# RESEARCH APPLICATIONS OF REMOTE SENSING AND GIS IN DETERMINATION THE VOLATILE AND FORECAST CHANGES IN THE CHAIN OVERLAY MARKOV CHAIN IN Y YEN DISTRICT – NAM DINH PROVINCE – VIETNAM

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Land's natural resource invaluable for each country, the conditions for the existence and development of human beings and other creatures on earth.In recent years, the impact of the economic orientation – society should demand increasing land use, including special-use land as residential land, transport, irrigation land, land for construction structural building infrastructure... tends to rise sharply to agricultural land, continues to shrink. Consequently, the allocation and efficient use of land is a matter of primary concern must be to enable sustainable development, environmental protection and ecology. Therefore researchers identified fluctuations and determine trends change surface coating is a major problem today. And to carry out this study the authors used remote sensing technology, GIS, Markov Chain chains combined in order to determine volatility and forecasting changes overlay in Y Yen district – Nam Dinh province – Viet Nam country. This will create a rationale help managers to grasp the situation in local land use management.

**Keywords: In Nam Dinh Yen, remote sensing, GIS, Markov Chain**

Determination of fluctuations and changing trends of surface coating is an urgent issue in the process of development in our country. Currently information technology is growing strongly, allowing simplification of work to solve complex problems of the economy – society of the country in general and land management sectors in particular. Specifically, remote sensing technology with resources that satellite imagery has a resolution higher and higher, large number of spectral channels, short iteration cycles, cover large spaces and faithfully reflect the earth's surface at the time of shooting. Simultaneously associated with processing capabilities and data analysis of GIS technology has created a useful tool in Research on fluctuation and management of land resources. Addition with the assistance of Markov Chain chain gives basic assumptions about trends in coatings. This is a new method, modern, a lot more advanced countries in the world to adopt and bring better efficiency compared to traditional methods, which we can manage and update revised land information quickly and timely.

Y Yen district, Nam Dinh province, with total area of natural land is 24,129.74 ha (2013). In recent years, the impact of the economic orientation – the society makes the demand for increasingly high land, specialized land tends to increased sharply, agricultural land continues to shrink. Therefore, the allocation and efficient use

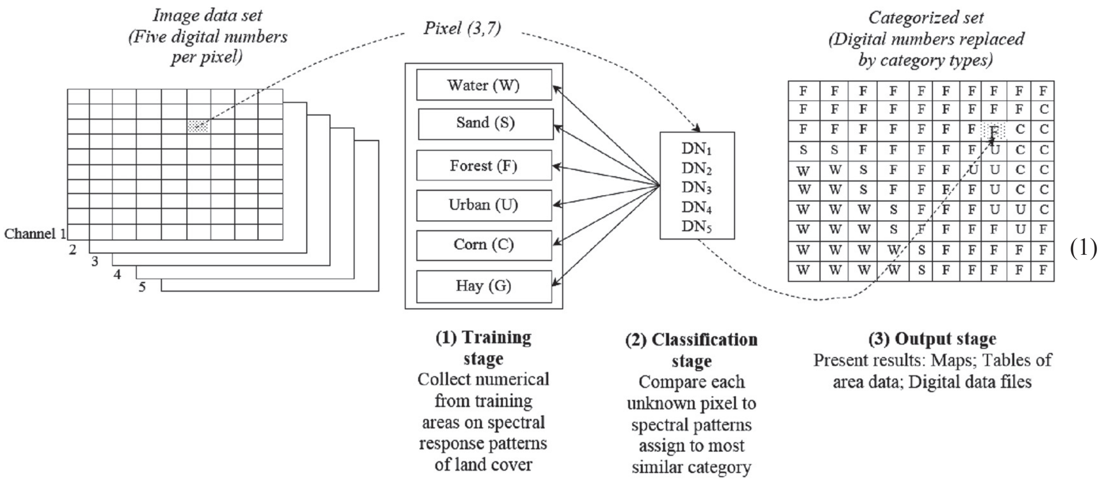



Fig. 1. Classification method with accreditation

of land is a matter to be top concern. Stemming from the practical needs as well as the urgency of identifying changes and trends change overlays Y Yen district – Nam Dinh Province – Viet Nam country the author conducted *"Research Applications of Remote Sensing and GIS in determination the volatily and forecast changes in the chain overlay Markov Chain in Y Yen district – Nam Dinh province – Viet Nam country"*.

## Materials and methods of research

***1. Method classification inspection***

This is a form of classification. The classification criteria are established based on the sample area and enforce decisions based on appropriate algorithms to label each pixel corresponding to a specific service area.Based on data collected on a sample area each sample area, the statistical parameters are determined. From that, the classification criteria used in the process of appointing the pixel belongs to each particular category.

In this research, method chosen to categorize the image classification method has expertise according to the maximum likelihood algorithm.

$$g_i(x) = 1np(\omega_i) - \frac{1}{2}1n|\Sigma_i| - \frac{1}{2}(x - m_i)^T \sum_i^{-1}(x - m_i).$$

Inside $i$ – Object classification; $x$ – The number of spectral channels; $p(\omega_i)$ – Value probability occurs when the object like other objects $\omega_i$; $|\Sigma_i|$ – Covariance matrix of the object $\omega_i$; $\sum_i^{-1}$ – The inverse of the object $\omega_i$; $m_i$ – Spectrum values change vector.

