preliminary shallow foundation planning?

1.3 Objectives of the Study

The main objective of this study is to estimate and spatially map shallow soil bearing capacity at 1.5 m and 3.0 m depths in Gapan City using selected DPWH geotechnical records and GIS-based interpolation. Specifically, the study aims to:

1. Compile and analyze available soil and bearing capacity data at 1.5 m and 3.0 m depth from 16 selected barangays in Gapan City.
2. Identify the soil types present in the selected locations.
3. Apply GIS-based interpolation techniques to estimate bearing capacity values in barangays without available records.
4. Generate a citywide map showing the estimated spatial distribution of shallow soil bearing capacity at 1.5 m and 3.0 m depths.
5. Classify areas into relative bearing capacity zones to support preliminary site screening and shallow foundation planning.

1.4 Significance of the Study

The study provides preliminary geotechnical information that may support shallow foundation planning, land-use assessment, and future geotechnical investigations in Gapan City. The findings may also help planners, engineers, and the community in understanding soil conditions and estimated bearing capacity for safer and more informed construction decisions.

Local Government and Urban Planners. The study provides essential information on soil strength, bearing capacity, and terrain characteristics in Gapan City, which can guide land-use planning and safe residential development.

Engineers and Builders. The estimated soil bearing capacity and terrain assessment will help engineers design foundations appropriately and prevent potential structural problems due to weak soil conditions.

Future Researchers. The study can serve as a reference for future studies on soil assessment, land suitability, or environmental planning in Gapan City or similar areas.

The Community. By identifying areas suitable for residential construction, the study helps ensure the safety and sustainability of housing projects, ultimately benefiting residents.

1.5 Scope and Delimitations of the Study

This study focuses on investigating the soil characteristics and Safe Bearing Capacity (SBC) across the geographic extent of Gapan City using secondary geotechnical data obtained from official Department of Public Works and Highways (DPWH) borehole records. The study utilizes QGIS and Inverse Distance Weighted (IDW) interpolation to produce thematic maps showing estimated bearing capacity values at 1.5-meter and 3.0-meter embedment depths. These maps are intended to serve as preliminary tools for shallow foundation planning and land suitability assessment.

However, the study has several limitations. It does not include primary field or laboratory testing such as Standard Penetration Tests (SPT) or Unconfined Compressive Strength (UCS) tests and relies solely on existing DPWH data and interpolation methods. Since interpolation provides generalized estimates, localized soil variability, groundwater conditions, seasonal effects, and micro-geological changes are not fully considered. The computed bearing capacity values are based on the official records, which commonly apply Meyerhof's Theory. The interpolated maps are intended only for preliminary planning purposes and should not replace site-specific geotechnical investigation and foundation design analysis.

1.6 Conceptual Framework

The study follows the Input–Process–Output (IPO) model in assessing the spatial distribution of soil characteristics and estimated bearing capacity in Gapan City. The inputs include secondary geotechnical data from the Department of Public Works and Highways (DPWH), such as soil type classifications, soil characteristics, and Safe Bearing Capacity (SBC) values at 1.5-meter and 3.0-meter depths, together with geographic and GIS data. The process involves data validation, GIS encoding, spatial interpolation using Inverse Distance Weighted (IDW) analysis, and zoning classification of bearing capacity values into low, moderate, and high categories. The outputs consist of thematic maps showing the spatial distribution of soil types and estimated bearing capacity, which may support preliminary shallow foundation planning and land-use assessment in Gapan City.

INPUT

- DPWH geotechnical records from selected barangays in Gapan City.
- Soil characteristics (e.g., soil classification, properties).
- Soil bearing capacity values at 1.5 m and 3.0 m depth.
- Geographic location data (barangay boundaries/coordinates)

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PROCESS

- Data Collection
- Data Validation
- GIS Encoding
- IDW Interpolation
- Spatial Mapping
- Zonation Analysis

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OUTPUT

- Interpolated Spatial Map of Soil Bearing Capacity (at 1.5 m and 3.0 m depth)
- Citywide Spatial Distribution Map of Estimated Shallow Soil Bearing Capacity (at 1.5 m and 3.0 m depth)
- Zoning Map Showing Low, Moderate, and High Bearing Capacity Areas
- Basis for Preliminary Shallow Foundation Planning in Gapan City

Figure 1. Conceptual Framework.

