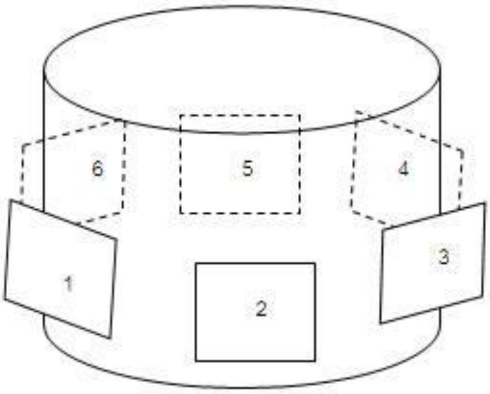
CHAPTER 5

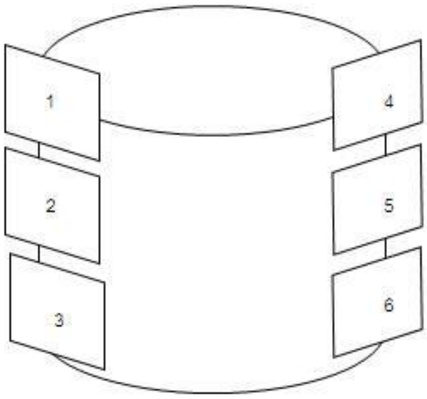
Classify of Longan Fruits on Bush by Image Processing Techniques

5.1 Taking Photos of Longan Bushes

At each selected farm, two longan trees were chosen for photographic documentation. The process for choosing which trees to photograph depended on whether the tree could be photographed from six different positions around the tree as well as on whether the shape of the trees represented those of the remaining trees in the orchard. Plastic pipes with a circumference of 1 inch were used to construct an area of interest (AOI) 1x1 meter in size. The AOI's were placed in six different positions around the tree's canopy. Two patterns of placing the AOI's were used. The first pattern was used for trees no higher than 4 meters, which is considered small for a longan tree. In this pattern, the AOI's are placed level with each other around the canopy of the tree, equally distant from one another, as shown in Figure 26-a. The second pattern was used for trees taller than 4 meters, which is considered tall for a longan tree. In this pattern, only two sides of the canopy are photographed because the trees at this size are too close together to take pictures from every angle. Therefore, the AOI's are placed on two different sides of the tree's canopy at three different levels: highest, medium, and lowest (Figure 26-b). The canopy displayed in each AOI was photographed with a digital camera at a resolution of at least 1600x1200 pixels per inch. All other settings of the camera were on "Auto."



a)



b)

Figure 26 a) The six photograph positions on longan trees shorter than 4 meters b) The six photograph positions on longan trees taller than 4 meters .

Photographic documentation at the selected 30 farms resulted in 60 chosen trees with six photos taken of each tree's canopy. This totals 360 photos of longan tree canopies. This process was performed over several days and in both sunny and cloudy weather and at varying times of the day from morning to evening. Therefore, there are a variety of different conditions represented among the 360 photos. These varying conditions affect the process of identifying the data which can be learned from the trees' canopies.

5.1.1 Physical Conditions of the Images

The 360 photos taken were divided into five groups based on the conditions under which each was made. This process of grouping improved the performance results of the next steps in the study. The five groups of photos were 1) sunny/less bright 2) sunny/medium bright 3) sunny/very bright 4) cloudy/less bright and 5) cloudy/medium bright. Figures 27 a to e are examples of each of the five conditions.

