Geospatial Analysis of Land Cover Changes in the Municipality of Bayombong Province of Nueva Vizcaya

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Abstract – The research study focuses on the geospatially analyzing land cover changes in the municipality of Bayombong, province of Nueva Vizcaya. The objective is to assess the land cover changes between the year 2010 and 2020, determine the classification of land cover, and identify the factors influencing these changes. The study employed a qualitative-quantitative approach to address its objectives. Data was collected from the from the Provincial Planning and Development Office (PPDO) of Nueva Vizcaya to determine land cover classifications and changes in Bayombong of the year 2010 to 2015 and 2015 to 2020. A survey questionnaire was used with non-probability sampling to identify factors influencing land cover changes, targeting 100 respondents from various sectors including local stakeholders and government offices. GIS tools and excel software were utilized for the data processing, classification, mapping geospatial analysis, data analysis and presentation. The study found significant changes in land cover over the studied period. Annual crop emerged as the dominant land cover, while fishpond became the smallest category. Factors such as population growth, urbanization, infrastructure development, agricultural expansion, and policy implementation were identified as drivers of these changes. It also heighted the awareness of respondents regarding land cover changes. By analyzing the dynamics of land cover in Bayombong, this study aims to provide valuable insights for environmental management and urban planning, aiding in informed decision-making and promoting sustainable land use practices in the region.

Keywords – land cover changes, land cover classifications, geospatial, mapping.

I. INTRODUCTION

Land cover change is a complex and dynamic process that is influenced by a variety of natural and anthropogenic factors. And these have become a significant concern worldwide, especially in the context of environmental management and urban planning (Turner II et.al.,2007). These changes are driven by various factors such as population growth, urbanization and infrastructure development, agricultural expansion, and natural resource exploitation (Verburg et.al., 2015)

According to the World Band (2007), land cover changes due to human activities and the development of megacities by the year 2020 will be in developing countries, such as the Philippines. This was seen in the study of Mishra et.al.2019, wherein there are changes in land cover due to the urban expansion in Mega Manila. Land cover changes have negative impacts on the economic, social, and ecological in the country. These changes have led to declines in agricultural productivity, soil erosion, loss of ecosystem services, increased vulnerability to natural hazards, and losing access to traditional land and resources of indigenous communities (Sato, Palau and Tanaka,2021)

The maps of land cover can provide a “bird’s eye view”. The classification and examination of land cover are essential for effective planning and decision-making in various fields, such as urban planning, disaster management, and natural resource management due to the accurate geo-referencing procedures, a digital format suitable for computer processing, and repetitive data acquisition of Geographic Information System (GIS), it became the most common method for qualification, mapping, and detection of patters of Land Use Land Cover (LULC) change (Rahman et.al.2011). in the similar study of Mallupatu, P.K et.al. 2013, wherein their research paper focuses on assessing land use land cover changes in a specific urban area, in Tirupati, India, using geospatial analysis techniques. The study utilizes remote sensing data and GIS to analyze and visualize the changes in land use land cover over a specified period.

With the aid of GIS, geospatial analysis enables the collection, integration, analysis, and visualization of spatial date, facilitating a comprehensive understanding of land cover dynamics. Therefore, geospatial analysis plays a crucial role in studying and monitoring land cover change, which refers to the transformation of the Earth's surface or any specific area to be observed due to human activities and natural processes. In short, it is an efficient tool, providing accurate and reliable data for aspatial data analysis (Clarin et.al.2021). In that case, significant progress has been made in analyzing the land cover change in different watersheds and regions in the country using GIS, together with remote sensing techniques whenever researchers use satellite imagery, to identify the causes, patterns and potential efforts of landscape changes (Combalicer et.al.2011)

Land cover changes have been observed in many municipalities in the country including Bayombong, it is the capital town of Nueva Vizcaya with a total land area of 163.36 square kilometers, that is characterized by mix of agricultural, forest, and urban land uses (Philippine Statistics Authority, 2020). One of these changes is converting land from agricultural to non-agricultural use, due to the intense demand for housing triggered by a growing population (Jocson, 2018). In addition, the Borobbob watershed showed significant changes in the area and a reduction of grassland due to its potential for conversion (Combalicer et.al.2011)

While there have been some studies on land cover changes in Luzon, there is a lack of emphasis on the municipality in which determining the land cover change in the municipality in which determining the land cover change in the municipality over the past decade can then be use to inform policy and decision-making processes related to environmental management and urban planning. Therefore, this study aims to assess the land cover changed in Bayombong from the years 2010, 2015 and 2020, compare the land cover classifications from 2010 to 2020 with the interval of 5 years, and identify the factors affecting the changes in land cover.

Objectives

This study aimed to geospatially analyze the land cover changes in the municipality of Bayombong, province of Nueva Vizcaya. Specifically, it aimed to achieve to following objectives:

1. To determine and map the classification of land cove in Bayombong from year 2010, 2015, and 2020;
2. To determine the changes in land cover in Bayombong from 2010 to 2015 and 2025 to 2020 in terms of classification and area and to map such in terms of classification; and
3. To determine factors affecting the changes in land cover in Bayombong

II. METHODS

Research Design

The research study uses a qualitative-quantitative approach, whin is in line with its objectives and procedures. Qualitative research aims to summarize, classify, and analyze data, wherein it allows a researcher to conclude with proper findings and presents them in an understandable manner (Austin and Sutton, 2015). The researcher collected the land cover data from the Provincial Planning and Development Office (PPDO) of Nueva Vizcaya and determine their areas in hectares according to their classifications of land cover within the Bayombong in 2010, 2015, and 2020. Also, they determine the land cover changes, and their major driving factors through a survey questionnaire using non-probability sampling in selecting respondents. The researchers, generated the maps of these classifications and their changes in two different periods, from 2010 to 2015 and 2015 to 2020.

As the researchers compared the land cove data in three years, we calculated the percentage of the cover change. Then, we used descriptive statistics in determining the factors affecting the changes, and it fell under quantitative approach.

Conceptual Framework

Figure 1 shows the conceptual framework of the study that involves data of the classification of land covers found in Bayombong during the years 2010, 2015 and 2020. The GIS tools was utilized for classifying and mapping the land cover present in Bayombong. The expected outputs are the land cover maps in the years 2010, 2015, 2020, map of land cover changes and the factors affecting the land cover change.

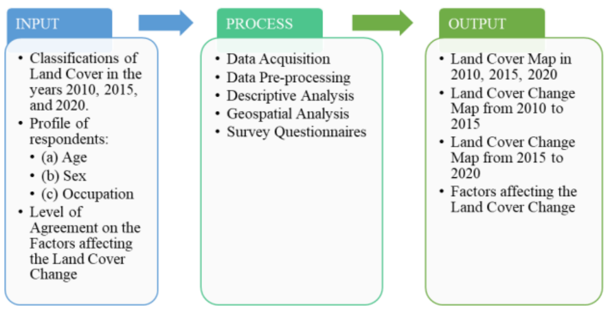

Figure 1.Conceptual Framework of the Study

Research Locale

The study was conducted in Bayombong, Nueva Vizcaya. It is the provincial capital of Nueva Vizcaya, it consist of 25 barangays. The municipality covers an approximate area of 163.36 square kilometers which constitutes 3.39% of Nueva Vizcaya's total area. Its population as determined by the 2020 Census was 67,714. It represents 13.61% of the total population of Nueva Vizcaya. Based on these figures, the population density is computed at 415 inhabitants per square kilometer and the population increased by 10.08% from 2015 to 2020 (Philippine Statistics Authority, 2020). The location map and barangay political boundary map of Bayombong were presented in figures 2 and 3 respectively.

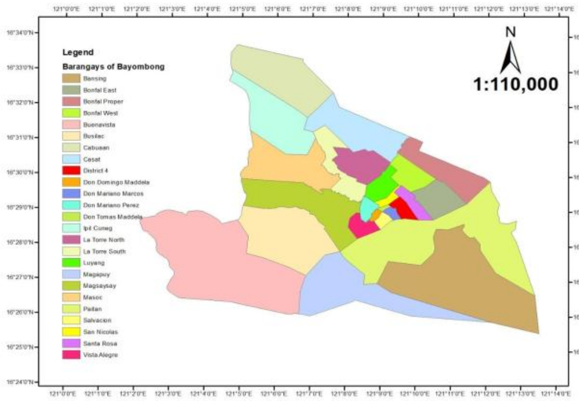

Figure 3.Barangay Political Boundary Map of Bayombong

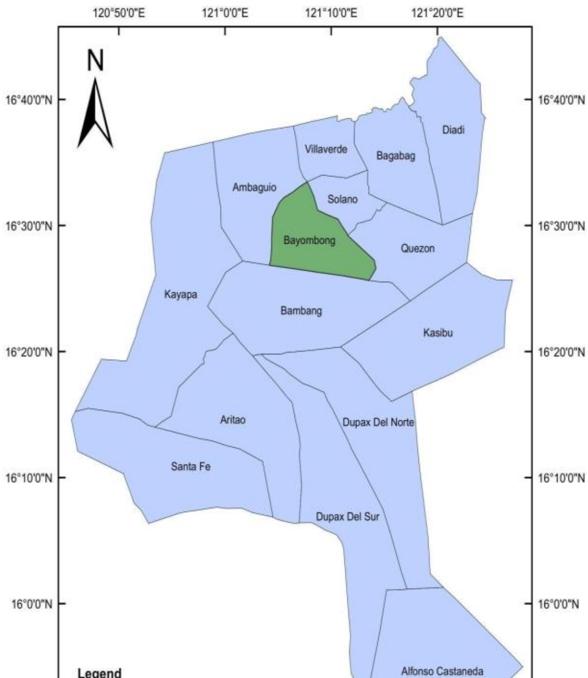

Figure 2.Location Map of Bayombong

Research Respondents

The researchers selected a total of 100 respondents coming from the different barangays of the municipality of Bayombong. Randomly are local stakeholders such as residents, farmers and who have an understanding of changes in land cover as the sample fits the criterial of being knowledgeable about the changes in their respective areas. Representative from the government sectors such as the Department of Environment and Natural Resources-Provincial Environment and Natural Resources Bayombong (DENR-PENRO), Provincial Assessor's Officer (PASSO), Provincial Planning and Development Office (PPDO), Municipal Planning and Development Office (MPDO), and Provincial Engineering Office (PEO) as this study's area of analysis is related to the practices of said office and that help and support the objectives of this study.

