ASSESSMENT OF AGRICULTURAL LAND-COVER CHANGE IN NUEVA ECIJA USING GEOGRAPHIC INFORMATION SYSTEM AND REMOTE SENSING TECHNOLOGIES

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KEYWORDS: Forest, Urban, Disturbance, Land-use, Urbanization

ABSTRACT: Land cover is a significant element in understanding the relation of human activities with the agriculture and therefore to maintain a sustainable agriculture, change detection is necessary. The study was carried out through Remote Sensing and GIS approach using Landsat Imageries (Landsat 4 TM, Land Sat 7 ETM+, Landsat 5 TM and Landsat 8 OLI_TIRS) to assess the changes in land cover of the province of Nueva Ecija. For this purpose, unsupervised, supervised and object-based image classification technique were applied to the satellite imageries acquired from 1989 to 2018. Results indicate that land cover changes have occurred in agricultural, urban and forestry areas which have been experienced in the study areas from 1989 to 2018. Urban areas, although covering a much smaller proportion of the landscape/landcover in both time periods, it increased at a much higher rate than any other land cover classes. The increase in agricultural and urban areas mostly result in deforestation which means some forest areas were removed and converted to agriculture and settlement in the Province.

1. INTRODUCTION

Nueva Ecija is one of the leading producers of rice and vegetables in the Philippines. Several areas in Nueva Ecija, Philippines are transitioning from largely agrarian to urban societies due to industrialization. These changes in the environment which may be caused by urbanization, deforestation, and agricultural intensification in the region may affect local, regional, and global climate and atmospheric chemistry. The study of agricultural land cover changes is very important to have proper planning and utilization of natural resources and their management [1]. Traditional methods for gathering data such as field investigation are often expensive, time consuming, laborious and prone to error [2]. Since many problems often presented in environmental issues and great complexity of handling the multidisciplinary data set; we require new technologies like satellite remote sensing and Geographical Information Systems (GIS). These technologies provide data to study and monitor the dynamics of natural resources for environmental management.

The study is about the changing pattern of the agricultural areas and the impact of such change is a growing need to uphold the agricultural biodiversity of the province. Geospatial technology (Geographical Information Systems and Remote Sensing) was used in this study to signify the importance of agricultural land cover changes, which possibly help to assess the change dynamics of the area. Agricultural area change assessment may also help the policymakers to understand the natural state of the area and the complex relation between the physiographic and man-made features.

2. OBJECTIVES

The main objective of the research was to utilize GIS and Remote Sensing applications to assess the nature, significance, and rate of agricultural land cover change from 1989 to 2018. It also aimed to find out the areas of rapid change, magnitude of change and assess the past and present condition of agricultural land cover to understand the dynamics and trend of change.

3. METHODS

3.1. Study area

Province of Nueva Ecija was selected as study area for change detection because of being subjected to urbanization. The province is the largest in Central Luzon, covering a total area of 5,751.33 square kilometers. Its terrain begins with the southwestern marshes near the Pampanga border. It levels off and then gradually increases in elevation to rolling hills as it approaches the mountains of Sierra Madre in the east, and the Caraballo and

Cordillera ranges in the north. Nueva Ecija is considered the main rice growing province of the Philippines and the leading producer of onions in the Municipality of Bongabon in South East Asia.