II. REVIEW OF RELATED LITERATURES AND STUDIES

Soil bearing capacity is a fundamental concept in geotechnical engineering that refers to the ability of soil to safely support structural loads without experiencing shear failure or excessive settlement. According to Joseph E. Bowles (1996), Braja M. Das (2021), G. G. Meyerhof (1963), and Donald P. Coduto et al. (2011), bearing capacity is influenced by soil properties such as cohesion, internal friction angle, density, moisture content, and unit weight, as well as foundation dimensions and depth. These theories explain that different soil types respond differently to structural loading, where dense granular soils generally exhibit higher strength while cohesive soils are more susceptible to settlement and shear failure. Meyerhof’s modifications to classical bearing capacity theory further improved the evaluation of shallow foundation performance by incorporating shape, depth, and load inclination factors. Coduto et al. also emphasized that site-specific conditions such as groundwater level, stratification, and soil variability significantly affect foundation behavior, highlighting the importance of geotechnical investigation in engineering design.

Recent developments in Geographic Information System (GIS) applications have expanded the use of geotechnical data for spatial analysis and preliminary foundation assessment. GIS-based geotechnical mapping allows soil properties and bearing capacity values to be visualized spatially through interpolation techniques such as Inverse Distance Weighted (IDW), Kriging, and Spline methods. Among these, IDW interpolation is commonly used in preliminary geotechnical zonation because it estimates unknown values based on the influence of nearby data points and produces practical thematic maps for engineering planning. A. Ajaj et al. (2018) demonstrated that GIS-based IDW interpolation can effectively estimate spatial distributions in areas with limited measured data and can generate continuous thematic maps for spatial analysis and decision-making. Spatial interpolation methods are useful in identifying variations in soil strength across large geographic areas, especially in locations with limited borehole information. Through GIS-based zonation, areas may be classified into low, moderate, and high bearing capacity zones, providing preliminary guidance for shallow foundation planning, land-use assessment, and future site-specific geotechnical investigations.

Despite the advantages of GIS-based interpolation methods, several studies emphasized that interpolation accuracy may still be affected by spatial variability, uneven distribution of sampling points, and distance-weighting assumptions. Guangquan Lu and David W. Wong (2008) explained that although IDW interpolation is widely applied because of its simplicity and efficiency, uncertainties may occur when predicting values in areas with sparse or irregularly distributed data. Their study highlighted the importance of evaluating interpolation reliability and selecting appropriate interpolation parameters to improve spatial prediction accuracy. These limitations indicate that GIS-generated bearing capacity maps should primarily serve as preliminary planning tools and should still be supported by site-specific geotechnical investigations for final engineering design and construction decisions.

III. METHODOLOGY

3.1 Research Design

This study follows a descriptive–spatial analysis research design. This design is appropriate for systematically describing and analyzing the spatial distribution of soil characteristics and estimated bearing capacity in Gapan City using existing geotechnical data and Geographic Information System (GIS) techniques.

The study is descriptive in nature because it aims to present and interpret existing soil data obtained from the Department of Public Works and Highways (DPWH) without manipulating variables. It is also spatial analytical because it involves the use of GIS-based interpolation methods to estimate and visualize soil bearing capacity across different locations within the city.

This design allows the integration of engineering data and spatial modeling to generate maps and classifications that represent soil conditions at 1.5 meters and 3.0 meters depths. Through this approach, the study is able to identify spatial patterns and classify areas into different bearing capacity zones, which are essential for preliminary shallow foundation planning and land use evaluation.

3.2 Research Locale

The study was conducted in Gapan City, Nueva Ecija, Philippines, which is a component city characterized by a mix of urban and agricultural land use. The city is composed of multiple barangays with varying soil conditions that are significant for geotechnical and foundation-related studies.

Gapan City was selected as the research locale due to its relevance in infrastructure development and the availability of geotechnical data from the Department of Public Works and Highways (DPWH). The variation in soil properties across different barangays makes it suitable for spatial analysis of soil type and bearing capacity.