The selection was in purposive sampling and snowball sampling. Purposive is a non-probability sampling technique where the sample is selected based on a specific purpose or criteria, and snowball sampling involves selecting participants who can refer to other participants who may meet the inclusion criteria.

Research Instrument

The researchers used a survey questionnaire to gather data on the factors affecting the land cover changes in Bayombong. This instrument for data collection was designed as a structured closed-form questionnaire. The structured questionnaires are questions in which some control or guidance is given for the answer because those are basically short, requiring the respondents to provide a "yes" or "no" response or check an item out of a list of given responses. It short, the respondent's choices are limited to the set of options provided.

In the questionnaire, the closed-form questions were about the possible factors affecting the land cover changes. Each of the questionnaire items has been developed to support the objectives of this study. The questionnaire has two parts. Starting with the personal information of the respondent, wherein, each question is to be answered accordingly with a check inside the box that corresponds to their insight and a question to be answered by a 'yes' or 'no.' The second part of the questionnaire is a tabular response category, using the Likert scale. Each is described as 1-strongly disagree, 2-disagree, 3- neutral, 4-agree, and 5-strongly agree which is shown or indicated in the instruction. For each of the 10 items tabulated, there should only be one corresponding answer by the respondent specified by a check in the set of categories provided for each item. Overall, there are five (5) questions in the first part and a 10-item tabulated response category in the second part of the questionnaire.

Data Gathering Procedure

A. Data Acquisition and Pre-Processing

The researchers forwarded a letter signed by the researchers, Research Adviser, and College Dean to the assigned personnel of PPDO. The researcher indicated in the letter the period and place of the land cover data to be studied.

The shapefiles were imported into the GIS software and were checked for data completeness and to remove any inconsistencies. Then, the researchers converted the data to a common projection which is in Universal Traverse Mercator (UTM) Zone 51 North coordinate system and the WGS84 (World Geodetic System 1984) datum.

B. Identification of Land Cover Classification and Land Cover Changes

The researchers identified the land cover for the years 2010, 2015, and 2020. The classification scheme from the NAMRIA, PPDO-GIS, and MPDO was adopted. They tabulated the necessary information such as classification and the corresponding area in hectares. Then, the researchers created maps of the land cover for each indicated year.

The intersection of geoprocessing tools of ArcGIS 10.3 was used to identify the land cover changes. The analysis of land cover changes was comparing the classifications of land cover from 2010 to 2015 and from 2015 to 2020. The researchers manipulated the attribute table by adding two columns for the "change_class" and "area_change." They also used Excel software to calculate the percentage of the change using the formula stated in Data Analysis. The researchers summarized the changes in land cover classifications and their corresponding change in the area. And then, legends, the north arrow, the title, and other parts of a typical map were included in the making.

C. Identification of the Factors Affecting the Land Cover Changes

Once the researchers have determined the places where the major land cover changes occurred, they conducted a survey using a questionnaire to the stakeholders who have adequate knowledge about the land covers in the area. The researchers also used secondary data such as literature reviews and implemented policies regarding the factors affecting land cover changes.

Statistical Tool

The researchers used GIS software for data pre-processing, data extraction, generating output maps, and data analysis. They also used Excel software to execute the descriptive analysis such as the frequency and percentage to describe the classifications of land cover and their changes for the period of 2010 to 2015 and 2015 to 2020, as well as their corresponding areas, and one of the measures of variability, which is standard deviation in determining the consistency of the factors affecting the changes based on the perception of respondents. They also determined the means to interpret it into verbal interpretation using the scale below:

Table 1: Equivalence of Level Agreement

Scale	Mean	Verbal Interpretation
5	4.20 - 5.00	Strongly Agree (SA)
4	3.40 – 4.19	Agree (A)
3	2.60 – 3.39	Neutral (N)
2	1.8 – 2.59	Disagree (D)
1	1.00 – 1.79	Strongly Disagree (SD)

Data Analysis

The researchers used geospatial analysis technique to identify the changes in land cover using GIS software. The area and classifications of the land cover changes were computed using the Field Calculator feature of GIS. The percentage of change from 2010 to 2015 and 2015 to 2020 were tabulated and calculate the percentages of land cover changes using the following formula adopted from the study of Sugianto et al. (2022):

$$percentage\ of\ land\ cover\ change = \frac{(A - A')}{A'} x\ 100\%$$

where A is the area of the land cover in the following 5-year period; and A' is the area of the land cover in the previous five-year period.

After conducting a survey with the respondents, the data gathered undergone descriptive analysis using Excel to determine the factors affecting the land cover changes. Standard deviation and mean were used to analyze the consistency of the answers of the respondents.

III. RESULTS AND DISCUSSION

A. Classifications of land cover in Bayombong in year 2010, 2015 and 2020

Table 2 shows the land cover classifications of Bayombong in 2010 with their corresponding area in hectares. Wooded grassland has the largest area among the classified land cover with an area of 4253.024 hectares. It was followed by annual crop having an area of 3977.557 hectares and closed forest with an area of 3211.612 hectares. While open forest has 2264.787 hectares and grassland has 1159.929 hectares. The built-up has 558.157 hectares; open/barren has 488.974; inland water has 135.910 hectares; perennial crop has 113.441 hectares; and fallow has 2.383 hectares. Based on the findings, the wooded grassland is the dominant land cover in the Bayombong during 2010 while fallow has the least area among the land cover classifications.

Table 2: Area of Land Cover Classifications in 2010

Land Cover Classifications	Area in Hectares
Annual Crop	3977.557
Built-up	558.157
Closed Forest	3211.612
Fallow	2.383
Grassland	1159.929
Inland Water	135.910
Open Forest	2264.787
Open/Barren	488.974
Perennial Crop	113.441
Wooded grassland	4253.024

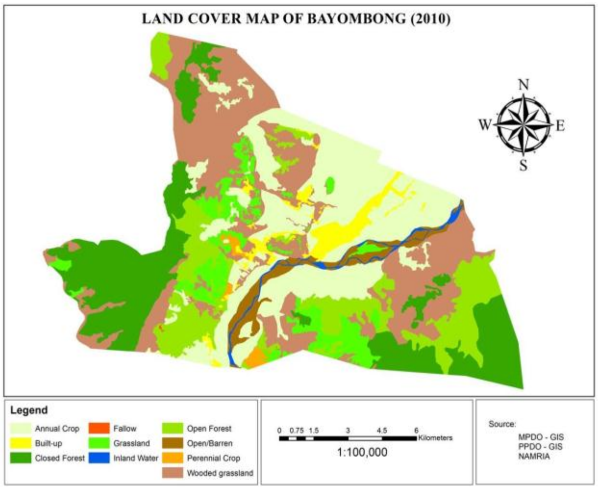

Figure 4. Land Cover Map of Bayombong in 2010

Table 3 shows the land cover classifications of Bayombong in 2015 with their corresponding area in hectares. Annual crop has the largest area among the classified land cover with an area of 4999.108 hectares. It was followed by brush/shrubs having an area of 3461.623 hectares and open forest with an area of 2736.783 hectares. While grassland has 1491.693 hectares and closed forest has 1429.434 hectares. Followed by built-up having an area of 873.053 hectares and open/barren with 490.565 hectares. While perennial crop has 421.023 hectares, inland water having 239.857 hectares and fishpond having the least area of 22.602 hectares.

Based on the findings, the annual crop was the dominant land cover in the Bayombong during 2015 while the fishpond has the most minor area among the land cover classifications. According to DAR (2015), Bayombong is one of the major urban centers in the Region 2 with primary activities that involves rice.