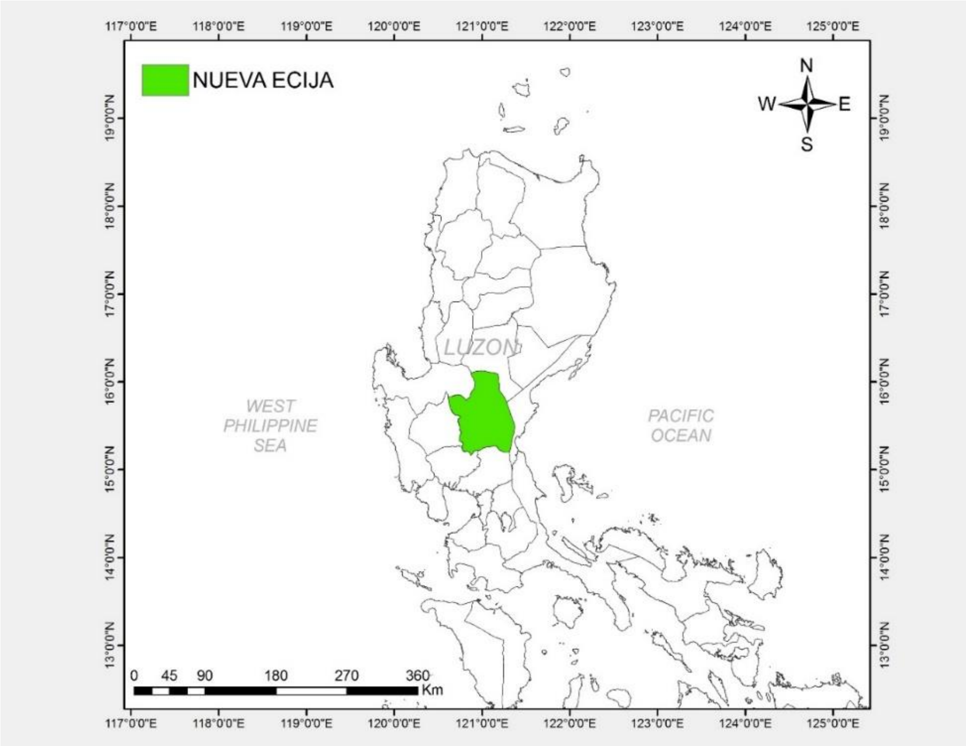

Figure 1. Study Area; Province of Nueva Ecija, Philippines

3.2. Data sets

3.2.1. Satellite Imageries

The data used in this research were satellite data from Landsat and ancillary data. Ancillary data included ground truth data for the land cover classes, and aerial imagery of study area. The ground truth data were in the form of reference data points collected using Geographical Positioning System (GPS) from January to April 2018 image analysis, used for image classification and overall accuracy assessment of the classification results. Satellite data from 1979 to 2018 were acquired from Landsat satellite. Specifications of the satellite data acquired for land cover change assessment are given in Table 1.

Table 1. Satellite data specifications.

Year	LANDSAT	Res	Sensor	Bands	Season	Cloud Area	Acquisition
1989	Landsat 4	30	TM	7	Wet Season	Cloud area replaced by secondary data	1989-06-02
2001	Landsat 7	30	ETM+	8	Wet Season		2001-06-26
2010	Landsat 5	30	TM	7	Wet Season	116 ha	2010-06-12
2018	Landsat 8	30	OLI_TIRS	11	Wet Season	95 ha	2018-06-06

Table 2. Landsat used for reference to no data from cloud cover

Year	Satellite	Res	Sensor	Bands	Season	Data for year	Acquisition
2009	Landsat 5	30	TM	7	Wet Season	2010	2009-10-08
2017	Landsat 8	30	OLI_TIRS	11	Wet Season	2018	2017-08-07

3.2.2. Landcover classification system

1. General Guidelines and Classification System:
    - (FAO) Food and Agriculture Organization of the United Nations
2. Specific Landcover Classes in the Study Area
    - (PSA) Philippine Statistics Authority
    - (PhilGIS) Philippine GIS Data Hub: Land Cover Classes Nueva Ecija
3. Secondary Data (Maps and General Land Cover Data)
    - (NAMRIA) National Mapping and Resource Information Authority

