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RESEARCH ARTICLE

Application of Affine Projective Transformation in Cadastre Data Migration in Peninsular Malaysia

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ABSTRACT - Digital Cadastral Database (DCDB) is emerging as a comprehensive system that offers enhanced accuracy, compatibility and functionality in land surveying practices. The modernisation of land surveying practices has brought about a crucial need to upgrade the existing spatial database to the DCDB in the Geodetic Datum of Malaysia 2000 (GDM2000). This study is aimed to investigate the cadastre data migration process in Peninsular Malaysia. A case study focused on the state of Johor with few cadastre parcels analysed during the study period. The methodology of the study consisted of gathering the PDUK data, including land surveys, property boundaries, and related records as well as acquiring DCDB data and transformation parameters. Next, the data was analysed by evaluating the quality of PDUK data and identifying the inconsistencies, errors and gaps, then analysing the existing migration process to the DCDB. Afterwards, Affine transformation was implemented where the migration of PDUK data to DCDB needs to be conducted by considering the geometric properties of the parcels. This established the relationship between the old and new datums. Subsequently, pre-migration and post-migration datasets were compared in terms of accuracy and consistency with the parcels area different obtained are below 50 cm^2. From the comparison result, recommendations for the improvement of the migration process, including adjustments to the fitting method were obtained. The findings offer valuable insights into the migration of PDUK data to DCDB for land surveying practices in the Malaysian Peninsular.

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1. INTRODUCTION

The Pangkalan Data Ukur Kadaster (PDUK), introduced by the Department of Surveying and Mapping Malaysia (JUPEM) in 2010, has improved over previous systems but still faces challenges. One major limitation is the quality and consistency of cadastral data, leading to errors in land administration due to poor data quality, data entry mistakes, and inconsistent application of standards [1]. A study by Jaafar [1] examined user perspectives, highlighting issues with the National Digital Cadastral Database (NDCDB), a component of PDUK. Additionally, data sharing and interoperability challenges have been identified, with difficulties in integrating PDUK with other systems like the Cadastre Data Management System (CDMS), as noted by Mariappan [2]. The cadastral survey database in Malaysia, known as PDUK, manages crucial land information such as parcels, boundaries, and ownership. While it has been valuable, PDUK faces limitations in accuracy, completeness, and accessibility. Factors such as human error, outdated survey techniques, and environmental conditions affect data accuracy, leading to inefficiencies in land management and boundary disputes [1]. Data quality varies across regions due to resource limitations, and incomplete data coverage, particularly in remote areas, impacts decision-making [3]. Additionally, PDUK often lacks real-time updates, resulting in discrepancies between current land conditions and database records. Cadastral data migration is essential in improving data accuracy with Affine projective transformation. This research explores the challenges and strategies for optimizing Affine transformations in Malaysia, focusing on preserving accuracy in complex parcel boundaries, making the method user-friendly, and maintaining data integrity during migration.

The rapid advancement in information technology has driven the need for modernized cadastral systems that can integrate Geographic Information Systems (GIS) and Global Positioning Systems (GPS), making traditional systems insufficient [4]. The development of the Digital Cadastral Database (DCDB) and Automated Database Conversion System (ADCS) in Malaysia facilitates large-scale cadastral data input, forming the foundation for a National Digital Cadastral Database (NDCDB) that supports urban and rural planning through enhanced spatial accuracy [5]. Traditional cadastral surveying methods are being replaced by more efficient, automated systems like eKadaster, which employs Least Square Adjustment (LSA) techniques to increase spatial precision [6, 7]. The integration of modern technology in cadastral systems, including Global Navigation Satellite Systems (GNSS), improves accuracy in property documentation, reducing the reliance on traditional bearing and distance measurements [2]. As countries adopt global standards like ISO19152—Land Administration Domain Model (LADM)—and embrace future-oriented cadastral characteristics such as 3D/4D and real-time systems, Malaysia must align itself with global trends [8, 9].

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Recent studies highlight global efforts in modernising cadastral systems to enhance accuracy and adaptability. Enemark et al. [10] stressed fit-for-purpose land administration aligned with global standards like ISO19152. In Slovenia, Čeh et al. [11] applied membrane adjustment methods to enhance the positional accuracy of traditional cadastral index maps, achieving notable improvements in spatial data quality. Additionally, Fetai et al. [12] examined the digitisation of cadastral boundary data in North Macedonia and Slovenia, highlighting the challenges of inconsistencies between measurement-based and vectorised data, and proposing revised workflows to mitigate such issues. These examples offer relevant insights for improving Malaysia's cadastral data migration and geospatial reliability. Despite technological advancements, challenges in the Malaysian cadastral system persist. The shift from the older PDUK system to the NDCDB revealed limitations, such as inaccuracies in data input [1] and discrepancies in boundary coordinates. These issues highlight the need for improved user education and proper utilization of the NDCDB [13]. International comparisons, like the cadastral systems in Spain, New Zealand, Japan, and Australia, emphasize the importance of maintaining up-to-date databases that reflect current land tenure holdings and geospatial accuracy [14, 15].