Geographically, the city is located within the Central Luzon region and experiences flat to gently sloping terrain, which is generally suitable for construction but requires proper soil evaluation for safe foundation design. The presence of existing DPWH borehole and soil investigation records further supports the feasibility of conducting GIS-based spatial interpolation in the area.

By focusing on Gapan City, the study aims to provide a comprehensive spatial assessment of shallow soil bearing capacity that can serve as a reference for engineering planning, infrastructure development, and land use management.

Legend: ☆ Gapan

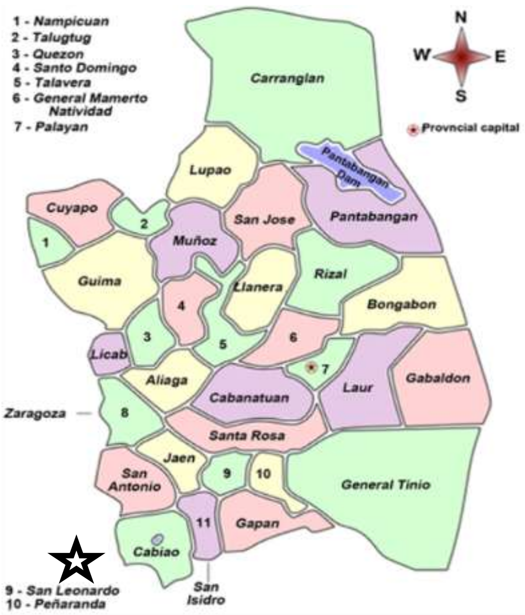

Figure 2. Research Locale

3.3 Data Collection Procedure

The data collection procedure of this study involved the systematic acquisition, validation, and organization of geotechnical and spatial data necessary for the assessment of soil bearing capacity across Gapan City.

3.3.1 Acquisition of Geotechnical and Spatial Data

The researchers utilized two primary sources of data:

- Geotechnical Data: Secondary records were obtained from the Department of Public Works and Highways (DPWH), specifically borehole investigation results conducted at various public school sites within Gapan City. These records provided the allowable soil bearing capacity values and soil classifications at depths of 1.5-meters and 3.0-meters.
- Spatial Data: Land area (in hectares) and geographic boundaries of the 27 barangays were extracted through Quantum Geographic Information System (QGIS).

3.3.2 Data Validation and Inventory

After acquisition, the collected information was carefully reviewed to ensure completeness and consistency. The researchers developed a data inventory to distinguish between barangays with existing DPWH records and those requiring estimation. This inventory, which serves as the study’s baseline, is presented in Table 1.

			1.5 m		3.0 m	
No.	Barangay	Area (ha)	Soil Type	Soil Bearing Capacity (kPa)	Soil Type	Soil Bearing Capacity (kPa)
1	Balante	357.797	Silty Clay	65	Silty Clay	125
2	Bayanihan	661.551	Silty Clay	75	Silty Clay	115
3	Bulak	441.408	Clayey Silt	-	Clayey Silt	125
4	Bungo	762.612	-	-	-	-
5	Kapalangan	988.752	-	-	-	-
6	Mabunga	759.797	Sandy Silt	70	Sandy Silt	120
7	Maburak	956.658	Sandy Silt	70	Sandy Silt	150
8	Mahipon	663.248	Sandy Silt	-	Sandy Silt	90
9	Makabaclay	3045.816	Sandy Silt	70	Sandy Silt	130
10	Malimba	543.222	-	-	-	-
11	Mangino	573.407	Clayey Silt	70	Clayey Silt	150
12	Marelo	426.412	-	-	-	-
13	Pambuan	1017.047	Silty Clay	-	Silty Clay	90
14	Parcutela	193.461	-	-	-	-
15	Puting Tubig	754.729	Poorly Graded Sand	80	Poorly Graded Sand	100
16	San Lorenzo	549.578	Silty Clay	65	Silty Clay	125
17	San Nicolas	426.443	Sandy Silt	-	Sandy Silt	70
18	San Roque	446.71	Clayey Silt	100	Clayey Silt	100

19	San Vicente	470.132	-	-	-	-
20	Santa Cruz	965.424	Sandy Silt	200	Sandy Silt	200
21	Santo Cristo Norte	621.851	Clayey Silt	170	Clayey Silt	170
22	Santo Cristo Sur	355.203	Clayey Silt	70	Clayey Silt	125
23	Santo Nino	357.752	-	-	-	-

Table 1. Inventory of Geotechnical Data and Soil Characteristics of Barangays in Gapan City.