3.3. Flow Chart

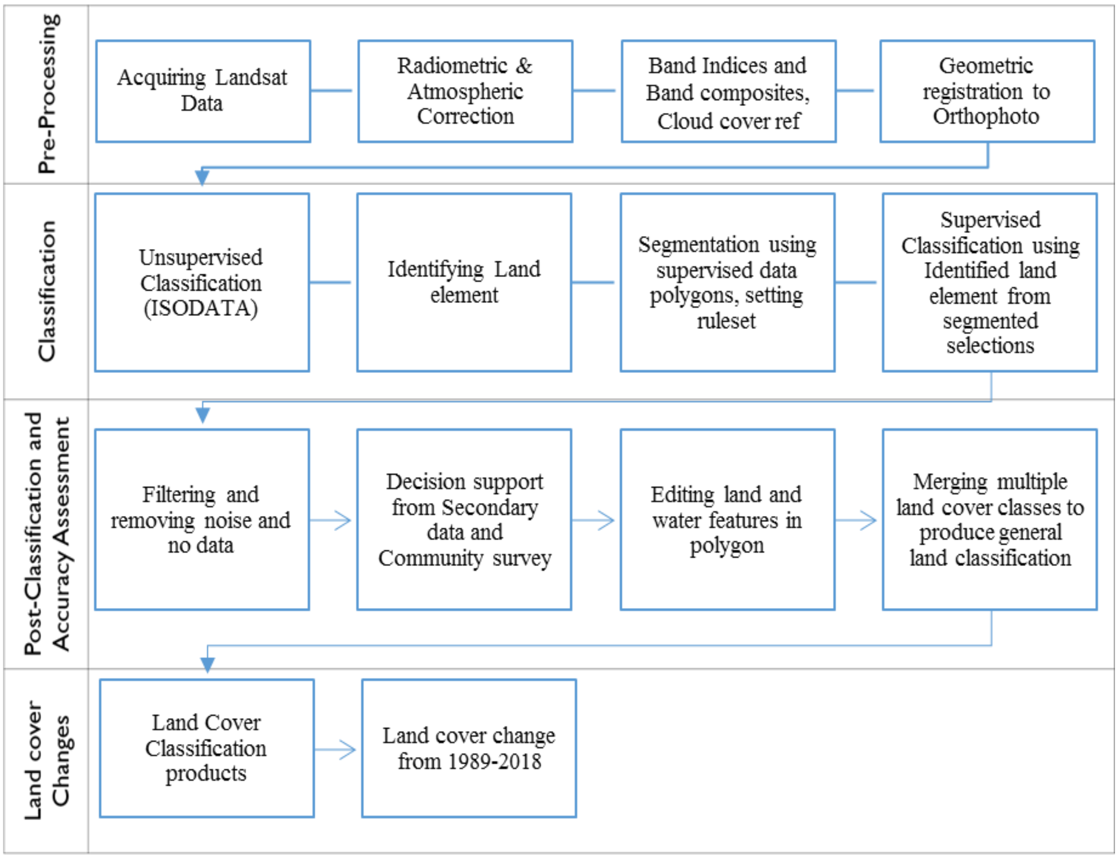

Figure 2. Work flow of the study

3.4. Preprocessing

The images were geometric/atmospheric correction done after download. The images then undergo compositing wherein band indices were selected to fully project land elements for the red-blue-green (RGB) combination which will clearly identify the land cover classes. Clouds observed were very small in size and found in only few areas of the images and does not significantly obscure any landscape thus processing of the clouds were done using reference data from nearby year of acquisition of Landsat imageries. Secondary data were also taken wherein cloud clusters attribute was change to the proper landscape classification. The shapefile of the Provincial Boundary of Nueva Ecija was downloaded in PhilGis website wherein municipal boundaries were included and will be used for clipping. Due to the large scale of the acquired satellite image, each municipal boundary was clipped and was used for supervised classification. The municipal scale provides accurate classification and less error in processing. Noise and no data or sinks were observed in the classification scheme but was reduced using filter tool and flow tool to clearly delineate land boundaries (Figure 3). Remaining noise and no data were manually edited and converted to the nearest land cover class. The orthophoto was used as reference for image analysis.

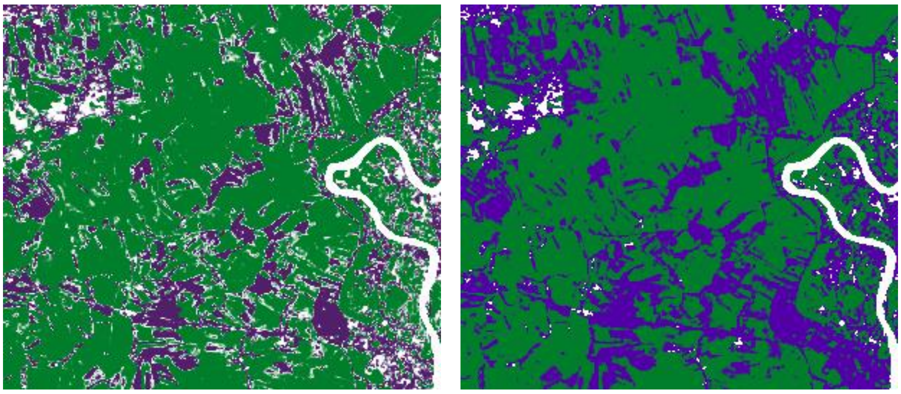

Figure 3. Filtering and removing noise and no data (data sinks)

3.5. Land Classification in Nueva Ecija

The study area was composed of 6 observed classes for level one category; Water body, Agricultural, Fallow, Roads, Trees and Built-up, classification breakdown (level 2 and 3) is shown in Figure 4.

