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Spatial Conformity Analysis of Paddy Field Land (LBS) Against the Detailed Spatial Plan (RDTR) of Gorontalo City: A Temporal Comparative Study (2019–2024)

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Abstract: This study examined the spatial conformity of the Standard Paddy Field Map (LBS) against the Detailed Spatial Plan (RDTR) of Gorontalo City, Indonesia, for 2019 and 2024 using GIS-based vector intersect overlay. LBS coverage declined by 374.51 ha (32%) from 1,135.16 ha to 760.65 ha at 74 ha/year, with no additions in 2024. In 2019, 78% of LBS (885.72 ha) fell within non-agricultural RDTR zones; by 2024 this declined to 68% (515.73 ha), not through RDTR revision but because non-conforming LBS converted faster. High-density residential zones dominated non-conforming LBS in both periods, reflecting planning misalignment and the structural incompatibility between urban expansion and paddy cultivation competing for the same flat, low-lying terrain. A temporal change matrix identified 511.77 ha of persistently non-conforming LBS as the highest legal conversion risk, and 244.86 ha of persistently conforming LBS as the minimum extent for Sustainable Agricultural Land (LP2B) designation. The study concludes that a structural non-conformity trap rooted in temporal data misalignment and asymmetric planning update cycles drives continued paddy field loss. Priority interventions include immediate partial RDTR revision before the mandatory five-year review, LBS integration into the national permit system, and biennial field verification.

Keywords: Paddy Field Land (LBS); spatial conformity; RDTR; LP2B; land conversion.

Introduction

The conversion of productive agricultural land driven by rapid urban expansion represents one of the most structurally consequential land-use challenges of the twenty-first century. Rice (*Oryza sativa* L.) remains the dominant staple food crop for more than half of the world's population, with its cultivation concentrated in the river deltas and lowland plains of Asia and Southeast Asia precisely the regions experiencing the most intense urbanization pressure (Kuenzer & Knauer, 2013). Globally, urbanization transforms approximately 1.2 million hectares of agricultural land annually, generating escalating risks of food scarcity that disproportionately affect developing nations (GeoJournal, 2026). Projections by Bren d'Amour et al. (2017) demonstrate that future urban expansion between 2000 and 2030 is expected to encroach upon 1.8–2.4% of global cropland, with 84% of associated production losses concentrated in Africa and Asia regions where land for agricultural extensification is already severely constrained. This structural competition between urbanization and food production is further aggravated by the geographic reality that cities have historically been established in the most fertile lowland zones, meaning that urban growth inherently targets the world's most productive agricultural land (Bren d'Amour et al., 2017; Li et al., 2024). The multidimensional consequences of this process extend beyond food supply reduction to encompass ecosystem degradation, the erosion of agrarian livelihoods, and

How to Cite:
Example: Susilawati, S., Doyan, A., Muliyadi, L., & Hakim, S. (2019). Growth of tin oxide thin film by aluminum and fluorine doping using spin coating Sol-Gel techniques. *Jurnal Penelitian Pendidikan IPA, 1*(1), 1-4. https://doi.org/10.29303/jppipa.v1i1.264

deepening socioeconomic vulnerability for smallholder farming communities (Li et al., 2024).

Indonesia exemplifies this global challenge with particular severity. Paddy fields supply approximately 95% of national rice production, making them the irreplaceable foundation of food sovereignty for a population exceeding 270 million (Gandharum et al., 2025; Firmansyah et al., 2021). Yet the national inventory of registered paddy land formally designated as *Lahan Baku Sawah* (LBS), or the Standard Paddy Field, representing the geospatially verified extent of active paddy cultivation has contracted persistently, declining from 8.4 million hectares in 1990 to 7.18 million hectares in 2022, equivalent to an annual net loss exceeding 38,000 hectares (Suciati & Kunu, 2026). This contraction is most acute in peri-urban transition zones, where the highest concentrations of irrigated paddy land coincide geographically with the highest rates of urban population growth, creating a direct spatial competition between rice agriculture and urban development (Mulya et al., 2026; Rizq & Manessa, 2025). The phenomenon mirrors the broader *desakota* dynamic documented across Java's peri-urban fringe, in which agricultural and urban land uses overlap in a chaotic mosaic of transition as land values rise and farming's social and economic centrality diminishes (Pribadi & Pauleit, 2015). This structural vulnerability has positioned Indonesia among the countries with the highest rates of paddy field conversion globally, compounding the urgency of implementing robust, data-driven protection mechanisms.

The application of remote sensing technology and Geographic Information Systems (GIS) has been firmly established as the most effective methodological approach for the temporally continuous, spatially precise monitoring of paddy field dynamics. Kuenzer & Knauer (2013) provided comprehensive evidence that satellite-based remote sensing enables accurate, scalable detection of paddy cultivation extent across geographically diverse contexts, significantly outperforming conventional ground-based inventories in terms of temporal resolution and spatial coverage. Integration of high-resolution satellite imagery with GIS-based spatial overlay analysis further allows the precise quantification of conformity between actual paddy field distribution and the zoning designations contained in spatial planning documents producing objective, reproducible evidence that is not achievable through periodic field surveys alone (Wijayanto et al., 2025; Nur et al., 2024). It is this methodological strength that underpins the construction of Indonesia's National LBS Map by the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (ATR/BPN) through Presidential Regulation (*Peraturan Presiden*/Perpres) No. 59 of 2019, and that constitutes the analytical foundation of the present study in evaluating LBS spatial conformity against the RDTR of Gorontalo City.