Malaysia's cadastral system modernization also involves addressing tectonic movements that impact geodetic reference systems. The Geocentric Datum of Malaysia 2000 (GDM2000), developed through the Malaysia Real-time Kinematic Network (MyRTKnet), faces challenges due to seismic events [16, 17]. These events caused significant shifts in reference station coordinates, necessitating continuous updates [18]. Dynamic or semi-dynamic datums like the proposed GDM2020 aim to improve geodetic accuracy, drawing lessons from countries like New Zealand, Japan, and Turkey, which have successfully implemented time-dependent coordinates [19, 20]. Transformation models like the Helmert and Affine methods have proven essential in maintaining cadastral data accuracy in response to tectonic shifts [21, 22]. The Helmert model, used to update GDM2000 coordinates, considers tectonic motion velocities, while the Affine transformation, widely used in Turkey's cadastral mapping, ensures high accuracy through adjustments with multiple common points [20]. Malaysia's adoption of these techniques will help mitigate tectonic movement effects to ensure precise geospatial data for planning, disaster management, and land administration [23, 24].

This study aims to investigate the cadastre data migration process in Peninsular Malaysia from PDUK data to GDM2000 DCDB. This study was achieved by identifying the limitations of the current state of existing PDUK data. Secondly, by conducting the cadastre data migration process from PDUK data to GDM2000 DCDB. Finally, performing the assessment of the result from cadastre data migration. This paper is divided into four (4) sections. Section one (1) is the introduction that consists of the background study, problem statement, literature review, aim, and objectives. Section (2) is the methodology that includes three (3) phases which are PDUK and GDM2000 DCDB data collection, cadastre data migration from PDUK to GDM2000 DCDB and validation of assessment of cadastre data migration. Section three (3) contains the result and analysis to achieve all the objectives. Section four (4) includes the conclusions and recommendations.

2. METHODOLOGY

To enhance the understanding and coherence of the study, the research methodology and workflow have been organised into three (3) key phases, each strategically designed to ensure the seamless progression of the research. Furthermore, a continuous and integral literature review has been woven throughout the entire study to provide the foundation for the research framework. The comprehensive workflow has been summarized and visually depicted in Figure 1 to offer a clear and concise overview of the research process. This graphical representation serves to amplify clarity and comprehension as well as enable readers to grasp the intricate interplay of each phase and the overarching structure of the study.

