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Assessing the Impact of Rural Built-up Expansion on Agricultural Land Use Cover Change: The Case of Urbiztondo, Pangasinan, Philippines

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Abstract

Rapid changes in population dynamics and economic development have a significant impact on the availability of cultivated land resources. The pursuit of economic growth drives various anthropogenic activities, encompassing both vertical and horizontal development, leading to the continuous conversion of agricultural lands into built-up areas. To address these challenges, this study investigates the spatial expansion of rural built-up areas and their impact on agricultural lands in Urbiztondo, Pangasinan. It further examines the factors influencing this spatial transformation, such as population growth, infrastructure development, accessibility, and proximity to economic centers, and forecasts built-up area expansion for the year 2037. Using Quantum Geographic Information Systems (QGIS) and Cellular Automata (CA) modeling, the study analyzes the historical land-use patterns and simulates future changes. The results reveal that built-up areas are projected to increase by 131.78 hectares between 2016 and 2037, resulting in an equivalent loss of agricultural land. The findings underscore the role of demographic pressure and infrastructure-driven development in shaping rural land use. This study emphasizes the importance of spatial dynamics monitoring to inform local policies and strategic land-use planning aimed at mitigating the progressive loss of agricultural lands in Urbiztondo.

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Introduction

The United Nations Department of Economic and Social Affairs (2018) reports that 60% (about 4.7 billion people) of the global population currently live in urban areas. This shift has primarily driven the demand for essential human needs, such as housing and employment, that accompany rural expansion. According to Ashraf *et al.* (2022, 2023), rural growth is fueled not only by natural increase of population and migration but also by the rising demand for critical services such as transportation, education, water supply, and sanitation. This growing demand frequently results in the conversion of agricultural lands to other uses (Aliyu & Amadu, 2017; Yousafzai *et al.*, 2022). Consequently, the rapid population growth and intensified human activities have substantially altered the spatial patterns, contributing to a shortage of land resources (Chandel & Mathewos, 2023).

Built-up area expansion resulted in the reduction of cultivated land (Wang *et al.*, 2019). Similarly, it harms the production of agricultural yields, which threatens the food security in the country. If this expansion is uncontrolled, and claims millions of hectares of arable land (Andrade *et* *al.*, 2022). Li *et al.* (2016) emphasized that the growing population has significantly influenced rural areas, resulting in depopulation and creating a global challenge for land-use management. Wu (2023) identifies two outcomes of urban expansion: a reduction in cultivated agricultural land and alterations in the classification and suitability of farmland. This rapid expansion, combined with increasing population density and limited land resources, poses considerable challenges for governments (Wen & Goodman, 2013). Achieving a balance in built-up expansion is particularly challenging in rural regions, where the primary concerns are ensuring food security and facilitating access to land resources for growth.

Rural built-up areas have significantly affected cultivated agricultural and ecological land (Cao et al., 2017; Conrad *et al.*, 2015). Naab *et al.* (2013) contend that as the population rises, the demand for land resources for housing and economic development increases, resulting in a reduction in both agricultural land and its productivity. Bardhan & Tewari (2010) emphasize that these activities exert pressure on land resources, thereby complicating policymakers' efforts to maintain ecological balance and achieve sustainable development related to livelihoods and food security. Additionally, land use has shifted from agricultural crop production to residential development, creating challenges for both livelihoods and the agricultural sector (Yang & Li, 2000). Rahman *et al.* (2023) agree that this expansion has led to the unplanned conversion of arable land, driven by economic growth and rural migration. These changes highlight the implications of physical transformations in land development. Moreover, Paegelow *et al.* (2013) and Verburg *et al.* (2004) characterize land use changes as a dynamic process influenced by interactions between humans, their environment, and intricate patterns of land use. Furthermore, in the Philippine setting, built-up expansions are linked to the extension of existing areas by transforming agricultural lands into non-agricultural use by way of land conversion (Chaves *et al.* 2020). In relation to this, rural built-up areas contributed significantly to the spatial and land use land cover (LULC) of a city. The objectives of the study are to determine the main driving factors that influence the rural built-up expansion that encroaches on the agricultural land of the study area. Additionally, to identify the extent of built-up expansion in terms of land area between agricultural lands by the year 2037, and provide guidance on rural built-up expansion as a reference for policy and decision-making for land use management.

As an agricultural country, the government must intervene to mitigate the impact of urban expansion in rural areas. A comprehensive planning policy is necessary for this action. The Philippines has been experiencing shortages in crop production and is increasingly reliant on importing agricultural products from other nations. Support for farmers from both national agencies and local government units is essential to ensure sustainable farming practices throughout the Philippines. Effective land use plans, policies, and interventions are fundamental components needed to develop an efficient and self-sufficient agricultural sector.

Figure 1. Urbiztondo, Pangasinan (The Study Area)
Source: Municipal Planning and Development Office, Urbiztondo

The Municipality of Urbiztondo (15° 49' 21.72" N, 120° 19' 46.2" E) is located in the central-southern portion of the province of Pangasinan. It covers approximately 0.7% of the total land area of the province. This municipality is mainly characterized by a significant proportion of prime agricultural land, particularly adjacent to major river systems like the Agno River and the floodplains of the Laoag River (Figure 1). Additionally, the region faces ongoing land use issues, including encroachment of prime cultivated land by residential and commercial developments, which poses a concern for food security (National Economic and Development Authority, 2023).