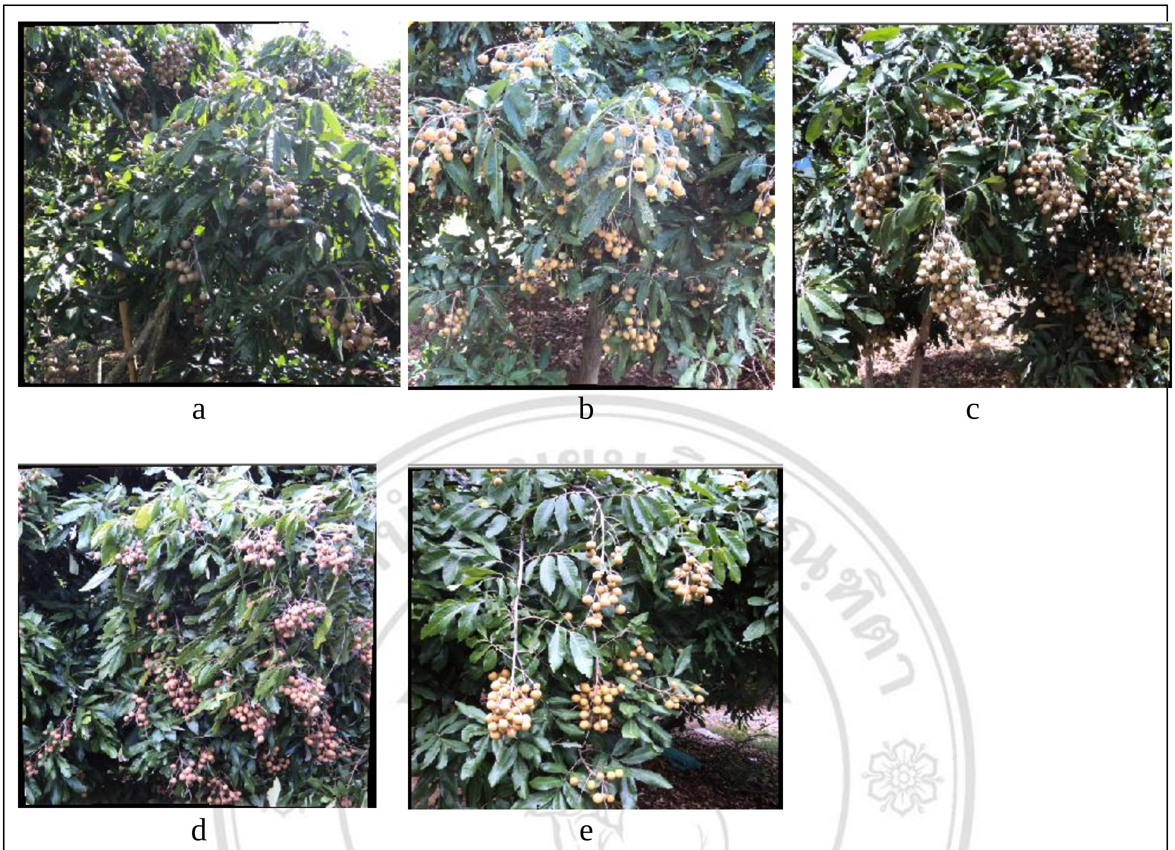
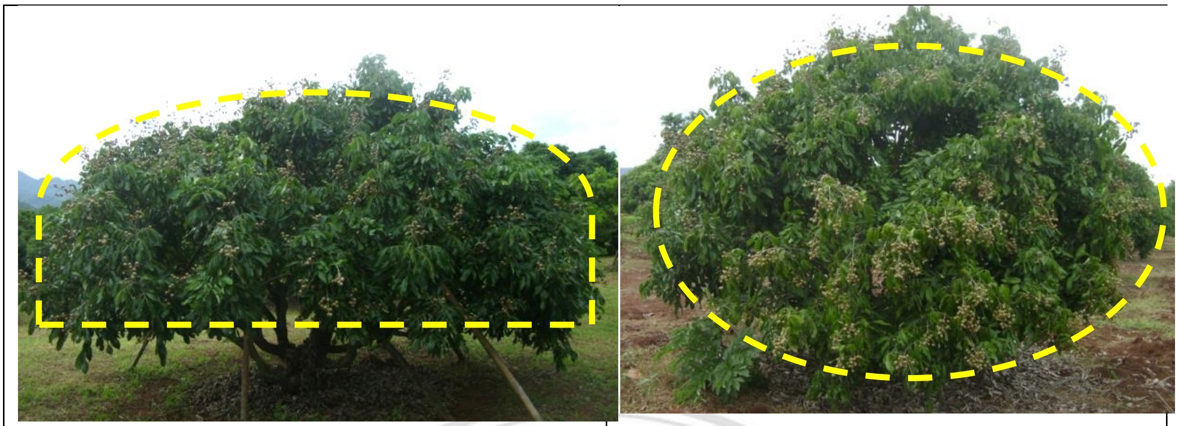


Figure 27 Physical conditions of the image a) sunny/less bright b) sunny/medium bright c) sunny/very bright d) cloudy/less bright e) cloudy/medium bright

5.1.2 Canopy Area

In this study, longan tree canopies came in two different shapes: Flat shape and Regular shape or Circle shape. If a tree had a well-defined canopy shape, this meant that the farmer had done a good job trimming and taking care of it. A well-managed tree showed signs of good health in its leaves, flowers, and trunk, and it produced more fruits in its season. Trees not properly cared for will have other canopy shapes. Only a few examples of these were found in this study (Figure 28).



a b

Figure 28 The two shapes of a longan tree's canopy a) canopy with a Flat shape b) canopy with an Regular shape or Circle shape.

In this study, only trees with half-circle or oval-shaped canopies were chosen to have their canopy area calculated. The canopies with the correct shapes were identified based on the photos taken of each tree. In order to find the area of a tree's canopy, the following equations were used. Equation 4 is used to calculate oval shape (oblate spheroids).

$$\text{oval shapes area} = \pi\left(2a^2 + \frac{b^2}{e}\log\left(\frac{1+e}{1-e}\right)\right) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where $e = \sqrt{1 - \frac{b^2}{a^2}}$, *Eccentricity of Ellipse*

a = *Tree Height*

b = *Tree Width*

Equation 5 is used to calculate area of half-circle shape.

$$\text{half circle area} = 2\pi r^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

r = *Radius*

5.1.3 Preparing the Photographic Information

The photos of the trees were analyzed, specifically concerning the longan fruits. The Image processing technique was used in this study. It is part of the ERDAS Imagine 9.0 program (Leica Geosystems Geospatial Imaging, 2012). Through this process, the longan fruits in the photos were identified based on each image's visible wavelengths. The layered data were displayed in red, green, and blue. Because each photo displayed more than just what was in the AOI, whatever laid outside of the AOI's boundaries was cropped out. Some of the photos also suffered imbalanced leveling issues, so that problem had to be fixed as well. Results varied depending on the degree of imbalance each photo had. Small degrees of imbalance were easy to fix; the larger the imbalance, the more difficult it was to completely correct (Figure 29). Moreover, each photo had to be resampled so that all photos had the same pixel size. The pixel width was set at 0.5 cm. This process was necessary to keep the images as sharp and clear as the originals in order to make it easier to spot the fruits.

a b

Figure 29 Fixing the imbalance issues a) original image b) fixed image.

Photos that had been completely fixed of all issues were then ready to be converted from RGB to IHS, which is a very beneficial format because of the variety of ways it can be used and manipulated. It also creates a clearer image, which makes it easier to identify the fruits. The technique used to convert the photos intensified the lighting, which emphasized whatever colors desired in the photos. The IHS format is an acronym: "I" stands for intensity, as in the intensity of the colors which designates the concentration of colors; “H” stands for hue, as in the shade of the colors; and “S” stands for saturation, as in the saturation of the colors which designates the concentration levels. IHS is different from RGB in that RGB works on the principle of combining red, green, and blue together to create the many levels and hues of color. Both formats were beneficial for this study, so both formats were used in the analysis of the photos.