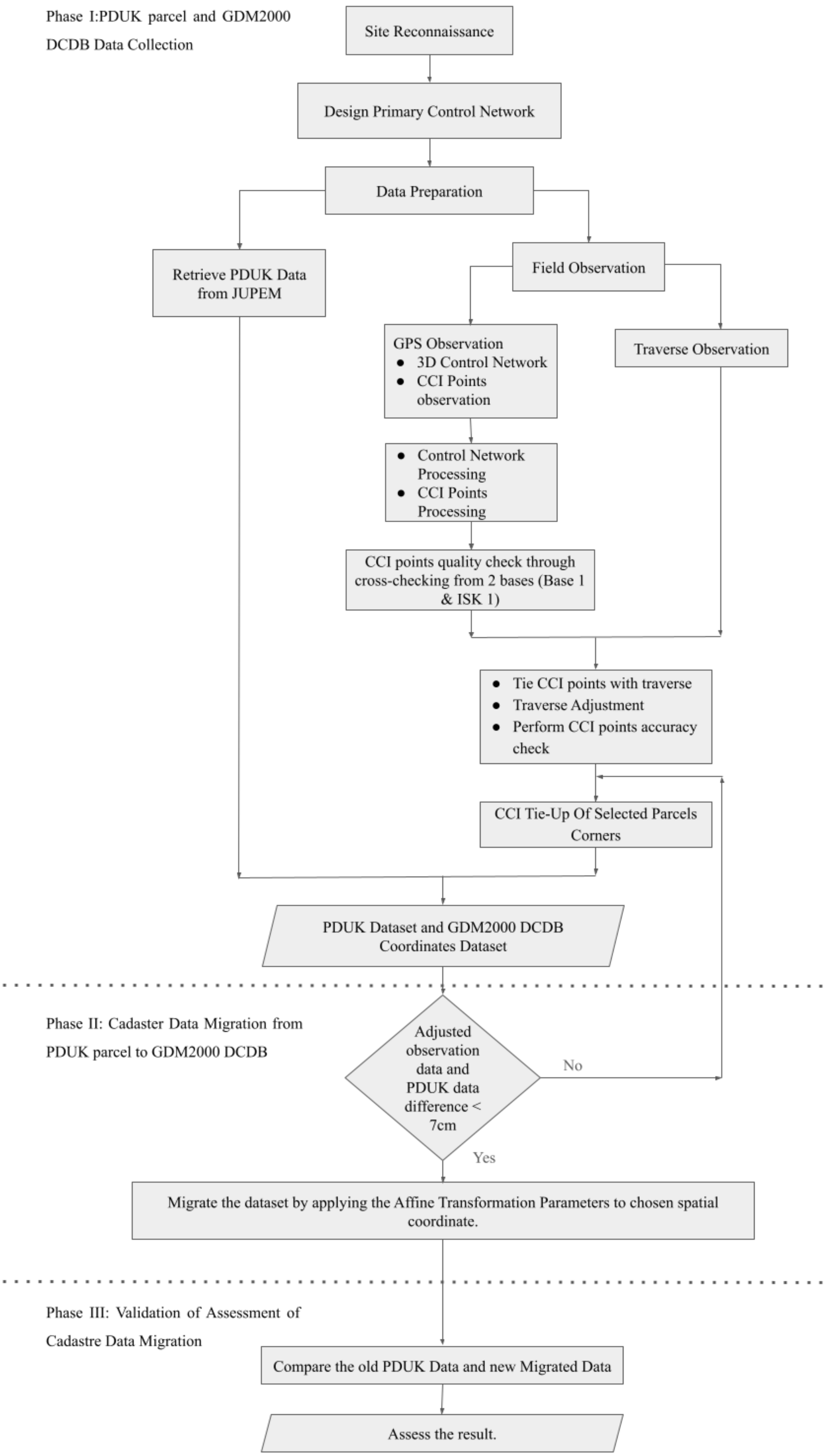

Figure 1. Research workflow

2.1 PDUK and GDM2000 DCDB Data Collection

A site reconnaissance was conducted to select an optimal area for data collection, focusing on analysing the terrain, structures, and access points. During this process, boundary points were identified, and 6 CCI points were marked for future observations. The specific selection of the CCI points was based on the points were evenly dispersed around the study area to provide balanced spatial coverage, which is crucial for reducing distortion during the Affine transformation. Secondly, the locations were chosen in open, unobstructed areas suitable for GPS observations, minimising multipath errors and signal blockage. Lastly, the selected points were positioned near cadastral boundary markers to ensure alignment between physical ground features and the digital dataset.

Figures 2 to 4 present certified plans acquired from JUPEM and CORS data gathered from the MyRTKnet website, based on their proximity to the study area.