Materials and Methods

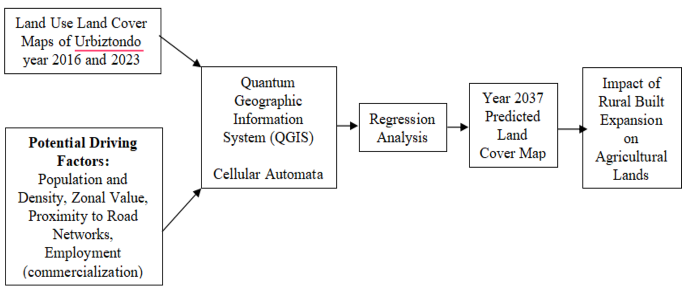

Figure 2. Research Framework from base data to land cover prediction

The research study is a highly quantitative and descriptive approach, drawing on secondary data from various government agencies. Spatial planning tools were utilized for effective analysis of land area and expansion (Figure 2).

Secondary data were acquired from various government agencies, including the Department of Agriculture, Municipal Planning and Development Office, and the Comprehensive Land Use Plan (CLUP). This data was crucial for investigating the impact of built-up area expansion on agricultural lands.

To quantify the land area of Urbiztondo, land cover maps for 2016 and 2023 were obtained from the Municipal Planning and Development Office. These maps utilized the EPSG:32651-WGS-84/UTM zone 51N Coordinate Reference System (CRS) in QGIS with a 10m x 10m pixel size and a resolution of 1060 x 900. Raster files and shape files (vector format) were converted into Tagged Image File Format (TIFF) raster images, composed of pixels to facilitate accurate calculation of land cover areas for different land uses (e.g., residential, commercial, institutional, industrial, agricultural). The existing land use map of Urbiztondo, provided by the Planning Department, was also utilized to analyze land use relationships.

Using Quantum Geographic Information System (QGIS) software, land use data from 2016 was integrated to create a vector file (comprising polygons and paths), which was subsequently converted into a raster file of pixel-based images. This process enabled the quantification of land area based on QGIS software and its land cover. The land use and land cover maps generated with QGIS were categorized into three primary land use classes:

1. Agricultural Land: Including Annual Crop and Perennial Crop.
2. Built-up Area: Encompassing residential, commercial, institutional, and industrial areas.
3. Waters: Bodies of Water

Since the study primarily focuses on the impact of built-up area expansion on agricultural land, the generated maps were simplified into basic land use categories (Figure 4).

The study incorporated several socio-economic and environmental variables as potential driving factors for rural built-up expansion. These included:

1. Population: Municipality's census population in 2015 and 2020.
2. Number of Business Establishments: per barangay.
3. Accessibility Factors: Represented by road networks (presence of municipal and provincial roads).
4. Geological Aspects: Including the percentage of Slope.
5. Zonal Values: This refers to the assessed value of real estate per square meter in a specific zone or barangay, as determined by the Bureau of Internal Revenue (BIR) for taxation purposes. It distinguishes between Zonal Values (Residential) and Zonal Values (Agricultural), reflecting the economic valuation of land based on its designated use.

These potential driving factors were assessed through regression analysis to identify their influence on land use cover change, particularly in shaping rural built-up expansion.

Land use cover changes for the years 2030 and 2037 were predicted using an integrated approach within the QGIS environment. The Molusce Plugin in QGIS was employed, which integrates an Artificial Neural Network-Multilayer Perceptron (ANN-MLP) model with Cellular Automata modeling.

The ANN-MLP component was used to identify potential areas likely to transition into built-up land, considering the relationship between historical land use (2016 and 2023 actual maps) and the identified driving factors (population, business establishments, accessibility, slope, and zonal values). The network architecture involved multiple layers of neurons, where input layers process the spatial variables and land cover types, and an output layer determines the transition potential for each cell (Figure 3).

Subsequently, Cellular Automata (CA) modeling was applied to simulate future land use changes based on the transition potentials generated by the ANN-MLP and a set of spatial rules. The CA model operates on grid cells, in which the cell's state (e.g., agricultural land, built-up areas, bodies of water) changes over time according to the influence of driving factors. For this study, the CA model was configured to simulate a complex dynamic system of land use change, prioritizing transitions towards built-up areas in response to increased driving-factor influence. The neighborhood definition for the CA model is typically considered a 3x3 window (Moore Neighborhood) around each cell to evaluate local influences. The simulation for 2037 involved iterating these rules over time steps, projecting the spatial expansion of built-up areas and the corresponding loss of agricultural land.

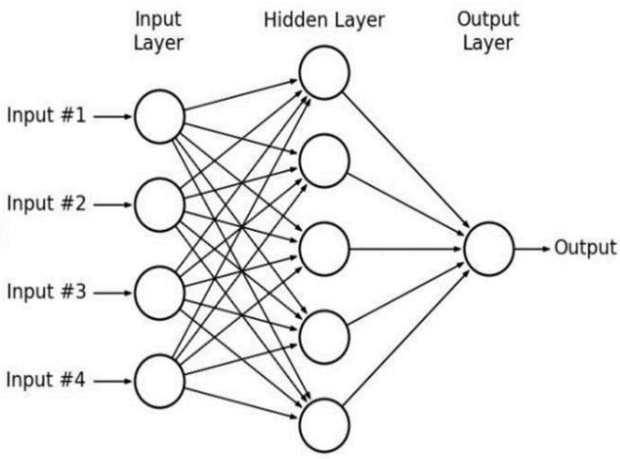

Figure 3. A Hypothetical Example of Artificial Neural Network -Multilayer Perceptron (ANN-MLP)

The integrity and reliability of the predicted land cover maps for 2030 and 2037 were rigorously tested through accuracy assessment using Cohen's Kappa Coefficient. This statistical measure evaluates the agreement between the predicted classification and a reference or actual classification, beyond what would be expected by chance.

