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The Knowledge-Based Analysis on Medium Resolution Images of Remote Sensing to Extraction Information Land use Type SCS-CN, the Case Study on Grompol Watershed

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Abstract

Remote sensing imagery Landsat-8 is one image that has a good temporal resolution; in addition to the availability of data, this image can be obtained free of charge. Land cover type SCS-CN is part of a unit of land that affects runoff. The use of medium resolution imagery in reducing the SCS-CN land use type is considered relatively difficult, and it yields less good accuracy. Limitations on multispectral classification only rely on facts derived from spectral reflection, so that the two data are the same since different characteristic results are not so good. This study aims to determine the accuracy of precision medium-resolution imagery in reducing parameter land use type SCS-CN by using the knowledge-based analysis. The importance of understanding the landscape-ecology can be used to assist the translation from land cover in the form of land use. Vegetation factors and ecosystems are often used to generate metrics-based landscape. Accuracy from the interpretation of remote sensing image medium-resolution is obtained by 85.17%. Therefore, Landsat-8, in addition to easy retrieval of data, can also be used to identify the type of land cover SCS-CN, which is useful for the interests of surface water resources.

Keywords: knowledge-based, landsat, land use SCS-CN, remote sensing

1. Introduction

The remote sensing data have been used in various fields of application, as well as in the field of hydrology studies [1]. The use of remote sensing and GIS technology in runoff estimation has gained increased attention [2]. Efficiency in integrating spatial and non-spatial databases is important to make the hydrological modeling of remote sensing data more widely used [3]. One of the most common functions in the image processing system is primary image classification of land use information extraction [4]. The data classification is important for making decisions relating to the planning and management of land resources [5,6]. Monitoring land use is useful to obtain data on changes that can be used for analysis [7].

Land use data generated from remote sensing image interpretation are the basis of hydrological response units [8], highly correlated with the characteristics of the watershed and in the process of a land surface [9].
The physical parameters and interactive distribution of various processes consider the spatial heterogeneity [10]. Thus, it can be used to estimate the spatial variation of hydrological parameters [3]. The use of the spatial data distribution model will be more accurate by using remote sensing and GIS techniques [11]. The use of remote sensing data to estimate runoff depth with the SCS-CN method shows good results that can be recommended for estimating runoff [12,13]. The remote sensing data from the Landsat imagery is used to obtain information about landform, soil texture, and the use of land [14].

Landsat satellites have been operating since 1972; Landsats 2 and 3 were respectively launched in 1975 and 1978 with the same configuration. Landsat-4 was launched in 1984 with a new instrument called a thematic mapper (TM), and in 1993 the launch of Landsat 6 failed. Landsat-7 was launched in 1999 to bring the ETM + sensor [15]. In May 2003 the Landsat 7 satellite was damaged in the SLC (scan line corrector). In 2013, Landsat 8 officially began operations with a sensor OLI (operational land imager) and thermal infrared (TIRS) [16,17].

The Landsat imagery has a medium resolution and is provided for free with a relatively good temporal resolution. The Landsat images are widely used [18]. It provides remote sensing data to monitor and manage the resources of the earth [19]. Although the first generation of Landsat sensor is no longer in operation, this satellite acquires land conditions around the world [20]. This is because that the mission of the program is to provide acquisition of Landsat multispectral data recurring on the global earth's surface [15].

Land cover classification of multispectral information with remote sensing data takes into consideration the spectral value criterion [21]. The criterion categorization is done automatically [22]. However, the interpretation remains based on the external knowledge assessment area with the training area [18] as groups of pixels that form the feature space which shows the spectral values [21,23]. Limitations in this classification only rely on facts derived from spectral reflection [24] and also on the similarity in spectral values because of reduced variability and difficulty to be separated [25,26]. The analysis of spectral values for the same two data gives different characteristics results [27].

Knowledge-based methods try to use human knowledge in solving problems [28]. The complexity of the data is processed using GIS as spatial data sets, so that the geographical analysis is considered to simplify the decision process [27]. The addition of external variables, such as other data sources, is needed in determining the decision on the classification of types of land use [18,24], in addition to the practical field experience in knowing the specific application also petrified in classification [28,29]. Aspects of spectral reflection, spatial aspects, and external variables are associated with the environment as a feature in the classification [24,30]. The use of a hierarchical structure can be used to identify objects in a comprehensive manner [23].