Classification by maximum likelihood method that is considered the statistics of each class of each transmission channel is dispersed in a conventional way and this method takes into account the possibility of a pixel belonging to a certain class. If not choose a probability threshold, it must classify all pixels. Each pixel is assigned to a class with the highest probability. According to this method the spectral distribution channels and the pixel standards will be classified in the class that has the highest probability. This method of classification accuracy, but take time and depend calculate the standard distribution of data. Includes the following steps:

– *Identify the types:* Landsat Data As always reflect honesty, objectivity soil surface at the time of imaging, should map built after deciphering the map vegetation cover. To cater to the construction of image interpretation course, first need to determine the type of land use for the purposes in the research area.

– *Selection of Features:* The characteristics include spectral characteristics and structural features. The selection has important significance, it allows separate object classes together.

– *Choose the form:* The selection of sample areas are critical to the classification results. To ensure accuracy in choosing the right form noting the following requirements:

+ The number of sample areas to suit each object: The number of sample areas too little will not ensure the accuracy. The number of sample areas too little will not ensure the accuracy, whereas if too much will increase the volume of calculations a lot, sometimes disturbing results of calculations;

+ The area of the sample is large enough, and the form is not located near the boundary between the object class;

+ The sample was selected to characterize the object classification and evenly distributed across the research area;

+ Calculation of the sample statistical indicators: After sampling conducted statistical indicators calculation sample area and the difference between the sample.

– *Assessing precision sample file:* Each sample classification will be calculated to compare the difference with the remaining samples.

– *Assessment of image classification accuracy:* The accuracy of the image classification does not depend on the accuracy of the sample but also depends on the density and the distribution of plots.To assess the nature of the errors committed in the course of classifying people based on the index Kappa (κ), the index is within the range from 0 to 1 and indicates the proportional reduction in error is performed by one factor completely random classification.

$$\kappa = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_{i+} \cdot x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+} \cdot x_{+i})}. \quad (2)$$

Inside $N$ – total number of sampling points; $r$ – The object class classification; $x_{ii}$ – Points right field in the 1st class; $x_{i+}$ – The field point of the ith layer of the sample; $x_{+i}$ – Total points of class ith field after sorting.

***2. Methods of determining volatility in comparative overlays after sorting***

The essence of this approach is that the resulting image classification at two different times we established status map overlays at two moments. Then overlay the two maps to overlays mapping volatility (Fig. 2). The status map may take the form of raster or vector maps.

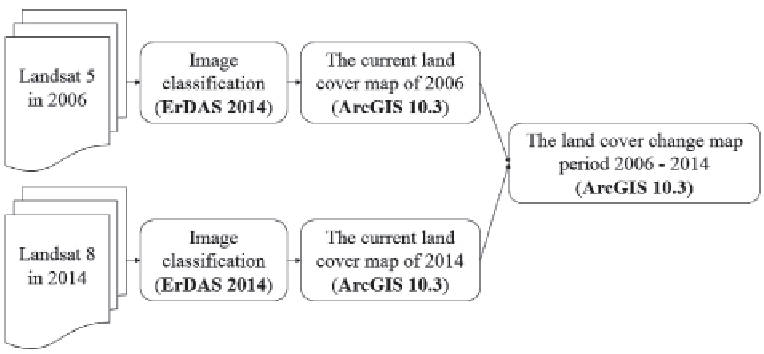



Fig. 2. Comparison method after sorting

Comparison method after classification is the most widely used, simple, easy to understand and easy to implement. After 2 satellite imagery geometrically corrected to conduct independent classification to form two maps. Two maps were compared by comparing pixel matrix forming volatile.

According to J. Jensen, the advantage of this method is that the change from what kind of land into what type of soil; Disadvantages of this method is to classify independent of remote sensing to precision depends on the accuracy of each taxonomy and high precision often because of errors in the classification of each photo remain in the map changes.

***3. Method of determining the trend change in the chain overlay Markov Chain***

Using Markov Chain chain forecasts trend to change land use in a certain period. Markov Chain chain model is used to determine the ability to change the land use based on evolution of land use and the factors affecting the change.

$$\begin{pmatrix} \text{The proportion} \\ \text{of land use in} \\ \text{the first time} \end{pmatrix} \times \begin{pmatrix} \text{Matrix change of} \\ \text{land use between the} \\ \text{first and second times} \end{pmatrix} = \begin{pmatrix} \text{The proportion} \\ \text{of land use type in} \\ \text{the second time} \end{pmatrix}. \quad (3)$$