For validation, the actual land cover data from 2023 was used as a reference to assess the predictive accuracy of the model outputs. The Overall Kappa Coefficient was calculated for both the 2030 and 2037 predicted maps, as shown in Table 3. According to Cohen's Kappa interpretation:

- Values ≤ 0 indicate no agreement
- 0.01– 0.20 as no to slight agreement
- 0.21 – 0.40 as fair agreement
- 0.41 – 0.60 as moderate agreement
- 0.61 – 0.80 as substantial agreement
- 0.81 – 1.00 as perfect agreement

A high kappa coefficient (e.g., >0.81) indicates a perfect agreement between the predicted and actual land cover data, signifying that the model's outcome is statistically significant and suitable for planning purposes.

To assess the relationships between built-up area expansion and the identified driving factors, statistical analyses were performed. Pearson's product-moment correlation was conducted to determine the strength and direction of the linear relationships between built-up areas (from 2016, 2023, 2030, and 2037) and variables such as population, presence of roads (municipal and provincial), zonal values(residential and agricultural), and the number of businesses. This analysis helped identify the statistically significant correlations between these variables and built-up area growth.

Subsequently, a multiple linear regression analysis was performed to examine how a combination of these factors collectively predicts built-up area expansion. The initial regression model included population, zonal values, and the number of businesses as predictors. The software utilized for this statistical analysis was JAMOVI software. This analytical framework, which combines correlation and regression analysis with spatial modeling, is a common practice in land use change studies to identify and quantify the driving forces behind observed and predicted spatial transformations.

Results and Discussion

This section presents an analysis of data collected from various sources, interpreting, discussing, and further explaining the study's results. It includes tables that display the computed actual land cover changes from the base year of 2016 to 2023. Based on the initial calculations, the land use cover of the municipality was projected through the years 2030 and 2037. Land cover maps for the years 2016, 2023, 2030, and 2037 have been provided to support the findings from the QGIS. These maps quantify the study's results and illustrate the area changes over 21 years.

Table 1. Area of built-up compared with agricultural land use from 2016 to 2023 and from 2030 to 2037

Class	2016 (Actual)		2023 (Actual)		2016-2023		2030 (Predicted)		2037 (Predicted)		2030-2037		Total 2016-2037	
	Area (ha.)	Percentage (%)	Area (ha.)	Percentage (%)	Diff. in Area (ha.)	Diff. in (%)	Area (ha.)	Percentage (%)	Area (ha.)	Percentage (%)	Diff. Area (ha.)	Diff. In (%)	Diff. in Area (ha.)	Diff. in (%)
Built-up	256.85	5.98	359.05	8.36	102.20	+2.38	373.52	8.69	387.78	9.02	14.26	0.33	130.93	+3.04
Agricultural Land	4,038.65	94.02	3,934.77	91.64	103.88	-2.38	3,921.13	91.30	3,906.87	90.97	-14.26	-0.33	131.78	-3.05

Note: Table 1 shows the change of built-up areas and agricultural land in hectares from 2016 to 2023 and from 2030 to 2037. The percent (%) change indicated in Table 1 is the share of the land use as to the whole area of the municipality's land area that changed due to built-up expansion.

Source: QGIS.org, 2025. QGIS Geographic Information System. QGIS Association. http://www.qgis.org

The land area of the municipality in 2016 was predominantly an agricultural area. The study area was exposed to different spatial and temporal land use transitions as illustrated in the actual data depicted in Figure 4, particularly the 2016 and 2023 land cover maps. As shown in Table 1, there is a gradual growth in the built-up areas in the municipality, with a value of 2.38% from 2016 to 2023, equivalent to 102.20 hectares of land, respectively. On the other hand, there was a continuous decline of arable lands in the study area, with a value of -2.38% from 2016 to 2023, respectively. Table 1 presents the combinations of built-up areas and agricultural land in terms of built-up area expansion and agricultural land use cover change that were experienced in 7 years, as analyzed from thematic maps gathered. In 2016, Urbiztondo was a crop production-centered municipality. Irrigation facilities and soil fertility were not a challenge in producing yields.

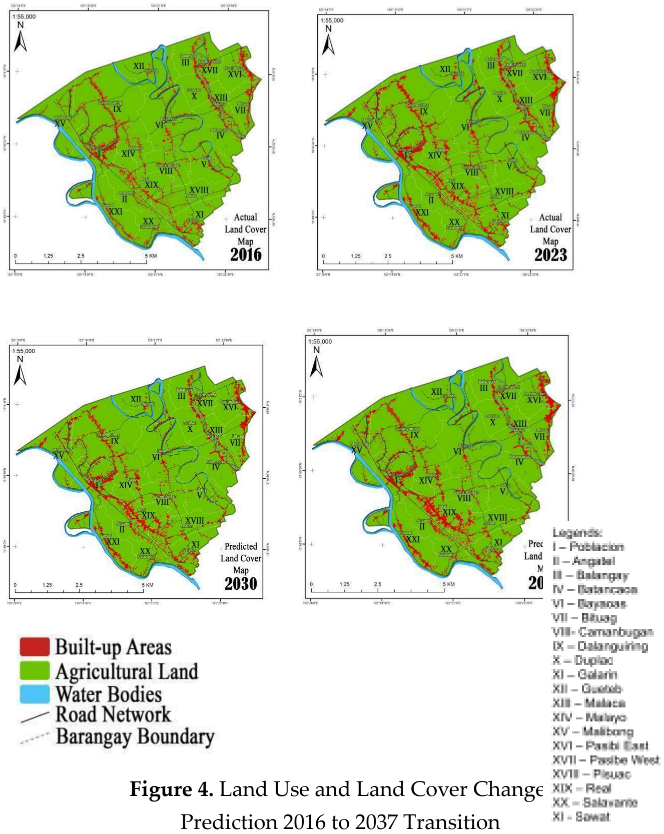

Figure 4. Land Use and Land Cover Change Prediction 2016 to 2037 Transition

Note: Figure 4 shows the built-up area and agricultural land use cover change from 2016 to 2037 to identify the spatiotemporal changes of land cover in the span of twenty-one(21) years.