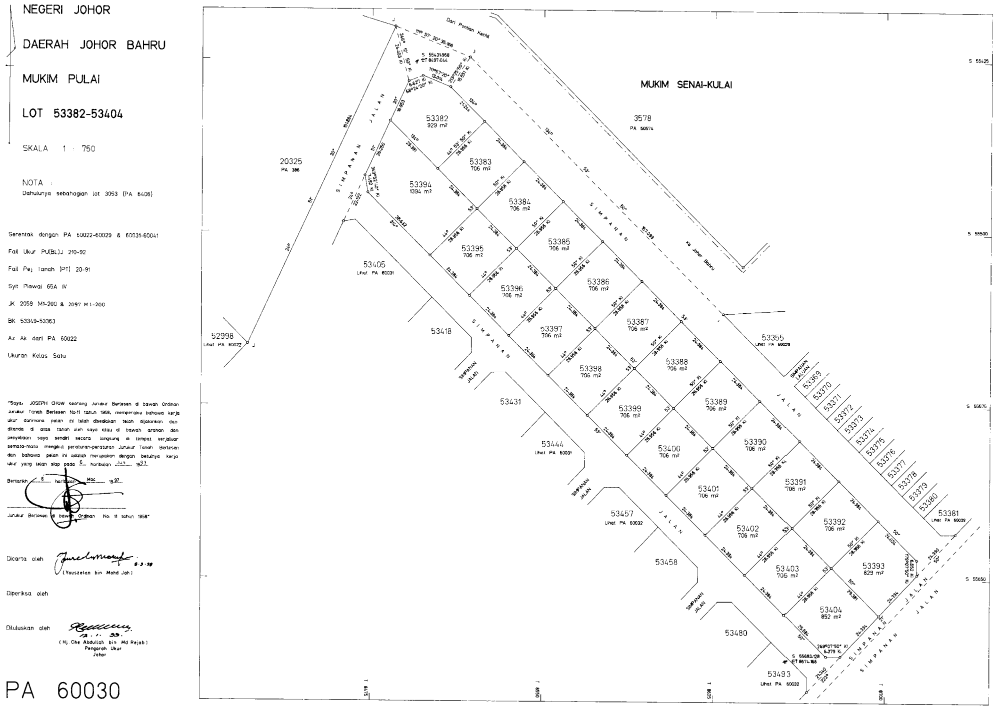

Figure 2. Certified Plan (CP 60030) that used Cassini Soldner Projection

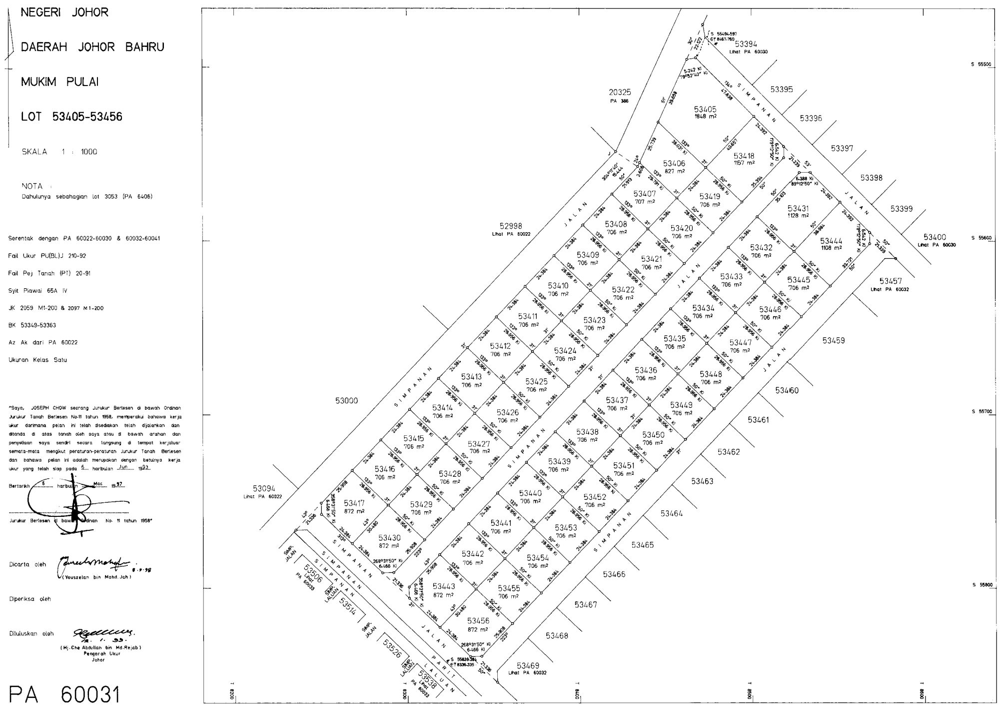

Figure 3. Certified Plan (CP 60031) that used Cassini Soldner Projection

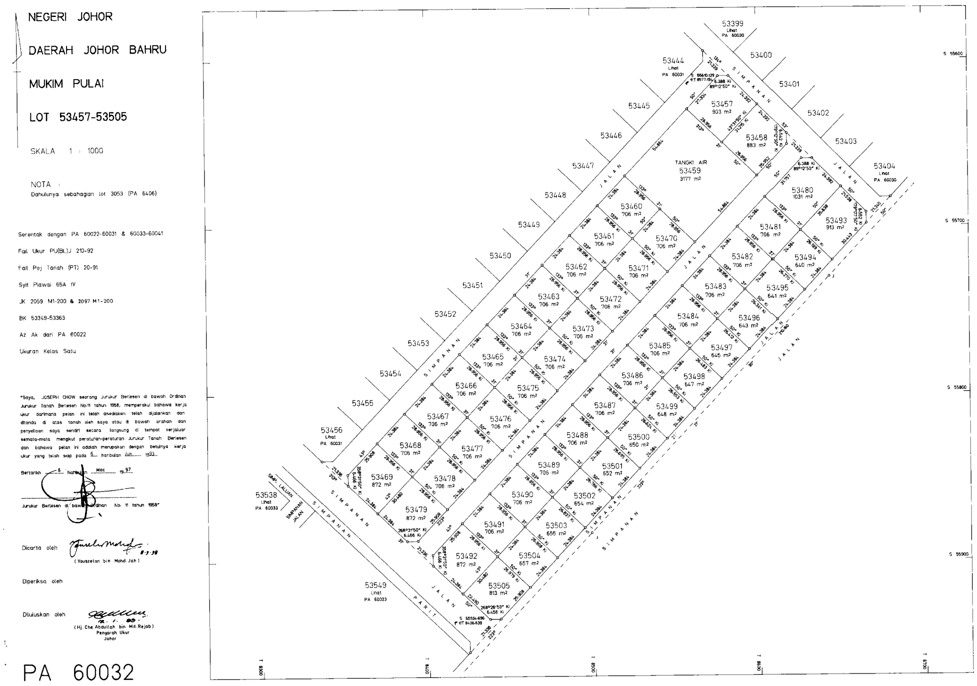

Figure 4. Certified Plan (CCP 60032) that used Cassini Soldner Projection

The control network, including CORS stations JHJY, SPRG, TGPG, ISK1, and Base 1, was processed using TBC software to ensure precision in coordinate determination. The decision to exclude JHJY was due to its high minimum constraint value, which could distort the network. Instead, ISK1, SPRG, and TGPG were selected for maximum constraint, enhancing the network's stability and accuracy.