Biomass at the surface is the result of the interaction possibilities of environmental factors [31]. The importance of understanding the landscape-ecology can be used to assist in translating land cover into land use or specific land cover to a particular method. Factors of vegetation and ecosystems are often used to generate landscape-based metrics to assess and monitor conditions during a particular time interval [32]. Landform and vegetation as well as the dependence relationship, both provide a concept for the use of land [33].

NDVI (Normalized Difference Vegetation Index) transformation is associated with vegetation [18], and the use of this transformation is simple and can reduce the spectral characteristics of heterogeneous land cover [34]. NDVI in land cover classification of multi-temporal produces relatively good classification accuracy [35]. Land cover types of different vegetation cause the variation of the spectral reflection which indicates that there is a diversity of ecosystems [36]. The composition of land cover change is an important factor that affects the ecosystem [32].

The analysis of soil based landscape is the geographical distribution of soil characteristics, and soil boundary is equivalent to constituent units of land that can be used as the landscape limit [37]. The study emphasizes the shape of the landscape function of topography, lithology, soil, hydrology, and vegetation / land use, which is used as a classification approach of the surface, and the shape of geomorphology brings criterion differences on the surface [38].

Landsat imagery has a pixel size of 30 meters x 30 meters. Hence, with the medium spatial resolution is relatively difficult to obtain good accuracy in reducing the parameters on the SCS-CN method in particular classification of land cover / land use. This study aims to determine the accuracy of medium resolution imagery in reducing parameter cover / land use type SCS-CN by using the knowledge-based analysis.

2. Methods

This research was conducted in the Grompol watershed (subzone of the upstream Bengawan Solo River Basin) located in Karanganyar, Central Java province with geographical coordinates between 110 ° 55'15 "and 111 ° 11'20 " east longitude and between 7 ° 30 '10 " and 7 ° 38'50 " south latitude (Figure 1). The location of this research is in western slopes of Lawu Volcano. The data
used in this study include: Landsat-5 (1994); Landsat-8 (2013); RBI map, scale 1: 25000 (2000); geological maps, scale 1: 100000 (1992); soil map, scale 1: 250000 (1966); and data analysis laboratory tests: texture, moisture content, organic content.

Landsat-8 (2013) has been georeferenced well, considering that the level of this image already corrects LIT showing the radiometric correction and geometric correction systematically, using the control points for the accuracy of DEM topography [39]. This level consists of product data of L1R using ground control points (GCP), cartographic projection, with the reference to the WGS 84 [40].

Radiometric calibration is done to change the pixel values (DN) into the form of radiance to the reflectance at the sensor. L1 Data pixel values are represented as a digital number (Qcal), for radiometric calibration, and the pixel values (Q) of the image data level 0 are converted to absolute-radiance units using floating-point calculations 32 bit. Conversion of Qcal in the L1 product back to Lλ requires knowledge of the original rescaling factor [41].

Landsat-8 has a 16-bit dynamic range better than previous satellites [42]. The conversion value of the pixel values into radiance on Landsat-8 is different from the previous series. In this study, Lminλ, Lmaxλ, Qcalmin, and Qcalmax have been replaced with a radiance minimum band x, radiance maximum band x, quantize cal min band x, and quantize cal max band x. Instead, the study uses this value in a set of coefficients, radiance multi band x and radiance add band x (x = number of bands) contained in the file metadata (MTL). The equation for the conversion of DN to radiance is as follows [43]:

\[ L_{\lambda} = M L Q_{\text{cal}} + A L \]
where, \( L_\lambda \) is a radiance value in watts / (metersquared * ster * \( \mu m \)); \( M_\lambda \) is a band-specific rescaling factor multiplication of metadata (multi-band radiance \( x \), where \( x \) is the number of bands); \( Q_{cal} \) is a calibration quantized pixel value of DN (digital number); \( A_\lambda \) is a band-specific additive rescaling factor of metadata (radiance_add_band \( x \), where \( x \) is the number of bands). DN value conversion to reflectance uses the pixel values (Qcal) and the reflection coefficient of rescaling in the file metadata (MTL) for reflectance_mult_band \( x \) and reflectance_add_band \( x \), and these two values are the same for each band in the image because those cover the same range of reflectance values. The following equation is used to convert the DN to the reflectance values on Landsat-8 [43]:

\[
\rho'_\lambda = M_\lambda Q_{cal} + A_\lambda
\]

