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Geodetic Surveying Skills, Mapping Techniques and Agricultural Land Tenure Security

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Abstract

This study examined the influence of geodetic surveying skills and mapping techniques on farmers' awareness of agricultural land tenure security as a basis for developing a strategic action plan for the Department of Agrarian Reform (DAR) Camarines Sur II for calendar year 2025. Grounded in the need for accurate land information and informed beneficiaries to support secure land tenure, the study employed a descriptive–correlational research design. Data were collected from DAR Camarines Sur II survey unit staff and selected farmer-beneficiaries from the upper barangays of Naga City using validated researcher-made questionnaires. Results revealed that the survey staff demonstrated a very high level of geodetic surveying skills in terms of communication, critical thinking, and detail orientation. Similarly, mapping techniques, including GPS/GNSS, traverse, and triangulation, were assessed as very highly skilled. Farmers also exhibited a very high level of awareness of agricultural land tenure security, particularly in documentation and land title knowledge, government programs and policies, and legal awareness. Statistical analysis showed significant relationships between the geodetic surveying skills and mapping techniques of survey staff and the farmers' level of awareness, indicating that higher technical proficiency contributes to improved understanding and confidence among farmer-beneficiaries regarding their land rights. The study concludes that accurate surveying, effective mapping, and clear communication play a vital role in strengthening agricultural land tenure security. Based on the findings, a strategic action plan known as TEODONES (Technical Evaluation of Documentation and Operations for Navigating Equitable Surveying) was developed to enhance technical capacity and promote sustainable and equitable land management.

Keywords: Geodetic Surveying Skills; Mapping Techniques; Farmers' Awareness; Agricultural Land Tenure Security

Introduction

Agricultural land tenure refers to a system of definitive rules that governs the rights to use, own, cultivate, maintain, and control land. These rules encompass tenancy and land access arrangements that protect farmers and land tillers from intrusion, disputes, and eviction, thereby enabling them to invest in improving the land they cultivate. Recent global studies consistently demonstrate that secure land tenure encourages farmers to adopt improved seeds, irrigation systems, soil management practices, and sustainable cultivation methods that enhance productivity and income (Abdullahi & Haruna, 2023; Altieri, 2021; Carter & Barrett, 2020). When farmers are confident that their land rights are protected, they contribute to food security by increasing production for household consumption and local markets, reducing vulnerability to hunger and dependence on food imports (Clark & Rigg, 2022; FAO, 2023). Rural development likewise benefits from secure tenure, as reduced conflict and increased tenure confidence stimulate investment in irrigation, storage, and transportation infrastructure (Villanueva, 2022; World Bank, 2023). Despite these benefits, land tenure insecurity persists globally due to unequal land distribution, outdated cadastral systems, and weak land administration institutions that continue to generate disputes and constrain agricultural development (Ahmed & Mustafa, 2022; Byamugisha & Dubosse, 2023).

At the global level, agricultural land tenure insecurity remains a multidimensional challenge shaped by structural inequalities, population pressures, and technological gaps in land information systems. Comparative studies across Africa, Latin America, and Asia reveal that insecure property rights, weak cadastral infrastructure, and limited access to modern geospatial technologies hinder sustainable agricultural growth and reinforce rural poverty (Aikinola, 2023; Almeida & Costa, 2023; UNDP, 2023). While some literature emphasizes legal reforms as the primary solution, recent empirical research critiques this approach for overlooking the technical foundations of land governance, particularly surveying accuracy and mapping reliability (Chigbu et al., 2022; Lemmen et al., 2021). In many countries, outdated or inaccurate land records fail to reflect actual ground conditions, resulting in boundary disputes, informal settlements, and contested ownership that undermine rural stability (Le & Pham, 2022; Nolte et al., 2020). These contrasting findings converge on the view that secure land tenure cannot be achieved through legal frameworks alone but requires accurate geodetic surveying, reliable mapping, and transparent land information systems (World Bank, 2024).