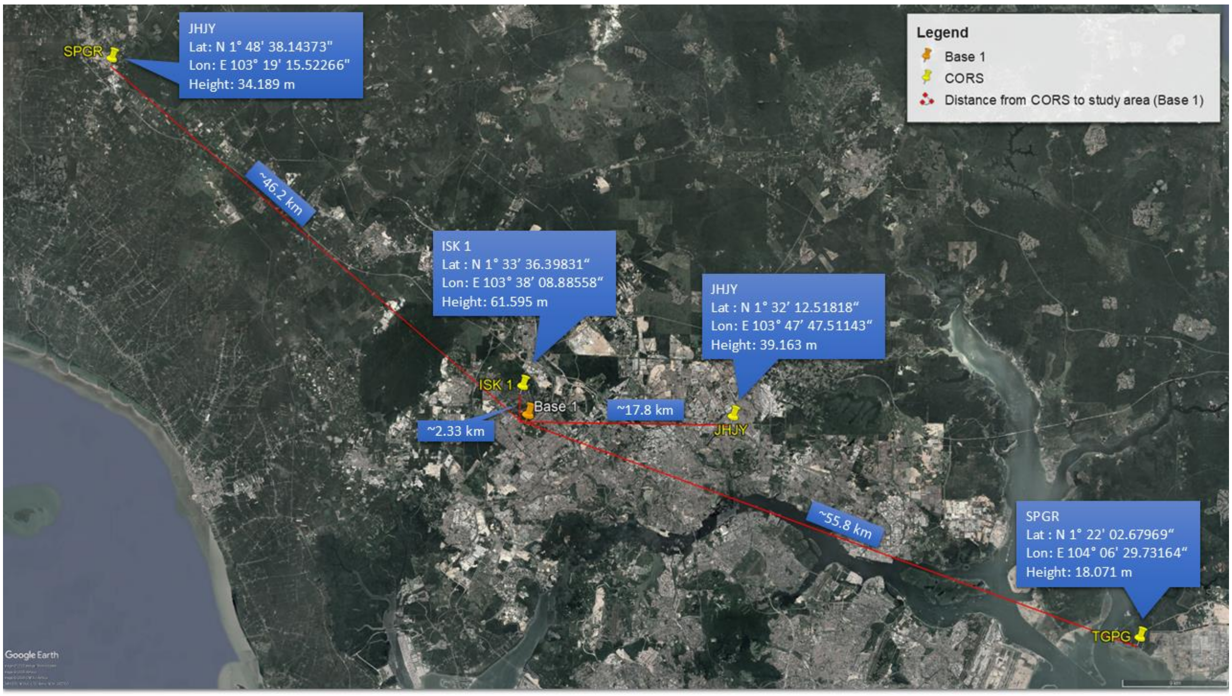

Figure 5. Distance of CORS to study area

Six CCI points were marked, and GPS observations at these points lasted 15 minutes each (see Figure 6). These points were processed with Base 1 and ISK1 to derive precise coordinates. Base 1 located within the study area, and ISK1 as a reference point were selected to ensure the accuracy of the CCI points' coordinates through single baseline processing. Two base stations, Base 1 and ISK1, provided cross-validation, mitigating errors and enhancing cadastral infrastructure reliability. Four traverse loops were established around the area, linking boundary marks with CCI points for alignment. MicroSurvey STAR*NET was used to adjust the traverse data for accurate and reliable boundary coordinates.

Figure 6. 6 CCI Points

2.2 Cadastre Data Migration from PDUK to GDM2000 DCDB

Quality checks were performed by confirming that the selected points were reliable and evenly distributed across the study area to ensure accurate and consistent common points between PDUK coordinates and adjusted observations for an Affine transformation. In the first phase, the PDUK and observation data were imported into ArcGIS, where six Affine transformation parameters were calculated. These include two translations (shifts in N and E), two rotations, and two scale factors along the X and Y axes. Mathematically, the transformation is represented as:

$$N_i = a \cdot \ N_o + b \cdot E_i + c \ , \tag{1}$$

$$E_i = d \cdot \ N_o + e \cdot E_i + f. \tag{2}$$

where:

N_o, E_o :	coordinates in the source system (PDUK)
N_i, E_i :	transformed coordinates in the target system (GDM2000 DCDB)
a, b, c, d, e, f :	Affine transformation parameters estimated via least squares adjustment

The Affine transformation was chosen over other models such as the Helmert and Polynomial transformations due to its balanced combination of simplicity, flexibility, and accuracy. Unlike the Helmert transformation, which is typically limited to preserving distances and angles through uniform scaling and rotation, the Affine model allows for non-uniform scaling and shearing. This makes it especially suitable for cadastral data where distortions may not be uniformly distributed across the region. Moreover, while Polynomial transformations can model complex distortions, they often lead to overfitting and spatial warping, especially when using higher-order terms. Affine transformation, by contrast, maintains a linear relationship between the source and target coordinates, providing sufficient geometric flexibility without compromising spatial integrity. To verify the transformation, both visual and statistical comparisons were made between the original and transformed datasets. This analysis confirmed the accuracy of the transformation, ensuring the smooth integration of data from different sources within a coherent spatial framework.