The scientific literature on paddy field spatial conformity with planning documents in Indonesia has expanded considerably over the past decade. Studies applying GIS overlay methods have consistently documented systematic mismatches between the spatial distribution of actual paddy fields and their classification within regional land-use zoning schemes, with conformity gaps ranging from moderate to severe depending on the level of integration between LBS data and planning documents (Harpudiansyah & Apriyanti, 2025; Khairullah et al., 2025; Ekafitrawan et al., 2020). The legal and institutional dimensions of this problem have received increasing scholarly attention following the enactment of Government Regulation (*Peraturan Pemerintah*/PP) No. 21 of 2021, which integrated the Detailed Spatial Plan (*Rencana Detail Tata Ruang*/RDTR) into the Online Single Submission (OSS) licensing mechanism, establishing the RDTR as the automatic reference document for the issuance of Space Utilization Activity Conformity permits (*Kesesuaian Kegiatan Pemanfaatan Ruang*/KKPR). Research has demonstrated that under this framework, productive paddy fields classified under non-agricultural zones in the RDTR can receive legal conversion permits automatically, without additional agricultural land evaluation effectively rendering the LBS–RDTR spatial relationship a direct determinant of paddy field legal vulnerability (Harpudiansyah & Apriyanti, 2025; Irawan & Wibisono, 2025). In Gorontalo City specifically, the provincial capital of Gorontalo Province, documented paddy land contraction from 852 ha (2015) to 795 ha (2019) a loss of 57 ha or 6.7% within four years has been compounded by a further reduction to 725 ha by 2024, bringing total LBS loss during 2019–2024 to 70 ha, or 8.8% of the 2019 baseline (Ekafitrawan et al., 2020; Djafar et al., 2026).

Despite this expanding body of research, a critical methodological limitation persists across existing conformity studies in Indonesia: the near-universal reliance on a single temporal snapshot of paddy field data. This single-period approach captures the state of LBS–RDTR conformity at one fixed moment but cannot track how the spatial relationship between these two datasets evolves as paddy field extent changes over time, nor can it identify whether converted paddy fields originated from agriculturally zoned areas indicating a failure of Sustainable Agricultural Land (*Lahan Pertanian Pangan Berkelanjutan*/LP2B) implementation or from zones already designated for non-agricultural use,

indicating a structural "non-conformity trap" arising from the absence of LBS data integration into spatial planning documents (Harpudiansyah & Apriyanti, 2025; Khairullah et al., 2025). These two scenarios carry fundamentally distinct policy implications, yet the analytical framework to distinguish them has not previously been applied to Gorontalo City. The present study addresses this gap by conducting, for the first time in Gorontalo City, a dual-period comparative spatial conformity analysis using the official LBS maps for 2019 and 2024. The specific objectives are: (1) to map the spatial distribution and quantify LBS reduction in Gorontalo City between 2019 and 2024; (2) to assess the degree of conformity between LBS 2019 and LBS 2024 against the spatial zoning pattern (*pola ruang*) of the Gorontalo City RDTR (Mayor Regulation No. 44 of 2021); (3) to identify changes in conformity and non-conformity zones across the two periods; and (4) to formulate spatially-grounded policy recommendations to strengthen LP2B protection in Gorontalo City.

The urgency of this research is amplified by a set of structural conditions that render formal regulatory alignment uniquely critical in the Gorontalo City context. Approximately 90% of paddy field owners in Gorontalo City are non-resident landowners, substantially diminishing the effectiveness of community-based or informal land protection mechanisms and concentrating the burden of agricultural land control entirely on formal spatial governance instruments (Chairani et al., 2025). Under the KKPR-OSS framework established by PP No. 21 of 2021, the RDTR functions as the automatic reference for conversion permit issuance; any misalignment between LBS boundaries and RDTR agricultural zones therefore constitutes a direct legal vulnerability through which productive paddy fields may be lost without triggering the safeguards mandated by Law No. 41 of 2009 on the Protection of Sustainable Agricultural Food Land (LP2B) and Perpres No. 59 of 2019. Most recently, Presidential Regulation No. 4 of 2026 on the Control of Paddy Field Land Conversion designating approximately 6.39 million hectares of LBS as Protected Paddy Fields (*Lahan Sawah Dilindungi*/LSD) and LP2B has reinforced the national commitment to regulatory-based agricultural land protection, making the synchronization of LBS data with RDTR zoning a prerequisite for effective implementation of this policy. Generating spatially precise, temporally comparative evidence on the LBS–RDTR relationship in Gorontalo City is therefore not merely an academic exercise but an immediate empirical foundation for evidence-based spatial governance reform.

Method

Research Design

This study employs a quantitative spatial research design based on a temporal comparative framework, combining vector-based Geographic Information System (GIS) overlay analysis with multi-period secondary spatial data. The research is grounded in the principle that the spatial relationship between the official Standard Paddy Field Map (*Lahan Baku Sawah*/LBS) and the land zoning designations contained in the Detailed Spatial Plan (*Rencana Detail Tata Ruang*/RDTR) constitutes a direct, measurable determinant of paddy field legal vulnerability under Indonesia's current spatial licensing framework (Harpudiansyah & Apriyanti, 2025). By comparing two officially verified LBS datasets for 2019 and 2024 against a single operative RDTR document (Mayor Regulation No. 44 of 2021), the study produces not only a static conformity assessment for each period but also a dynamic change matrix that captures the trajectory of spatial conformity as paddy field extent changes over time. This dual-period design enables the identification of whether paddy fields lost between 2019 and 2024 originated from agriculturally zoned areas indicating a failure of the Sustainable Agricultural Land (*Lahan Pertanian Pangan Berkelanjutan*/LP2B) protection mechanism or from non-agricultural zones, indicating a structural "non-conformity trap" embedded in the planning document itself (Khairullah et al., 2025; Irawan & Wibisono, 2025).

Study Area

The study was conducted in Gorontalo City, the provincial capital of Gorontalo Province, located at coordinates 0°28'17"–0°35'56" N; 122°59'44"–123°05'59" E, covering a total administrative area of 79.03 km² across 9 sub-districts (kecamatan) and 50 urban villages (kelurahan). The city occupies a strategic position as the administrative, commercial, and service center of Gorontalo Province and has experienced rapid urban growth during the past two decades, driven by expansion of residential, commercial, and infrastructural land uses into formerly agricultural areas (Djafar et al., 2026). The selection of Gorontalo City as the study area was based on three criteria: (1) the availability of two officially verified LBS datasets for different periods (2019 and 2024) from the ATR/BPN Gorontalo City Office; (2) the existence of a legally operative RDTR document (Mayor Regulation No. 44 of 2021) providing the reference spatial zoning plan.