(2)

\[
\rho_\lambda = \rho'_\lambda / (\cos \theta)
\]

(3)

where, \( P_\lambda \) is the value of the reflection object on the image sensor (reflectance at the sensor); \( \rho'_\lambda \) is the value of the reflection of an object on the image sensor without correction for the angle of the sun; \( M_\rho \) is a band-specific rescaling factor of the multiplication of metadata (reflectance_mult_band \( x \), where \( x \) is the number of bands); \( Q_{cal} \) is a calibration quantized pixel value of DN (digital number); \( A_\rho \) is a band-specific additive rescaling factor of metadata (reflectance_add_band \( x \), where \( x \) is the number of bands); \( \theta \) is an angle of peak sun.

---

**Figure 2. Flowchart of the Study**
Classification uses NDVI transformation associated with the landforms in the search for land cover information SCS-CN, and NDVI transformation equation is as follows [28].

\[
NDVI = \frac{\rho_{\text{nir}} - \rho_{\text{red}}}{\rho_{\text{nir}} + \rho_{\text{red}}} \tag{4}
\]

Thus, \( \rho_{\text{nir}} \) is near an infrared channel (band 5), and \( \rho_{\text{red}} \) is the Red channel (band 4). Map results of NDVI transformation have done a range of classification that will be checked in the field. This was performed on each sample of the plot of NDVI classes in each unit of land characteristics, and the sample size of the plot is the following equation [44]:

\[
A = P(1+2L) \tag{5}
\]

Thus, \( A \) represents dimensions minimum sample; \( P \) represents spatial resolution imagery; \( L \) represents RMSE, root mean square error.

Landform identification is easier with a visual what? by considering key image interpretation, such as shape, size, texture, and pattern of flow. The use of composite RGB 457 gives the impression of a topographic surface clearly, so that the appearance of the configuration of the earth's surface is easy to be recognized. The assumptions used in the study of landforms and slope can represent an analysis of soil characteristics or land characteristics that show a realistic surface, i.e., the relationship in each landform morphology, processes, lithology, and general topography. Figure 2 is a flow chart of the research.

Testing the accuracy of the model uses a dimension of a nxn matrix where \( n \) is the number of classes, and this matrix shows the relationship between the two sample measurements, i.e. from observation data (reference data) and data from the classification (classified data). A test of accuracy was also conducted for each class that has different accuracy, that is, from the standpoint of the map makers’ and map users’ points of view [21].

### 3. Results and Discussion

**Radiometric calibration.** Landsat-8 (OLI) recording the date of July 19, 2013 is considered easier in the process, namely to obtain reflectance (Table 1), and the value of pixel (DN) can be directly obtained by looking at the data conversion MTL (metadata file). This image has a sun elevation angle 44.90347873° with Multi Band Reflectance (Mp) of 0.00002 and Reflectance Add Band (Ap) of -0.100000.

The results obtained for the value of NDVI in 2013 show the highest value of 0.802 with the mean and standard deviation of ±0.530075 and ±0.145853. The lowest value shows the results of -0.385. Testing among vegetation classes then used samples in the field, using the plotting area of 60 m x 60 m. These results are used to determine the correlation among the results of the regression of NDVI values of the vegetation density in the field as shown in Figure 3.

Regression (R2) of 0.89 was obtained, and a discrepancy that occurs is influenced by many factors, especially their rotation cropping season between remote sensing image recording data and field measurements. As is known in the upstream region, a growing season moor or fields have high cropping intensity, so that this affects the outcome of the value of this regression. In addition to the downstream areas, high cropping intensity also occurs, and the area with good irrigation of paddy fields has resulted in the use of high productivity.