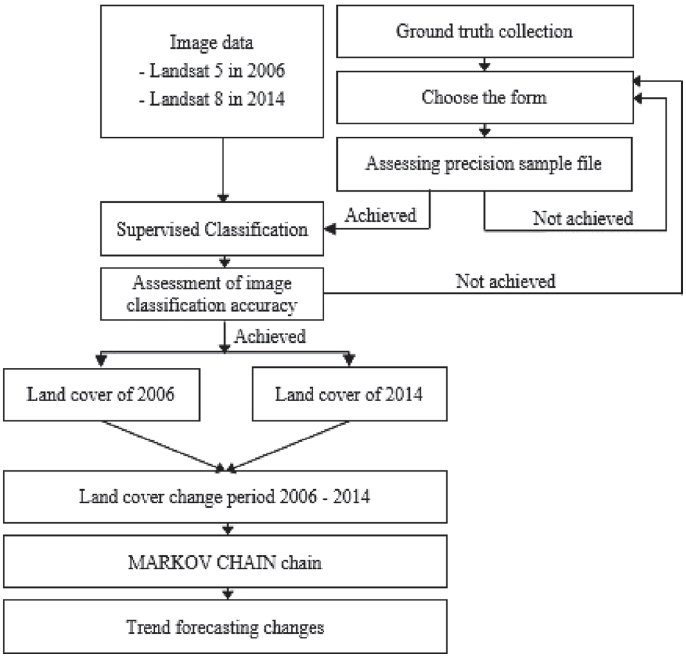



Fig. 3. The process of identifying and forecasting volatility change overlays

Can be rewritten as a generalization of the matrix:

$$[V1, V2, V3]_1 \times \begin{bmatrix} \gamma_{11}, \gamma_{12}, \gamma_{13} \\ \gamma_{21}, \gamma_{22}, \gamma_{23} \\ \gamma_{31}, \gamma_{32} \ \gamma_{33} \end{bmatrix} = [V1, V2, V3]_2 .$$

Inside: $\gamma_{ij}$ is probable change is determined from the overlay map land use at different times.To predict the distribution of land use in the next moment can be applied to this model.

***4. The process of identifying and forecasting volatility change overlays***

## Results of research and their discussion

***1. Introduce Landsat satellite system***

Landsat satellite is experimental aerospace agency NASA (National Aeronautics and Space Administration). It is a system very close orbit satellites (orbital plane angle than the equatorial plane is 98,2°), originally named ERST (Earth Remote Sensing Satellite), after 2 years since launch ERST – renamed Landsat 1, then the Landsat – TM and Landsat – ETM.

The first Landsat satellite was launched into orbit dated 23.07.1972 and retired on 01.06.1978 date named Landsat 1. At present there are 8 Landsat generation. Landsat research applications in many fields of research from the status quo to monitor fluctuations and most commonly used, at low cost.

***2. Research Documentation***

– Satellite images used for research are downloaded directly from the site (*http://earthexplorer.usgs.gov/*) of the US Geological Survey (United States Geological Survey – USGS) to area Y Yen District , Nam Dinh province include:

**Table 1**

The Landsat satellite system

| Satellite | Launch | Decommissioned | Remote |
|---|---|---|---|
| Landsat 1 | 23.07.1972 | 06.01.1978 | MSS – TM |
| Landsat 2 | 22.01.1975 | 25.02.1982 | MSS – TM |
| Landsat 3 | 05.03.1978 | 31.03.1983 | MSS – TM |
| Landsat 4 | 16.07.1982 | 15.06.2001 | MSS – TM |
| Landsat 5 | 01.03.1984 | 08.1995 | MSS – TM |
| Landsat 6 | 05.03.1993 | Failure lunch | TM/ETM |
| Landsat 7 | 15.04.1999 | Active | ETM + |
| Landsat 8 | 11.02.2013 | Active | OLI – TIRS |

+ Landsat satellite 5 data with 30 m resolution for spectral channels 1, 2, 3, 4, 5, 7 and 60 meters for secondary channels 6 were included in the day 06/11/2006, the path is 126 and the row is 46.

+ Landsat satellite 8 data with 30 m resolution for spectral channels 1, 2, 3, 4, 5, 6, 7, 9; 15 m for 8-channel Universal and Universal Channel 100m for 10, 11 were enrolled in day 10/11/2014, the path is 126 and the row is 46.

***3. Results and Discussion***

**3.1. Establishing image interpretation course**

To establish an image interpretation course, it is a need to identify land types under land use purposes in the research area. Basing on the current situation of land use, the features of landsat data and image resolution, the author has set out 4 land cover types as shown in the classification table of land use types (Table 4). Thereby, the establishment of the landsat image interpretation course is performed by carrying out field research with the support of handheld GPS (Table 5).

**3.2. Development of template file and assessment of template file accuracy**

Basing on the field survey data, the current land use map, four types of land cover have been highlighted directly onto the image that needs classifying. (Fig. 4).

**Table 2**

Data collected satellite

| Satellite | Data name | File date | Path/Row |
|---|---|---|---|
| Landsat 5 | LT51260462006310BJC00 | 06.11.2006 | 126/ 46 |
| Landsat 8 | LC81260462014284LGN00 | 11.10.2014 | 126/46 |