3.3.3 Georeferencing and Distance Measurement

The validated data were encoded into the GIS environment. To facilitate the Inverse Distance Weighted (IDW) interpolation, the researchers utilized QGIS to measure the linear distances (di) between the centroid of the target barangay (without data) and the centroids of the surrounding neighboring barangays (with known data). These measured distances, expressed in kilometers (km), served as the primary basis for the weighting analysis in the estimation process.

3.4 Data Analysis

This study employs a systematic geotechnical and spatial analysis framework to evaluate the Allowable Soil Bearing Capacity across Gapan City. The analysis primarily utilizes existing geotechnical records and spatial interpolation to ensure a data-driven assessment of land suitability.

3.4.1 Data Organization and Standardization

The analysis begins with the collection and categorization of raw soil investigation data from the Department of Public Works and Highways (DPWH). The researchers organized the available Allowable Soil Bearing Capacity (qa) values into a centralized database, categorized according to their specific embedment depths: 1.50 meters and 3.00 meters.

These depths were selected to represent standard engineering practices for shallow foundations in the Philippines, specifically for residential structures and multi-storey public buildings. By segregating the data, the study ensures that the mapping reflects the distinct soil strength variations at different stratigraphic levels.

3.4.2 Estimation for Barangays Without DPWH Data

To address spatial gaps where specific borehole records or DPWH data were unavailable, the researchers employed the Inverse Distance Weighted (IDW) Interpolation method. This mathematical approach is based on the principle of geological continuity, assuming that the soil characteristics of an unsampled barangay are more similar to nearby test locations than those farther away.

The estimation process is governed by the following strict protocols:

- Depth-Specific Interpolation: Calculations are performed separately for the 1.5 m and 3.0 m embedment depths. Only known values from a specific depth are used to estimate the target value for that same depth.
- Spatial Proximity Rule: Only barangays directly adjacent or immediately surrounding the target area are utilized as reference points to maintain localized spatial consistency.
- Centroid-to-Test Point Distance: To increase precision, distances are measured from the Centroid of the target barangay to the actual DPWH soil test locations (e.g., specific school sites or infrastructure projects) of the neighboring barangays, rather than simple centroid-to-centroid measurements.

The estimated value (qest) is derived using the following mathematical model:

$$qest = \frac{\Sigma\left(\frac{qi}{d_i^2}\right)}{\Sigma\left(\frac{1}{d_i^2}\right)}$$

Where:

- qest = estimated allowable soil bearing capacity of the target barangay.
- qi = known soil bearing capacity of the neighbouring barangay at the same depth.
- di = distance from the target barangay centroid to the known test point.
- Power = 2 (Inverse Square Law).

3.4.3 GIS Integration and Suitability Mapping

The consolidated data, comprising both actual DPWH records and interpolated values, are integrated into QGIS (Quantum Geographic Information System). This allows for the generation of thematic maps illustrating the geographic distribution of soil bearing capacity across Gapan City.

Finally, a Land Suitability Assessment is performed by categorizing the city into zones (e.g., High, Moderate, or Low SBC). This categorization aids in urban planning and provides a preliminary guide for future infrastructure development. though the researchers emphasize that these estimates are for planning purposes and do not replace site-specific soil investigations.

IV. RESULTS AND DISCUSSION

This chapter presents the findings of the geotechnical mapping and spatial analysis for Gapan City. It provides a comparative evaluation of estimated soil bearing capacity (*qa*) at two distinct embedment depths (*Df = 1.5 and 3.0*) utilizing available DPWH-sourced records and the results derived from Inverse Distance Weighted (IDW) interpolation.