**NDVI transformation.** The results of the NDVI measurements (Figure 3) with a density of vegetation on the ground show that the lowest value (-0.384-0.070) is the value of a body of water where the measurements are performed on samples for plotting Delingan Reservoir. In 0.155-0.262 NDVI values characterize residential areas and open land, while the 0.070-0.160 NDVI value is the use of wetland vegetation in the form of crop residue equivalent to grass and shrubs with land cover less than 50%. Early rice crop has NDVI values around 0.160-0.239, and also on the value of NDVI 0239-0318 it is equivalent to the type of vegetable crops.

<table>
<thead>
<tr>
<th>Band</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std. Deviasi</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLI 2</td>
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<td>1.637</td>
<td>0.194</td>
<td>0.176</td>
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<tr>
<td>OLI 3</td>
<td>-0.014</td>
<td>1.836</td>
<td>0.181</td>
<td>0.171</td>
</tr>
<tr>
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<td>1.836</td>
<td>0.167</td>
<td>0.171</td>
</tr>
<tr>
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<td>0.278</td>
<td>0.242</td>
</tr>
<tr>
<td>OLI 6</td>
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<td>1.836</td>
<td>0.213</td>
<td>0.183</td>
</tr>
<tr>
<td>OLI 7</td>
<td>-0.014</td>
<td>1.836</td>
<td>0.159</td>
<td>0.138</td>
</tr>
</tbody>
</table>

**Figure 3. Regression Equations of NDVI with Vegetation Density**
types on both NDVI classes are also found in NDVI classes 0318-0397, but in this class there are variations in other land cover types with denser vegetation density. NDVI values 0397-0639 of land use include paddy, mixed garden, grass, while the value of NDVI 0639-0802 of the average land cover is forest or mixed garden with medium to high density.

**Landform.** By using a Geological Map for Surakarta-Giritontro scale 1: 100,000 [45] study area located on the western slopes of Volcano Lawu has Geologic Formations that form Lawu volcanic rocks (QVL), and Alluvium (Qa) (Figure 4). Lawu volcanic rock units distinguishes the form of deposition of lava, and rock fragments in the breccia are generally tiered andesite, the thickness of this layer is approximately 250 meters.

Classification of landforms made from Lawu volcanic in the study area includes corrugated lava flows (V12b); volcanic lava flows (V12a); volcanic hills-strong denudation (V19a); volcanic hills-weak denudation (V19b); foot volcano-wavy (V6a); foot volcanic-steep slopes (V6b); foot volcanic-plains (V7); volcanic lava (V11); upper slopes (V3); middle slopes (V4).

Landform by denudational and erosional processes among others is peneplains-bumpy (D5c); peneplains-flat (D5a); peneplains-ramps (D5b); pediment (D8); Eroded hills-above (D1a); Eroded hills-below (D1b); eroded hills-strong (D1c); roded hills-weak (D1d).

Fluvial landform processes in the study area are alluvial plains (F1).

The visual interpretation of landforms has differences in the morphology: lithology, topography, river networks, texture, slope, and erosion processes. The composites of RGB TM 4, TM 5, and TM 7 are used as the basis for a visual interpretation of landforms. The use of composites emphasizes more on the appearance of the surface configuration, and the image shows a more impressed physical surface and the appearance of land use seems more vague.