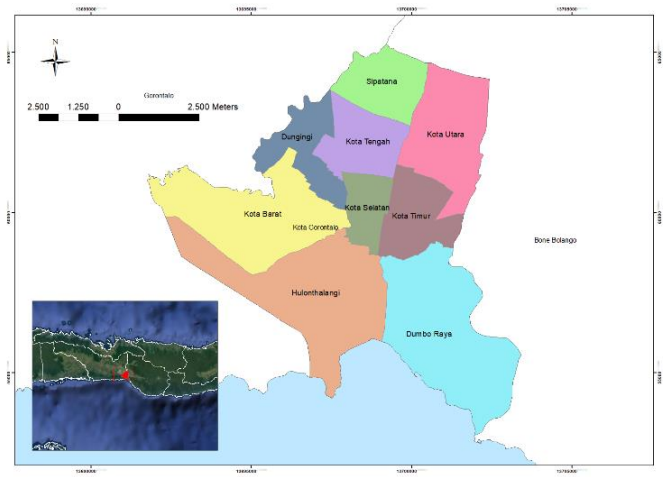


Figure 1. Research Location Map of Gorontalo City

Data Sources and Materials

This study relies exclusively on official secondary spatial datasets obtained through formal requests submitted to the relevant government agencies. All spatial data were received in shapefile format (.shp), the standard vector data format for GIS analysis (QGIS Development Team, 2024). Four primary datasets were used, as summarized in Table 1.

Table 1. Primary Spatial Datasets Used in the Study

Dataset	Year	Source / Legal Basis	Format
LBS Map	2019	ATR/BPN Ministerial Decree No. 686/SK-PG.03.03/XII/2019	Shapefile (.shp)
LBS Map	2024	ATR/BPN Gorontalo City — Latest field verification	Shapefile (.shp)
RDTR Spatial Zoning Map	2021–2041	Gorontalo City PUPR Office — Mayor Regulation No. 44/2021	Shapefile (.shp)
Administrative	Current	ATR/BPN + BIG via Ina-Geoportal	Shapefile (.shp)

The LBS 2019 dataset was compiled by the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (ATR/BPN) under ATR/BPN Ministerial Decree No. 686/SK-PG.03.03/XII/2019, establishing the National LBS Map as the mandatory geospatial reference for paddy field governance under Presidential Regulation No. 59 of 2019. The LBS 2024 dataset represents the most recent field verification update conducted by the ATR/BPN Gorontalo City Office using the multi-source verification methodology mandated by ATR/BPN Ministerial Regulation No. 2 of 2024, which integrates high-resolution satellite imagery, ground-truth field surveys, and participatory mapping. The use of a consistent verification methodology across both periods ensures the inter-period comparability required for valid temporal analysis (Gandharum et al., 2025). The RDTR spatial zoning map (pola ruang) was obtained from the Gorontalo City Public Works and Spatial Planning Office (Dinas PUPR), representing the legally operative detailed spatial plan for Gorontalo City covering the period 2021–2041, as established under Mayor Regulation No. 44 of 2021. The administrative boundary dataset was obtained from ATR/BPN and the Geospatial Information Agency (BIG) through the Ina-Geoportal national geospatial data platform.

Software and Tools

All spatial processing and analysis were performed using QGIS Desktop version 3.4, a free and open-source GIS platform widely adopted in academic spatial research across earth and environmental sciences (Brovelli et al., 2017; QGIS Development Team, 2024). QGIS provides a comprehensive suite of vector geoprocessing tools including clip, intersect, dissolve, and calculate geometry functions that are functionally equivalent to those available in proprietary GIS platforms, while ensuring reproducibility and accessibility of the analytical workflow (Brovelli et al., 2017). Tabular data aggregation, statistical calculations, and result formatting were conducted using Microsoft Office Excel, which is widely used in GIS-based land-use research as a complement to spatial processing software for the generation of area summary tables and percentage calculations.

Data Processing and Analysis Procedures

The analytical workflow followed eight structured, sequential geoprocessing steps designed to produce comparable spatial conformity outputs for each study period. The complete workflow is summarized in Table 2 and described in detail below.

Table 2. Analytical Workflow: Geoprocessing Steps

Step	Process	Tool / Operation	Output
1	Coordinate standardization	Reproject all layers → WGS 1984 UTM Zone 51N	Unified CRS across all datasets
2	Administrative clipping	Clip LBS 2019 & LBS 2024 to city boundary	City-specific LBS layers per period
3	LBS change detection	Intersect LBS 2019 ∩ LBS 2024	Retained, lost, and added paddy area polygons
4	RDTR layer preparation	Clip pola ruang to LBS spatial extent	Analysis-ready RDTR zoning layer
5	Conformity overlay — 2019	Intersect LBS 2019 ∩ RDTR pola ruang	LBS 2019 × RDTR conformity layer
6	Conformity overlay — 2024	Intersect LBS 2024 ∩ RDTR pola ruang	LBS 2024 × RDTR conformity layer
7	Conformity classification	Attribute query: S = agricultural zone; TS = non-agricultural zone	Binary conformity field added to both layers
8	Area calculation & aggregation	Calculate Geometry (Ha); disaggregate by sub-district and RDTR zone	Statistical tables per period & comparative matrix

1. Coordinate System Standardization

All spatial datasets were reprojected to a common Projected Coordinate Reference System (CRS): WGS 1984 UTM Zone 51N (EPSG: 32651). Standardization to a single projected CRS is a fundamental prerequisite for multi-layer spatial analysis, as it eliminates geometric distortions arising from differences in map projection and ensures that area calculations are performed in metric units (metres/hectares) rather than angular units (degrees), which would introduce systematic measurement errors (Tiede, 2014). UTM Zone 51N was selected as the appropriate zone for Gorontalo's geographic position (approximately 123° E longitude), providing meter-scale coordinate accuracy essential for precise polygon area calculations.