Moreover, the image data were transformed into yet another format by using the OHTA Color Space technique, developed by Yuichi Ohta (Okamoto and Lee, 2009). This technique uses certain linear relationships between red, green, and blue to make the separation of colors clearer, and it requires very little time to perform (Guo Feng et al., 2008). In this study, the two relative equations (2R-G-B)/4 and (2G-R-B)/4 were used, which were found to emphasize the fruit in the photos. The redness of the images was also transformed by using the equation 3R-G+B as well as other formulas.

All of this layered data were used to create the threshold through which each photo’s longan fruits could be identified and counted the easiest. Next the area of the entire canopy of each tree was calculated, and the total amount of its fruits was estimated by using equation 6. This equation was the multiplication of the total area of the canopy and the sum of the total areas of longan fruits in each of the six AOI’s which was then divided by the sum of the areas of each of the 6 AOI’s. The result represented the area of longan fruits in each tree out of the total area of the canopy.

$$Ft = \frac{\sum_{i=1}^{6} A_i \; x \; C_a}{\sum_{i=1}^{6} Ao_i} \ldots\ldots\ldots\ldots..(6)$$

Where: F_t is Total amount of fruit

A_i is the sum of the areas of longan fruits in all 6

C_a is the canopy area of Tree

Ao_i is The sum of the areas of the 6 AOI’s in Tree

5.1.4 Digital Image Processing Analysis

In order to count the longan fruits in each photo, the digital images were analyzed with image segmentation. This method makes it easier to differentiate between each object in the photo based on their visible characteristics (Cheng et al., 2001). At the same time, a classification analysis of the photos took place as well. The original photos were JPG images, so they had to be converted into the IMG format using the ERDAS program in order to carry out the analysis of the reflectance levels of red, green, and blue. The reflectance information was already present from the time the photo was taken with a digital camera, but in order to be analyzed, the photo must first be converted. The next step was to take measurements of the reflectance of RGB, normalize their values, and translate them into either the OHTA color space format (Ohta Yu-Ichi & Kanade Takeo, 1980), which pixelates the image to a higher degree than the value of grey or into the IHS format, which shows greater variety in details within the image. Next, the normalized photos were processed through the ERDAS program using the Knowledge Classification method and based on the designated threshold already established. The threshold value is the condition that determines the identification of longan fruits. The program, "Model Maker" was used to aid in this process. The results represented the areas of longan fruits in each tree within their corresponding AOI boundary, which is 1x1 meter (1 square meter). The results of all six AOI areas for each tree were added together, and this number became one of the factors in the creation of the BBN model (Figure 30).

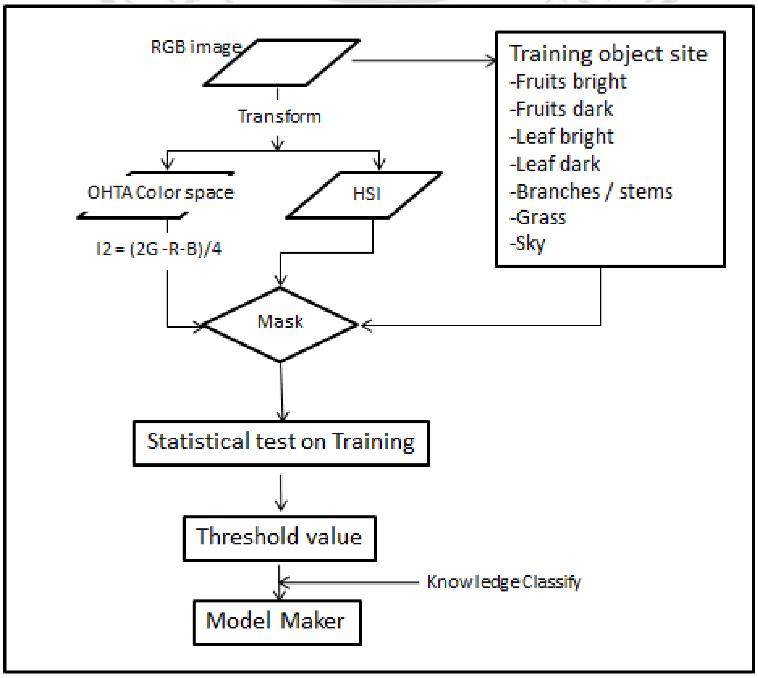


Figure 30 Image processing steps.

The goal of this image analysis process was to identify the longan fruits from amidst the leaves, branches, trunk, ground, grass, and sky which may also be in the photos. The result of this process was the separation of the area of the fruits from the rest of the background. In order to identify the longan fruits in this way, the knowledge-based method of classification had to be used with the layered RGB data in order to define the proper threshold value. Again, these layered data originated from the field study in the training site and were sent through the ERDAS 9.0 program for analysis in order to create the correct threshold. Once the threshold value was in place, it was used to create a model using "Model Maker" tool. The model was a picture of the fruit areas (shown in square centimeters) among the other objects in the background.

The first step in the process to create a model was to pick five photos for each weather and lighting condition which occurred during the time of photographing. The seven types of objects were documented in each picture: longan fruits in bright light, longan fruits in less light, longan leaves in bright light, longan leaves in less light, the branches and trunk of the tree, the dirt and grass around the tree, and the sky behind the tree. In each photo, the goal was to locate a maximum of five examples of each of the seven objects and designate each one as a "training site;" that is, an area of interest (AOI). Therefore, each photo has up to 35 areas highlighted as "training sites." Most photos displaying all 35 "training sites" came from small longan trees or trees which had fewer branches than normal. As for tall longan trees or trees with lots of branches, their photos averaged 20-30 "training sites." Each photo's colors and reflectance were then calculated, and these data were inserted into the proper equations (Figure 31).