4.1 Spatial Interpolation and Weighting Results

The initial phase of the analysis focused on the numerical data generated through interpolation. This process provided an estimation of the Safe Bearing Capacity (SBC) for barangays lacking direct subsurface records by weighting the influence of known data points based on their geographic proximity.

Table 2. Spatial Interpolation and Weighting Analysis (1.5 m Depth)

Target Barangay	Neighbours	Distance d (km)	Weight (1/d^2)	SBC (kPa)	Estimated qest (kPa)
Bulak	San Roque	2.595	0.1485	100	94.77 kPa
	Makaba clay	5.652	0.031	70	
Pambuan	Mabunga	3.6056	0.0769	70	66.98 kPa
	San Lorenzo	2.9152	0.1177	65	
Malimba	San Roque	1.360	0.541	100	105.224 kPa
	Bulak	2.543	0.155	94.77	
	Santo Cristo Norte	2.341	0.182	170	
	Balante	2.347	0.182	65	
Marelo	Bulak	2.613	0.1465	94.77	78.91 kPa
	Mabunga	3.606	0.0769	70	
	San Lorenzo	2.915	0.1177	65	
San Vicente	Bayanihan	2.262	0.195	75	69.327 kPa
	San Lorenzo	1.896	0.278	65	
	Mangino	2.631	0.144	70	
San Nicolas	Bayanihan	2.821	0.126	75	108.299 kPa
	Santo Cristo Norte	3.848	0.068	170	
Santo Nino	Bayanihan	2.010	0.2475	75	92.46 kPa
	San Nicolas	1.286	0.6047	108.299	
	San Vicente	2.097	0.2274	69.327	
Parcutela	Marelo	1.617	0.3825	78.91	90.41 kPa
	San Roque	1.477	0.4584	100	
Kapalangan	Makaba clay	7.098	0.020	70	110.214 kPa
	Puting Tubig	2.125	0.221	80	
	Balante	4.532	0.049	65	
	Santa Cruz	3.040	0.108	200	
Mahipon	Malimba	4.124	0.059	105.224	102.239 kPa
	Kapalangan	3.305	0.092	110.214	
	Bungo	4.051	0.061	105.930	
	Bulak	2.569	0.152	94.770	
Bungo	Makaba clay	5.651	0.0313	70	105.93 kPa
	Kapalangan	1.951	0.2627	110.214	

At an embedment depth of 1.5 meters, the estimated values (*qest*) demonstrate a range from a minimum of 66.98 kPa in Pambuan to a maximum of 110.21 kPa in Kapalangan. These variations stem from the distance and influence of neighboring barangays; locations in closer proximity to established test points received higher weighting factors, reflecting the localized data trends of those specific central points.

Table 3. Spatial Interpolation and Weighting Analysis (3.0 m Depth)

Target Barangay	Neighbors	Distance d (km)	Weight (1/d^2)	SBC (kPa)	Computed qest (kPa)
Malimba	San Roque	1.360	0.5407	100	118.41 kPa
	Bulak	2.543	0.1546	125	
	Santo Cristo Norte	2.341	0.1825	170	
	Balante	2.347	0.1815	125	

	Mahipon	4.124	0.0588	90	
Kapalangan	Mahipon	3.305	0.092	90	123.888 kPa
	Makaba clay	7.098	0.020	130	
	Puting Tubig	2.125	0.221	100	
	Balante	4.532	0.049	125	
	Santa Cruz	3.040	0.108	200	
Bungo	Makaba clay	5.651	0.031	130	103.478 kPa
	Mahipon	4.051	0.061	90	
San Vicente	Bayanihan	2.262	0.1954	115	127.68 kPa
	San Lorenzo	1.896	0.2782	125	
	Mangino	2.631	0.1445	150	
Santo Nino	Bayanihan	2.010	0.2475	115	92.47 kPa
	San Nicolas	1.286	0.6047	70	
	San Vicente	2.097	0.2274	127.68	
Parcutela	Marelo	1.617	0.3825	123.871	110.86 kPa
	San Roque	1.477	0.4584	100	

Interpolation for the 3.0-meter depth indicates a general upward trend in estimated soil bearing capacity. Within this stratum, the minimum estimated value rose to 92.47 kPa in Santo Niño, while San Vicente reached a peak of 127.68 kPa.