Table 3: Area of Land Cover Classifications in 2015

Land Cover Classifications	Area in Hectares
Annual Crop	4999.108
Brush/Shrubs	3461.623
Built-up	873.053
Closed Forest	1429.434

Fishpond	22.602
Grassland	1491.693
Inland Water	239.857
Open Forest	2736.783
Open/Barren	490.565
Perennial Crop	421.023

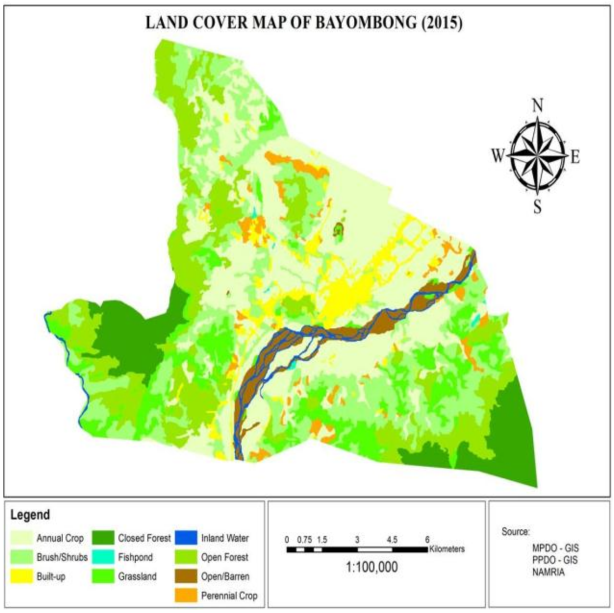

Figure 4. Land Cover Map of Bayombong in 2015

Table 4 shows the land cover classifications of Bayombong in 2020 with their corresponding area in hectares. Annual crop has the largest area among the classified land cover with an area of 4652.831 hectares. It was followed by brush/shrubs having an area of 3470.841 hectares and open forest with an area of 2771.654 hectares. While closed forest has 1608.535 hectares and grassland has 1343.885 hectares. And the built-up has area of 1014.222 hectares and perennial crop has 564.260 hectares. While open/barren has 427.986 hectares, inland water having 294.279 hectares and fishpond having the least area of 17.248 hectares. Based on the findings, the annual crop is the dominant land cover in the Bayombong during 2020 while fishpond has the most minor area among the land cover classifications.

Table 4: Area of Land Cover Classifications in 2020

Land Cover Classifications	Area in Hectares
Annual Crop	4652.831
Brush/Shrubs	3470.841
Built-up	1014.222
Closed Forest	1608.535
Fishpond	17.248
Grassland	1343.885
Inland Water	294.279
Open Forest	2771.654
Open/Barren	427.986
Perennial Crop	564.260

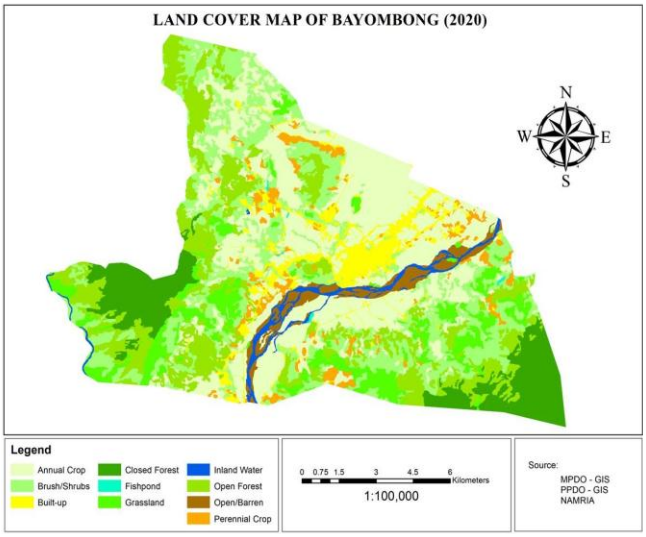

Figure 5. Land Cover Map of Bayombong in 2020

B. Changes in land cover in Bayombong in terms of classifications and area

Table 5 presents the transition matrix of land cover change from 2010 to 2015. The annual crop changed into built-up having the largest area change of 227.842 hectares, followed by open/barren, brush/shrubs, inland water, perennial crop, open forest, grassland, and fishpond except closed forest. The built-up changed into annual crop with an area change of 47.933 hectares, followed by brush/shrubs, perennial crop, grassland, open forest, open/barren, and fishpond except closed forest, inland water and fishpond. While closed forest changed into open forest having the largest area change of 1148.164 hectares, followed by brush/shrubs, grassland, annual crop, inland water, perennial crop, built-up except open/barren and fishpond. Grassland changed into annual crop having an area change of 271.917 hectares, followed by brush/shrubs, open forest, perennial crop, open/barren, built-up, inland water, fishpond except closed forest. The inland water changed into open/barren having an area change of 86.091 hectares, followed by annual crop, brush/shrubs, grassland, built-up, perennial crop except closed and open forest. While open forest changed into brush/shrubs with an area change of 797.800 hectares, followed by annual crop, grassland, perennial crop, closed forest, built-up and fishpond except inland water and open/barren. Open/barren was changed into annual crop with an area change of 105.506 hectares, followed by inland water, grassland, brush/shrubs, built-up and perennial crop, except closed forest, open forest, and fishpond. Perennial crop changed into annual crop with an area change of 35.428 hectares, followed by brush/shrubs, built- up, grassland, open forest and open/barren except closed forest, inland water, and fishpond. Wooded grassland was changed into brush/shrubs having an area change of 1806.694 hectares, followed by annual crop, grassland, open forest, perennial crop, built-up, inland water, fishpond, and open/barren except closed forest. While fallow was only changed into open forest with an area change of 1.161 hectares, grassland and brush/shrubs.

The change of open forest into open/barren and grassland is due to the forest fire that happened on March 30, 2010. The 10-hectare reforestation and ecological station in Barangay Busilac in Bayombong, owned by the SMU have burned (PIA, 2010). Therefore, disturbances in the forest can cause significant damage to a forest ecosystem. If these disturbances are severe and recurring, they can lead to the loss of tree cover and create open/ barren areas within the forest. Over time, grasses and other herbaceous plants may colonize these open spaces and eventually dominate the landscape, resulting in a transition from an open forest to a grassland.

In addition, the change of annual crop to built-up was also found out in the study of Seto et al. (2012) which it was stated that urbanization leads to the conversion of agricultural and forest land to built-up areas, resulting in significant land cover change. While the change of wooded grassland to brush/shrub can happen due to ecological succession, which is the natural process of change in plant communities over time. In wooded grasslands, changes in environmental conditions such as soil fertility, moisture availability, or disturbance regimes can favor the establishment and growth of brush or shrub species over the existing grasses. As brush or shrubs become more dominant, they can gradually replace the grasses and transition the ecosystem from wooded grassland to brush or shrubland. And such change was seen in the study of Temesgen et al. (2013).

Furthermore, forests are dynamic ecosystems that go through stages of succession. As older trees die or are removed by natural processes or human activities, new trees regenerate in open/ barren spaces. If regeneration is dominated by shade-intolerant tree species or pioneer species that require lighter, they can grow and create a more open forest structure, leading to the transition from a closed forest to an open forest.

Table 5: Land Cover Change from 2010 to 2015

		Land Cover in 2015									
		AC	BU	CF	G	IW	OF	O/B	PC	B/S	FP
Land Cover in 2010	AC	3274.186	227.842	0	24.182	77.092	32.394	133.325	70.278	126.294	11.960
	BU	47.933	474.725	0	0.625	0	3.693	0.044	4.677	26.461	0
	CF	99.399	0.022	1390.072	172.880	12.432	1148.160	0	1.885	386.734	0
	G	271.917	13.078	0	492.956	6.034	49.879	16.306	36.677	270.974	2.102
	IW	10.408	1.576	0	2.008	30.099	0	86.091	0.011	5.716	0
	OF	179.658	36.297	39.359	155.398	0	967.126	0	89.132	797.800	0.012
	O/B	105.506	2.237	0	22.693	93.137	0	249.486	0.609	15.306	0
	PC	35.428	7.710	0	6.069	0	3.340	0.031	35.439	25.421	0
	FW	0	0	0	1.005	0	1.161	0	0	0.217	0
	WG	974.672	109.572	0	613.874	21.063	531.020	5.281	182.314	1806.684	8.528

**Area in terms of hectares in units*

***Legends: AC-Annual Crop; BU-Built-up; B/S-Brush/Shrubs; CF-Closed Forest; FW-Fallow; FP-Fishpond; G-Grassland; IW-Inland Water; OF-Open Forest; O/B-Open/Barren; PC-Perennial Crop; WG-Wooden Grassland*