Table 2. Relationship of NDVI with Landforms in the Study Area

<table>
<thead>
<tr>
<th>NDVI</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>V3</td>
<td>LK</td>
<td>PR</td>
<td>SB1</td>
<td>SB2</td>
<td>H2</td>
<td>H3</td>
<td>H3</td>
</tr>
<tr>
<td>V4</td>
<td>LK</td>
<td>PR</td>
<td>SB1</td>
<td>SB2</td>
<td>H2</td>
<td>H3</td>
<td>H3</td>
</tr>
<tr>
<td>V5</td>
<td>LK</td>
<td>PR</td>
<td>SB1</td>
<td>SB2</td>
<td>H2</td>
<td>H3</td>
<td>H3</td>
</tr>
<tr>
<td>V6a</td>
<td>LK</td>
<td>PR</td>
<td>SB1</td>
<td>TRP</td>
<td>H2</td>
<td>H3</td>
<td>H3</td>
</tr>
<tr>
<td>V6b</td>
<td>LK</td>
<td>TRP</td>
<td>SB1</td>
<td>TRP</td>
<td>H2</td>
<td>H3</td>
<td>H3</td>
</tr>
<tr>
<td>V7</td>
<td>TRP</td>
<td>TRP</td>
<td>TRP</td>
<td>TRP</td>
<td>R-CT</td>
<td>R-CT</td>
<td>H3</td>
</tr>
<tr>
<td>V11</td>
<td>TRP</td>
<td>TRP</td>
<td>TRP</td>
<td>TRP</td>
<td>R-CT</td>
<td>R-CT</td>
<td>H3</td>
</tr>
<tr>
<td>V12a</td>
<td>TRP</td>
<td>TRP</td>
<td>TRP</td>
<td>TRP</td>
<td>S-C2</td>
<td>S-C2</td>
<td>H3</td>
</tr>
<tr>
<td>V12b</td>
<td>TRP</td>
<td>TRP</td>
<td>TRP</td>
<td>TRP</td>
<td>R-CT</td>
<td>R-CT</td>
<td>KC2</td>
</tr>
<tr>
<td>V19a</td>
<td>TRP</td>
<td>TRP</td>
<td>TRP</td>
<td>TRP</td>
<td>S-C2</td>
<td>S-C2</td>
<td>KC2</td>
</tr>
<tr>
<td>V19b</td>
<td>TRP</td>
<td>TRP</td>
<td>TRP</td>
<td>TRP</td>
<td>S-C2</td>
<td>S-C2</td>
<td>KC2</td>
</tr>
<tr>
<td>D1a</td>
<td>LK</td>
<td>CR <em>CR</em></td>
<td>S-C1</td>
<td>*</td>
<td>S-C2</td>
<td>KC1</td>
<td>KC2</td>
</tr>
<tr>
<td>D1b</td>
<td>Air</td>
<td>CR <em>CR</em></td>
<td>S-C1</td>
<td>*</td>
<td>S-C2</td>
<td>KC1</td>
<td>KC2</td>
</tr>
<tr>
<td>D1c</td>
<td>LK</td>
<td>CR <em>CR</em></td>
<td>S-SR1</td>
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<td>S-C2</td>
<td>KC2</td>
</tr>
<tr>
<td>D1d</td>
<td>LK</td>
<td>CR <em>CR</em></td>
<td>S-SR1</td>
<td>*</td>
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<td>KC1</td>
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<tr>
<td>D5a</td>
<td>LK</td>
<td>CR <em>CR</em></td>
<td>S-SR1</td>
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<td>S-SR2</td>
<td>S-C2</td>
<td>KC2</td>
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<tr>
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<td>LK</td>
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<td>S-C2</td>
<td>KC2</td>
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<tr>
<td>D5c</td>
<td>Air</td>
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<td>CR <em>CR</em></td>
<td>S-SR1</td>
<td>*</td>
<td>S-SR2</td>
<td>S-C2</td>
<td>KC2</td>
</tr>
</tbody>
</table>

**explanation:**
- LK Bare Soil.
- PR Pasture, grassland, or range continuous forage for grazing.
- SB1 Brush-brush-forbs-grass mixture with brush the major element-poor.
- SB2 Brush-brush-forbs-grass mixture with brush the major element-good.
- CR Crop residue cover.
- TRP Farmstead-buildings, lanes, driveways, and surrounding lots.
- KC1 Woods-grass combination (orchard or tree farm)-poor.
- KC2 Woods-grass combination (orchard or tree farm)-good.
- S-C1 Small grain/paddy with contoured-poor.
- S-C2 Small grain/paddy with contoured-good.
- S-SR1 Small grain/paddy with straight row—poor.
- S-SR2 Small grain/paddy with straight row—good.
- R-CT Row crops (fruit and vegetables).
- H2 Woods are grazed, but not burned, and some forest litter covers the soil.
- H3 Woods are protected from grazing, and litter and brush adequately cover the soil.
- * Mixed with TRP.
Land cover is a manifestation of the condition of surface vegetation, and vegetation density can be used to translate the condition or type of the land cover surface. As already noted in the previous subsection, in this study the condition of the surface vegetation cover used NDVI transformation. The use of NDVI is very helpful to identify the levels of vegetation density on the same type of land cover. The land cover type SCS-CN is considered as land cover vegetation covering the soil surface. In those types of land cover the same what? can give different CN values, and it really depends on the condition of the hydrology soil group.