2. Administrative Boundary Clipping

The LBS 2019 and LBS 2024 layers were individually clipped to the administrative boundary of Gorontalo City using the vector clip function in QGIS. This step confines the analysis to the city's jurisdictional extent, eliminating any paddy field polygons that may cross the administrative boundary and ensuring that all area measurements reflect only land within Gorontalo City. The resulting city-specific LBS layers for each period serve as the two primary input layers for subsequent temporal and conformity analyses.

3. LBS Change Detection via Intersect Overlay

Temporal change in LBS extent was quantified through a vector intersect overlay between the LBS 2019 and LBS 2024 layers. The intersect operation one of the core overlay functions in GIS produces a new polygon layer containing only the spatial areas where both input layers overlap, preserving the attribute fields of both source layers in the output (Tiede, 2014). Areas present in LBS 2019 but absent from LBS 2024 were identified as lost paddy fields; areas present in both were classified as retained; and areas appearing in LBS 2024 but absent from LBS 2019 were classified as newly added paddy fields. This three-class change detection matrix enables the characterization of net LBS change as well as gross gains and losses between the two periods, providing a more complete picture of paddy field dynamics than net-change statistics alone (Gandharum et al., 2025).

4. RDTR Layer Preparation

The RDTR spatial zoning layer (pola ruang) was clipped to the combined spatial extent of both LBS layers using the vector clip function, reducing the dataset to the area relevant for conformity analysis. This step reduces computational processing load while maintaining the

full attribute content particularly the land zone type (zona) attribute required for the conformity classification in subsequent steps.

5. Spatial Conformity Overlay — 2019 and 2024

The central analytical operations of this study were the vector intersect overlays between LBS 2019 and the RDTR pola ruang layer (Step 5), and between LBS 2024 and the same RDTR layer (Step 6). The intersect overlay is the methodological standard for assessing the spatial alignment between two polygon datasets in land-use planning research (Harpudiansyah & Apriyanti, 2025; Khairullah et al., 2025). Each intersect operation generates a new polygon layer in which every output polygon carries the combined attribute fields of both input layers specifically the LBS polygon identifier and the RDTR zone type enabling a direct attribute-based determination of whether each unit of paddy land falls within an agriculturally designated zone or a non-agricultural zone in the RDTR. The deliberate use of the same RDTR document as the reference against which both LBS 2019 and LBS 2024 are compared ensures strict methodological consistency: any differences in conformity outcomes between the two periods reflect changes in LBS extent, not changes in the planning reference document.

6 Binary Conformity Classification

Following the intersect overlay, each output polygon was classified into one of two conformity categories based on the RDTR zone type attribute: (S — Sesuai, Conforming) where the RDTR zone is designated as an agricultural or LP2B zone; or (TS — Tidak Sesuai, Non-Conforming) where the RDTR zone is designated for non-agricultural purposes, including residential (permukiman), commercial and service (perdagangan dan jasa), office (perkantoran), or public facilities (fasilitas umum). This binary classification scheme is consistent with the zoning framework established under Government Regulation No. 21 of 2021 on the Implementation of Spatial Planning, which recognizes agricultural and LP2B designations as the operative legal categories for paddy field protection within the RDTR system (Harpudiansyah & Apriyanti, 2025).

7 Area Calculation and Spatial Aggregation

Area (in hectares) was calculated for all polygons in both the LBS 2019 conformity layer and the LBS 2024 conformity layer using the Calculate Geometry function in QGIS, operating on the projected UTM coordinate system to ensure metric accuracy. Results were then spatially disaggregated by sub-district (kecamatan) and by RDTR zone type for both study periods, enabling spatial pattern identification at the sub-district level. The conformity percentage for each period was computed using the following formulae:

$$\% \text{ conformity} = \frac{\text{Area of Conforming LBS}}{\text{Total LBS Area}} \times 100\%$$

$$\% \text{ Non-conformity} = \frac{\text{Area of Non-conforming LBS}}{\text{Total LBS Area}} \times 100\%$$

A temporal conformity change matrix was subsequently constructed by cross-tabulating the conformity class of each polygon in LBS 2019 against the conformity class of the corresponding spatial position in LBS 2024 (if still present), identifying four transition categories:

(i) Conforming → Conforming (retained, compliant);

(ii) Conforming → Lost (converted from an agricultural zone);

(iii) Non-Conforming → Non-Conforming (retained, non-compliant); and

(iv) Non-Conforming → Lost (converted from a non-agricultural zone).

This four-cell matrix enables the disaggregation of total LBS loss into its policy-relevant sub-components, providing the empirical evidence base for distinguishing LP2B implementation failure from structural planning non-conformity (Harpudiansyah & Apriyanti, 2025; Khairullah et al., 2025).

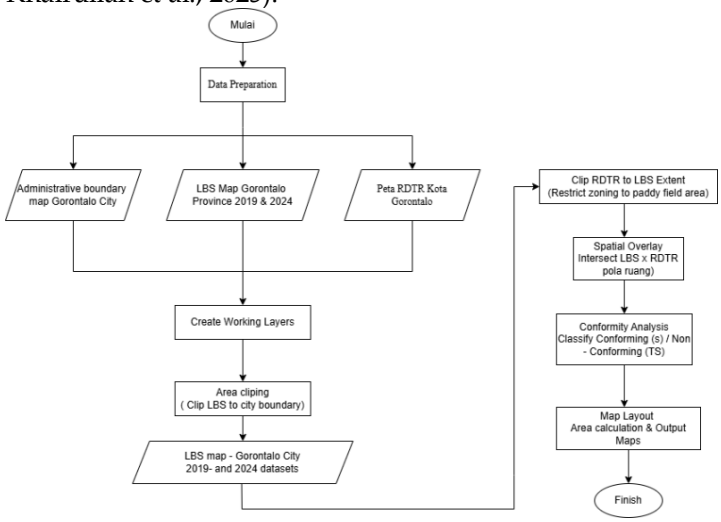


Figure 2. Research Flowchart.