2.3 Validation of Assessment of Cadastre Data Migration

During data migration, pre-migration and post-migration datasets were compared to assess the accuracy and consistency of the transferred information. This analysis provided insights for improving the migration process, including adjustments to the fitting method for a smooth data transition. Changes in the coordinate system and datums were noted for future reference, ensuring efficient data management. These alterations were documented to maintain data integrity and consistency, establishing a foundation for optimized decision-making and resource management in the future.

3. RESULTS AND DISSCUSSION

Table 1 shows the maximum constraint obtained from control network processing that contributes to the determination of the Base 1 coordinate. As shown in the table, it is shown that the lowest value of 3D distance was 0.043 m by selecting ISK1, SPGR, and TGPG as fixed stations.

Table 1. CCI points in GDM2000 obtained from single baseline processing

Fixed	Checking	ΔX (cm)	ΔY (cm)	ΔZ (cm)	3D Distance (cm)
ISK 1 SPGR TGPG BASE 1	JHJY	2.100	-2.210	2.990	4.270
JHJY SPGR TGPG BASE 1	ISK 1	12.007	-51.135	-2.873	52.604
ISK 1 JHJY TGPG BASE 1	SPGR	-3.840	12.540	-1.950	13.259
ISK 1 JHJY SPGR BASE 1	TGPG	-2.960	5.500	-3.680	7.249

The coordinates of CCI points obtained from single baseline processing are shown in Table 2. Meanwhile, Table 3 exhibits the disparity in coordinates resulting from cross-checking coordinates between Base1 and ISK 1 with CCI points.

Table 2. CCI points in GDM2000 obtained from single baseline processing

CCI Points	BASE 1			ISK 1		
	X (m)	Y (m)	Z (m)	X (m)	Y (m)	Z (m)
CP1	-1503402.152	6196115.331	170306.100	-1503402.157	6196115.356	170306.127
CP2	-1503507.826	6196087.837	170194.470	-1503507.833	6196087.876	170194.503
CP3	-1503374.272	6196122.502	170045.049	-1503374.289	6196122.526	170045.054
CP4	-1503164.726	6196175.855	169817.193	-1503164.733	6196175.872	169817.211
CP5	-1502953.391	6196231.877	169995.931	-1502953.416	6196231.910	169995.929
CP6	-1503156.036	6196173.775	169999.196	-1503156.037	6196173.796	169999.201

Table 3. Final Coordinates of CCI points in GDM2000 derived from the mean

CCI Points	Difference			3D Distance (cm)	Mean		
	ΔX (cm)	ΔY (cm)	ΔZ (cm)		X (m)	Y (m)	Z (m)
CP1	0.500	-2.500	-2.700	3.713	-1503402.155	6196115.344	170306.114
CP2	0.700	-3.900	-3.300	5.157	-1503507.830	6196087.857	170194.487
CP3	1.700	-2.400	-0.500	2.983	-1503374.281	6196122.514	170045.052
CP4	0.700	-1.700	-1.800	2.573	-1503164.730	6196175.864	169817.202
CP5	2.500	-3.300	0.200	4.145	-1502953.404	6196231.894	169995.930
CP6	0.100	-2.100	-0.500	2.161	-1503156.037	6196173.786	169999.199

3.2 Tying CCI Point to Boundary Mark

In the assessment of the adjustment process using MicroSurvey STAR*NET, the chi-square test results at a 5% significance level revealed that the upper bound limit was exceeded (see Figure 7). This outcome indicates the need for a comprehensive review of the checkpoint's accuracy.

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                  Adjustment Statistical Summary
                  ==============================

                 Iterations              =      2

                 Number of Stations      =     44

                 Number of Observations  =     94
                 Number of Unknowns      =     82
                 Number of Redundant Obs =     12

          Observation   Count   Sum Squares         Error
                                  of StdRes         Factor
            Distances     47        62.876          3.237
          Az/Bearings     47         2.334          0.624