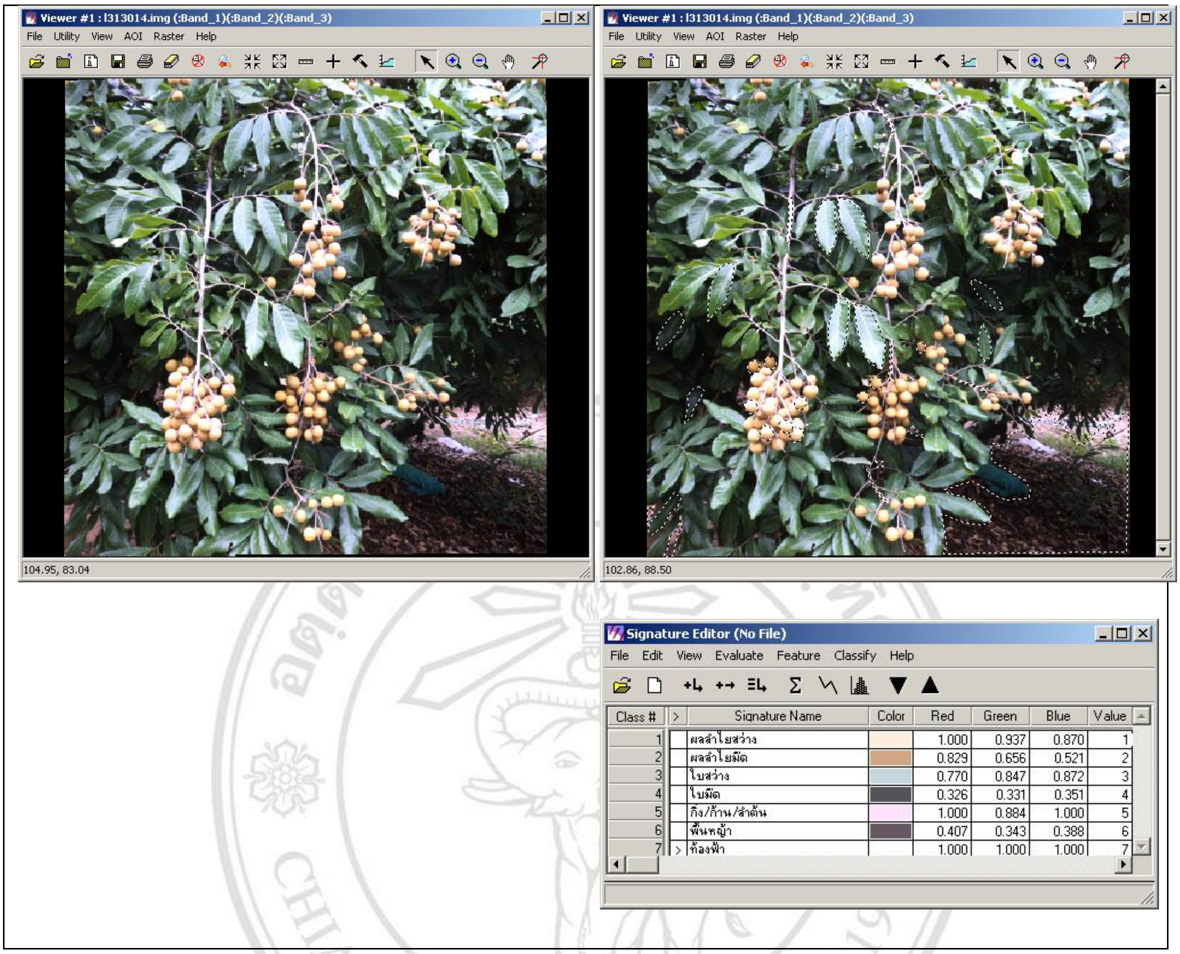


Figure 31 Process of choosing “training sites” in a photo.

Each area of interest in the photos was calculated according to the layered data process. Each picture was converted into the various formats chosen for use: RGB, redness, IHS, OHTA color space, etc., as mentioned earlier. The program calculated the statistical data received from the photos into four categories: minimum, maximum, mean, and standard deviation. Table 8 shows the average reflectance levels for red, green, and blue. The sky has the highest reflectance level, and it appears white in the photos to the human eye. Leaves in low light have the lowest reflectance levels, averaging around 40-60. These minimum and maximum reflectance levels create the boundaries needed to identify every other object in the photos. The longan fruits have different reflectance levels based on how much light they are in. longan fruits in more light averaged around 139-169, which are about the same levels as the reflectance of leaves in more light. longan fruits in less light averaged around 71-93, which are about the same levels as the reflectance of the grass and ground. All of the objects were separated into four groups based on their average reflectance levels. The four groups were sky, leaves in less light, longan fruits in bright light/leaves in bright light, and longan fruits in less light/grass and ground. Next, the average hue of each of the object types in the photos was documented as shown in Table 8. The longan fruits in bright light had a different hue average than the leaves in bright light. The longan fruits hue levels were lower than those of the leaves. As for the longan fruits in less light, they averaged lower hue levels than grass and ground. This difference in hue enabled the determination of what was a longan fruits and what was not. Moreover, when the photos' format was changed to OHTA color space, a high average of "red" ((2R-G-B)/4) was observed in longan fruits in both less light and more light. No other objects in the photos have these levels for "red." At the same time, the equations for red (3R-G+B) and green (3G-R+B) showed standard levels. However, these numbers still proved to be useful when they were combined with the layered data to create the threshold for locating the longan fruits in each picture. From all of these statistics, the unique traits for each object were pinpointed which enabled easier identification, especially for longan fruits.

Table 8 A comparisons of the statistical data of reflectance for each of the seven objects.