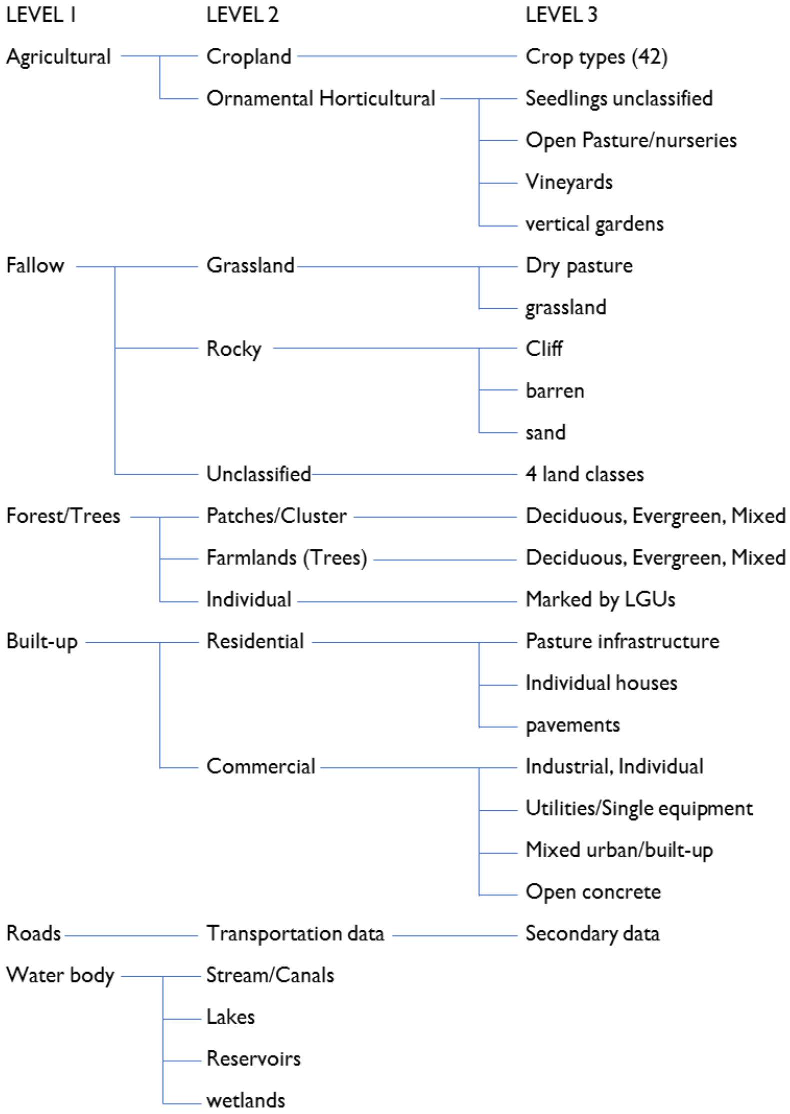

Figure 4. Final Land Classification of Nueva Ecija

3.6. Classification

3.6.1. Unsupervised Classification and Segmentation

Isodata for unsupervised classification was used to project 30 land cover classes. The raster output was compared from field data and converted to proper land classes with backed by secondary data and orthophoto. Raster classes were converted to polygons and manually edited using attribute table and guided by secondary data. The final output obtained were cluster polygons of different land cover classes used as segments and training polygons for supervised classification.

3.6.2. Supervised Classification

The predetermined land cover was used as training samples to aid the classification of the whole area. The polygons converted from unsupervised classification were used as training samples together with secondary data marking every possible polygon to aid in classification. Training samples were selected by delimiting polygons around representative sites. Training and validation points for different classes were selected based on the observation of the aerial image and secondary data. Interactive Supervised Classification algorithm was used. Cluster polygons of different land cover classes were assigned to every polygon in each municipality and training polygons were scattered around the study areas.