Source: QGIS.org, 2025. QGIS Geographic Information System. QGIS Association. http://www.qgis.org

Figure 4 shows the gradual loss of agricultural land that is suitable for farming to red spaces (built-up areas) as illustrated in Figure 4. This demonstrates that farmland cover intended for rice and corn production was lost due to economic development, such as the construction of vertical and horizontal infrastructure elements and demand for housing. The built-up change from 2016 to 2023 includes the infrastructure development, such as residential, commercial, and institutional, within the municipality, which has made gradual progress.

Built-up expansion significantly affected the land use pattern of Urbiztondo. These expansions initiated the development of the municipality. Furthermore, these impacts have corresponding driving factors that increase human habitation while decreasing the amount of productive land. Through the reviewed literature, the study defined the potential outcomes, particularly the negative effects of built-up expansion if proper land use management interventions are not implemented. The expansion of built-up areas in Urbiztondo was evident along major roadways from 2016 to 2023, as illustrated in Figure 4. The land use cover change was initially simulated in the Quantum Geographic Information System using the Molusce Plugin, which identified and categorized land uses. Since the study focused on the built-up area and agricultural land use, the gathered land cover maps from the local government unit were categorized into three (3) land use classes: built-up (represented by red color), which comprises residential, commercial, institutional, and industrial areas; water bodies (blue); and agricultural lands (green), while road networks are illustrated by continuous lines, and lastly, barangay boundaries are represented by broken lines.

In 2016, built-up areas in Urbiztondo covered 256.85 hectares, accounting for 5.98% of the municipality's total land area. The majority of these built-up areas comprised residential, commercial, institutional, and industrial zones, with residential land use occupying the largest portion. In contrast, agricultural land and non-built-up areas made up 94% of the municipality's overall land area. A significant concentration of built-up areas was found in Dalanguiring and Poblacion, shown in Figure 4, which host medium to large business establishments.

Furthermore, the study reveals that built-up areas are scattered in agricultural land and contribute to the loss of agricultural land use cover change. The spatial patterns of the built-up areas were fragmented and were not clustered in a specific location. The spaces created by this development added to the built-up area and decreased the land for cultivation. Figure 4 illustrates the gradual increase in built-up areas over seven (7) consecutive years from 2016 to 2023. Most of the built-up areas are concentrated along road networks. Built-up areas were continuously increased in a substantial expansion affecting the agricultural land use of Urbiztondo. It is shown in Figure 4 that built-up areas are most concentrated in Poblacion and Dalanguiring, which are considered the most densely populated barangays and urban barangays in Urbiztondo. This shift was supported by Bagarinao (2015). The conversion of agricultural lands and construction development is evident in areas that are experiencing significant changes in population.

The expansion of built-up areas continues to significantly impact agricultural land use in 2023. From 2016 to 2023, there has been an increase of 102.20 hectares, growing from 256.85 hectares in 2016 to 359.05 hectares in 2023, as illustrated in Figure 4. These built-up areas remain primarily concentrated along roadways, particularly on barangay and provincial roads. Additionally, the spatial distribution within the municipality aligns with Homer Hoyt's Sector Theory, which suggests that growth tends to occur along transportation routes and follows lines of least resistance. Consequently, land uses within each sector are expanding outward along these key transportation corridors (McDonagh, 2007).

The formation of built-up areas was perpendicular and parallel along road networks; however, due to the absence of arterial roads and new road opening, areas that have no accessibility were isolated, resulting in a conversion of agricultural lands that do not conform to the municipality's land use map and zoning ordinance. If this behavioral pattern of built-up expansion continued and encroached on the agricultural lands, the agricultural lands would become vacant, unproductive, and remain idle until the road opening or an arterial road was introduced. On the other hand, the agricultural lands located in rural barangays of Urbiztondo are continuously converted and reclassified into different land uses for the development of built-up areas, resulting in unplanned built-up expansion and not compliant with the zoning ordinance and land use map of the municipality.

From 2016 to 2023, the changes in land use between built-up areas and agricultural lands in the municipality have been minimal, particularly given its status as a newly classified first-class municipality. Furthermore, the municipal share from the national government during this period has been less than it is today, as it relies on the Internal Revenue Allocation (IRA) from the Bureau of Internal Revenue. The built-up area shown in Table 1 increased by 2.38% from 2016 to 2023, equivalent to 102.20 hectares, while agricultural lands decreased correspondingly from 4,038.65 hectares to 3,934.77 hectares. This alteration in land use indicates that the municipality's development is gradually transitioning to a new phase of economic growth and progress.

Similarly, in Table 1, the conversion of agricultural land to other uses decreased by 3.05% from 2016 to 2037 compared to the period from 2016 to 2023. These changes in land use were attributed to the existing road networks, with built-up areas concentrated along these roads. However, as the distance from the built-up areas to the roads gradually increased, the spatial pattern of development became more scattered, resulting in areas that are increasingly difficult to access. This trend indicates that roads catalyze development, particularly in relation to built-up areas, as illustrated in Figure 4.