Result and Discussion

The LBS datasets recorded a net reduction of 374.51 ha in Gorontalo City from 1,135.16 ha in 2019 to 760.65 ha in 2024 representing a proportional loss of 32% at approximately 74 ha/year (Table 1). No new paddy fields were identified in 2024, confirming a strictly unidirectional conversion trajectory. The spatial distribution of loss was uneven: Kota Utara recorded the largest absolute decline (−136.70 ha), while Dungingi (−76.7%) and Kota Barat (−67.4%) suffered the steepest

proportional losses. This spatial heterogeneity reflects the peri-urban transition dynamic in which conversion pressure concentrates at sub-districts directly adjacent to established commercial and residential corridors, where land values create strong incentives for agricultural land owners to sell or convert (Nuissl & Siedentop, 2021; Rizq & Manessa, 2025).

Table 3. LBS Change by Sub-District, LBS Distribution by RDTR Zone Type Gorontalo City (2019–2024)

No	District	LBS 2019 (Ha)	Conforming 2019 (Ha)	Non-Conforming 2019 (Ha)	LBS 2024 (Ha)	Conforming 2024 (Ha)	Non-Conforming 2024 (Ha)	Area Change (Ha)
1	Kota Barat	84,81	0,00	84,81	27,69	0,00	27,69	57,12
2	Kota Timur	126,63	40,73	85,91	107,05	40,50	66,54	19,59
3	Kota Utara	572,23	149,67	422,56	435,53	148,13	287,40	136,70
4	Kota Selatan	6,31	0,00	6,31	0,61	0,00	0,61	5,70
5	Kota Tengah	110,56	0,00	110,56	64,49	0,00	64,49	46,07
6	Hulonthalangi	0,00	0,00	0,00	0,00	0,00	0,00	0,00
7	Dungingi	67,21	0,00	67,21	15,63	0,00	15,63	51,58
8	Dumbo Raya	0,00	0,00	0,00	0,00	0,00	0,00	0,00
9	Sipatana	167,41	59,05	108,36	109,65	56,29	53,36	57,76
	Total	**1135,16**	**249,44**	**885,72**	**760,65**	**244,92**	**515,73**	**374,51**

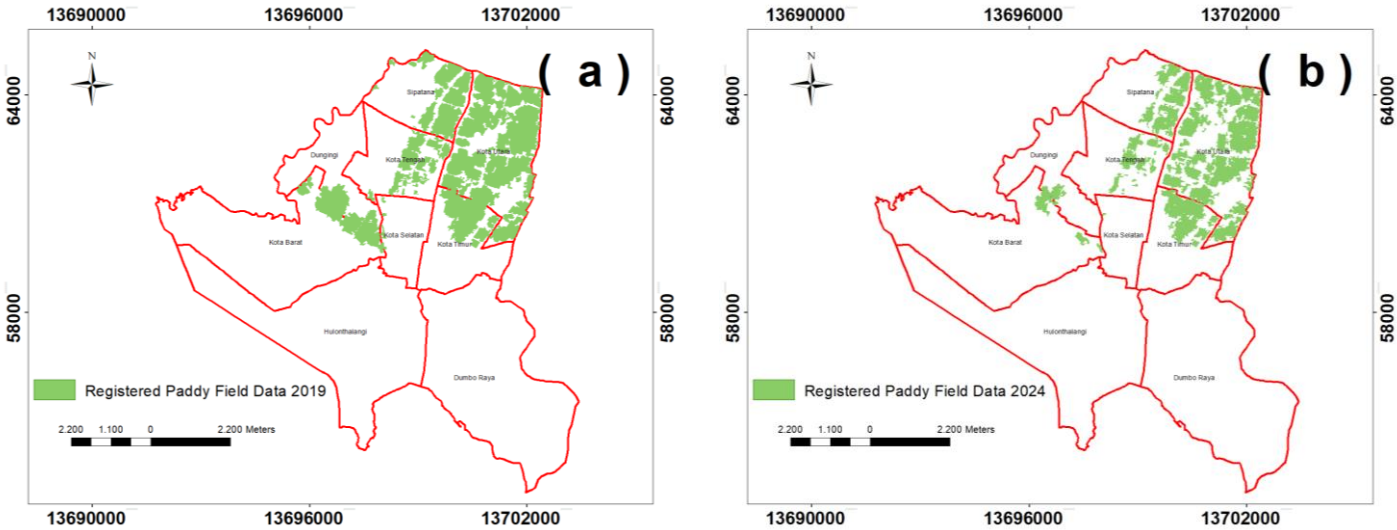


Figure 3. Map of LBS Gorontalo City 2019 (a) – Map of LBS Gorontalo City 2024 (b)

LBS–RDTR Spatial Conformity

Table 4: Conformity of LBS 2019 against the Spatial Pattern of the Detailed Spatial Plan (RDTR) of Gorontalo City

No	RDTR Zone	Raw Paddy Field (LBS) 2019 (Ha)	2019 (%)	Raw Paddy Field (LBS) 2024 (Ha)	2024 (%)	Remarks
1	Water Body	0,490	0,043%	0,040	0,005%	**Non-Conforming**
2	Road Body	11,428	1,007%	0,660	0,090%	**Non-Conforming**
3	Medium Intensity Mixed Use	13,039	1,149%	9,770	1,290%	**Non-Conforming**