**Table 3**

Comparison of images characteristic spectral channels Landsat satellite 5 and Landsat satellite 8

| Landsat 5 TM | | | Landsat 8 OLI and TIRS | | |
|---|---|---|---|---|---|
| | | | 30 m Coastal/Aerosol | 0,435–0,451 µm | Band 1 |
| Band 1 | 30 m Blue | 0,441–0,514 µm | 30 m Blue | 0,452–0,512 µm | Band 2 |
| Band 2 | 30 m Green | 0,519–0,601 µm | 30 m Green | 0,533–0,590 µm | Band 3 |
| Band 3 | 30 m Red | 0,631–0,692 µm | 30 m Red | 0,636–0,673 µm | Band 4 |
| Band 4 | 30 m NIR | 0,772–0,898 µm | 30 m NIR | 0,851–0,879 µm | Band 5 |
| Band 5 | 30 m SWIR-1 | 1,547–1,749 µm | 30 m SWIR-1 | 1,566–1,651 µm | Band 6 |
| Band 6 | 60 m TIR | 10,31–12,36 µm | 100 m TIR-1 | 10,60–11,19 µm | Band 10 |
| | | | 100 m TIR-2 | 11,50–12,51 µm | Band 11 |
| Band 7 | 30 m SWIR-2 | 2,064–2,345 µm | 30 m SWIR-2 | 2,107–2,294 µm | Band 7 |
| | | | 15 m Pan | 0,503–0,676 µm | Band 8 |
| | | | 30 m Cirrus | 1,363–1,384 µm | Band 9 |

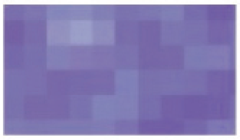
**Table 4**

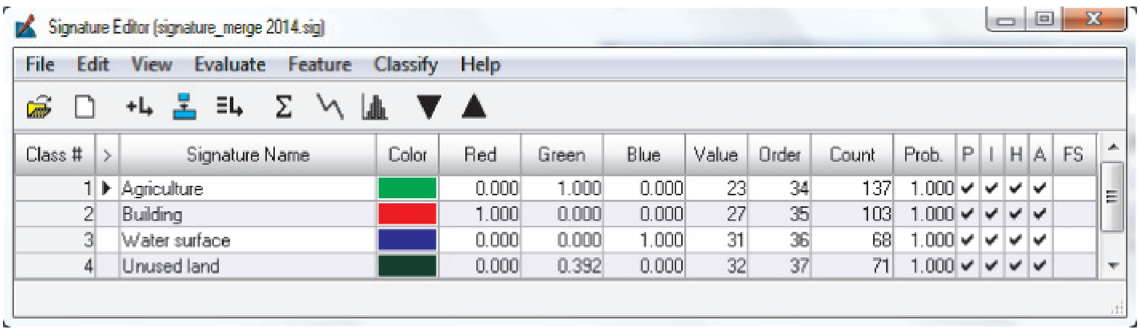
Classification ofland use types in Y Yen district

| Land cover type | Description |
|---|---|
| Agriculture | Paddy rice;Annual crops, Pedestrial crops; ... |
| Building | Residential land;Land used for transportation;Land in industrial zones;Land used as ground for construction of production and business premises;Land for construction of offices, public service delivery institutions;Land with communal houses, temples;Land for cemeteries, graveyards; … |
| Water surface | Land with rivers, streams, canals, and specialised water surface. |
| Unused land | Unused land. |

**Table 5**

Image interpretation sources Landsat 5 – 2006 and Landsat 8 – 2014

| Land cover type | Image 2006 | Image 2014 | Field image |
|---|---|---|---|
| Agriculture |  |  |  |
| Building |  |  |  |
| Water surface |  |  |  |
| Unused land |  |  |  |



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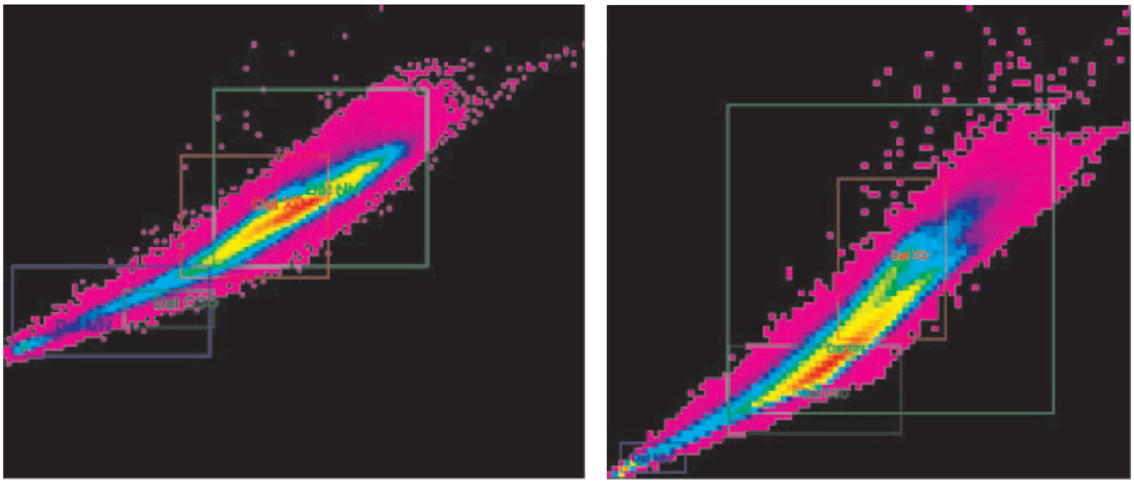
| Class # | > | Signature Name | Color | Red | Green | Blue | Value | Order | Count | Prob. | P | I | H | A | FS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | > | Agriculture | | 0.000 | 1.000 | 0.000 | 23 | 34 | 137 | 1.000 | ✓ | ✓ | ✓ | ✓ | |
| 2 | | Building | | 1.000 | 0.000 | 0.000 | 27 | 35 | 103 | 1.000 | ✓ | ✓ | ✓ | ✓ | |
| 3 | | Water surface | | 0.000 | 0.000 | 1.000 | 31 | 36 | 68 | 1.000 | ✓ | ✓ | ✓ | ✓ | |
| 4 | | Unused land | | 0.000 | 0.392 | 0.000 | 32 | 37 | 71 | 1.000 | ✓ | ✓ | ✓ | ✓ | |