Knowledge-based. Vegetation density controlled by landforms in this study is quite helpful in translating the land cover type SCS-CN as well as some high NDVI values contained in volcanic landform, landforms denudation, and fluvial landforms, but the third set of landforms have a mismatch with land cover. The use of controls by these landforms is easier to translate the classification of the land cover type SCS-CN. Such very dense vegetation cover classes with NDVI values Grade 7 (0.672-0.802) having a kind pentup SCS-CN land are forest on the upper slope landform, slope middle, and lower slopes of Volcano Lawu. However, the different classes of the land cover type SCS-CN are in the form of the garden and the tree farm on foot Plateau Volcanic landforms Lawu (Figure 5).

NDVI values Grade 7 (0.672-0.802) and 6 (0.570-0.672) at the top of the landform slopes, middle slopes, and lower slopes are comparable land cover types, namely in the form of good forest cover, protected from grazing and litter and shrubs enough to cover the ground (H3). Land cover type SCS-CN in the farmstead-buildings, lanes, roads, and surrounding lots by using NDVI are difficult to distinguish in particular landform units. Denudational landforms and landform fluvial have an engaging type of land cover (Table 2), but the type of land cover and its land and farm houses can be distinguished by the NDVI at the origin of the unit of volcanic landforms.

Figure 5. The Results of Image Analysis (A. Map of Landforms; B. Map of Land Cover Type SCS-CN)
This is possible because the pattern of settlement on land formations and the fluvial origin denudational process have demonstrated a variety of patterns. In addition, other types of land cover also show a more complex what? so that the NDVI values are the same. Land cover types are mixed with the settlement value in this research area at origin denudational landforms and landform fluvial origin of land cover which is a cover crop residues, small grain (paddy) contoured-poor, and small grain (paddy) straight row-poor.

**Land cover SCS-CN types.** In addressing these limitations, the results of classification by using NDVI and landforms are combined with multispectral classification with maximum likelihood supervised. The results of the digital classification are only to be taken on the type of land cover settlement contained in the origin denudational landforms and landform fluvial origin.

Residential land cover types are indistinguishable probably due to the different patterns and densities, in addition to the existing settlement which is also associated with vegetation and agricultural lands. The study area is a more residential area identified, and the existing settlement in the study area is a rural settlement; it is assumed that the irregular pattern and there are many settlements in the form of a dense vegetation cover. Table 2 explains the SCS-CN land cover in the study area.

**Overall accuracy.** The accuracy of image interpretation with the obtained with the facts in the field. The number of samples for each type of land cover in the data (number of columns) is 2, 26, 16, 56, 47, 13, 3, 39, 12, 64, 30, 82, 6, 12, 192 with total data of 600 data. The accuracy obtained in the overall classification (overall accuracy) is as follows:

\[
\frac{2+26+16+56+47+13+3+39+12+64+30+82+6+12+192}{600} = 85.17\%
\]

The accuracy for each type of land cover has different accuracy, and water bodies (TA) have the accuracy of 2/2 x 100% = 100% with a 0% error of omission. Farmstead-buildings, lanes, driveways, and surrounding lots (TRP) have the accuracy of 162/192 x 100% = 84.38% to a 16.63% omission error, and these can be seen from the perspective of the map maker. From the user's perspective, row crops-fruit and vegetables (RCT) have the accuracy of 32/44 x 100% = 27.73% to a 27.27% omission error. Moreover, this type of bare land (LK) has the accuracy of 13/15 x 100% = 86.67% with an error of omission 13.33%.

### 4. Conclusions

The interpretation of land cover type SCS-CN at medium resolution imagery (Landsat-8) can obtain good accuracy, even though the coverage of the research is not extensive, using the knowledge-based analysis. This analysis tries to combine the spectral appearance of the image and appearance of the spatial remote sensing imagery. In the mountains the appearance of a spatial location is based on its landforms. Accuracy (overall accuracy) from the interpretation of remote sensing image interpretation medium resolution is obtained by 85.17%. Therefore, using Landsat-8, in addition to easy retrieval of data, can also be used to identify the type of land cover SCS-CN that is useful for the interests of surface water resources.

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**References**