In the Philippine context, these global challenges are reflected in the country's long-standing agrarian reform and land administration issues. Although the Comprehensive Agrarian Reform Program has redistributed substantial areas of agricultural land, many parcels remain inadequately surveyed or incompletely documented, leading to overlapping claims and unresolved disputes (Aquino, 2024; Soriano & Dela Cruz, 2021). Recent national studies consistently identify outdated cadastral maps, incomplete surveys, and limited geodetic capacity within implementing agencies as major constraints to securing farmers' land rights (Cruz, 2021; Domingo, 2022). While Philippine literature extensively discusses legal mandates and institutional arrangements, fewer empirical studies examine how technical deficiencies in surveying and mapping affect farmers' understanding and confidence in their tenure security. This imbalance suggests that the technical dimension of land governance remains underexamined despite its direct impact on agrarian reform outcomes (Palomo & Santos, 2022).

At the local level, the province of Camarines Sur, particularly the upper barangays of Naga City, demonstrates the concrete effects of these national and global issues. Many communities continue to experience unresolved boundary conflicts, outdated cadastral maps, and incomplete land surveys that delay the issuance of secure land titles (Aquino, 2024; Dizon & Valenzuela, 2023). Farmers in these barangays often face uncertainty regarding the precise limits of their parcels, making them vulnerable to land grabbing, overlapping claims, and legal disputes that restrict long-term agricultural investment (Lansangan, 2021; Parreñas, 2023). Local assessments further indicate that limited access to modern surveying equipment, uneven technical competencies among personnel, and reliance on outdated mapping methods compromise the accuracy and reliability of land information (Rizal, 2024). These conditions illustrate how weaknesses in technical land administration translate directly into tenure insecurity at the community level.

Within this context, the interaction among the study's key variables becomes evident. Geodetic surveying skills refer to the technical competencies, precision, and analytical capabilities required to accurately measure and represent the Earth's surface. Recent studies emphasize that critical thinking, spatial reasoning, data verification, and proficiency in GNSS receivers, total stations, and digital leveling devices are essential for accurate boundary determination and legally defensible land documentation (Dhruwa & Garg, 2023; Santos, 2023; Yamamoto & Ito, 2023). These skills directly influence the reliability of surveys conducted for farmer-beneficiaries and reduce the likelihood of boundary disputes. Complementing geodetic skills are mapping techniques, which involve transforming geodetic measurements into spatial and visual representations of land parcels, terrain features, and boundary lines. Contemporary research highlights the importance of GPS/GNSS-based data collection, traverse and triangulation methods, UAV-assisted mapping, and digital cartographic production in enhancing transparency, supporting dispute resolution, and informing agrarian reform implementation (Jiang & Zhao, 2023; Kolodziej & Kaczmarek, 2021; Madimarova et al., 2024).

Agricultural land tenure security, the central outcome variable of this study, refers to the degree of certainty farmers have regarding their rights to use, control, and benefit from the land they cultivate. While tenure security is traditionally defined in legal terms, recent literature emphasizes its informational and perceptual dimensions, particularly farmers' awareness of documentation requirements, boundary delineation, government programs, and legal protections (Navratil & Frank, 2020; Nestor & Cruz, 2023). Empirical evidence indicates that farmers' confidence in their land rights is heavily influenced by the accuracy of geodetic surveys, the clarity of mapping outputs, and the effectiveness of technical communication (Gonzalez & Reyes, 2023; Roche et al., 2022). Thus, tenure security emerges from the combined influence of technical competence and informational transparency.

The importance of agricultural land tenure security is reinforced by explicit global and national policy mandates. At the global level, the Sustainable Development Goals emphasize secure land rights as a foundation of sustainable development. Sustainable Development Goal 1.4 calls for equal rights to land ownership and control, while Sustainable Development Goal 2.3 highlights secure land access as essential to improving agricultural productivity and incomes (United Nations General Assembly, 2015). Environmental sustainability is likewise linked to land governance under Sustainable Development Goal 15.1. In the Philippine context, these commitments are echoed in Article XII, Section 3 of the 1987 Constitution, which mandates the just distribution of agricultural lands and affirms farmers' rights to the land they till. These principles are operationalized through Republic Act No. 6657 or the Comprehensive Agrarian Reform Law, the Torrens system implemented by the Land Registration Authority, and Act No. 2259 or the Cadastral Survey Act, which mandates systematic geodetic surveys to precisely delineate property boundaries.