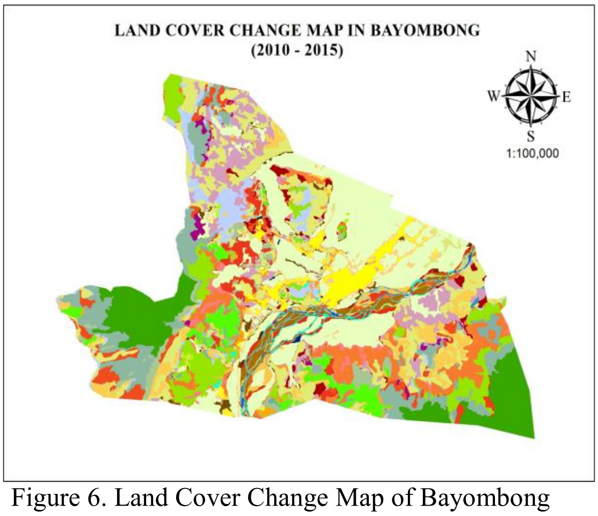

Figure 6. Land Cover Change Map of Bayombong from 2010-2015

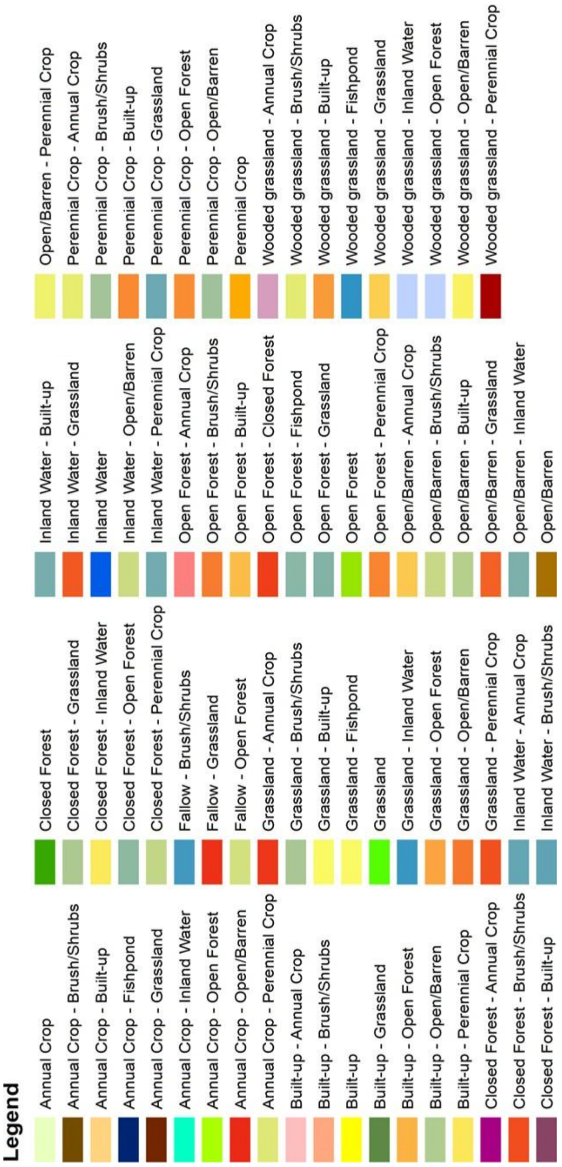

Table 6 is the transition matrix of land cover change from 2015 to 2020. Annual crop changed into brush/shrubs having the largest area change of 451.765 hectares, followed by built-up, perennial crop, open forest, inland water, open/barren, grassland, and fishpond except closed forest. Brush/shrubs was changed into open forest having the largest are change of 497.138 hectares, followed by annual crop, grassland, perennial crop, built- up, inland water, closed forest, open/barren, and fishpond. Built-up was changed into annual crop with largest area change of 75.265 hectares, followed by brush/shrubs, perennial crop, open forest, inland water, fishpond, grassland, and open/barren. While fishpond changed into annual crop having the largest area change of 2.885 hectares, followed by brush/shrubs, inland water, perennial crop, built-up, and open/barren except closed forest, grassland, and open forest. Grassland changed into brush/shrub having the largest area change of 203.633 hectares, followed by annual crop, open forest, open/barren, perennial crop, closed forest, built-up, and inland water except fishpond. Inland water was changed into open/barren having the largest area change of 92.383 hectares, followed by annual crop, brush/shrubs, open forest, grassland, fishpond, built-up, and perennial crop except closed forest. While open forest was changed into brush/shrubs having the largest area change of 251.730 hectares, followed by closed forest, annual crop, grassland, perennial crop, built-up, fishpond and inland water except open/barren. Open/barren was changed into inland water with the largest area change of 131.047 hectares, followed by annual crop, grassland, built-up, fishpond, brush/shrubs, and perennial crop except closed and open forest. Perennial crop was changed into brush/shrub having the largest area change of 46.119 hectares, followed by annual crop, built-up, open forest, grassland, fishpond, inland water, and open/barren except closed forest. While closed forest was only changed into open forest with the largest area change of 47.919 hectares, grassland and brush/shrubs.

The change of brush/shrub to open forest might be the same reason as Temesgen et al. (2013), where natural succession is the reason. It is the process by which plant communities change over time. In areas with brush or shrub vegetation, if conditions such as soil fertility, moisture availability, or disturbance regimes change, it can create favorable conditions for tree seedlings to establish and grow. Over time, the tree seedlings can develop into a more dense and diverse forest, resulting in the transition from brush or shrub vegetation to an open forest.

From annual crop to brush/shrub can be caused by abandonment of agricultural land. Economic or societal changes can cause farmers to abandon agricultural land. This can happen due to factors such as market fluctuations, declining profitability, or changes in agricultural practices (Movahedi et al., 2021). When land is left unmanaged or without regular agricultural activities, native plant species, including brush or shrubs, can establish and succeed the previous annual crops.

The change from open forest to brush/shrub can be caused by human activities. Human-induced factors can also contribute to the transition from an open forest to brush or shrub vegetation. Land use practices such as selective logging, clearing for agriculture, or the removal of specific tree species can alter the forest structure and create openings for brush or shrub species to establish and proliferate (Introduction to Silvicultural Systems, n.d.).

According to Hashiguchi et al. (2016), there is an established community-based forest management policy implemented by a local forest institution in barangay Buenavista, Bayombong. The findings of the result implied that the communities were experiencing difficulties concerning the utilization of forest resources because of the strict forest policies. Some had to leave the area near an open forest and comply with these policies as they were encroaching on the area of the forest. Therefore, the changes from built-up to open forest may be caused by the policies implemented in the area.

Table 6: Land Cover Change from 2015 to 2020

		Land Cover in 2015									
		AC	B/S	BU	CF	FP	G	IW	OF	O/B	PC
Land Cover in 2010	AC	4121.588	451.765	180.769	0	1.186	17.088	31.845	51.674	27.134	115.389
	B/S	225.700	2458.893	74.658	2.658	0.192	105.275	4.255	497.138	1.351	91.503
	BU	75.265	50.099	712.895	0	0.034	0.020	0.217	9.554	0.006	24.962
	CF	0	0.376	0	378.110	0	3.029	0	47.919	0	0
	FP	2.885	2.782	0.729	0	12.849	0	2.495	0	0.001	0.862
	G	49.932	203.633	2.770	4.430	0	1168.511	2.182	41.223	12.661	7.351
	IW	17.650	4.554	0.253	0	0.272	1.459	121.937	1.166	92.383	0.181
	OF	80.661	251.730	12.588	223.337	0.607	39.502	0.182	2113.104	0	15.073
	O/B	52.049	0.890	3.640	0	1.279	6.987	131.047	0	294.380	0.292
	PC	28.100	46.119	25.919	0	0.159	2.014	0.120	9.875	0.070	308.647

**Area in terms of hectares in units*
***Legends: AC-Annual Crop; BU-Built-up; B/S-Brush/Shrubs; CF-Closed Forest; FW-Fallow; FP-Fishpond; G-Grassland; IW-Inland Water; OF-Open Forest; O/B-Open/Barren; PC-Perennial Crop; WG-Wooden Grassland*

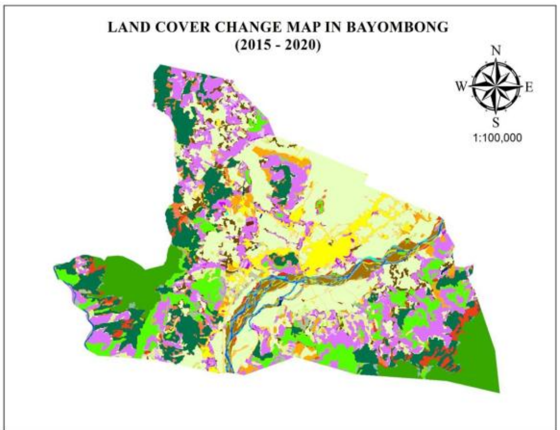

Figure 7. Land Cover Change Map of Bayombong from 2015 to 2020

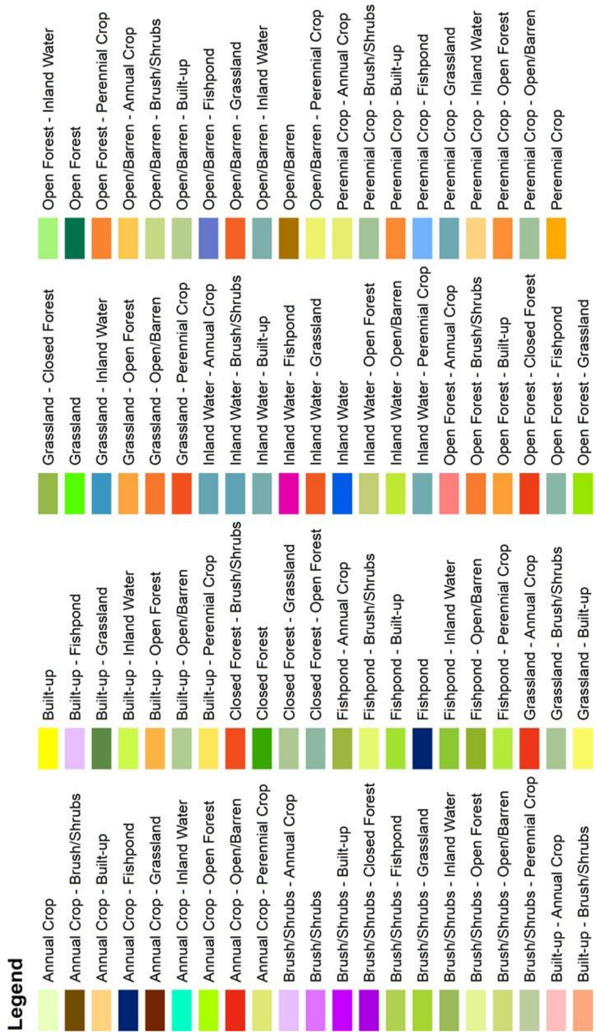

Table 7 shows the classification changes in land cover of Bayombong. Over the period of 2010-2015, the landscape underwent substantial changes in land cover. Between 2010 and 2015, there were significant changes in land cover across various categories. The area covered by annual crops increased by 227.842 hectares, with the largest change destination being built-up area. Conversely, built-up areas expanded by 47.933 hectares, with the largest change destination being annual crop land. Brush/shrubs and fishponds did not exhibit specific changes during this period. Closed forests saw a significant increase of 1148.160 hectares, with the largest change destination being open forests. Grasslands expanded by 271.917 hectares, primarily influenced by changes in annual crop areas. Inland water areas increased by 86.091 hectares, mainly transitioning to open/barren land. Open forests experienced notable growth, expanding by 797.800 hectares, with brush/shrubs as the largest change destination. Open/barren land also expanded by 105.506 hectares, primarily influenced by changes in annual crop areas. Perennial crops increased by

35.428 hectares, with the largest change destination being annual crop land. Wooded grasslands underwent the most significant change, expanding by 1806.694 hectares, with brush/shrubs as the largest change destination. Fallow land has a minor increase of 1.161 hectares, with open forests as the largest change destination. Overall, these changes demonstrate the dynamic nature of land cover and the interplay between different land use categories during the specified period.