Figure 4 shows the land use cover change of Urbiztondo from 2030 to 2037. As presented in Figure 4, the built-up areas continuously transitioned and occupied the agricultural lands of Urbiztondo. Also, as observed, the agricultural lands in Poblacion were retained. There was still a presence of fragmented built-up areas distributed in the remote areas of the municipality, where access roads are difficult.

Table 1 presents a substantial shift of agricultural land to built-up area caused by land conversions. Markedly, based on the projected land cover of Urbiztondo, agricultural land is expected to decrease by 131.78 hectares in the span of 21 years. While built-up areas in Urbiztondo are projected to increase by 130.93 hectares in 2037.

Agricultural land has experienced a significant loss of cultivated land from 2016 to 2037. The rural built-up expansion demonstrates the gradual encroachment on agricultural land that affects the production and livelihood in Urbiztondo. Urbiztondo has continuously experienced a decline in agricultural land in exchange for economic growth and development. Interventions to mitigate the adverse impact of the rural built-up expansion that balances the need for food sustainability are key to preserving and saving the remaining cultivated lands. This signifies that the agricultural land trend is downward. As presented, the continuous impact of rural built-up expansion consistently pressured the cultivated land. The need for a comprehensive physical framework plan can lessen the impact of the expansion and gradually minimize the built-up intrusion in the study area.

Table 2. Number of Registered Business Establishments in Urbiztondo for 2019, 2020, and 2023

Barangay Name	No. of Business Establishment 2019	No. of Business Establishment 2020	No. of Business Establishment 2023
Angatel	5	6	9
Balangay	5	6	6
Batancaoa	3	3	10
Baug	0	0	3
Bayaoas	5	4	21
Bituag	6	5	15
Camanbugan	0	1	3

Dalanguiring	26	25	40
Duplac	0	1	2
Galarin	3	6	5
Gueteb	1	2	4
Malaca	1	1	2
Malayo	6	7	10
Malibong	6	9	6
Pasibi East	8	6	15
Pasibi West	4	3	3
Pisuac	4	3	9
Poblacion	236	206	390
Real	3	3	13
Salavante	0	0	0
Sawat	1	2	2
Total No. of Business Establishments	**323**	**299**	**568**

Note: The data collected was the number of registered business establishments from pre-pandemic to post-pandemic (COVID-19)
Source: Office of the Municipal Treasurer, Urbiztondo

To link the predicted land cover map results of Urbiztondo, the number of business establishments in relation to the built-up area is presented in Table 2. As of 2023, the Business Permit and Licensing Division of the Treasurer's Office registered 568 business establishments. With this, the Poblacion and Dalanguiring logged the highest among the 21 barangays of the municipality. Based on the gathered data, Urbiztondo logged a total of 323 business establishments in the 2019 pre-pandemic period. In 2020, the COVID-19 pandemic hit the country, forcing other businesses to close. However, in the post-pandemic period, businesses gradually recovered from the effects of COVID-19, and in the event, business establishment increased by 568 additional businesses added to the built-up area of Urbiztondo in 2023. In relation to this shift, Poblacion and Dalanguiring had the highest recorded business establishment during the pre-pandemic up to the post-pandemic period.

Land use and land cover change are connected with anthropogenic activities or human-induced influences (Daba & You, 2022). Built-up area expansion from 2023 to 2037 marked 387.78 hectares and yielded 9.02% of the municipality's total land cover area from 256.85 hectares or 5.98% of the total land cover of Urbiztondo. The spatial pattern of built-up areas compared to agricultural lands from 2016 to 2037 was driven by different influencing factors that resulted in encroachment of non-agricultural establishments into agricultural lands in Urbiztondo. Table 1 reveals that the transition of cultivated land to non-agricultural purposes signified a continuous build-up of concrete infrastructures, and in contrast, the decline and the weakening of the agriculture sector.

Table 3. Accuracy and Kappa Statistics for the predicted classification

The Study Year	2030	2037
Overall Kappa Coefficient	0.97720	0.97720

Note: Generated using the Molusce Plugin and validated the integrity of the result of the study
Source: QGIS.org, 2025. QGIS Geographic Information System. QGIS Association. http://www.qgis.org

As shown in Table 3, the integrity of the results of the study was tested by the accuracy test and the Kappa statistic. The predicted land use land cover map of Urbiztondo in 2030 and 2037 has above 0.97 overall kappa coefficient and indicates perfect agreement as the ANN-MLP that the 0.81 to 1.00 kappa coefficient suggested that it has perfect agreement, meaning the test result is considerably significant in the study. This test was conducted to determine if the outcome of the study is logically correct and can serve as a reference for planning purposes.

Although the accuracy test yielded a high rating, it is important to note that the classification of remotely sensed images is predicted land cover maps and only suggests that the simulated land cover maps have perfect agreement based on the results of Cohen's Kappa value interpretation. This outcome was derived from spatiotemporal analyses conducted using QGIS to predict the future expansion of Urbiztondo. The actual spatial patterns in the future will be influenced by policies, interventions, and anthropogenic activities of all the organizations responsible for managing rural development and implementing land use management strategies.