This observed increase in SBC at the 3.0m depth is likely associated with increased overburden pressure and confinement. As depth increases, the weight of the overlying soil layers exerts a confining pressure that typically enhances the shear strength of the soil matrix, potentially increasing its resistance to displacement. Furthermore, deeper strata may exhibit a higher degree of natural compaction compared to near-surface layers, which are often more susceptible to seasonal moisture fluctuations and organic disturbances. However, it is essential to acknowledge that these interpolated values assume a degree of geological continuity that may not fully capture localized subsurface variability. Due to the limited density of available borehole data, these results are intended as a preliminary assessment and not as a definitive site profile.

4.2 Geotechnical Suitability Maps and Color Gradation

To visualize the spatial distribution of estimated soil strength, the data were translated into thematic maps. These maps utilize a color gradation system to categorize the relative preliminary suitability of various areas across Gapan City.

Figure 3. Spatial Distribution Map of Allowable Soil Bearing Capacity (1.5m Embedment Depth)

Barangays represented in Yellow (65–70 kPa), Light Orange (70–74 kPa), and Orange (74–92.9 kPa) are predominantly located in the northern sector, such as Pambuan and San Lorenzo at the shallow depth. These colors suggest areas with relatively lower bearing capacities. This trend in the north may be related to alluvial variability; being situated within a flood-prone plain, these areas might consist of younger, unconsolidated sediment deposits which often possess higher void ratios. These indicators suggest that such locations may necessitate wider footing dimensions or soil stabilization techniques to meet structural requirements.

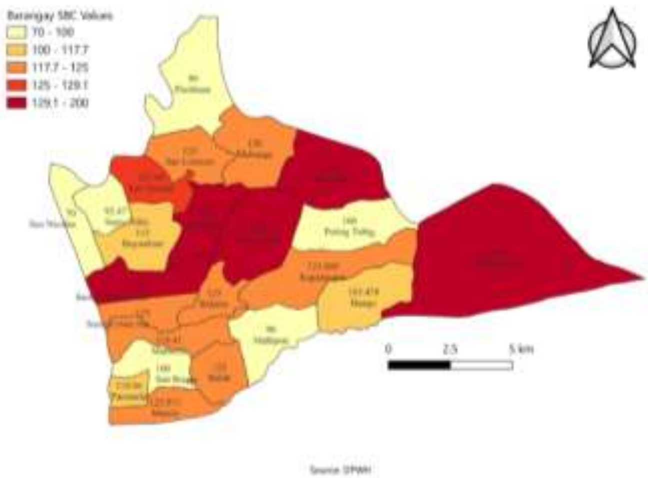

Figure 4. Spatial Distribution Map of Allowable Soil Bearing Capacity (3.0m Embedment Depth)

In contrast, the Dark Orange (92.9–105.6 kPa) and Dark Red (105.6–200 kPa) zones indicate moderate to relatively higher soil stability. In the 1.5-meter map, Dark

Red zones are largely limited to areas like Santa Cruz and San Nicolas. However, upon transitioning to the 3.0-meter map, a significant expansion of Dark Orange and Dark Red sectors is observed.

The comparison between the two embedment depths suggests that the soil bearing capacity in Gapan City generally improves by 15% to 40% when the foundation depth is increased from 1.5 m to 3.0 m. A notable example is San Vicente, which recorded 69.33 kPa at the shallow depth and rose to 127.68 kPa at the deeper stratum.

While this trend may be useful for preliminary planning considerations, particularly for residential and school buildings, it does not replace the need for site-specific testing. In zones identified with lower bearing capacities, structures may require further geotechnical evaluation and deeper foundation considerations to ensure adequate Safe Bearing Capacity and long-term structural integrity. These findings serve as a general guide for identifying areas that may require more rigorous subsurface investigation.

V. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The structural integrity of residential and institutional developments in Gapan City is fundamentally tied to the geotechnical characteristics of its ground. This study was conducted as an assessment to evaluate soil strength and estimated bearing capacity across the city using a GIS-based approach. By utilizing secondary data from DPWH-sourced borehole records and processing it through Inverse Distance Weighted (IDW) interpolation, the researchers identified and plotted the spatial distribution of soil bearing capacities across the city boundary.

To provide a data-driven assessment of construction suitability, estimated bearing capacity (qest) values were derived for two distinct embedment depths: 1.5 meters and 3.0 meters. The investigation focused on how these numerical values influence the ability of the ground to support structural loads, providing a comparative evaluation that highlights the transition from low suitability to high suitability zones as foundation depth increases.

Summary of Findings:

1. Based on the spatial interpolation at an embedment depth of 1.5 meters, the specific soil bearing capacities in Gapan City demonstrate a broad range, from a minimum of 66.98 kPa in Pambuan to a maximum of 110.214 kPa in Kapalangan.
2. The computed results for the 3.0-meter depth showed a significant upward trend in soil capacity, where the lowest estimated value increased to 92.47 kPa in Santo Niño, while San Vicente reached a peak of 127.68 kPa.
3. Through QGIS mapping, the spatial distribution was effectively visualized, revealing a gradient where the northern sector, including Pambuan and San Lorenzo, exhibits lower bearing capacities (yellow and light orange zones), while high-strength areas like Santa Cruz and San Nicolas consist of superior soil resistance (dark red zones).
4. Based on the comparative analysis, the soil bearing capacity typically improves by 15% to 40% when the foundation depth is increased from 1.5 m to 3.0 m, suggesting that residential and school buildings in lower-strength zones should consider deeper embedment for long-term structural integrity.

CONCLUSION

Based on the findings of the study, the following conclusions are drawn:

1. The geotechnical data from DPWH records indicates that Gapan City soil bearing capacity is significantly influenced by depth. At 1.5 meters, the available records show values ranging from 66.98 kPa to 110.214 kPa, while at 3.0 meters, these values notably increase to a range of 92.47 kPa to 127.68 kPa. This demonstrates that deeper strata provide higher estimated bearing capacity due to increased confinement pressure.
2. The soil types identified in the selected barangays vary across the city's topography. Areas with lower bearing capacities, such as Pambuan and San Lorenzo, are characterized by soil types that offer less resistance at shallow depths, whereas barangays like Kapalangan and San Vicente exhibit generally higher estimated bearing capacities suitable for higher structural loads.
3. The Inverse Distance Weighted (IDW) interpolation technique served as a useful preliminary tool to estimate the bearing capacity for the remaining barangays. By utilizing the 16 reference points, the study provided preliminary estimates for areas without available records, creating a citywide numerical model that predicts geotechnical performance in locations without direct borehole records.
4. The resulting spatial distribution maps for both 1.5 m and 3.0 m depths reveal a clear upward trend in suitability. At 1.5 m, the map shows significant low suitability zones (yellow/light orange) in the northern sector. However, the 3.0 m map shows a dominant shift toward high suitability (dark red), indicating that increasing foundation depth effectively moves most of Gapan City into higher estimated bearing capacity zones.
5. Gapan City may be categorized into three distinct zones for preliminary planning: Low Bearing Capacity zones (65–74 kPa) predominantly found at shallow depths in the north, Moderate zones (74–

92.9 kPa) located in central areas, and High Bearing Capacity zones (above 92.9 kPa) which become prevalent citywide at the 3.0-meter stratum. This classification provides a preliminary reference for engineers in determining the necessary foundation depth and stabilization methods.

Recommendations

Based on the results and conclusions of the study, the following recommendations are proposed:

1. Engineers and planners may use the generated bearing capacity maps as a preliminary reference for shallow foundation planning in Gapan City.
2. Areas with relatively lower estimated bearing capacity may require deeper foundation embedment or further geotechnical assessment before construction.
3. Site-specific soil investigation is still recommended for multi-storey buildings and heavy infrastructure projects to verify actual ground conditions.
4. Future researchers may include additional borehole data, groundwater conditions, and seismic considerations to improve the accuracy of the spatial assessment.

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