Between 2015 and 2020, there were notable changes in land cover across different categories. The largest change destination for annual crops was brush/shrubs, with an increase of 451.765 hectares. Brush/shrubs expanded by 497.138 hectares, primarily transitioning into open forest. Closed forests experienced a minor increase of 47.919 hectares, with the largest change destination being open forests. Grassland areas increased by 203.633 hectares, mainly contributing to brush/shrubs. Inland water areas expanded by 92.383 hectares, primarily transitioning to open/barren land. Open forests had a growth of 251.730 hectares, primarily transitioning into brush/shrubs. Open/barren land increased by 131.047 hectares, with the largest change destination being inland water. Perennial crops increased by 46.119 hectares, primarily contributing to brush/shrubs. Wooded grassland and fallow land did not exhibit specific changes during this period. Fishponds had a minor increase of 2.885 hectares, with the largest change destination being annual crops. These changes highlight the dynamic nature of land cover and the shifting interactions between different land use categories from 2015 to 2020.

Table 7: Classification Changes in Land Cover

Land Cover Classification 2010 -2015	2010-2015 Area Change (hectares) A rea Change (hectares)	Largest Change Destination	2015-2020 Area Change (hectares)	Largest Change Destination
Annual crop	227.842	Built-up	451.765	Brush/shrubs
Built-up	47.933	Annual crop	75.265	Annual crop
Brush/shrubs	-	-	497.138	Open forest
Closed forest	1148.160	Open forest	47.919	Open forest
Grassland	271.917	Annual crop	203.633	Brush/shrubs
Inland water	86.091	Open/barren	92.383	Open/barren
Open forest	797.800	Brush/shrubs	251.730	Brush/shrubs
Open/barren	105.506	Annual crop	131.047	Inland water
Perennial crop	35.428	Annual crop	46.119	Brush/shrubs
Wooded grassland	1806.694	Brush/shrubs	-	-
Fallow	1.161	Open forest	-	-
Fishpond	-	-	2.885	Annual crop

Table 8 shows the area change of land cover change from 2010 to 2015 and 2015 to 2020. The largest area change in 2010-2015 is perennial crop which increased by 271.14% (307.582 hectares) and followed by inland water which increased by 76.48% (103.947 hectares). And built-up increased by 56.42% (314.896 hectares) and followed by closed forest with a decrease of 55.49% (-1782.178 hectares). While grassland, annual crop, open forest and open/barren increased by 28.60% (-62.579 hectares), 25.68% (1021.550 hectares), 20.84% (471.997 hectares), 0.33% (1.590 hectares) respectively. Fallow and wooded grassland were diminished entirely. On the other hand, fishpond and brush/shrubs were added as new classification with an area of 22.602 hectares and 3461.623 hectares, respectively.

Additionally, the largest area change in 2015 to 2020 is perennial crop which increased by 34.02% (143.237 hectares) and followed by fishpond which decreased by 23.69% (-5.354 hectares). And inland water increased by 22.69% (54.422 hectares) and followed by built-up with an increase of 16.17% (141.168 hectares). While open/barren, grassland, and annual crop decreased by 12.76% (331.764 hectares), 9.91% (-147.808 hectares), and 6.93% (-346.277 hectares), respectively. On the other hand, closed forest, open forest and brush/shrubs increased by 12.53% (179.101 hectares), 1.2% (34.871 hectares) and 0.27% (9.218 hectares), respectively.

Based on the findings, the highest change of area was the perennial crop in the period 2010-2015, which continued to increase in 2015-2020. The area of built-up, inland water, and open forest were increased in both periods. Meanwhile, the area of annual crop, grassland, and open/barren in the period 2010-2015 increased but they decreased in 2015- 2020. The brush/shrub and fishpond were new land cover classification in 2010-2015, and the area of the brush/shrub increased but the fishpond decreased in 2015-2020. The woodland grassland and fallow were decreased in the period 2010-2015.

According to the Municipal Disaster Risk Reduction and Management (MDRRM- LGU Bayombong), the decrease in perennial crop in 2015 to 2020 was mostly because of production of agricultural areas converted into either commercial, residential and institutional areas. They also said that the decrease of closed forest was due to the increase of tenurial instruments issued to People's Organization such as Certificate of Ancestral Domain Title (CADT) and to Informal Settler Families (ISF). They added that the increase of built-up was due to the residential subdivision within designated in La Torre South, Magsaysay, Bonfal Proper and Bonfal West. Moreover, the increase of built-up was the result of upgrading of existing roads and construction of new farm to market roads and barangay roads. Aside from that, the disappearance of fallow and wooded grassland was due to the reduction of land cover classification, from 14 in 2010 to 12 in 2015 (Santos, 2018).

Table 8: Area Change in Land Cover

Land Cover Classification	Area (ha) Change from 2010-2015	%	Area (ha) Change from 2015-2020	%
Annual Crop	1021.550	25.68	-346.277	-6.93
Brush/Shrubs	3461.623	100.00	9.218	0.27
Built-up	314.896	56.42	141.168	16.17
Closed Forest	-1782.178	-55.49	179.101	12.53
Fallow	-2.383	-100.00	0.00	0.00
Fishpond	22.602	100.00	-5.354	-23.69
Grassland	331.764	28.60	-147.808	-9.91
Inland Water	103.947	76.48	54.422	22.69
Open Forest	471.997	20.84	34.871	1.274
Open/Barren	1.590	0.33	-62.579	-12.76
Perennial Crop	307.582	271.14	143.237	34.02
Wooded grassland	-4253.024	-100.00	0.00	0.00

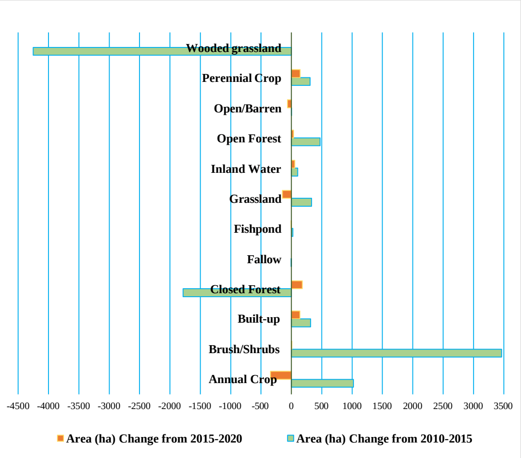

Figure 8. Area Change of Land Cover in Bayombong

C. Factors affecting the changes in land cover in Bayombong

Table 9 presents the frequency distribution of respondent's age. It shows that out of 100 respondents, there are 23% with the age 25-32, 18% with the age of 33-40 and 57- 64, 19% of respondents with the age of 41-48. While 16% of respondents were aged between 49 and 56. There are only 2% and 4% respondents from the range of 65-72 and 73-80, respectively. This only means that most of the research respondents are between the ages of 25 and 32.

Table 9: Distribution of the Respondents' Age

Age	Frequency	Percentage
25 -32	23	23%
33 - 40	18	18%
41 - 48	19	19%
49 - 56	16	16%
57 - 64	18	18%
65 - 72	2	2%
73 - 80	4	4%
	100	100%

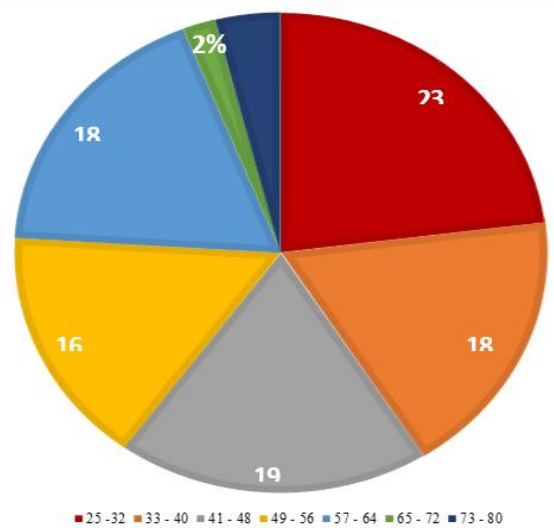

Figure 9. Distribution of Respondents' Age

Figure 10 shows the frequency distribution of respondents' sex. It shows that out of 100 respondents, 61% are male and 39% are female. This means that there are more male than female respondents. Similarly, Fikadu and Olika (2023) also have interviewed 89.7% of their respondents who are males and 10.3% who are females. This was also the case in the study of Maung et al. (2019) wherein 83% were males and 17% were females.