3.7. Post-processing

The final output of classification was converted to polygons without simplification. The misclassified areas based on secondary data and orthophoto were edited in the attribute table replacing with the correct classification. Due to the pixel size of the imageries, trees were hardly identifiable from agricultural land cover. Proper decision-making for editing the polygons were checked from Local Data and Google Earth which also help in determining tree clusters around the image. The roads digitized using Google Earth together with the secondary data from PhilGIS were overlaid in the output map. The unclassified digitized road was buffered at 10 meters in width as per road standards in the Philippines. The digitized Built-up, roads and water bodies was overlaid in the classified image. The aforementioned digitized features were used as overlaying tools to flatten the image and form the final six classification of land cover each independent by its areas and boundaries. Dissolve tool was then used to combine multi-part polygons into one polygon of its class.

3.8. Water Bodies Delineation

Using the DEM, a flow direction grid was created using the Flow Direction Tool and assigned value to each cell to indicate the direction of flow based on the underlying topography of the landscape. The Flow Accumulation tool were used to calculate the flow into each cell which identified the upstream cells that flowed into each downslope cell. The pour points of the area were placed in the map and with the help of the orthophoto and secondary data provided an ease for visual inspection of the area. Using the watershed tool in ArcMap, parameters were set including the flow direction raster and pour point data. The left and right riverbank were delineated and traced from the upstream to the different networks, including water swamps and other water bodies.

3.9. Land Cover Change Assessment

Temporal Satellite dataset from 1989 to 2018 were analyzed individually and projected to create a time series. After the analysis of each satellite data the results were compared to evaluate the study findings The whole analysis procedure was performed following the underlying flowchart (Figure 2).

In the attribute table of the final classification, a field was added in a long integer form and the areas of each class were computed by calculating the geometry into hectares. The computed area of each class in each municipality was compared per year to monitor the land cover change.

4. RESULTS AND DISCUSSION

4.1. Land cover Change Assessment

The Philippine Climate is Rainy and Dry Season. During June to September (6th-9th month) it was rainy season and October to April (10th- 5th month) is dry season. In 1989, the satellite imagery was collected on June 2, 1989 during Harvest Time (and start of dry season), the agricultural lands may have been converted to fallow and water bodies may increase due to rainy season. Figure 5 shows the generated Land-Cover Map of Nueva Ecija (Level 1). The Municipality comprised of 6 land cover classes at level 1 namely; Fallow, Built-up, Forest, Agricultural, Road and Water.

Most of the land cover of Nueva Ecija was cultivated lands (Agricultural) amounting up-to 61 % of the total area. (Table 3). The forest areas were intact in 1989 and 2001 located in the upper and lower right side of the province while in 2010 and 2018 most of the forest areas were converted to fallow and some to urban area (built-up). The trees as a result decreased from 1989 to 2018, in contrast, the buildings continuously expand. The roads generally increased in size overtime while the water bodies have generally decrease overtime.

Table 3: Landcover area in hectares of Nueva Ecija from 1989 to 2018

YEARS AFTER	***0***		***12***		***9***		***8***	
LEVEL 1 **CLASSIFICATION**	**1989**	**%**	**2001**	**%**	**2010**	**%**	**2018**	**%**
AGRICULTURAL	322,561	*59*	325,493	59	331,421	61	332,370	61
FALLOW	389,61	*7*	37,892	7	36,036	7	35,087	6
WATER BODY	4,612	*1*	4,592	1	4,599	1	4,585	1
FOREST	170,225	*31*	166,588	30	161,221	29	160,474	29
BUILT-UP	10,687	*2*	12,411	2	13,660	2	14,340	3
ROADS	682	*0*	752	0	791	0	872	0