Table 4. Pearson's Correlation of Spatial Variable with Built-up Area

Spatial Variable		Population	Presence of Municipal Road	Presence of Provincial Roads	Zonal Values Residential	Zonal Values Agricultural	No. of Business
Built-Up Area	Correlation	0.876	0.245	0.027	0.873	0.818	0.621
Area 2016	Sig. (2-tailed)	0.000	0.143	0.453	0.000	0.000	0.001
Built-Up Area	Correlation	0.941	0.365	0.021	0.823	0.720	0.505
2023	Sig. (2-tailed)	0.000	0.052	0.464	0.000	0.000	0.010
Built-Up Area	Correlation	0.926	0.382	0.041	0.799	0.699	0.537
2030	Sig. (2-tailed)	0.000	0.440	0.429	0.000	0.000	0.006

Built-Up Area	Correlation	0.747	0.390	0.005	0.595	0.896	0.407
2037	Sig. (2-tailed)	0.000	0.400	0.491	0.002	0.000	0.033

Note: table generated using JAMOVI Software-Pearson's
Correlation Source: Jamovi Software

As shown in Table 4, a Pearson product-moment correlation was conducted to determine the relationship of the built-up area from 2016 to 2037 to population, zonal values, and the number of businesses. The correlation revealed that the variables population, zonal values, and number of businesses are statistically significant. There was a strong, positive correlation between the built-up area from 2016 to 2037 and population, which was statistically significant at $p<0.05$. This indicates that built-up area tends to increase as population increases, and there is sufficient evidence to conclude that there was a significant relationship between the built-up area from 2016 to 2037 and population. There was also a strong positive correlation between built-up area from 2016 to 2037 and zonal values, which was statistically significant at $p<0.05$. This indicates that built-up area also tends to increase as zonal value increases, and there was sufficient evidence to conclude that there was also a significant relationship between built-up area from 2016 to 2037 and zonal values.

The analysis indicated that the built-up area from 2016 to 2037 and the presence of roads are not statistically significant. Although a weak positive correlation was observed between the built-up area during this period and the presence of roads, this relationship was not statistically significant. Since road networks in Urbiztondo are not increasing over time, it corresponds with the weak correlation of built-up area in the study; however, as seen in Figure 4, built-up areas in Urbiztondo are arranged in a linear pattern in road networks.

A multiple regression analysis was conducted to examine the relationship of built-up and the four predictors: 1) population, 2) zonal value for residential, 3) zonal value for agricultural. and

Table 5. Multiple Regression Result

Model Summary				
Model	**R**	**R^2**	**Adjusted R^2**	**Std. Error of the**
1	0.941[a]	0.885	0.879	3.522614921374582
2	0.954[b]	0.910	0.899	3.205546491074545
3	0.964[c]	0.929	0.916	2.924959509005403

a. Predictors: (Constant), Population CY 2020
b. Predictors: (Constant), Population CY 2020, Zonal Values (Residential)
c. Predictors: (Constant), Population CY 2020, Zonal Values (Residential), Zonal Values (Agricultural)

Note: Table generated using open source software (JAMOVI Software-Pearson's Correlation)

The Model Summary table is presented in Table 5 and includes three models, with the second model building upon the first. The first model uses only population as the primary predictor of built-up areas. In the second model, zonal values of residential areas are incorporated, while the third model further includes zonal values for agricultural areas. The variable representing the number of businesses was excluded due to its lack of statistical significance.

For Model 1, the summary reveals an R value of 0.941 and an Adjusted R^2 of 0.885. This indicates that 88.5% of the variation in built-up areas can be explained by population alone. The summary for Model 2 shows an R value of 0.954 and an Adjusted R^2 of 0.910. This model results in an increase in R^2 of 0.025, leading to a final R^2 of 0.910 and an Adjusted R^2 of 0.899, thus accounting for approximately 91% of the variance with just two predictors. The third model yields an additional increment in R^2 of 0.019, resulting in a final R^2 of 0.929 and an Adjusted R^2 of 0.916, which means it explains about 92.9% of the variance with three predictors. Therefore, Model 3 is deemed the most appropriate as it predicts 92.9% of the variation in built-up areas.

The multiple regression conducted to predict built-up from population, zonal values, and the number of businesses resulted in only population. Zonal values were statistically significant in predicting built-up, as shown in Table 6. These three variables statistically predicted built-up ($F(3,17) = 73.996, p<0.05$), $R^2 = 0.929$. This indicates that 92.9% of the variation in built-up can be explained by population and zonal values. This only shows that population, business establishments, and the cost of land are the driving factors of built-up area expansion. Furthermore, the majority of these rural built-up areas were located in the proximity of the public market, Poblacion, and Dalanguiring, shown in Figure 4, where these driving factors are evident and dominant in the municipality. The economic development and demand for human settlements were influenced by the rural built-up expansion and spatial pattern of Urbiztondo as the transition maps from 2016 to2037, which was shown in Figure 4.

Table 6. Result of Regression in Analysis of Variance (ANOVA)

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
3	Regression	1899.195	3	633.065	73.996	0.000
	Residual	145.442	17	8.555		
	Total	2044.637	20			

Predictors: (Constant), Population CY 2020, Zonal Values (Residential), Zonal Values (Agricultural)

The study shows that the demand for housing due to an increasing population has significantly influenced the distribution and encroachment of built-up areas on agricultural lands. Previous study reveals that rapid built-up expansion and population growth rate are the driving forces of uncontrolled land conversion of agricultural land and its environment (Hassan *et al.*, 2016; van Vliet *et al.*, 2015). Additionally, built-up area agglomeration in Urbiztondo takes place in agricultural lands. The land values of agricultural lands compared with other land classifications, such as residential, commercial, and institutional, in the municipality are lower, resulting in the conversion of agricultural land into non-agricultural use. Currently, the values of agricultural lands tend to be lower than those of other land classifications, such as commercial, residential, and industrial. Rondh *et al.* (2018) state that a higher value of agricultural land for agricultural use limits the land conversion activities and is driven by the significant difference in land use classifications.