Fig. 4. Template file of Landsat 8 – 2014

Basing on the features of spectral reflectance energy of the selected objects in the template file, to conduct the calculation of the difference between templates, and the selected evaluation method is Feature Space Layers (spectral space), it can be seen that the less the spectral range of intersecting layers is, the higher the accuracy is. Thereby, it can be found that the accuracy of the selected template file on both images is good (Fig. 5).



a b

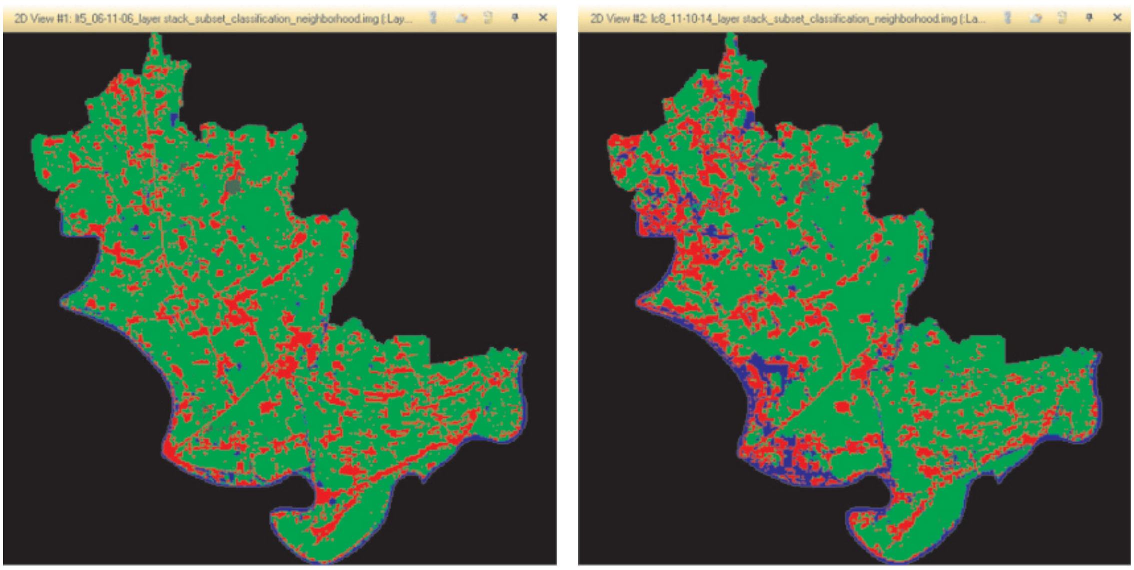
Fig. 5. Evaluation result ofthe template file accuracy
Landsat image 5 – 2006 (a) and Landsat image 8 – 2014 (b)

**3.3. Image classification and evaluation of the accuracy of classifying result**

With the tested classification method under Maximum likelihood, the results obtained are classification image in 2006 in 2014 (Fig. 6), simultaneously apply Majority Analysis against the obtained classification results to combine scattered pixels or the pixels classified in classes into the class containing it.

To evaluate the accuracy of image classification results, for the image classification in 2014, handheld GPS shall be used to compare to the field research with GPS 100 points; as for image classification in 2006, to evaluate the accuracy, the author has combined field surveys and current land use map in 2005 with 103 points. The evaluation process has been automatically performed on ERDAS 2014 and achieved good results.

– The accuracy of the classification result of Landsat image 5 – 2006 is 97,00 % and Kappa statistic is 0.9575. (Fig. 7, a).



a b

Fig. 6. Image classification results
Landsat image 5 – 2006 (a) and Landsat image 8 – 2014 (b)

```
                CLASSIFICATION ACCURACY ASSESSMENT REPORT
                -----------------------------------------
ERROR MATRIX
-------------
                                  Reference Data
                                  --------------
Classified Data   Dat NN      Dat XD       Dat MN       Dat CSD      Row Total
---------------   ----------  ----------   ----------   ----------   ----------
       Dat NN         34           0            2            1           37
       Dat XD          0          35            0            0           35
       Dat MN          0           0           17            0           17
      Dat CSD          0           0            0           11           11

Column Total          34          35           19           12          100
                ----- End of Error Matrix -----
ACCURACY TOTALS
----------------

          Class   Reference     Classified     Number  Producers      Users
          Name      Totals        Totals       Correct  Accuracy      Accuracy
     ----------  ----------   ----------      -------  ---------     -----
         Dat NN       34            37            34    100.00%       91.89%
         Dat XD       35            35            35    100.00%      100.00%
         Dat MN       19            17            17     89.47%      100.00%
        Dat CSD       12            11            11     91.67%      100.00%

         Totals      100           100            97

Overall Classification Accuracy =      97.00%
                ----- End of Accuracy Totals -----
KAPPA (K^) STATISTICS
---------------------

Overall Kappa Statistics = 0.9575

Conditional Kappa for each Category.
------------------------------------

Class Name                 Kappa
----------                 -----
   Dat NN                  0.8771
   Dat XD                  1.0000
   Dat MN                  1.0000
  Dat CSD                  1.0000

                ----- End of Kappa Statistics -----
```