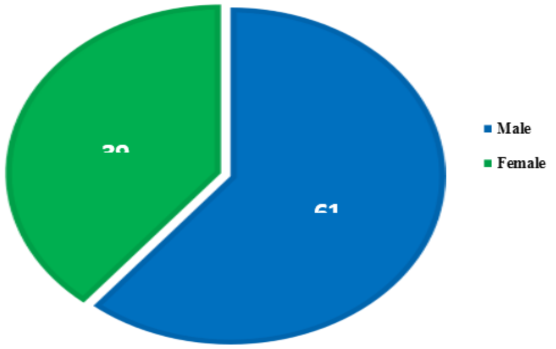

Figure 10. Distribution of the Respondents' Sex

Figure 11 shows the distribution of respondents' occupation. Out of the 100 respondents, there are 53 or 51% government employees, 21 or 20% farmers, eight or 7.5% professionals, eight or 7.5% housewives, five businessmen, five private employees, three construction workers, and one tricycle driver. This means that the most respondents are government employees.

Government employees, through their roles and responsibilities, often have access to various sources of information and data related to land cover change. They may gather data through field surveys, remote sensing technologies, monitoring systems, and engagement with local communities. This accumulated knowledge allows them to develop a nuanced understanding of the dynamics, patterns, and drivers of land cover change in their area of expertise.

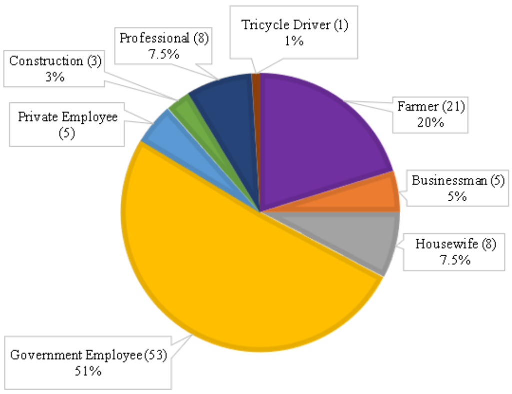

Figure 11. Distribution of the Respondents' Occupation

Table 10 shows the frequency distribution of the year the respondents started living in Bayombong. Out of 100 respondents, there are 22 who started living in 1992-2001, 21 in 2002-2011, 20 in 1962-1971, 15 in 1982-1991, 14 in 1972-1981, five in 1952-1961 and three in 1942-1951. This means that most of the respondents started living in Bayombong in 1992-2001.

This result is connected to the respondents of Bufebo and Elias (2020) where all their interviewees have lived through the complete study period and were able to answer questions about all period that resulted into the notion that the respondents had a good perception on their historical land cover pattern of the study area.

Table 10: Distribution of Respondents' Years of Stay in Bayombong

Year	Frequency	Percentage
1942 - 1951	3	3%
1952 - 1961	5	5%
1962 - 1971	20	20%
1972 - 1981	14	14%
1982 - 1991	15	15%
1992 - 2001	22	22%
2002 - 2011	21	21%
	100	100%

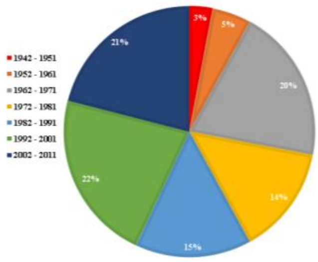

Figure 12. Respondents' Years of Stay in Bayombong

Table 11 shows the awareness of respondents on land cover changes. All the respondents have noticed the land cover changes in Bayombong from 2010 to 2015 and 2015 to 2020. This means that all the respondents are aware and noticed these changes in Bayombong from 2010 to 2015 and 2015 to 2020.

Table 11: Respondents' Awareness on Land Cover Changes

Notice Land Cover Changes	Yes	No
2010 to 2015	100	0
2015 to 2020	100	0

Table 12 presents the observed land cover change in Bayombong by the respondents during 2010 to 2015. There are 70 respondents who had observed the changes from annual crop to built-up; 34 in grassland to brush/shrubs; 27 in grassland to annual crop; and 25 in perennial crop to annual crop. There are also 21 who had observed both open forest to annual crop and open forest to built-up. These were followed by 19 who had noticed the changes in closed forest to built-up; 17 in wooded grassland to annual crop; 16 in inland water to built-up, 14 in closed forest to annual crop, and 11 respondents who had noticed the changes from annual crop to fishpond. There were also 10 respondents who had observed the changes from the closed forest to grassland, open/barren to built-up and perennial crop to grassland. Nine respondents had also observed the changes from closed forest to brush/shrubs, perennial crop to built-up and wooded grassland to built-up. Eight respondents had noticed the changes from annual crop to brush/shrub, closed forest to open forest, closed forest to perennial crop, grassland to open forest and perennial crop, and inland water to perennial crop. There were also seven respondents who had observed the changes from annual crop to open/barren and grassland to fishpond. Six respondents had noticed the changed from perennial crop to open forest and five in built-up to brush/shrubs and open forest, inland water to open/barren, open barren to annual crop, perennial crop to open/barren and wooded grassland to grassland. Four respondents had noticed the changes from annual crop to grassland and open forest, built-up to perennial crop, inland water to grassland, open forest to grassland and perennial crop and wooded grassland to open/barren. Three people were also noticed the changes of built-up to annual crop, grassland to built-up, inland water to annual crop and brush/shrubs, open forest to fishpond, open/barren to grassland and perennial crop, and wooded grassland to brush/shrubs. Two respondents had noticed the changes from annual crop to perennial crop, built-up to grassland, fallow to open forest, grassland to open/barren, open forest to brush/shrub and wooded grassland to perennial crop. There was only one person who noticed the changes from annual crop to inland water, built-up to open-barren, fallow to brush/shrubs and grassland, grassland to inland water, and open/barren to brush/shrubs. Meanwhile, the respondents didn't observe any changes from annual crop to closed forest, from built-up to closed forest, fishpond and inland water; from closed forest to fishpond, inland water, open/barren; from fallow to annual crop, built-up, closed forest, fishpond, inland water, and open/barren; from grassland to closed forest; from inland water to closed forest, fishpond and open forest; from open forest to closed forest, inland water and open/barren; from open/barren to closed forest, fishpond, inland water and open forest; from perennial crop to closed forest, fishpond and inland water; and from wooded grassland to closed forest, fishpond, inland water, and open forest.

Most of the respondents observed the changes from annual crop to built-up. When compared to Table 5, the area of the converted annual crop to built-up is 227.842 hectares, which is the largest area change from annual crop. There are 34 respondents who had noticed the conversion of grassland to annual crop with an area of 271.917 hectares. This means that the significant change in area of these land covers causes the respondents to notice such changes. Moreover, the land covers that did not change to another in table 5was not noticed based on the table above. This means that the responses of the respondents coincide with the data analyzed in table 5.

Table 12: Respondents' Observation on land Cover Changes during 2010-2015

		Land Cover (2015)									
		AC	B/S	BU	CF	FP	G	IW	OF	O/B	PC
Land Cover (2010)	AC		8	70	0	11	4	1	4	7	2
	BU	3	5		0	0	2	0	5	1	4
	CF	14	9	19		0	10	0	8	0	8
	FW	0	1	0	0	0	1	0	2	0	0
	G	27	34	3	0	7		1	8	2	8
	IW	3	3	16	0	0	4		0	5	8
	OF	21	2	21	0	3	4	0		0	4
	O/B	5	1	10	0	0	3	0	0		3
	PC	25	3	9	0	0	10	0	6	5	
	WG	17	3	9	0	0	5	0	0	4	2

*Legends: AC - Annual Crop; BU - Built-up; B/S - Brush/Shrubs; CF - Closed Forest; FW – Fallow; FP – Fishpond; G – Grassland; IW – Inland Water; OF – Open Forest; O/B – Open/Barren; PC – Perennial Crop; WG – Wooded grassland

Table 13 presents the observed land cover change in Bayombong by the respondents during 2015 to 2020. There are 61 respondents who had observed the changes from annual crop to built-up; 44 in grassland to brush/shrubs; 29 in grassland to annual crop; and 19 in perennial crop to built-up and open forest to brush/shrubs. Also, there are 18 respondents who observed the changes of open/barren to built-up; 16 in open forest to annual crop; 14 in closed forest to grassland; 12 in open forest to closed forest; and 11 in inland water to annual crop and annual crop to fishpond. There are nine respondents who had observed the change of annual crop to grassland; brush/shrubs to built-up; closed forest to brush/shrubs; and perennial crop to brush/shrubs. Eight respondents noticed the change from annual crop to brush/shrubs and open forest, and perennial crop to open/barren; seven in annual crop to open/barren and perennial crop, open forest to perennial crop, and open/barren to annual crop; and six in perennial crop to annual crop. And there are five respondents who noticed the changes from built-up to annual crop and fishpond; closed forest to open forest, open forest to grassland; and perennial crop to grassland and open forest. There are four respondents who had noticed the changes form built-up to grassland and open forest; fishpond to built-up; grassland to built-up, closed forest and perennial crop; inland water to fishpond and perennial crop. There are also two respondents who had noticed the changes from built-up to brush/shrubs and inland water; grassland to open/barren; inland water to built-up and open/barren; and open/barren to brush/shrubs and fishpond. There was also one respondent who noticed the changes from annual crop to inland water, brush/shrubs to annual crop and grassland; built-up to open/barren and perennial crop; grassland to inland water and open forest; open forest to fishpond and inland water; open/barren to inland water; and perennial crop to fishpond. On the other hand, they do not observed changes from annual crop to closed forest; brush/shrubs to closed forest, fishpond, inland water and open/barren; from built-up to closed forest, from closed forest to annual crop, built-up, fishpond, inland water, open/barren and perennial crop; from fishpond to brush/shrubs, closed forest, grassland, and open forest; from grassland to fishpond; from inland water to brush/shrubs, closed forest, grassland, and open forest; from open forest to open/barren; from open/barren to open forest; and from perennial crop to closed forest and inland water.