	Red	Green	Blue	Hue	(2G-R-B)/4	(2R-G-B)/4	3R-G+B	3G-R+B
Fruit (bright)	169	164	139	119	5	8	204	183
Fruit (dark)	93	91	71	125	4	6	119	107
Leaf (bright)	166	197	136	144	23	0	165	289
Leaf (dark)	41	61	50	186	7	-7	13	90
Branches	104	109	97	146	4	0	106	125
Ground/Grass	76	84	66	160	6	1	78	110
Sky	254	255	254	41	0	0	252	255

However, the statistics in Table 8 were still not enough data to clearly identify the area of each object. The only way to find the area of each "training site" was to plug the data into relative equations concerning the objects' reflectance levels. Since the photos were in the RGB format, they contained the 3-layered data concerning visible wavelengths. Special focus was given to the longan fruits's wavelength data, and the value difference was found between its red and green wavelengths (the higher values) and its blue wavelength (the lowest value). In this way, the relationship between its wavelengths was determined, which helped in identifying which objects were or were not longan fruits. This in turn was helpful information when creating the threshold. Experimentation took place with the relationship values of the three wavelengths until seven key relationships were discovered: (R-G) - (G-R), (R-B) - (G-R), (2R-G-B)4 – (2G-R-B)/4, (3R-G+B), R – G, R – B, and Hue. These 7 groups of information helped define the threshold.

5.1.5 The Threshold Value as a Condition for Classification

The tests on the relationships between the layered data of the photos revealed that the results varied from each of the five lighting conditions. For example, in condition a, the value difference between red and green ((R-G) – (G-R)) in longan fruits averaged an area greater than 0. All other objects had a value difference which averaged in the negatives. When the blue wavelength was added into the equation ((R-B) – (G-R)), the longan fruits' mean area was at a high value whereas other objects had a low value. These results are similar to the results of the equation (2R-G-B)/4 – (2G-R-B)/4 where the longan fruits averages a high value while other objects average a low value. Analyzing the results in each of the five conditions provided the information needed to help designate the threshold (Table 9). The threshold was used to classify what is and what is not a longan fruits in each photo is in Appendix section A.

Table 9 Threshold used in each lighting condition to identify longan fruits in the photos.

	(R-G) - (G-R)	(R-B) - (G-R)	(2R-G-B)/4 - (2G-R-B)/4	R-G	R-B	HUE	3R-G+B
Condition a	> -2	> 15	> 0	-	-	-	-
Condition b	> 0	> 15	> 0	-	-	-	-
Condition c	> 15	> 40	> 5	-	-	-	-
Condition d	> 20	> 20	> 5	-	-	-	-
Condition e	> 0	-	-	> 0	> 30	-	-

5.1.6 Model of the Longan Fruits Identification

The ERDAS Imagine 9.0 program was used to analyze the digital images. This program provides a proper tool for the user in each stage of the decision-making process, as well as what techniques to use and what conditions to apply. This program was used to create the entire model for the process. The specific program used was called Model Maker. This study used the statistics learned from the layered data under each of the five lighting conditions to create the model.

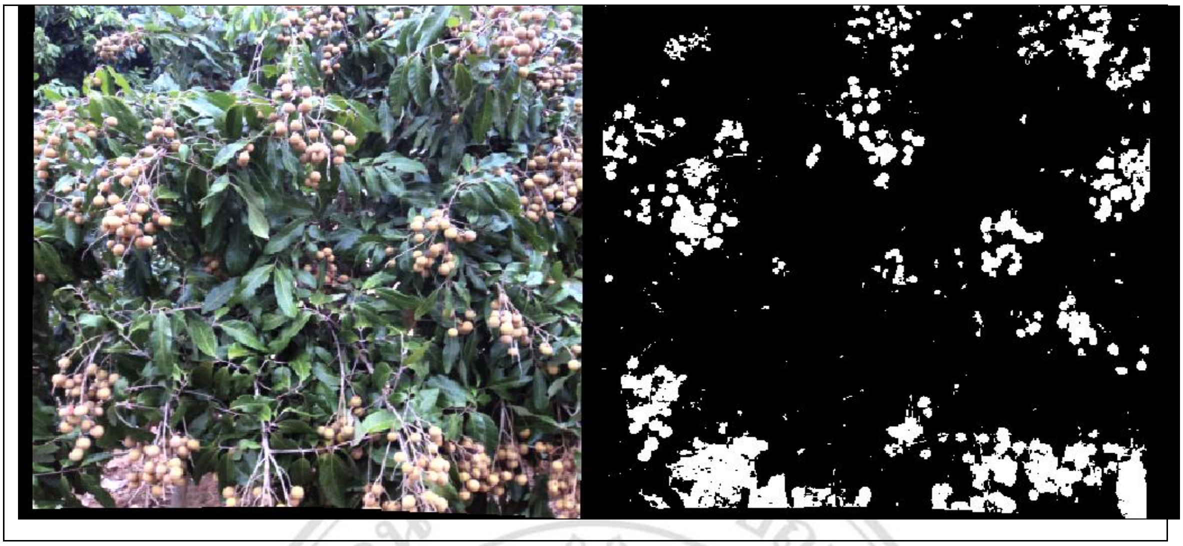
In order to classify longan fruits in the photos, first each image which had already been processed had to become input data. Next, they were transformed into the correct formats, so that the equations could reveal the relationships between all of the layers of data. The results of those equations were stacked together in layers because of the positive and negative results of the data (single-precision floating-point format). Then the threshold was designated using this stacked layered data and then used to classify what is and what is not a longan fruits according to the threshold definitions. Pixels in an image which fall within the boundaries of the threshold were given a value of 1 and were defined as part of the area of a longan fruits. Pixels outside of the threshold boundaries were given a value of 0 and were not defined as part of the longan fruits area. After the image was checked against the threshold, the results were filtered in units of 3x3 pixels into a low-pass filter in order to get rid of single dots and to fill in gaps. The output image represented the area of longan fruits. The next step was the creation of histograms of the output data concerning longan fruits area in each photo. The fruit area tables of a single tree were combined to provide the total fruit area in the canopy.