Landsat image 5 – 2006 (a)

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                CLASSIFICATION ACCURACY ASSESSMENT REPORT
                -----------------------------------------
ERROR MATRIX
-------------
                                  Reference Data
                                  --------------
Classified Data   Dat NN      Dat XD       Dat MN       Dat CSD      Row Total
---------------   ----------  ----------   ----------   ----------   ----------
       Dat NN         32           3            3            1           39
       Dat XD          2          33            4            2           41
       Dat Mn          0           0           14            0           14
      Dat CSD          0           0            0            9            9

Column Total          34          36           21           12          103
                ----- End of Error Matrix -----
ACCURACY TOTALS
----------------

          Class   Reference     Classified     Number  Producers      Users
          Name      Totals        Totals       Correct  Accuracy      Accuracy
     ----------  ----------   ----------      -------  ---------     -----
         Dat NN       34            39            32     94.12%       82.05%
         Dat XD       36            41            33     91.67%       80.49%
         Dat Mn       21            14            14     66.67%      100.00%
        Dat CSD       12             9             9     75.00%      100.00%

         Totals      103           103            88

Overall Classification Accuracy =      85.44%

                ----- End of Accuracy Totals -----
KAPPA (K^) STATISTICS
---------------------

Overall Kappa Statistics = 0.7914

Conditional Kappa for each Category.
------------------------------------

Class Name                 Kappa
----------                 -----
   Dat NN                  0.7321
   Dat XD                  0.7000
   Dat Mn                  1.0000
  Dat CSD                  1.0000