The number of business establishments also influenced the built-up area accumulation, since employment and basic services, where the majority of commercial and institutional establishments are located at Dalanguiring and Poblacion, as illustrated in Figure 4. The rapid increase of built-up area is associated with social and economic services such as demand for housing due to growing population, health care services, educational institutions, and employment-related facilities (Liu, 2018). Rahman *et al.* (2023) found that people from rural areas are motivated in search of better opportunities and quality of life. This movement resulted in the unplanned expansion of built-up areas in open agricultural lands, which caused a considerable decrease in arable lands converted into non-agricultural purposes. Factors in built-up area expansion include the employment opportunities, economic development, and spatial distribution of infrastructures (Seto *et al.*, 2012).

While this study provides valuable insights into the rural built-up expansion and agricultural land use cover change in Urbiztondo, it is important to acknowledge certain limitations that inform the interpretation of these findings and suggest avenues for future research. Firstly, the reliance on available land cover data from government agencies for specific timeframes (2016 and 2023) means the analysis is constrained by the resolution and classification schemes of these datasets. Although careful validation was performed using QGIS and Molusce, potential inaccuracies or inconsistencies inherent in secondary data could influence the precise quantification of land cover changes. Future studies could benefit from integrating multi-source remote sensing data with higher-temporal resolution to refine change detection analyses.

Secondly, the Cellular Automata (CA) modeling employed for forecasting, while robust (as evidenced by a high kappa coefficient of 0.97720 in Table 3), operates on assumptions about drivers of land cover change. The model simplifies complex human-decision-making g processes and socio-economic dynamics, which are inherently difficult to capture entirely in spatial models. For instance, while population, zonal values, and business establishments were identified as statistically driving factors (Table 4, Table 6), the model does not fully account for unforeseen policy shifts, major infrastructure projects beyond current road networks, or localized community resistance to development, which can profoundly alter land use trajectories.

Furthermore, the study's macro-level land use change (agricultural vs built-up area) does not delve into the specific types of crops affected or the socio-economic impacts on farming communities, such as displacement of changes in livelihoods. Future research could incorporate qualitative data, such as surveys or interviews with affected farmers, to provide a more holistic understanding of the human dimensions of these land transformations. Exploring the ecological implications, such as biodiversity loss or changes in ecosystem services due to agricultural land conversion, would also enrich the disciplinary contribution.

Lastly, while the study provides policy guidance for Urbiztondo, the transferability of its findings to other regions should be considered cautiously, given the unique socio-economic and geographical context of the municipality. However, the methodological framework (QGIS-CA modeling combined with statistical analysis of driving factors) is broadly applicable and can serve as a template for similar assessments in other agricultural regions facing comparable development pressures.

Conclusion

This study has demonstrated that population growth, zonal values, and the number of business establishments are significant drivers of rural built-up expansion in Urbiztondo, with population growth showing the strongest correlation. The expansion of built-up areas, particularly in Poblacion and Dalanguring, has led to a measurable reduction in agricultural lands, posing important challenges to local food security and sustainable land management. From 2016 to 2037, built-up area expansion is projected to increase by approximately 131.78 hectares, resulting in a corresponding decline in cultivated lands.

The findings highlighted the critical role of local government units in enforcing land use policies and zoning regulations to protect remaining agricultural areas. National-level legislation, such as the proposed National Land Use Act, would further support coherent and sustainable land resource management across jurisdictions. However, the successful implementation of these policies will require addressing practical challenges, including stakeholder engagement and consistent enforcement.

Ethical Statement

This study is highly quantitative in nature and qualified for an exemption from ethics review by the University Research & Innovation Center Research Ethics Committee, Saint Louis University, Baguio City.

Conflict of Interest Statement

There is no conflict of interest in this research from other government agencies where the data sources are gathered. Courtesies and requests are observed before data collection.

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Declaration of Generative AI and AI-Assisted Technologies

During the preparation of this work, the authors utilized Grammarly for grammar correction. Additionally, it utilized Turnitin for plagiarism detection to ensure the integrity of the study. Following the use of these tools, the authors conducted a review and made necessary modifications, assuming full responsibility for the content of the publication.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

BCLT: Conceptualization and Validation; **LBFG:** Methodology and Formal Analysis.

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References

Aliyu, A.A., and Amadu, L. (2017). Urbanization, cities and health: The challenges to Nigeria-A Review. Ann. Afr. Med.16, 149-158, doi: 10.4103/aam.aam_1_17

Andrade, J.F., Cassman, K.G., Rattalino Edreira, J.I., Agus, F., Bala, A., Deng, N., & Grassini, P. (2022). Impact of urbanization trends on production of key staple crops. *Ambio, 51* (5), 1158-1167

Ashraf, H., Mobeen, M., Miandad, M., Khan, M.A, Rahaman, G., and Munawar, S. (2022). Assessment of urban sprawl in Sargodha city using remotely sensed data. Ecol. Quest. 33, 1-16. Doi: 10.12775/eq.2022.030

Ashraf, H., Rahman, G., Khan, M. A., Moazzam, M.F.U., and Miandad, M. (2023)."Spatio Temporal urban sprawl of Sargodha city, Punjab Pakistan," in Urban Environment and smart cities in asian countries, Editor U.C.E Al (Cham Swithzerland:Springer)

Bagarinao, R. T. (2015). A spatial analysis of population growth and urbanization in Calamba City using GIS. *Journal of Nature Studies*, 14(2), 1-13. https://www.journalofnaturestudies.org/files/JNS14-2/14(2)%2013%Bagarinao-fullpaper.pdf/search/public/detail/patents? Id=PH22017000046

Bardhan, D., S.K. Tewari (2010). An Investigation in Land Use Dynamics in India and Land under-Utilisatio, Indian Journal of Agricultural Economics, 65(4), pp.658-676