Once all preparations were in place, mapping out the longan fruits areas in the photos was a quick and easy process which provided excellent results (Figures 32-a to e).

a) Conditions 1: sunny and less light

b) Conditions 2: sunny and medium light

c) Conditions 3: sunny and bright light



d) Conditions 4: cloudy and less light

e) Conditions 5: cloudy and medium light

Figure 32 Results of the classification process a) Conditions 1: sunny and less light b) Conditions 2: sunny and medium light c) Conditions 3: sunny and bright light d) Conditions 4: cloudy and less light and e) Conditions 5: cloudy and medium light

5.1.7 Accuracy Assessment of Longan Fruits Classification

There are several ways to do an accuracy assessment, but for this study, the Error Matrix method was chosen. Special focus was given to testing the "training sites" and the "tested areas." This was done by overlaying a grid of 100 x 100 squares on a photo and randomly choosing 30 of the squares. In this way, the naked eye could identify what lay within each of those squares and thereby test the results of the identification process (Figure 33).

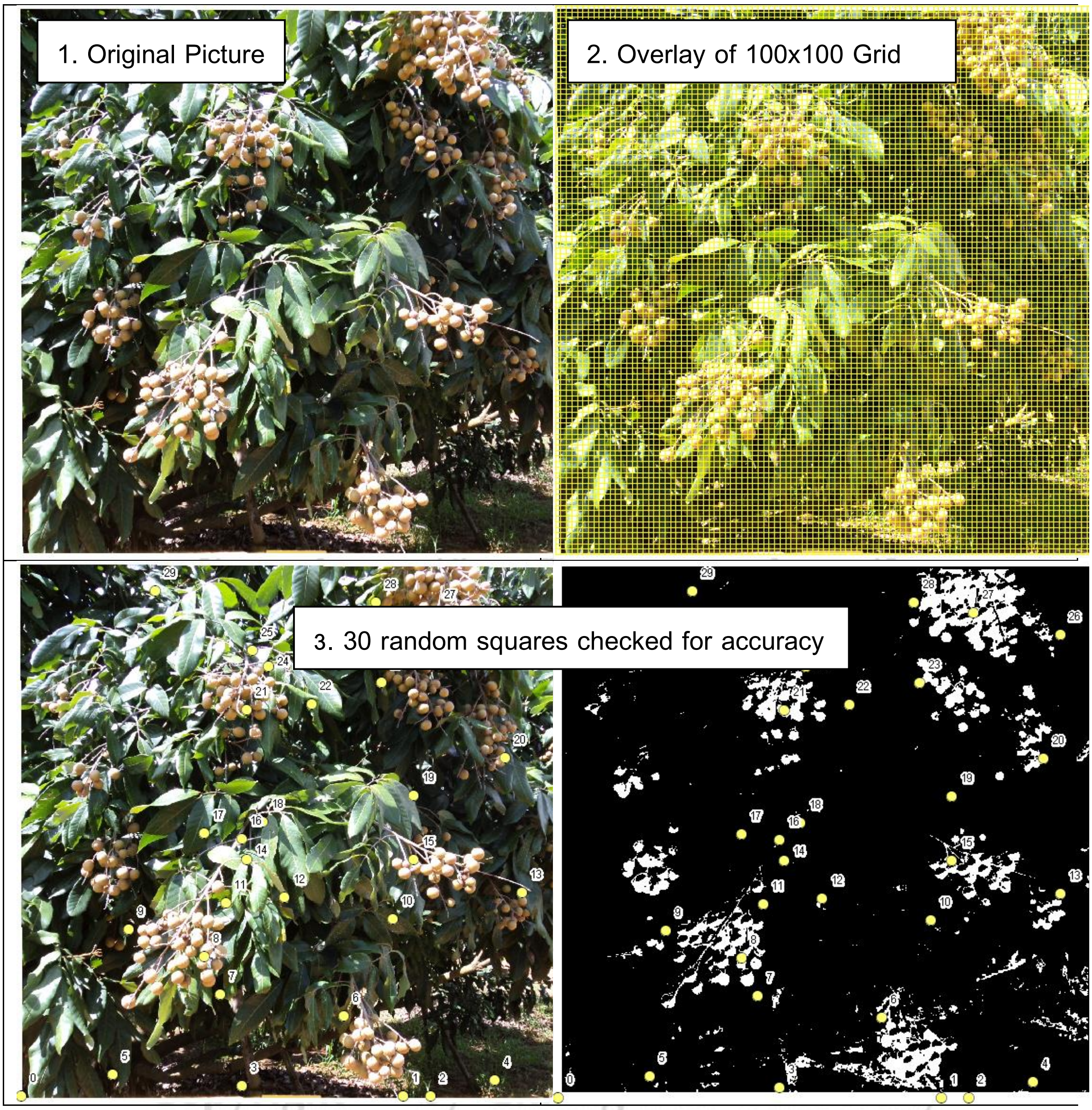


Figure 33 Accuracy assessment of longan fruit classification

In this study, 5 photos were chosen to be tested, and the results proved a high rate of accuracy. The highest rate of accuracy was 92.3% with a kappa value of 0.94. All of the other pictures had accuracy rates higher than 80% with a kappa value of 0.77 (Figure 34).