                ----- End of Kappa Statistics -----
```

and Landsat image 8 – 2014 (b)

Fig. 7. Accuracy evaluation result of classified

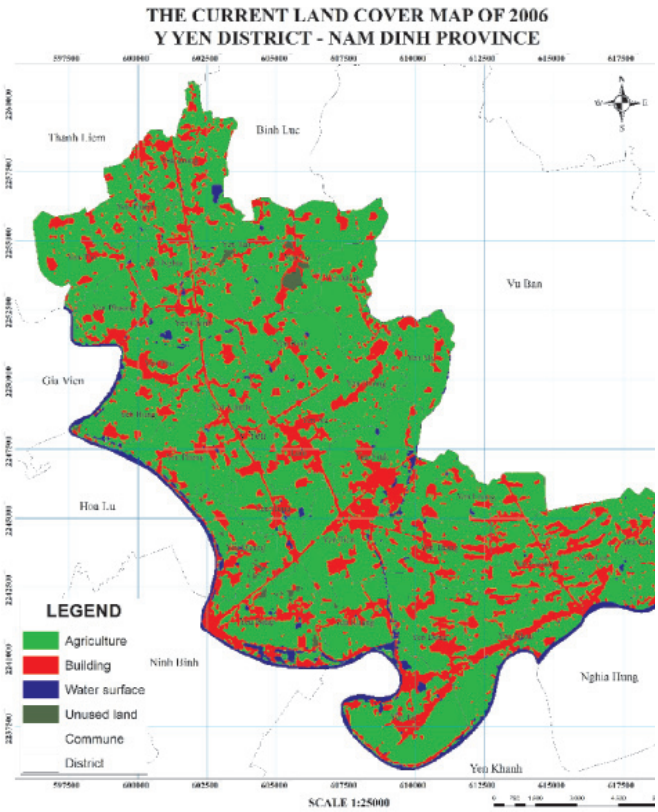
– The accuracy of the classification result of Landsat image 8 – 2014 is 85,44 % and Kappa statistic is 0.7914. (Fig. 7, b).

**3.4. Convert the classified image into vector**

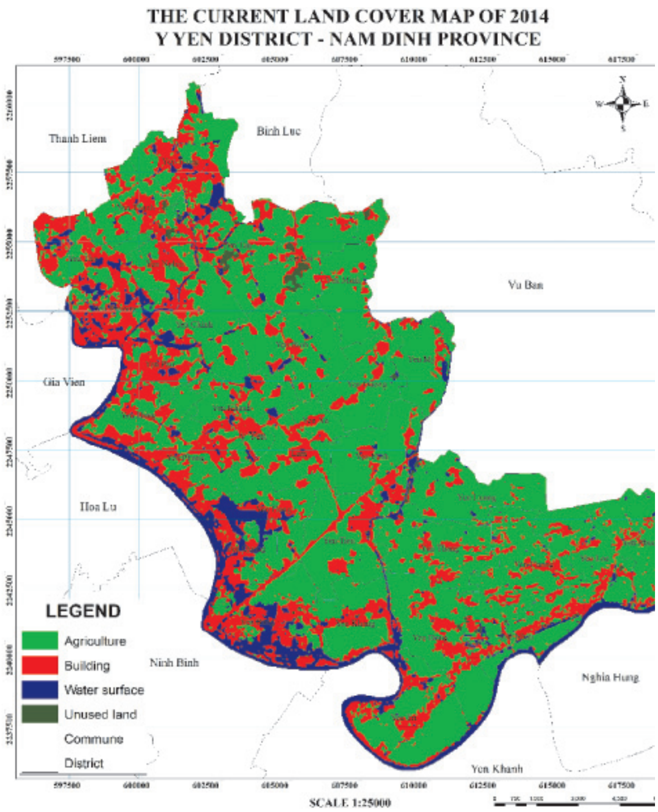
In order to form a current land cover map basing on remote sensing and GIS, the last manipulation to create the current land cover map for users is to convert images from raster to vector (Fig. 8). This is the main mission of the integration of remote sensing and GIS.

**3.5. Determination of land cover change**

Analyzing land cover change should be based on table of interchange of land cover types, especially the Land for construction. Using Union to identify the area change of land cover types by stacking two land cover maps of 2006 and 2014 to find out the changing area (Fig. 9), using Tabulate Are to build the table of interchange of land cover types (Table 7), the change is clearly shown in the chart of Fig. 10.




a




b

Fig. 8. The current land cover map of 2006 (a) and thecurrent land cover map of 2014 (b)

**Table 6**

Statistics of the area of land cover types

| Land cover type | Year 2006 | | Year 2014 | | Increase (+) Reduced (–) |
|---|---|---|---|---|---|
| | Area (ha) | Percentage (%) | Area (ha) | Percentage (%) | |
| Agriculture | 16 516,39 | 68,45 | 15 970,68 | 66,19 | –545,71 |
| Building | 4 921,43 | 20,40 | 5 755,79 | 23,85 | +834,36 |
| Water surface | 2 471,74 | 10,24 | 2 190,34 | 9,08 | –281,40 |
| Unused land | 219,05 | 0,91 | 211,80 | 0,88 | –7,25 |
| **Total** | **24 128,61** | **100** | **24 128,61** | **100** | |

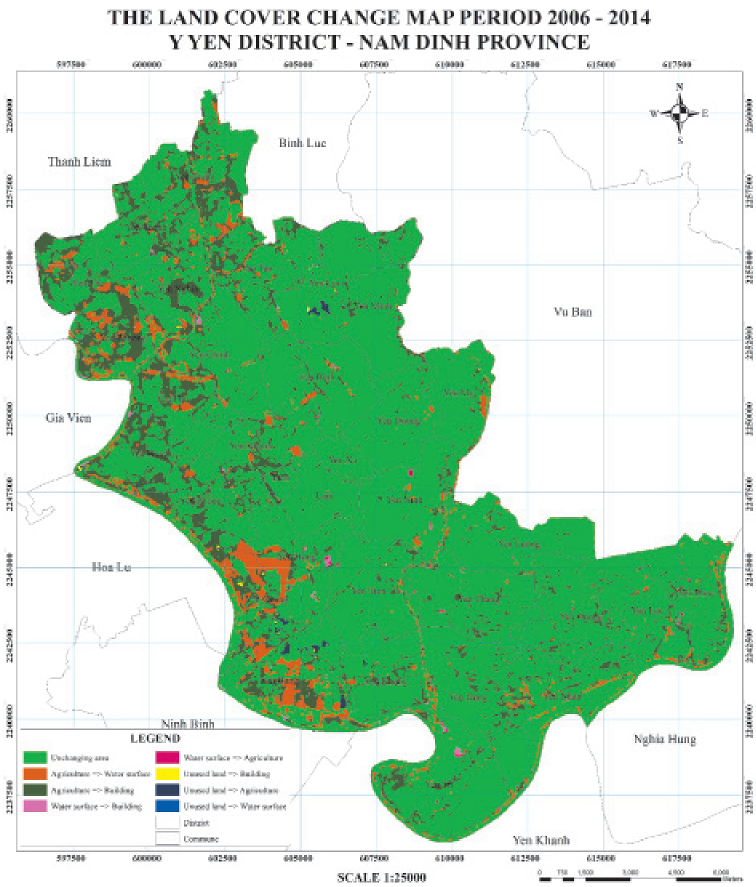



Fig. 9. The land cover change maps period 2006–2014

**Table 7**

Chart of land cover change period 2006–2014

| Land cover type | Agriculture | Building | Water surface | Unused land | Total – 2014 |
|---|---|---|---|---|---|
| Agriculture | **15 816,39** | 0 | 153,00 | 1,29 | 15 970,68 |
| Building | 501,65 | **4 921,43** | 329,65 | 3,06 | 5 755,79 |
| Water surface | 198,35 | 0 | **1 989,09** | 2,90 | 2 190,34 |
| Unused land | 0 | 0 | 0 | **211,80** | 211,80 |
| Total – 2006 | 16 516,39 | 4 921,43 | 2 471,74 | 219,05 | **24 128,61** |
| Increase | 154,29 | 834,36 | 201,25 | 0 | 1 189,90 |
| Reduced | 700,00 | 0 | 482,65 | 7,25 | 1 189,90 |
| **Land cover change** | **–545,71** | **+834,36** | **–281,4** | **–7,25** | |

**Table 8**

Matrix of change ratePeriod 2006–2014

| Land cover type | Agriculture | Building | Water surface | Unused land |
|---|---|---|---|---|
| Agriculture | 0,96 | 0,03 | 0,01 | 0 |
| Building | 0 | 1 | 0 | 0 |
| Water surface | 0,06 | 0,13 | 0,81 | 0 |
| Unused land | 0,01 | 0,02 | 0,01 | 0,97 |

| | | | |
|---|---|---|---|
| 0.96 | 0.03 | 0.01 | 0.00 |
| 0.00 | 1.00 | 0.00 | 0.00 |
| 0.06 | 0.13 | 0.81 | 0.00 |
| 0.01 | 0.02 | 0.01 | 0.97 |

×

| Current land in 2014 | | | |
|---|---|---|---|
| Agriculture | Building | Water surface | Unused land |
| 15,970.68 | 5,755.79 | 2,190.34 | 211.80 |

=

| Current land in 2022 | | | |
|---|---|---|---|