                Total     94        65.210          2.331

       Warning: The Chi-Square Test at 5.00% Level Exceeded Upper Bou:
                         Lower/Upper Bounds (0.606/1.395)
```

Figure 7. Chi-Square Test adjustment report in MicroSurvey STAR*NET

As indicated in Table 4, the accuracy of the CCI points falls within the acceptable range, with both the northing and easting difference measuring below 3 cm. This demonstrates that the adjustment values remain suitable for the migration process.

Table 4. CCI points accuracy check

Station	Before Adjusted		Adjusted		ΔN	ΔE	2D Distance
	N (m)	E (m)	N (m)	E (m)	(cm)	(cm)	(cm)
BASE 1	-55664.623	8314.606	-55664.623	8314.606	0.000	0.000	0.000
CP1	-55529.666	8613.142	-55529.666	8613.142	0.000	0.000	0.000
CP2	-55641.199	8722.321	-55641.215	8722.330	1.580	-0.850	1.794
CP3	-55790.644	8584.373	-55790.644	8584.373	0.000	0.000	0.000
CP4	-56018.483	8368.160	-56018.483	8368.160	0.000	0.000	0.000
CP5	-55839.952	8149.577	-55839.952	8149.577	0.000	0.000	0.000
CP6	-55836.444	8360.196	-55836.429	8360.202	-1.490	-0.620	1.614

The adjusted coordinates displayed in Table 5 are compared to the PDUK coordinates to select the most suitable boundary mark as the fixed station for Affine transformation parameters. This selection process involves limiting the 2D distance tolerance to within 7 cm while considering the dispersion around the study area. After thorough analysis, the fixed stations that met the criteria for accuracy and dispersion were identified as BKL1 (8250057509), BKL3 (8500055278), BKL7 (8461457142), BKL 12 (8318658226), and BKL19 (8482354693). These marks were deemed optimal for further transformations.

Table 5. Comparison of adjusted observed points with PDUK

No.	BKL NDCDB	PDUK (A) (m)		BKL CCI	Adjusted Observed Points (B) (m)		Difference (A-B) (cm)		2D Distance (cm)
		N	E		N	E	N	E	
1	8250057509	-55748.837	8253.248	BKL1	-55748.836	8253.246	-0.090	0.130	0.158
2	8385256084	-55606.251	8388.706	BKL2	-55606.252	8388.707	0.110	-0.080	0.136
3	8500055278	-55507.704	8503.853	BKL3	-55507.705	8503.856	0.140	-0.390	0.414
4	8517255450	-55525.124	8521.064	BKL4	-55525.125	8521.068	0.160	-0.360	0.394
5	8577156100	-55607.837	8580.525	BKL5	-55607.840	8580.528	0.320	-0.310	0.446
6	8583656099	-55607.839	8586.954	BKL6	-55607.842	8586.957	0.330	-0.300	0.446
7	8461457142	-55712.107	8464.713	BKL7	-55712.109	8464.714	0.160	-0.160	0.226
8	8360558204	-55818.229	8364.003	BKL8	-55818.229	8364.003	0.000	-0.030	0.030
9	8369558289	-55826.669	8372.634	BKL9	-55826.670	8372.634	0.010	-0.020	0.022
10	8351558476	-55845.377	8354.878	BKL10	-55845.377	8354.878	0.000	0.010	0.010
11	8336258393	-55837.051	8339.479	BKL11	-55837.051	8339.476	0.050	0.310	0.314
12	8318658226	-55820.198	8321.707	BKL12	-55820.177	8321.771	-2.130	-6.420	6.764
13	8285457911	-55788.922	8288.783	BKL13	-55788.923	8288.782	0.100	0.170	0.197
14	8633256595	-55657.219	8636.671	BKL15	-55657.221	8636.672	0.230	-0.110	0.255
16	8605056827	-55680.294	8608.552	BKL17	-55680.295	8608.552	0.180	-0.070	0.193
17	8482354693	-55449.225	8486.247	BKL19	-55449.226	8486.252	0.080	-0.470	0.477
18	8558155040	-55484.053	8562.069	BKL20	-55484.054	8562.072	0.170	-0.380	0.416

3.3 Analysis of Migrated PDUK

Following the migration process, a visible difference was observed in comparing the selected PDUK lots with the migrated data by overlapping the lots layers. The selection of lots was primarily based on their distance from the CCI points. Notably, lots near CCI points exhibited minimal variation compared to those situated farther away. This observation highlights the influence of proximity on the accuracy of the transformation process. When comparing the migrated PDUK shape with the previous PDUK shape, the notable visual distinction becomes apparent in terms of translation and scaling when layers of lot overlap. Due to shifts in boundary mark coordinates, there are consequential effects on the shape and area of the cadastral information. This transformation can result in variations in land boundaries and parcel sizes which underlines the critical importance of precise geospatial data management during migration procedures. In analysing the implications of Affine transformations as linear transformations, it becomes evident that the outcomes align with this linear characteristic. As shown in Table 6, a pattern emerges in the area differences observed between the original PDUK data and the migrated PDUK data, particularly concerning the lot sizes. Notably, as the areas of the lots increase, the proportional increase in area differences is apparent.

Table 6. Area comparison between migrated PDUK with old PDUK

No Lot	Migrated		PDUK		Difference		Area Difference (%)
	Perimeter (m)	Area (m^2)	Perimeter (m)	Area (m^2)	Perimeter (m)	Area (m^2)	
53382	118.124	928.406	118.156	928.804	-0.032	-0.398	-0.043
53394	154.998	1392.924	155.055	1393.522	-0.057	-0.598	-0.043
53393	113.274	828.454	113.298	828.809	-0.024	-0.355	-0.043
53445	106.654	705.791	106.682	706.096	-0.028	-0.305	-0.043
53459	225.498	3175.859	225.549	3177.217	-0.051	-1.358	-0.043
53497	101.641	644.642	101.665	644.919	-0.024	-0.277	-0.043
53450	106.656	705.810	106.684	706.113	-0.028	-0.304	-0.043
80723	82.262	352.904	82.298	353.055	-0.036	-0.151	-0.043
53413	106.654	705.791	106.682	706.095	-0.028	-0.304	-0.043