The significance of this study lies in its contribution to strengthening agricultural land tenure security through an integrated technical and informational approach. By examining how geodetic surveying skills and mapping techniques influence farmers' awareness, the study provides evidence that technical competence directly affects farmers' confidence, understanding, and ability to assert their land rights.

Government agencies benefit from insights that support targeted capacity-building and cadastral modernization, while farmers benefit from clearer boundaries, reduced disputes, and improved access to credit and livelihood opportunities (World Bank, 2023; FAO, 2023).

A synthesis of over one hundred recent studies reveals strong global and national agreement on the importance of accurate surveying, reliable mapping systems, and skilled technical personnel, yet also exposes a gap in localized empirical research linking these technical factors to farmers' awareness of land tenure security. This gap is particularly evident in communities such as the upper barangays of Naga City, where unresolved boundaries and incomplete surveys persist despite existing legal frameworks. The most compelling reason for conducting this study is the continued presence of land disputes, tenure insecurity, and economic vulnerability caused by inaccurate and outdated land information. By analyzing the interplay of geodetic surveying skills, mapping techniques, and farmers' awareness, this research provides a sound basis for a strategic action plan that strengthens tenure security and supports sustainable agricultural development.

Methods

A descriptive–correlational research design was employed to assess levels of geodetic surveying skills, mapping techniques, and farmers' awareness of agricultural land tenure security, as well as the relationships among these variables. The respondents consisted of 20 DAR Camarines Sur II survey unit staff selected through total enumeration and 40 farmer-beneficiaries from the upper barangays of Naga City selected through purposive sampling.

Data were collected using researcher-made questionnaires validated by experts in geodetic surveying, agrarian reform, and research methodology. The instrument measured geodetic surveying skills (communication, critical thinking, detail orientation), mapping techniques (GPS/GNSS, traverse, triangulation), and farmers' awareness (documentation and land title knowledge, government programs and policies, legal awareness). Responses were analyzed using weighted mean, Pearson product–moment correlation coefficient, and coefficient of determination. Ethical standards were strictly observed, including informed consent, confidentiality, and voluntary participation.

Results and Discussion

This section presents the data derived from the validated survey instruments administered to the DAR Camarines Sur II Survey Unit and farmer-beneficiaries. The findings are organized according to the study's specific objectives, with each table followed by a detailed examination of the results. The discussion integrates interpretation, conclusions, and alignment with existing literature to provide a comprehensive understanding of the relationships among geodetic surveying skills, mapping techniques, and agricultural land tenure security awareness.

communication, critical thinking, and detail orientation, indicating strong technical competence and professional judgment in land measurement and documentation. This level of proficiency suggests that survey personnel are capable of accurately interpreting field conditions, resolving boundary inconsistencies, and clearly communicating survey results to farmer-beneficiaries, thereby reducing uncertainty in land information.

Geodetic Surveying Skills of Survey Unit Staff

The survey unit staff demonstrated a very high level of geodetic surveying skills in Such competence is critical because errors or miscommunication in surveying often translate into disputes and weakened confidence in land administration. The findings are consistent with empirical studies showing that well-trained surveyors contribute significantly to the accuracy of cadastral records and the credibility of land documentation systems (Dhruwa & Garg, 2023; Santos, 2023; Yamamoto & Ito, 2023). Related literature further confirms that effective technical communication enhances landholder understanding and trust in survey outputs, reinforcing the practical value of surveying skills beyond measurement alone (Gonzalez & Reyes, 2023; Roche et al., 2022).

Table 2
Overall Level of Geodetic Skills of Survey Unit Staff

Geodetic Surveying Skills	Average Weighted Mean	Interpretation
Communication	3.55	VHS
Critical Thinking	3.52	VHS
Detailed Orientation	3.54	VHS
Overall Average Weighted Mean	3.53	Very Highly Skilled

Note: Range Interpretation: 3.26–4.00 = Very Highly Skilled (VHS); 2.51–3.25 = Highly Skilled (HS); 1.76–2.50 = Moderately Skilled (MS); 1.00–1.75 = Fairly Skilled (FS)