Cao, Y.; Bai, Z.; Sun, Q.; Zhou, W. Cao, Y.; Bai, Z.; Sun, Q.; Zhou, W. (2017). Rural Settlement Changes in Compound Land Use Areas: Characteristics and reasons of changes in a mixed mining- rural-settlement area in Shanxi, Province of China , Habitat Int., 61, 9-21

Chandel, A.S. & Mathewos, M., (2023). Effects of urban expansion on the surrounding agricultural communities of the southern Ethiopian town of Jajura, Urban Planning and Transport Research,Vol.11,No.1,2283110, https://doi.org/10.1080/21650020.2023.2283110, P.1

Chaves C. et al.(2020). Settlements Development Model for New Growth Areas in the Philippines. Final report. Planning and Development Research Foundation Inc. (PLANADES)

Conrad, C., Rudloff, M., Abdullaev, I., Thiel, M., Löw, F., Lamers, J.P.A. (2015). Measuring Rural Settlement Expansion in Uzbekistan using remote sensing to support spatial planning, Appl. Geogr. 62, 29-43

Daba, M.H., & You, S., (2022). Quantitatively Assessing the Future Land-Use/ Land-Cover Changes and Their Driving

Factors in the Upper Stream of the Awash River Based on the CA-Markov Model and their Implications for Water Resources Management. *Sustainability MDPI, 14 (3).* https://doi.org/10.3390/su14031538

Hassan, Z.M., Shabbir, R., Ahmad, S. S., Malik, A., Aziz, N., Butt, A., & Erum, S. (2016). Dynamics of Land Use and Land Cover Change (LULCC) using geospatial techniques: a case study of Islamabad Pakistan. SpringerPlus,5 (1) https://doi.org/10.1186/s40064-016-2414-z

Li, Y.H., Westlund,H., Zheng, X.Y., Liu, Y.S, (2016). Bottom-up initiatives and revival in the face of rural decline: case studies from China and Sweden. J. Rural Stud. 47, 506-513.

Liu, Y.(2018). Introduction to land use and rural sustainability in China. Land use policy, 74-1-4

McDonagh, J. (2007). Theories of Urban Land Use and their Application to the Christchurch Property Market. Lincoln University. Retrieved January 12, 2024, from https://researcharchive.lincoln.ac.nz/items/5907e8bc-6c2d-4409-bae2-809441f1462b

Naab. F.Z, Romanus dogkubong dinye and Raphael kasim kasanga, (2013). Urbanisation and its impact on Agricultural Lands in growing cities in developing countries: A case study of tamale in Ghana, Modern Social Science Journal, 2, No.2, 256- 287 issn 2051-5499

National Economic and Development Authority (2023). Regional Development Plan 2023- 2028,National Economic and Development Authority, Region 1.

Paegelow, M., Camacho Olmedo, M. T., Mas, J. F., Houet, T., & Pontius Jr, R. G. (2013). Land change modelling: moving beyond projections. *International Journal of Geographical Information Science*, 27(9), 1691-1695. https://doi.org/10.1080/13658816.2013.819104

Rahman G., Chandio N.H., Ul Moazzam M.F., Al Ansari N., (2023). Urban Epansion impacts on agricultural land and thermal environment in Lakarna, Pakistan, Frontiers in Environmental Science, doi, 10.3389/fenvs.2023.1115553

Rondh, M., Pratiwi, P.A., Handin, V.T., & Sunartomo, A.F.(2018,November). Agricultural Land Conversion, Land Economic Value, and Sustainable Agriculture: A Case Study in East Java, Indonesia. Land MDPI, 7(4), 1-19. https://dx.doi.org/10.3390/land7040148

Seto, K.C., Reenberg, A., Boone, C.G., Fragkias, M., Haase, D., Langanke, T., & Simon, D. (2012). Urban land teleconnections and sustainability. Proceedings of the National Academy of Sciences, 109(20), 7687-7692

United Nations – Department of Social and Economic Affairs (2018). 2018 Revision of world urbanization prospects, New York N.Y USA: United Nations Department of Economic and Social.

van Vliet, J., De Groot, H., Rietveld, P., & Verburh, P.H. (2015). Manifestation and underlying drivers of agricultural land use change in Europe. Landscape and Urban Planning, 133, 24-36. https://doi.org/10.1016/j.landurbplan.2014.09.001

Verburg, P. H., Schot, P. P., Dijst, M. J., & Veldkamp, A. (2004). Land use change modelling: current practice and research priorities. *GeoJournal*, 61(4), 309-324. https://doi.org/10.1007/s10708-004-4946-y

Wang, L., Anna, H., Zhang, L., Xiao, Y., Wang, Y., Xiao, Y. & Ouyang, Z. (2019). Spatial and temporal changes of arable land on land driven by urbanization and ecological restoration in China. *Chinese Geographical Science, 29*,809-819

Wen, H., & Goodman, A. C. (2013). Relationship between urban land price and housing price: Evidence from 21 provincial capitals in China. Habitat International, 40, 9-17. https://doi.org/10.1016/j.habitatint.2013.01.004

Wu, X. (2023). Rural residential land expansion and its impacts on cultivated land in China between 1990 and 2020, Land Use Policy, ResearchGate, P10, https://www.researchgate.net/publication/372526984

Yang, H. & Li. X. B (2000). Cultivated land and food supply in China. Land Use Policy 17, 73"C88

Yousafzai, S., Saeed, R., Rahman, G., & Farish S. (2022). Spatio-Temporal assessment of land use dynamics and urbanization: Linking with environmental aspects and DPSIR framework approach, Environ.Sci.Pollut.Res.29, 81337-81350. Doi: 10.1007/s11356-022- 2193-6