No	RDTR Zone	Raw Paddy Field (LBS) 2019 (Ha)	2019 (%)	Raw Paddy Field (LBS) 2024 (Ha)	2024 (%)	Remarks
4	Wastewater Treatment Plant (WWTP)	0,477	0,042%	0,180	0,020%	**Non-Conforming**
5	Drinking Water Treatment Plant (DWTP)	0,009	0,001%	0,000	0,000%	**Non-Conforming**
6	City-Scale Trade and Services	5,247	0,462%	0,610	0,080%	**Non-Conforming**
7	SWP-Scale Trade and Services	85,465	7,529%	49,050	6,448%	**Non-Conforming**
8	WP-Scale Trade and Services	69,297	6,105%	31,700	4,167%	**Non-Conforming**
9	Warehousing	1,163	0,102%	0,230	0,030%	**Non-Conforming**
10	Office	19,622	1,729%	7,190	0,945%	**Non-Conforming**
11	Local Protection Zone	0,311	0,027%	0,050	0,006%	**Non-Conforming**
12	Defense and Security	0,043	0,004%	0,010	0,002%	**Non-Conforming**
13	Medium-Density Residential	280,625	24,721%	128,030	16,830%	**Non-Conforming**
14	High-Density Residential	334,937	29,506%	241,610	31,760%	**Non-Conforming**
15	Urban Forest	0,231	0,020%	0,000	0,000%	**Non-Conforming**
16	District-Scale Public Facility (SPU)	0,109	0,010%	0,000	0,000%	**Non-Conforming**
17	Kelurahan-Scale Public Facility (SPU)	0,855	0,075%	0,011	0,001%	**Non-Conforming**
18	City-Scale Public Facility (SPU)	61,913	5,454%	46,430	6,103%	**Non-Conforming**
19	RW-Level Park	0,461	0,041%	0,158	0,021%	**Non-Conforming**
20	Food Crops / Agricultural Land (LP2B)	249,441	21,974%	244,920	32,199%	**Conforming – Protected LP2B**
	TOTAL AREA	**1.135,163**	**100%**	**760,649**	**100%**	

Notes: RDTR = Detailed Spatial Plan | SWP = Sub-Planning Area | WP = Planning Area | SPU = Public Utility Facilities | LP2B = Protected Agricultural Land for Food Sustainability | WWTP = Wastewater Treatment Plant | DWTP = Drinking Water Treatment Plant

The apparent improvement in the conformity rate from 22% (2019) to 32% (2024) does not reflect any revision of the RDTR zoning document. Rather, it is an artefact of the disproportionate conversion of non-conforming LBS: because a greater absolute area of non-conforming LBS was lost than conforming LBS, the conforming fraction grew proportionally. High-density residential zones dominated non-conforming LBS in both periods (29.51% in 2019; 31.76% in 2024), consistent with findings from comparable Indonesian studies (Harpudiansyah & Apriyanti, 2025; Khairullah et al., 2025; Amri et al., 2025), and confirming that RDTR-designated urban expansion areas structurally overlap with productive paddy field zones. The 78% non-conformity rate recorded for Gorontalo City substantially exceeds the 23.6% reported for Aceh Province (Amri et al., 2025), a difference attributable to the higher spatial precision and urban

functionality orientation of city-level RDTR zoning relative to provincial spatial plans.

Cross-tabulation of conformity status across both periods produced the change matrix in Table 3. The largest single category 511.77 ha of persistently Non-Conforming LBS (TS→TS) represents the most legally vulnerable paddy field segment under the Space Utilization Activity Conformity (Kesesuaian Kegiatan Pemanfaatan Ruang/KKPR) Online Single Submission (OSS) framework established by Government Regulation No. 21 of 2021. Since the RDTR functions as the automatic reference for KKPR permit issuance, LBS located in non-agricultural zones is structurally eligible for conversion without triggering agricultural land safeguards under Law No. 41 of 2009 and Presidential Regulation No. 59 of 2019 a condition this study terms the "non-conformity trap" (Harpudiansyah & Apriyanti, 2025; Irawan & Wibisono, 2025). The 244.86 ha of persistently Conforming LBS (S→S) constitutes the legally safest category and the empirically grounded minimum extent for formal LP2B designation in the next RDTR revision.

Table 3. Temporal Conformity Change Matrix of LBS (2019–2024)

No	Change Category	Area (ha)	Description
1	LBS Retained — Conforming (S→S)	244.86	LP2B-zoned, safest category
2	LBS Retained — Non-Conforming (TS→TS)	511.77	Highest legal conversion risk under KKPR-OSS
3	LBS Lost (Converted)	378.53	Confirmed paddy field loss 2019–2024
4	LBS New 2024	0.00	No new paddy fields identified in 2024

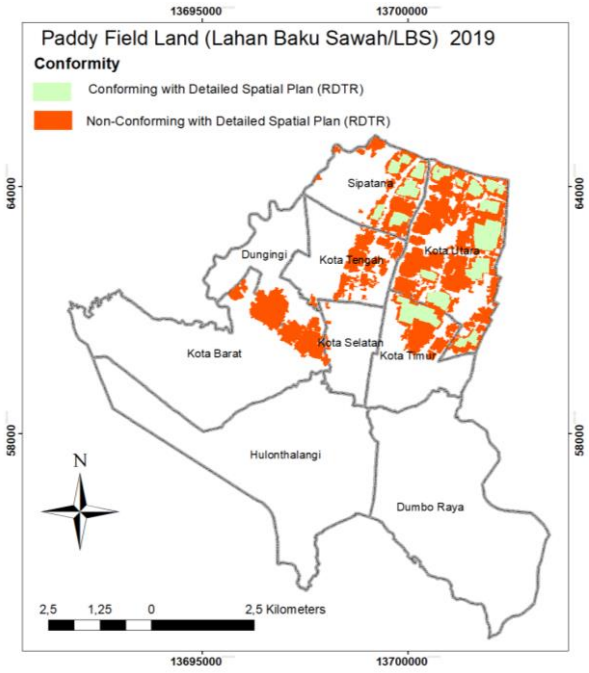


Figure 4. Spatial Conformity Map of LBS 2019 against the Detailed Spatial Plan (RDTR) of Gorontalo City