Most of the respondents noticed that there are changes from annual crop to built- up and grassland to brush/shrubs. And when compared to Table 6, the areas of such changes are 451.765 hectares and 203.633 hectares, which the former was the second largest area changed from annual crop and the latter was the largest area change from grassland. Moreover, the land covers that did not change to another in table 6 were not noticed based on the table above. This means that the responses of the respondents coincide with the data analyzed in table 6.

Table 13: Respondents' Observation on Land Cover during 2015 to 2020

		Land Cover (2020)									
		AC	B/S	BU	CF	FP	G	IW	OF	O/B	PC
Land Cover (2015)	AC		8	61	0	11	9	1	8	7	7
	B/S	1		9	0	0	1	0	3	0	0
	BU	5	2		0	5	4	2	4	1	1
	CF	0	9	0		0	14	0	5	0	0
	FP	3	0	4	0		0	3	0	3	5
	G	29	44	4	4	0		1	1	2	4
	IW	11	0	2	0	4	0		0	2	4
	OF	16	19	3	12	1	5	1		0	7
	O/B	7	2	18	0	2	3	1	0		3
	PC	6	9	19	0	1	5	0	5	8	

**Legends: AC - Annual Crop; BU - Built-up; B/S - Brush/Shrubs; CF - Closed Forest; FW – Fallow; FP – Fishpond; G – Grassland; IW – Inland Water; OF – Open Forest; O/B – Open/Barren; PC – Perennial Crop; WG – Wooded grassland*

Table 14 shows the respondent's perception on the population growth as a factor on land cover changes. The level of agreement of the respondents in the population growth as a factor of land cover change in the years 2010 to 2015 and 2015 to 2020 is strongly agree, with the overall mean of 4.580. This suggests that the respondents believe that population growth has a noticeable impact on changes in land cover during the specified time periods. It implies that as the population grows, there is an associated effect on the transformation of land cover.

In relation to the published literature by Foley et al. (2005) stated that one of the primary drivers is population growth, which leads to an increased demand for food, housing, and infrastructure. As the population grows, the pressure on land resources increases, and this often results in the conversion of natural ecosystems to agricultural or urban areas. Also, it was shown in the study of Janiola et al. (2018) that as the surging population increases, it would also mean an increase in built-up area would also expand the necessity for the land of cultivation. And Handavu et al. (2019) mentioned in their study that population growth (18.3%) ranked third from the main causes of change in land cover in the miombo woodlands of the Copperbelt province in Zambia.

Moreover, in Bayombong, it was reported that one of the factors contributing to the low and unstable agricultural production is the transition of land from agricultural to non- agricultural uses, such as housing, which is prompted by a growing population that increases demand for housing (Jocson, 2018). As relevantly cited in PSA Census (2015, 2020), the population of Bayombong in the year 2010 is 57, 416, in 2015 is 61,512, and in 2020 is 67,714. This shows that the population from 2010 to 2015 and 2015 to 2020 had an increase of 7.13% and 10.08% respectively.

Table 14: Population Growth as a Factor on Land Cover Change

Statements	2010 to 2015								2015 to 2020								O.M.	O.I.
	Level of Agreement					M	σ	I	Level of Agreement					M	σ	I		
	1	2	3	4	5				1	2	3	4	5					
1. Rapid population growth in Bayombong can lead to changes in land use and land cover. As the population increases, there may be a higher demand for housing, infrastructure, and resources.	0	0	5	30	65	4.600	0.586	SA	1	0	0	29	70	4.670	0.587	SA	4.580	SA
2.Migration patterns to Bayombong influence	0	0	4	43	53	4.49	0	SA	1	0	1	3	60	4.5	0.	SA		

the demand for housing, infrastructure, and services, which can lead to changes in and cover.						0	.577					8		60	625			

**M – mean; σ– standard deviation; I – interpretation; OM – overall mean; OI – overall interpretation*
***SA = 4.20-5.00; A = 3.40 – 4.19; N = 2.60 – 3.39; D = 1.8 – 2.59; and SD = 1.00 – 1.79*

Sample computation

Since the researchers used Likert's scale, the responses were represented by numerical values which were stated in Table 2, and these were served as weights applied to X-values (wi). And the mean is the average of the responses. It is obtained by summing up the product of the quantity of responses and the numerical values of the responses and dividing them by the total number of responses as shown in equation 1.

$$\bar{x} = \frac{\sum_{i=1}^{z}(x_i \cdot w_i)}{n} = \frac{(x1 \cdot w1)+(x2 \cdot w2)+(x3 \cdot w3)+(x4 \cdot w4)+(x5 \cdot w5)}{n} \quad \text{equation 1}$$

where: $\bar{x}$ = mean
z = number of terms to be averaged n = total number of responses
w_i = weights applied to X-values
x_i = number of responses in each level of responses

And then, compute the deviation. It is obtained by subtracting the mean from each individual numerical response. These deviations represent the difference between each response and the mean. Square each of the deviations obtained as shown in equation 2. This step ensures that negative and positive deviations do not cancel each other out when computing the average variability. Then, calculated the square root of the quotient of the sum of these deviations and the total number of responses minus 1 as shown in equation 3. The equation 3 is the standard deviation (σ). And lastly, the overall mean was the average of the mean of the statement 1 and 2 in both periods.

$$deviation = (x_i - \bar{x})^2 \quad \text{equation 2}$$

$$\sigma = \frac{\sqrt{\sum(x_i - \bar{x})^2}}{n-1} \quad \text{equation 3}$$

$$overall\ Mean = \frac{\bar{x}_1 + \bar{x}_2 + \bar{x}_3 + \bar{x}_4}{4} \quad \text{equation 4}$$

where: $\bar{x_1}$ = mean of statement 1 in 2010-2015
$\bar{x_2}$ = mean of statement 2 in 2010-2015
$\bar{x_3}$ = mean of statement 1 in 2015-2020
$\bar{x_4}$ = mean of statement 2 in 2015-2020

For example, in the statement 1 (2010-2015) as follows:

$$Mean = \bar{x} = \frac{(5x3) + (30x4) + (65x5)}{(5 + 30 + 65)} = 4.6$$

$$deviation = (3 - 4.6)^2 = 2.56$$

$$\sum(x_i - \bar{x})^2 = 34$$

$$\sigma = \frac{\sqrt{\sum(x_i - \bar{x})^2}}{n-1} = \sqrt{\frac{34}{100 - 1}} = 0.586$$

For overall mean in table 12,

$$overall\ Mean = \frac{4.60 + 4.490 + 4.67 + 4.56}{4} = 4.580$$

Table 15 shows the respondent's perception on urbanization as a factor on land cover changes. The level of agreement of the respondents on urbanization as a factor on land cover change in the years 2010 to 2015 and 2015 to 2020 is strongly agree, with the overall mean of 4.373. This suggests that the respondents believe that urbanization has a noticeable impact on changes in land cover during the specified time periods. This implies that urbanization is considered a major driving force behind land cover change.

These findings were related to the disclosed information in Asian Land Forum held in Pasig City wherein Mercado (2016) revealed that the shifting of land cover in Upper Marikina from 2003 to 2012 is mostly caused by land conversion, and settlement expansion. Likewise, in the study of Seto et al. (2012), it stated that urbanization leads to the conversion of agricultural and forest land to built-up areas, resulting in significant land cover change. Another similar work by Clarin et al. (2021) discovered that there is a decrease in vegetation cover due to increasing built-up development as they evaluate the land cover change due to urbanization in Mactan Islan, Cebu.

Handavu et al. (2019) also found out that new settlements frequently lead to the permanent loss of natural and productive lands, causing the changes of land cover in the Miombo Woodlands of the Copperbelt province in Zambia. Also, the study of Alberto et al. (2019) concluded that land cover from 1989 to 2018 such as urban cover expanded due to the human activities such as settlement.

Table 15: Urbanization as a Factor on Land Cover Changes

Statements	2010 to 2015								2015 to 2020								O.M.	O.I.
	Level of Agreement					M	σ	I	Level of Agreement					M	σ	I		
	1	2	3	4	5				1	2	3	4	5					
1. Expansion of commercial and residential land use in response to economic growth and urbanization affects the land cover change in Bayombong	1	1	2	52	44	4.370	0.677	SA	1	1	3	48	47	4.390	0.695	SA	4.373	SA
2. More people constructed their houses along the newly built route	0	2	10	40	48	4.340	0.742	SA	1	1	9	36	53	4.390	0.777	SA		

**M – mean; σ– standard deviation; I – interpretation; OM – overall mean; OI – overall interpretation*
***SA = 4.20-5.00; A = 3.40 – 4.19; N = 2.60 – 3.39; D = 1.8 – 2.59; and SD = 1.00 – 1.79*

Table 16 shows the respondent's perception on infrastructure development factor on land cover changes. The level of agreement of the respondents on infrastructure development factor on land cover change in the years 2010 to 2015 and 2015 to 2020 is agree, with the overall mean of 3.998. The indicates that they believe infrastructure development plays a role in altering land cover patterns.