Fig.1	Longan	Others	Sum
Longan	12	3	15
Others	1	14	15
Sum	13	17	30

AA= 0.800 Kappa= 0.765

Fig.2	Longan	Others	Sum
Longan	12	2	14
Others	1	15	16
Sum	13	17	30

AA= 0.857 Kappa= 0.818

Fig.3	Longan	Others	Sum
Longan	14	1	15
Others	3	12	15
Sum	17	13	30

AA= 0.933 Kappa= 0.765

Fig.4	Longan	Others	Sum
Longan	11	2	13
Others	0	17	17
Sum	11	19	30

AA= 0.846 Kappa= 0.875

Fig.5	Longan	Others	Sum
Longan	12	1	13
Others	0	17	17
Sum	12	18	30

AA= 0.923 Kappa= 0.935

AA: Overall Accuracy

Kappa: Kappa index

Figure 34 Results of accuracy assessment

Based on the image results, the ratio between the longan fruits area and the total canopy area was analyzed. The hypothesis is that the total production of fruit is directly related to this ratio between the fruit area and the canopy area; that is, the larger the area, the higher the production rate of fruit. When the observed yield was compared to the analysis of the images, there was a definite relationship present between the amount of fruit produced and the area ratio. It was a direct relationship: when one increased, so did the other (Figure 35).

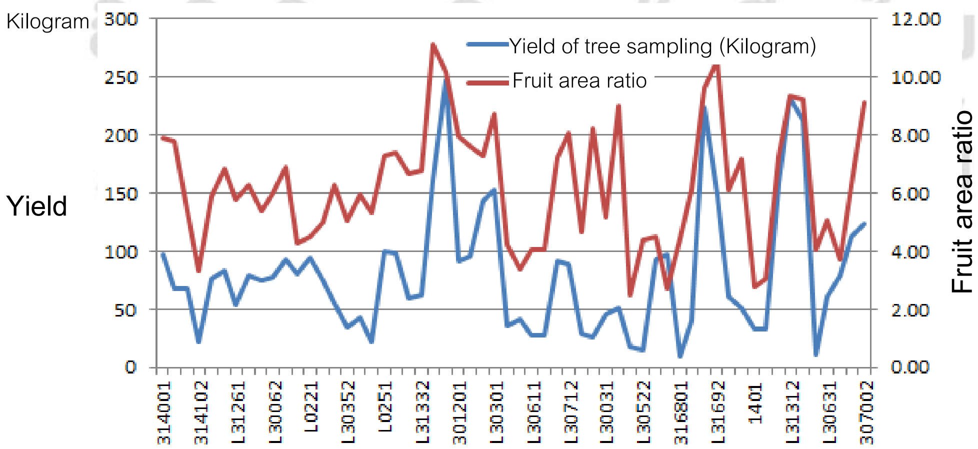


Figure 35 A graph comparing the yield of sampled trees to the ratio of fruit area in the canopies before harvest

When this relationship was tested, the tests showed it to be a direct relationship, heading in the same direction with the value of R^2 is 0.52 (Figure 36).

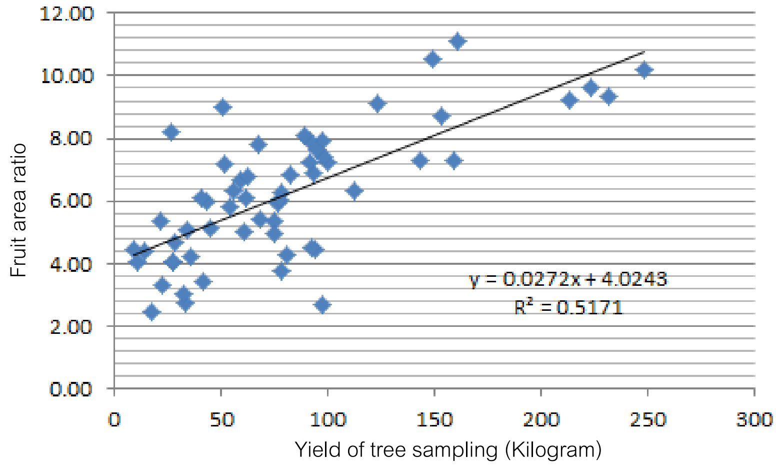


Figure 36 The relationship of the longan yield from sampled trees and the area of fruit in the canopies before harvest.

Therefore, the longan fruits area numbers were also incorporated into creating the yield estimation from photo model. This can calculated to the yield per rai in the sample orchard (Table10).

Table 10 Longan fruits area of each photo and the estimate yield.

Code	Photo 1	Photo 2	Photo 3	Photo 4	Photo 5	Photo 6	Sum	Yield of sample Tree (Kilogram)	Fruit area ratio	Estimate Yield (kg/rai)
314001	999.40	557.70	1,105.30	441.80	632.30	1,008.50	4,745.00	97.4	7.91	372
314002	1,272.10	541.50	511.90	588.40	951.50	813.00	4,678.40	67.9	7.80	
314101	674.90	728.00	352.00	387.70	582.20	513.70	3,238.50	68.5	5.40	909
314102	546.21	178.80	199.70	208.80	604.90	256.40	1,994.81	22.4	3.32	
L31301	752.10	657.40	769.30	555.40	432.60	379.61	3,546.41	76.7	5.91	558
L31302	651.40	627.10	832.40	669.90	611.20	709.28	4,101.28	82.8	6.84	
L31261	409.70	441.80	428.70	449.60	1,115.10	638.90	3,483.80	54.3	5.81	531
L31262	531.50	581.10	1,053.30	641.90	516.70	447.80	3,772.30	78.4	6.29	
L30061	695.63	731.25	429.31	454.65	469.65	450.69	3,231.18	74.7	5.39	608
L30062	762.99	625.14	485.63	380.76	762.36	594.31	3,611.18	77.3	6.02	
L31461	453.90	680.00	635.70	735.10	771.50	869.50	4,145.70	93	6.91	1,562
L31462	398.00	354.80	763.60	362.20	317.70	363.90	2,560.20	80.5	4.27	

Table 10 Longan fruits area of each photo and the estimate yields. (Continued)