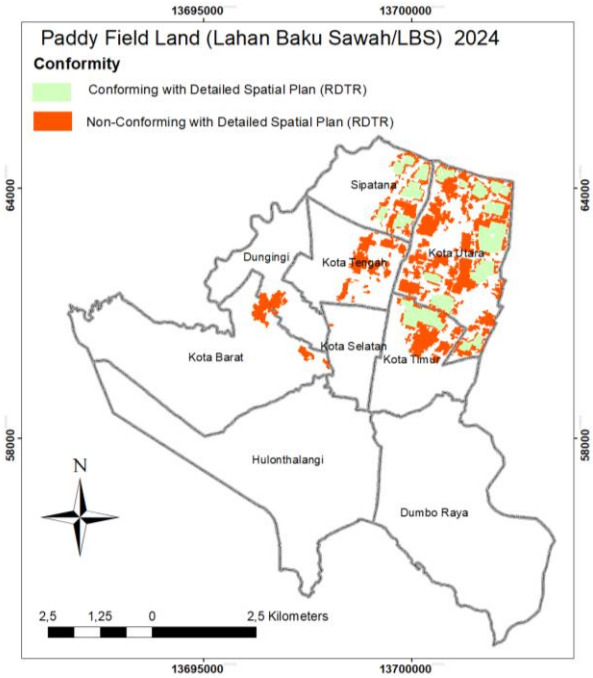


Figure 5. Spatial Conformity Map of LBS 2024 against the Detailed Spatial Plan (RDTR) of Gorontalo City

The 78% non-conformity rate recorded for LBS 2019 in Gorontalo City considerably exceeds rates reported in comparable Indonesian studies: 23.6% in Aceh Province (Amri et al., 2025), and substantial but lower inconsistencies in Boyolali Regency (Harpudiansyah & Apriyanti, 2025) and Purworejo Regency (Khairullah et al., 2025). This divergence is attributable to the higher spatial precision of city-level RDTR zoning relative to

provincial spatial plans finer-grained zone designations at the RDTR scale allocate more land to urban functions, creating a structurally larger overlap between non-agricultural zones and actual paddy field extent. The dominance of high-density residential zones as the primary non-conforming category (29.51% in 2019; 31.76% in 2024) is consistent with findings from Ekafitrawan et al. (2020) in Gorontalo Regency and confirms that RDTR-designated residential expansion areas systematically overlap with productive paddy field corridors across the Gorontalo context, reinforcing the structural character of the mismatch rather than attributing it to isolated zoning errors.

Three structural mechanisms explain the persistence of LBS–RDTR non-conformity. First, temporal data misalignment: the RDTR's agricultural zone boundaries were derived from local land inventories compiled during the document's drafting process, which predate and are less accurate than the multi-source verified National LBS Maps produced under the methodology mandated by ATR/BPN Ministerial Regulation No. 2 of 2024 (Gandharum et al., 2025). Second, historically non-mandatory LBS integration: prior to Presidential Regulation No. 59 of 2019, national spatial planning regulations did not explicitly require the use of LBS data as an input layer in RDTR compilation, producing a structural planning gap that no subsequent legislative correction has fully resolved (Harpudiansyah & Apriyanti, 2025; Irawan & Wibisono, 2025). Third, asymmetric update cycles: LBS verification is conducted periodically while the RDTR operates on a multi-decade planning horizon, causing verified field conditions to progressively diverge from static zone designations. Together, these mechanisms produce the "non-conformity trap" documented in this study a condition in which 511.77 ha of nationally verified paddy fields are positioned in non-agricultural RDTR zones, rendering them structurally eligible for automatic conversion permit issuance under the KKPR-OSS framework of Government Regulation No. 21 of 2021 without triggering the safeguards of Law No. 41 of 2009.

This study advances the existing literature in two principal ways. Methodologically, the dual-period temporal conformity framework applied for the first time in Gorontalo City enables the disaggregation of LBS loss into policy-relevant sub-components (loss from agricultural versus non-agricultural zones), overcoming the limitation of single-period designs that cannot capture this distinction (Amri et al., 2025; Khairullah et al., 2025). Substantively, the empirical identification of the non-conformity trap provides a theoretically coherent explanation for why regulatory instruments under Law No. 41 of 2009 and Perpres No. 59 of 2019 have been insufficient to arrest paddy field loss in cities where LBS data remain unsynchronised with RDTR zoning. In terms of policy implications, three priority interventions follow directly from the findings: a partial RDTR revision under ATR/BPN Ministerial Regulation No. 11 of 2021 to rezone the 511.77 ha of persistently non-conforming LBS as LP2B with Kota Utara and Sipatana as highest-priority sub-districts; formal spatialisation of the 244.86 ha persistently conforming LBS as a binding LP2B layer in the RDTR's zoning regulations; and integration of LBS data as an automatic evaluation trigger in the national OSS system, consistent with the direction of Presidential Regulation No. 4 of 2026 on the Control of Paddy Field Land Conversion.

This study has three principal limitations. The analysis operates at the polygon level and does not incorporate individual parcel permit records or land transaction data, precluding direct attribution of LBS loss to specific legal or informal conversion pathways. The binary Conforming/Non-Conforming classification does not differentiate conversion risk across non-agricultural zone types a refinement that future weighted conformity indices could address. Finally, the single-city scope means that the specific conformity rates and structural dynamics reported here reflect Gorontalo City's particular planning history and urban trajectory; replication across other Indonesian provincial capitals with available multi-period LBS datasets is needed to establish broader generalisability.

Beyond the institutional mechanisms already identified, the high non-conformity rate between LBS and RDTR in Gorontalo City is also structurally explained by a fundamental incompatibility between urban land-use logic and agricultural land requirements. Urban spatial planning particularly at the RDTR level operates under the logic of maximising land functionality for settlement, commerce, and public services, which is inherently oriented toward built-environment uses. Paddy field agriculture, by contrast, requires flat, low-lying terrain with reliable water access precisely the physical characteristics that make peri-urban land attractive for residential and commercial development (Sutrisno et al., 2021). This creates a structural overlap in which the land most suitable for paddy cultivation is simultaneously the land most targeted for urban expansion, and RDTR zone designations tend to reflect anticipated urban growth trajectories rather than existing agricultural land conditions. As a result, a high proportion of LBS area in city-level administrative units will inevitably fall within non-agricultural RDTR zones not due to planning error, but because the urban growth vision embedded in the

RDTR is fundamentally incompatible with the continuation of paddy agriculture in the same spatial footprint (Pribadi & Pauleit, 2015). This structural incompatibility is particularly acute in Gorontalo City, whose 79.03 km² administrative area leaves minimal spatial buffer between urban core zones and the remaining paddy field corridors, meaning that almost any urban expansion direction will encroach upon LBS-registered land.