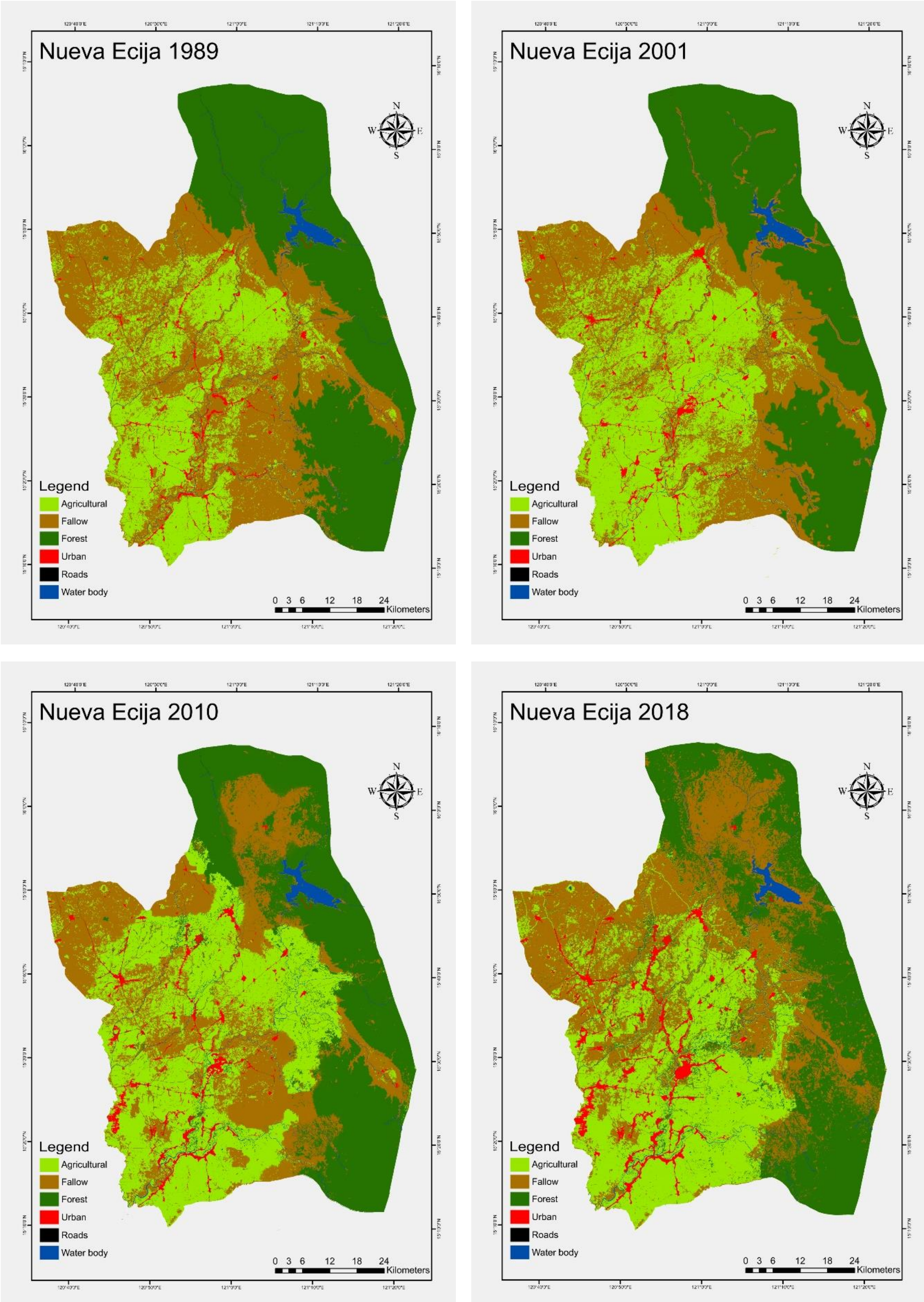

Figure 5: Landcover change map of Nueva Ecija

The results presented in Figure 6 reveal that land cover of Nueva Ecija has changed significantly since 1989. The share of forest declined in the study periods (Table 3). On the contrary, a considerable increase of agricultural areas and fallow were observed in the landscape from 1989 to 2018. Considering 1989 as the base year, built-up areas increased at a much higher rate than any other land cover classes. Forest areas were mainly converted to agricultural areas/fallow and built-ups. Increase in built-ups supported by the data from Philippine Statistical Office (PSA), the increase in the population count from 2000 to 2010 translated to an average annual population growth rate (PGR) of 1.65 percent. This is lower than the 2.37 percent annual PGR of the province between the census years 1990 and 2000.