Code	Photo 1	Photo 2	Photo 3	Photo 4	Photo 5	Photo 6	Sum	Yield of sample Tree (Kilogram)	Fruit area ratio	Estimate Yield (kg/rai)
L0221	419.72	620.49	373.26	530.56	275.49	465.90	2,685.42	94.1	4.48	848
L0222	561.20	452.30	765.50	810.80	242.60	154.50	2,986.90	75.4	4.98	
L30351	804.38	866.18	488.40	984.86	500.28	137.29	3,781.39	55.7	6.30	438
L30352	242.00	765.00	631.00	430.00	755.00	222.00	3,045.00	34.1	5.08	
309201	953.60	560.00	809.70	392.50	318.80	544.80	3,579.40	43.4	5.97	325
309202	889.50	194.10	466.00	363.50	406.20	887.00	3,206.30	21.5	5.34	
L0251	840.80	707.30	533.80	358.90	1,459.10	459.10	4,359.00	100.2	7.27	2,481
L0252	917.00	759.90	561.50	471.90	400.90	1,322.00	4,433.20	98.3	7.39	
L31331	832.70	184.00	352.40	777.00	764.30	1,084.20	3,994.60	58.9	6.66	426
L31332	982.90	832.20	743.80	500.60	594.90	407.40	4,061.80	62.8	6.77	
L31201	1,478.60	781.70	820.90	1,066.60	1,340.40	1,183.00	6,671.20	161.2	11.12	2,046
L31202	858.90	1,089.60	893.90	1,065.30	1,166.30	1,041.90	6,115.90	248	10.19	
301201	1,165.56	975.49	827.57	709.65	541.25	537.01	4,756.53	91.8	7.93	934
301202	872.92	620.42	582.15	1,224.86	590.49	673.61	4,564.44	95.3	7.61	
L30301	471.50	601.60	1,091.90	1,135.10	451.40	614.80	4,366.30	143.3	7.28	1,187
L30301	798.80	1,243.60	1,048.00	1,075.80	465.40	603.90	5,235.50	153.4	8.73	
L30321	463.54	356.60	467.22	394.24	442.78	410.00	2,534.38	35.9	4.22	233
L30322	618.82	219.38	180.56	311.94	237.57	477.29	2,045.56	41.9	3.41	
L30611	400.50	401.20	445.70	429.90	496.80	268.70	2,442.80	27.3	4.07	165
L30612	386.60	240.60	451.20	543.60	556.60	262.60	2,441.20	27.8	4.07	
L30711	630.30	1,036.60	752.50	603.00	518.40	802.00	4,342.80	92.1	7.24	905
L30712	786.60	851.30	892.10	622.70	818.20	871.40	4,842.30	88.9	8.07	
307201	604.50	639.20	378.70	473.20	286.80	429.50	2,811.90	28.8	4.69	55
307202	638.60	494.70	547.20	713.10	1,225.20	1,315.50	4,934.30	26.4	8.22	
L30031	462.01	769.17	575.49	425.69	322.71	533.61	3,088.68	45.1	5.15	216
L30032	965.76	809.17	791.74	934.17	1,097.22	812.29	5,410.35	50.9	9.02	
L30521	331.50	90.10	208.70	199.80	232.70	425.30	1,488.10	17.2	2.48	103
L30522	504.40	493.40	403.70	336.10	421.80	473.80	2,633.20	14.5	4.39	
L31131	311.10	368.70	230.80	371.60	409.10	997.80	2,689.10	92.6	4.48	949
L31132	283.90	91.00	238.40	407.40	382.40	218.60	1,621.70	97.2	2.70	

Table 10 Longan fruits area of each photo and the estimate yields. (Continued)

Code	Photo 1	Photo 2	Photo 3	Photo 4	Photo 5	Photo 6	Sum	Yield of sample Tree (Kilogram)	Fruit area ratio	Estimate Yield (kg/rai)
316801	307.70	463.10	487.90	498.30	581.40	326.60	2,665.00	9.1	4.44	249
316802	1,442.00	213.50	354.00	372.70	647.80	646.10	3,676.10	40.7	6.13	
L31691	1,589.30	554.90	1,024.10	762.80	1,045.10	784.90	5,761.10	223.2	9.60	1,116
L31692	730.50	841.60	973.40	833.70	1,504.40	1,454.30	6,337.90	148.8	10.56	
L30981	494.30	894.50	413.90	784.10	494.00	580.00	3,660.80	61.6	6.10	567
L30982	494.30	1,087.80	404.90	382.50	664.40	1,283.30	4,317.20	51.85	7.20	
1401	82.48	368.18	543.49	242.80	212.50	202.67	1,652.13	33.3	2.75	330
1402	200.60	377.80	370.70	644.50	62.75	160.50	1,816.85	32.6	3.03	
L31311	593.44	732.30	739.10	939.40	813.81	549.70	4,367.75	159	7.28	1,955
L31312	859.00	1,259.90	790.70	746.50	901.00	1,064.93	5,622.03	232	9.37	
301101	899.17	734.24	879.17	636.04	1,318.33	1,077.01	5,543.96	213	9.24	672
301102	399.10	265.14	433.61	453.19	376.18	519.17	2,446.39	11.1	4.08	
L30631	375.00	850.40	767.10	246.50	407.90	379.40	3,026.30	61.2	5.04	1,050
L30632	374.20	364.00	542.70	267.70	368.00	329.00	2,245.60	78.8	3.74	
307001	757.00	926.00	391.00	819.00	503.00	385.00	3,781.00	112.7	6.30	826
307002	892.10	870.90	1,004.20	890.40	1,062.30	759.60	5,479.50	123.3	9.13	

After it was determined that the accuracy rate was high enough, the next step use the calculated yield from the entire area of longan fruits within the tree's canopy became a yield variable for the BBN model.