In the study of Laurance et al. (2009), they found out that infrastructure development, such as road construction, dams, and mining activities, can also cause significant land cover change. They also noted that infrastructure projects can directly cause forest loss by clearing vegetation for construction and associated activities, such as logging and mining. It was also seen in the study of Lone and Meyer (2018) in which laying out the railway line and extension of two routes of the road (NH1A and NH1B) affects the agricultural land significantly.

According to the Municipal Disaster Risk Reduction and Management (MDRRM- LGU Bayombong), the decline in perennial crops from 2015 to 2020 was primarily caused by the production of agricultural areas transformed into either commercial, residential, or institutional areas. They added that the residential subdivisions within La Torre South, Magsaysay, Bonfal Proper, and Bonfal West were the reason for the growth in built-up areas. Additionally, the improvement of current roads and the building of new farm-to- market and barangay roads contributed to the growth in built-up areas.

Table 16: Infrastructure Development as a Factor on Land Cover Change

Statements	2010 to 2015								2015 to 2020								O.M.	O.I.
	Level of Agreement					M	σ	I	Level of Agreement					M	σ	I		
	1	2	3	4	5				1	2	3	4	5					
1. Construction and improvement of public transportation facilities, such as bus and jeepney terminals, and the upgrading of public transportation routes has led to changes in land cover in Bayombong	0	1	27	45	27	3.980	0.765	A	0	0	25	43	32	4.070	0.756	A	3.998	A
2. Improvement of public open spaces, and other recreational facilities within the agricultural land has led to changes in land cover in Bayombong	0	6	25	39	30	3.930	0.891	A	0	4	19	49	28	4.010	0.798	A		

**M – mean; σ– standard deviation; I – interpretation; OM – overall mean; OI – overall interpretation*
***SA = 4.20-5.00; A = 3.40 – 4.19; N = 2.60 – 3.39; D = 1.8 – 2.59; and SD = 1.00 – 1.79*

Table 17 shows the respondent's perception on agricultural expansion factor on land cover changes. The level of agreement of the respondents on agricultural expansion as a factor on land cover change in the years 2010 to 2015 and 2015 to 2020 is agree, with the overall mean of 4.00. This indicates that they consider agricultural expansion plays a role in altering land cover patterns.

In the research of Pailagao et al. (2010), they focused on the drivers of land cover change in Lantapan, Bukidnon and found out that the land cover change in Songco is influenced by anthropogenic activity. The high demand for vegetable and other crops have provided economic opportunities for farmers to expand their area, leading to the encroachment and clearing of forest area. Also, Drummond et al., 2012 found out that technological advancement, such as the development of irrigation technologies, has affected land cover change, expanding cultivated lands. And expanding agricultural land can increase crop productivity.

Lastly, land cover change was possible because of agricultural intensification according to Lambin and Meyfroidt (2011). Similarly, Handavu et al. (2019) mentioned in their study that agricultural expansion (25.6%) ranked second from the main causes of change in land cover in the miombo woodlands of the Copperbelt province in Zambia.

Table 17: Agricultural Expansion as a Factor on Land Cover Change

Statements	2010 to 2015								2015 to 2020								O.M.	O.I.
	Level of Agreement					M	σ	I	Level of Agreement					M	σ	I		
	1	2	3	4	5				1	2	3	4	5					
1. Agricultural activities in Bayombong are driven by market forces agricultural products, which can lead to changes in land cover	0	3	11	54	32	32	4.15	A	1	2	12	53	32	4.13	0.774	A	3.998	A
2. The introduction of new crop varieties and farming technologies has led to changes in land use and land cover in Bayombong	1	6	26	43	24	3.83	0.900	A	1	6	21	47	25	3.89	0.886	A		

*M – mean; σ– standard deviation; I – interpretation; OM – overall mean; OI – overall interpretation
**SA = 4.20-5.00; A = 3.40 – 4.19; N = 2.60 – 3.39; D = 1.8 – 2.59; and SD = 1.00 – 1.79

Table 18 shows the respondent’s perception on policy implementation as a factor on land cover changes. The level of agreement of the respondents on policy implementation as a factor on land cover change in the years 2010 to 2015 and 2015 to 2020 is agree, with the overall mean of 4.113.

According to Organisation for Economic Co-operation and Development (OECD, n.d.) of Ukraine, “land use planning and regulation restricts how land can be used”. And relative to the article of Markell (2016), it was stated that the local, state, and policies can alter land cover, for example, by requiring local comprehensive plans to address sea level rise. There has been a successful shift in land use/cover patterns that have resulted in both an increase in forest cover and agricultural output in some developing nations.

According to Hashiguchi et al. (2016), Barangay Buenavista, Bayombong, has a well-established community-based forest management policy that is carried out by a local forest institution. The findings of the study suggested that because of the strict forest policies, the communities were having difficulties using the forest resources. Some were forced to leave the vicinity of an open forest and abide by these regulations because they were encroaching on the forest's territory.

Table 17: Policy Implementation as a factor on land Cover Changes

Statements	2010 to 2015								2015 to 2020								O.M.	O.I.
	Level of Agreement					M	σ	I	Level of Agreement					M	σ	I		
	1	2	3	4	5				1	2	3	4	5					
1. tax policies, subsidies, and incentives encourage certain types of land use and development	0	3	22	46	29	4.01	0.798	A	0	3	18	53	26	4.02	0.752	A	3.998	A
2. Land use policies and regulations affect the way land is managed and developed in Bayombong	0	2	13	51	34	4.17	0.726	A	0	1	10	52	37	4.25	0.672	A		

*M – mean; σ– standard deviation; I – interpretation; OM – overall mean; OI – overall interpretation
**SA = 4.20-5.00; A = 3.40 – 4.19; N = 2.60 – 3.39; D = 1.8 – 2.59; and SD = 1.00 – 1.79

Table 18 shows the summary of tables 12.1 to 12.5, wherein this table indicates the factors and their corresponding overall mean and overall interpretation. the overall responses of respondents on the population growth, urbanization as factors on land cover changes has a mean of 4.58 and means they are “Strongly Agree.” Meanwhile, the level of agreement of the respondents on infrastructure development, agricultural expansion, and policy implementation as factors on land cover change in the years 2010 to 2015 and 2015 to 2020 is agree, with the overall mean of 3.998, 4.000, 4.113, respectively.

Table 18: Factors on Land Cover Changes

Factors	Overall Mean	Overall Interpretation
Population Growth	4.580	Strongly Agree
Urbanization	4.373	Strongly Agree
Infrastructure Development	3.998	Agree
Agricultural Expansion	4.000	Agree
Policy Implementation	4.113	Agree

* Strongly Agree = 4.20-5.00; Agree = 3.40 – 4.19; Neutral = 2.60 – 3.39; Disagree = 1.8 – 2.59; and
Strongly Disagree = 1.00 – 1.79

IV. CONCLUSION

The dominant land cover classification in 2010 was wooded grassland, while fallow was the minor land cover. By 2015 and 2020, annual crop became the largest land cover, while fishpond became the smallest area among land cover classification. The disappearance of fallow and wooded grassland suggests a modification in land cover classifications by NAMRIA.

The transition matrices (Tables 5 and 6) illustrate the conversion of land cover types between 2010 and 2015, as well as 2015 and 2020. Major changes in 2010-2015 include the conversion of annual crop to built-up, wooded grassland to brush/shrubs, and closed forest to open forest. Built-up areas expanded over time, indicating urbanization and infrastructure development. The change from wooded grassland to closed forest and closed forest to open forest can be caused by succession and regeneration. While in 2015-2020, major changes are brush/shrub to open forest, annual crop to brush/shrub and open forest to brush/shrub. These kinds of changes are due to the natural succession, abandonment of agricultural land and land management practices.

In the period of 2010-2015, perennial crop and inland water experienced notable increase, while closed forest had a significant decrease. The increase in built-up areas suggests urban development, while the reduction in closed forest indicates deforestation. From 2015 to 2020, perennial crop and inland water continued to increase, while open/barren, grassland, and annual crop showed decreases. Closed forest and open forest had slight increases, indicating potential reforestation efforts or natural regeneration.

The majority of respondents were between the ages of 25 and 32, indicating a relatively younger demographic group participating in the research. More male respondents were involved compared to females. Also, government employees constituted the largest group among the respondents, suggesting their access to information and knowledge related to land cover change.

All respondents had noticed the land cover changes in Bayombong from 2010 to 2015 and 2015 to 2020. This suggests a high level of awareness among the local population regarding changes in their environment. The findings align with other studies where respondents demonstrated good perception and knowledge about historical land cover patterns. Most of the respondents observed the changes in 2010-2015 from annual crop to built-up. And in 2015-2020, most of the respondents noticed that there are changes from annual crop to built-up.

The respondents strongly agree to the population and urbanization as a factors of land cover change in the years 2010 to 2015 and 2015 to 2020. Meanwhile, they agree to the infrastructure development, agricultural expansion, and policy implementation as factors on land cover change in the years 2010 to 2015 and 2015 to 2020.

Overall, the research findings highlight significant land cover changes in Bayombong over the studied period. The expansion of built-up areas shifts in agricultural practices, and variations in forest cover demonstrate the dynamic nature of land cover in the region. The engagement of government employees as respondents and their awareness of land cover changes signifies their potential role in monitoring and managing these changes. Further analysis and research could delve into the drivers and implications of specific land cover changes, including their environmental, social, and economic impacts on the local community and ecosystem.

ACKNOWLEDGEMENT

The researchers is sincerely acknowledges the Provincial Environment & Natural Resources, Provincial Assessors Office, Provincial Planning and Development Office

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