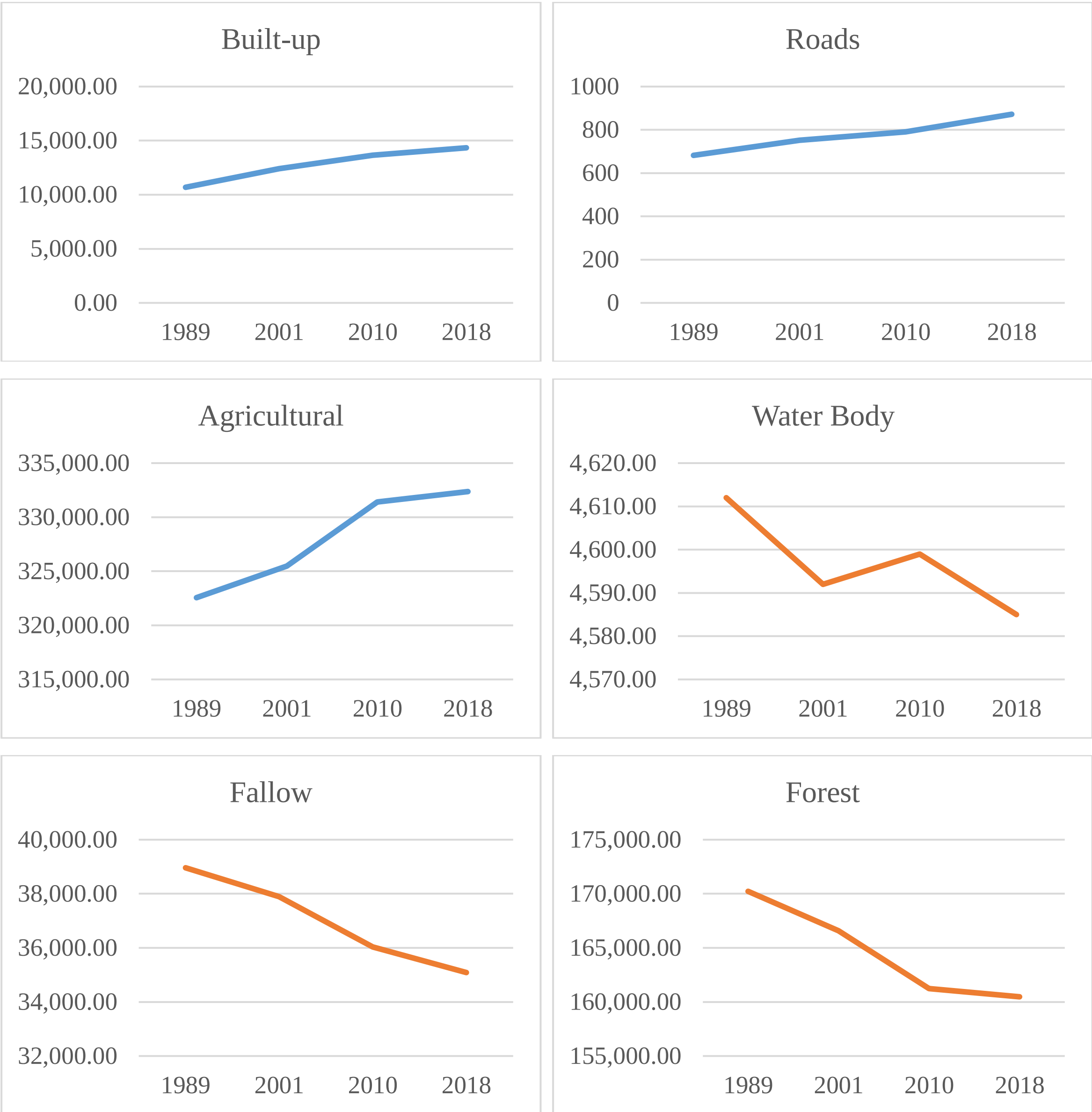

Figure 6. Trend Chart of the Landcover change in Nueva Ecija from 1989-2018

5. CONCLUSION

This study aims investigating land cover changes occurred in Agricultural areas from 1989 to 2018 using remote sensing and GIS. Satellite remote sensing and GIS technology are useful for understanding or assessment of land cover change. The temporal and spatial resolution of the satellite imagery and ground truth information helped project and obtain better result. The change in vegetation and no-vegetation cover using remote sensing and GIS technologies enabled fast and efficient land cover analysis; further data regarding historical changes and local knowledge of the area is recommended which can predict and conclude the causes for the changes. The present study is encouraging to carry out further analysis on how this change would be affecting the existing land cover.

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