A further dimension of the non-conformity problem concerns the revision cycle of the RDTR itself. Under Government Regulation No. 21 of 2021 on the Implementation of Spatial Planning, RDTR documents are subject to mandatory periodic review (peninjauan kembali) once every five years not every ten years as is sometimes assumed in practice. This review constitutes the primary formal window through which LBS data can be incorporated into RDTR zoning, agricultural zones can be updated, and LP2B boundaries can be spatialised within the planning document (Government of Indonesia, 2021). Beyond the scheduled five-year review, ATR/BPN Ministerial Regulation No. 11 of 2021 permits partial revision (revisi parsial) of the RDTR before the scheduled review period, provided that a significant change in strategic conditions such as newly verified LBS data demonstrating substantial divergence from current RDTR zone designations can be demonstrated. This partial revision mechanism is precisely the policy instrument through which the findings of this study could be operationalised most rapidly: rather than awaiting the next full five-year review cycle (which for Gorontalo City's 2021 RDTR would fall no earlier than 2026), a partial revision targeting the 511.77 ha of persistently non-conforming LBS could be initiated immediately on the basis of the spatial evidence generated here. The availability of this mechanism has not been sufficiently utilised by Indonesian local governments for LP2B synchronisation purposes, and activating it in Gorontalo City would represent a concrete, legally grounded response to the non-conformity trap documented in this study..

Conclusion

This study demonstrated that registered paddy field (Lahan Baku Sawah/LBS) coverage in Gorontalo City contracted by 374.51 ha from 1,135.16 ha in 2019 to 760.65 ha in 2024 a net loss of 32% at an average rate of approximately 74 ha/year, with no compensatory paddy field additions recorded in 2024. Spatial conformity analysis revealed that 78% of LBS 2019 (885.72 ha) fell within non-agricultural zones of the Gorontalo City Detailed Spatial Plan (Rencana Detail Tata Ruang/RDTR), declining proportionally to 68% in 2024 (515.73 ha) not through any RDTR revision, but because non-conforming LBS was converted at a faster rate than conforming LBS. High-density residential zones constituted the dominant non-conforming category in both periods (29.5% in 2019; 31.8% in 2024), a pattern attributable not only to institutional planning failures but also to the structural incompatibility between urban land-use logic and agricultural land requirements: the flat, low-lying terrain that paddy cultivation demands is simultaneously the terrain most attractive for residential and commercial development. In Gorontalo City, whose 79.03 km² administrative area leaves minimal spatial buffer between urban core zones and paddy field corridors, this structural overlap renders LBS–RDTR non-conformity a near-inevitable condition of city-level spatial governance.

The temporal conformity change matrix identified 511.77 ha of LBS as persistently Non-Conforming across both periods paddy fields that are nationally verified yet located in non-agricultural RDTR zones, making them structurally eligible for automatic conversion permit issuance under the Space Utilization Activity Conformity (Kesesuaian Kegiatan Pemanfaatan Ruang/KKPR)–Online Single Submission (OSS) mechanism without triggering the agricultural safeguards mandated by Law No. 41 of 2009 and Presidential Regulation No. 59 of 2019. This "non-conformity trap" rooted in the temporal misalignment between LBS data and RDTR zoning, the historically non-mandatory integration of LBS as a planning input, and the asymmetry between the periodic LBS update cycle and the multi-decade RDTR planning horizon constitutes the primary structural driver of continued paddy field loss in Gorontalo City (Harpudiansyah & Apriyanti, 2025; Irawan & Wibisono, 2025). The 244.86 ha of persistently Conforming LBS (S→S) represents the legally safest segment and the empirically grounded minimum extent for formal Sustainable Agricultural Land (Lahan Pertanian Pangan Berkelanjutan/LP2B) designation.

To operationalise these findings, four priority interventions are recommended. First, a partial RDTR revision (revisi parsial) permitted under ATR/BPN Ministerial Regulation No. 11 of 2021 and actionable before the next mandatory five-year review cycle established by Government Regulation No. 21 of 2021 should be initiated immediately to rezone the 511.77 ha of persistently non-conforming LBS as LP2B, prioritising Kota Utara (287.40 ha), Sipatana (53.36 ha), and Kota Timur (66.54 ha). The five-year mandatory review under PP No. 21 of 2021 not ten years as sometimes assumed in practice constitutes the primary formal window for LBS–RDTR synchronisation; exploiting the partial revision mechanism before this deadline is the most legally efficient pathway available. Second, the 244.86 ha of persistently conforming LBS should be formalised as

a spatially explicit LP2B layer with binding non-conversion provisions in the RDTR's zoning regulations. Third, LBS data should be integrated as an automatic evaluation trigger in the national OSS permit system, consistent with Presidential Regulation No. 4 of 2026. Fourth, biennial LBS field verification should be institutionalised in Gorontalo City given the documented loss rate of 74 ha/year, which outpaces the current five-year update cycle. This study's dual-period temporal conformity framework the first of its kind applied in Gorontalo City provides a transferable analytical model for other Indonesian municipalities where multi-period LBS datasets exist and LBS–RDTR synchronisation remains unresolved.

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MT : developing ideas, konseptualisasi, metodologi, pengolahan data, analisis, writing. ASR, AGK, RJ : method, analyze, data collection, writing, parafrase, reviewing, proofreading.

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Conflicts of Interest

The authors declare no conflict of interest.

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