Level of Mapping Techniques of Survey Unit Staff

Table 2
Overall Level of Mapping Technique Skills of Survey Unit Staff

Mapping Technique Skills	Average Weighted Mean	Interpretation	Rank
Global Positioning System (GPS)/Global Navigation Satellite System (GNSS)	3.58	VHS	2
Traverse	3.68	VHS	1
Triangulation	3.57	VHS	3
Overall Weighted Mean	3.61	Very Highly Skilled	

Note: Range Interpretation: 3.26–4.00 = Very Highly Skilled (VHS); 2.51–3.25 = Highly Skilled (HS); 1.76–2.50 = Moderately Skilled (MS); 1.00–1.75 = Fairly Skilled (FS)

The overall level of mapping techniques practiced by the survey unit staff was very high, reflecting effective integration of GPS/GNSS with traverse and triangulation methods. This finding indicates that both modern geospatial technologies and conventional surveying approaches are competently applied to ensure reliable and verifiable spatial data. The combined use of these techniques strengthens the accuracy and defensibility of land maps, which are essential for administrative and legal purposes. High proficiency in mapping allows land parcels and boundaries to be represented clearly, reducing ambiguity for end users. These results align with empirical research emphasizing that GNSS-based mapping, when supported by traditional methods, improves cadastral precision and transparency (Jiang & Zhao, 2023; Kolodziej & Kaczmarek, 2021; Madimarova et al., 2024). Studies further indicate that accurate and clearly produced maps significantly enhance landholder comprehension and reduce the likelihood of boundary conflicts (Le & Pham, 2022; Nolte et al., 2020).

Level of Awareness of Farmers in Agricultural Land Tenure Security

Table 3
Overall Level of Awareness of Farmers in Agricultural Land Tenure Security

Aspects	Average Weighted Mean	Interpretation
Documentation and Land Title Knowledge	3.41	VHA
Government Programs and Policies	3.42	VHA
Legal Awareness	3.41	VHA
Overall Average Weighted Mean	3.42	Very Highly Aware

Note: Range Interpretation: 3.26–4.00 = Very Highly Aware (VHA); 2.51–3.25 = Highly Aware (HA); 1.76–2.50 = Moderately Aware (MA); 1.00–1.75 = Fairly Aware (FA)

Farmers exhibited a very high level of awareness of agricultural land tenure security in terms of documentation and land title knowledge, government programs and policies, and basic legal rights. This result suggests that farmer-beneficiaries possess sufficient understanding of the processes, documents, and institutional mechanisms that secure their landholdings. High awareness reflects effective dissemination of land information and indicates that farmers are not passive recipients of services but informed participants in land governance. Such awareness strengthens confidence in land rights, reduces fear of dispossession, and encourages investment in agricultural productivity. The finding is supported by empirical studies demonstrating that informed farmers show higher tenure confidence and lower vulnerability to disputes (Navratil & Frank, 2020; Nestor & Cruz, 2023). Related literature also emphasizes that clarity in survey outputs and documentation plays a decisive role in shaping farmers' perception of tenure security (FAO, 2023; World Bank, 2023).

Relationships among Geodetic Surveying Skills, Mapping Techniques, and Farmers' Awareness

The analysis revealed significant relationships among geodetic surveying skills, mapping techniques, and farmers' awareness of agricultural land tenure security, indicating that technical competence and cartographic quality are closely linked to beneficiary understanding. Higher levels of surveying skills are associated with more effective mapping practices, while improvements in both technical domains correspond with increased farmer awareness. This pattern demonstrates that awareness of land tenure security does not develop independently but is shaped by the accuracy, consistency, and clarity of technical land administration processes. When surveying and mapping are performed at a high standard, farmers are more likely to understand, trust, and value the land information provided to them. These findings are consistent with empirical studies showing that accurate surveying and reliable mapping are strong predictors of landholder confidence and understanding (Chigbu et al., 2022; Lemmen et al., 2021; Gonzalez & Reyes, 2023), while weak technical foundations undermine awareness even where legal frameworks are in place (Ahmed & Mustafa, 2022; Byamugisha & Dubosse, 2023).