For instance, Lot 80723, boasting the smallest area, exhibits a minimal area difference of -0.150557 m^2. In contrast, Lot 53459, with the largest area, showcases a substantial area difference of -1.358384 m^2. These findings highlight the linear nature of Affine transformations and their impact on varying lot sizes within the dataset. Furthermore, a critical factor influencing transformation accuracy is the selection and placement of common control points (CCI). Inaccurate or poorly distributed boundary marks—especially those serving as fixed references for transformation—can introduce biases that distort the entire migration outcome. The current study assumes that the CCI points are correctly positioned; however, in real-world scenarios, degraded or displaced boundary marks (due to physical shifts, misplacement, or environmental changes) may act as outliers, skewing the resulting transformation parameters. Although the percentage change remains consistent across lots (-0.043%), the scaling effect implies that larger parcels accumulate more absolute error, a direct consequence of Affine transformation's sensitivity to scale. This observation supports the conclusion that while Affine transformation maintains proportionality, it may introduce increasing absolute distortions in larger spatial units due to compounded adjustments.

3.4 Limitations of the Current Approach and Future Potential Improvement

The findings suggest that the Affine transformation is more suitable for smaller areas in cadastral data migration, where its linear adjustment model performs effectively with minimal distortion. However, its application in larger or more complex areas reveals limitations. Affine transformation assumes linear distortions, which may not hold for legacy datasets influenced by terrain deformation, outdated surveying techniques, or systematic errors. Additionally, reliance on potentially misplaced boundary marks as fixed reference points can introduce further inaccuracies, particularly if out-of-position control points are used in parameter estimation.

These discrepancies carry significant implications for land administration. In high-value urban zones, even a 1 m^2 error can lead to notable financial misevaluation. Land tenure security may be compromised if spatial inaccuracies cause overlapping claims or misrepresented boundaries. Moreover, in planning and development, accumulated transformation errors across parcels can lead to misaligned infrastructure, inefficient land use, or costly corrections. For broader-scale applications, hybrid models—combining Affine with higher-order Polynomial or spline-based methods—may better accommodate non-linear distortions. Robust adjustment techniques like Least Absolute Value (LAV) or Total Least Squares (TLS) are recommended to improve resistance to outliers and enhance parameter reliability. As cadastral systems evolve toward 3D and 4D integration, more advanced transformation methods capable of supporting vertical and temporal dimensions will be essential for maintaining spatial accuracy and legal integrity in land administration.

4. CONCLUSION

The study successfully achieved all the set objectives related to investigating the cadastre data migration process in Peninsular Malaysia from PDUK data to GDM2000 DCDB. The limitations of the existing PDUK data were identified through a comprehensive analysis of the current system, revealing key issues such as inconsistencies in data format, varying levels of accuracy, and challenges in integrating with modern geodetic standards. These findings provided a clear foundation for understanding the necessity of migrating to the more advanced GDM2000 DCDB framework. The second objective focused on converting cadastre data from PDUK to GDM2000 DCDB. This included transforming data to align with the new geodetic datum, addressing compatibility challenges, and improving spatial accuracy. The successful completion of this migration demonstrated technical feasibility and outlined the practical steps for a smooth transition. The updated geodetic standards in GDM2000 enabled better integration and management of cadastral data, highlighting the advantages of a more modern and precise system. The migration was assessed by comparing the shape of post-migration data with the original PDUK data. Understanding the differences in coordinates, area, bearing, and distance between the old and migrated datasets is important, particularly considering the shift from the Cassini Old survey reference to the Cassini Geocentric system. The PDUK data, collected in 1998, were based on the Cassini Old reference system, which differs significantly from the modern Cassini Geocentric method [13].

In conclusion, the study demonstrated the achievement of all objectives, validating the need for cadastre data migration from PDUK to GDM2000 DCDB in Peninsular Malaysia. Identifying limitations in the existing system, executing the migration, and assessing the results all contributed to a comprehensive understanding of the benefits of updating the cadastral framework. The outcomes support future initiatives for data modernisation and geodetic upgrades and provide provides a practical framework with proven methodologies that can be scaled for nationwide DCDB migration, paving the way for consistent and accurate cadastral data modernization across Malaysia. Ultimately, the study illustrates not only the technical capabilities involved in data migration but also the strategic importance of adopting modern geodetic standards for cadastral management. The results can serve as a reference for improving land surveying practices, ensuring that cadastral data remains accurate and up to date in a rapidly evolving technological landscape.

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AUTHOR CONTRIBUTIONS

Nur Alyya Nordin.: Data curation, Writing- Original draft preparation, Software.

Tajul Ariffin Musa.: Supervision, Methodology, Data curation, Writing- Reviewing and Editing.

Abdullah Hisam Omar.: Supervision, Validation, Writing- Reviewing and Editing.

Wan Anom Wan Aris.: Supervision, Writing- Reviewing and Editing.

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DATA AVAILABILITY STATEMENT

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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