| Agriculture | Building | Water surface | Unused land |
| 15,430.64 | 6,535.94 | 1,957.24 | 204.79 |

**3.6. Forecasting of land cover change**

The forecasting of land cover change shall base on the proportion of urban land changes due to the transformation of other land use types. Basing on the change of land cover types in Table 7, the author has identified rate of transformation as shown in Table 8.

To predict the land cover changes in the future by MARKOV CHAIN, we multiply two matrices together including the matrix of current land in 2014 and the matrix of change rate period 2006–2014 (Table 8).

Similarly, if we want to predict the land cover change of the following year, we shall multiply the matrix of current land cover of the following year by the matrix of change rate.

From the chart in Fig. 10, it is shown that from 2006 to 2014, land for construction got the highest increase up to 834,36 hectares, agricultural land reduced to 545,71 hectares, water surface land reduced to 281,4 hectares, unused land reduced to 7,25 ha. By 2022, the land for construction will reach 6 535,94 hectares, agricultural land will reach 15 430,64 hectares,

**Table 9**

Forecasting of land cover change by 2030 *(Unit: Hectare)*

| Year | Agriculture | Building | Watersurface | Unusedland |
|---|---|---|---|---|
| 2006 | 16 516,39 | 4 921,43 | 2 471,74 | 219,05 |
| 2014 | 15 970,68 | 5 755,79 | 2 190,34 | 211,80 |
| 2022 | 15 430,64 | 6 535,94 | 1 957,24 | 204,79 |
| 2030 | 14 899,02 | 7 268,51 | 1 763,08 | 198,01 |

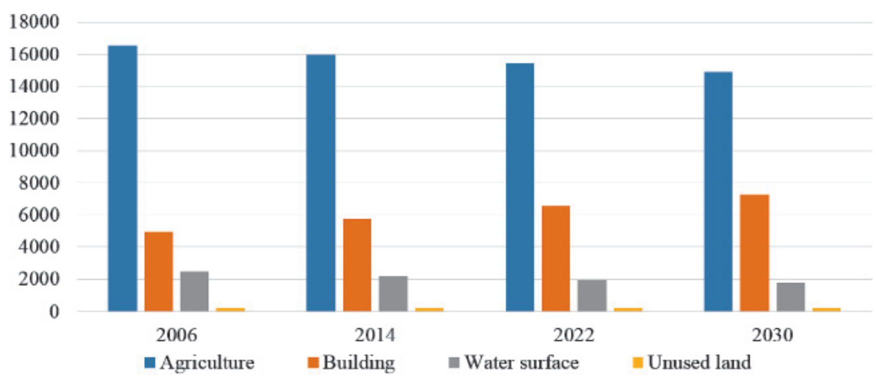



Fig. 10. Chart of Forecasting of land cover changeby 2030

the water surface land will reach 1 957,24 hectares, and the unused land will reduce to 204,79 hectares. By 2030, land for construction will reach 7 268,51 hectares, agricultural land will be 14 899,02 hectares, water surface land will be 1 724,87 hectares and the unused land will reduce to 198,01 ha (Table 9 and Fig. 10).

## Conclusion

Basing on the Landsat image 5 in 2006 and Landsat image 8 in 2014 of Y Yen district, an interpretation course of four land use types including agricultural land, land for construction, water surface land and unused land has been built as the basis for interpretation of remote sensing image.

The interpretation results shown that in period 2006–2014, the total area of non-agricultural land increased by 834,36 hectares, accounting for 3,46 % of the total natural area of the district, of which the agricultural land area transferred to non-agricultural land is 545,71 hectares, accounting for 2,26 %, the water surface land transferred into non-agricultural land is 281,4 hectares, accounting for 1,17 %, that of the unused land is 7,25 hectares, accounting for 0,03 %. This change shows that the pace of development of the district and people are more and more improved.

In combination with MARKOV CHAIN in forecasting of land cover change by 2030, this forecast shall only be exact without any change regarding land use policy in the applicable year. And vice versa, if there is any change regarding land use policy, this forecast shall not work effectively.

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