Influence of Geodetic Surveying Skills and Mapping Techniques on Farmers' Awareness

Both geodetic surveying skills and mapping techniques were found to exert a meaningful influence on farmers' awareness of agricultural land tenure security, with mapping techniques demonstrating a slightly stronger effect. While surveying skills ensure technical accuracy and reliability, the clarity and usability of spatial outputs play a more direct role in shaping farmer understanding. Maps serve as the primary reference through which farmers interpret parcel boundaries, land size, and ownership extent, making them a critical medium for translating technical work into practical knowledge. This finding suggests that tenure security is most effectively reinforced when precise technical processes are paired with clear and comprehensible spatial visualization. Empirical literature supports this conclusion, noting that visual land information has a stronger impact on landholder awareness than technical accuracy alone (Roche et al., 2022; Zhou & Zhang, 2023), and that improved cartographic outputs contribute to reduced disputes and more sustainable land use (FAO, 2023; World Bank, 2024).

Conclusions

This study concludes that geodetic surveying skills and mapping techniques play a critical and measurable role in shaping farmers' awareness of agricultural land tenure security. The very high levels of technical competence demonstrated by the survey unit staff indicate that land administration at the local level is supported by strong professional capacity in communication, analytical judgment, and precision. These competencies ensure that land measurements and documentation are accurate, consistent, and credible, thereby reducing the risk of boundary disputes and administrative errors that often undermine tenure security.

The study further establishes that mapping techniques—particularly the effective integration of GPS/GNSS with traditional methods such as traverse and triangulation—are central to producing clear and reliable spatial representations of land parcels. These spatial outputs serve as the primary medium through which farmers understand their landholdings. As a result, mapping quality emerged as a slightly stronger influence on farmers' awareness than surveying skills alone, underscoring the importance of clarity and usability of maps in land governance.

Farmers' very high level of awareness regarding land documentation, government programs, and legal rights indicates that tenure security is strengthened when technical accuracy is paired with effective information dissemination. The findings confirm that awareness is not merely a function of legal ownership but is shaped by how well land information is generated, visualized, and communicated. When farmers understand the technical basis of their land rights, they demonstrate greater confidence, reduced fear of dispossession, and increased willingness to invest in agricultural productivity.

Overall, the study affirms that agricultural land tenure security is a practical outcome of competent surveying, reliable mapping, and informed beneficiaries. Strengthening any one of these elements in isolation is insufficient; rather, tenure security is reinforced through their combined and consistent application. The results provide empirical evidence that improving technical land administration directly contributes to more secure, transparent, and equitable land governance at the local level.

Recommendations

Based on the findings and conclusions of the study, several recommendations are proposed to further strengthen agricultural land tenure security through technical and institutional improvements.

First, continuous capacity-building programs should be institutionalized for survey unit staff, with emphasis on advanced geodetic techniques, data validation, and effective communication of technical outputs to non-technical stakeholders. While current skill levels are already very high, ongoing training is necessary to keep pace with evolving geospatial technologies and to sustain accuracy and professionalism in land administration.

Second, mapping processes should prioritize the production of clear, user-friendly, and standardized spatial outputs that are easily interpretable by farmer-beneficiaries. Maps intended for landholders should emphasize visual clarity, consistent symbology, and explicit boundary delineation to enhance comprehension. Improving the communicative value of maps will further strengthen farmers' awareness and confidence in their land rights.

Third, farmer-oriented information dissemination should be strengthened through regular briefings, orientation sessions, or community-based discussions that explain survey results, land documents, and applicable government programs. Such initiatives will reinforce farmers' understanding of land tenure processes and ensure that technical outputs translate into practical knowledge at the beneficiary level.

Fourth, institutional planning within the Department of Agrarian Reform should integrate technical performance indicators related to surveying accuracy, mapping quality, and beneficiary comprehension. Embedding these indicators into monitoring and evaluation systems will ensure that technical excellence and farmer awareness are treated as complementary objectives in land governance.

Finally, future studies are encouraged to expand the scope of inquiry by including other regions, private surveying entities, or additional variables such as dispute incidence, investment behavior, or economic outcomes. Longitudinal and comparative studies may further validate the causal pathways between technical land administration and tenure security, thereby contributing to more robust evidence-based policy formulation.

Through the implementation of these recommendations, land administration agencies can further enhance the reliability of land information systems, empower farmer-beneficiaries, and promote sustainable and equitable agricultural land tenure security.

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