SEGMENTATION OF LANDSAT-8 IMAGES FOR BURNED AREA DETECTION WITH DEEP LEARNING

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KEY WORDS: Burned area, Segmentation, Deep learning, U-Net, Landsat-8, Satellite image, Remote sensing.

ABSTRACT:

Fires damage nature and living beings. Detection of this damage is important for future. In this study, it was aimed to determine burned areas. For this purpose, Landsat-8 images and U-Net model were used. Python language was preferred. Band combinations 7,5,4; 5,3,7; 5,4,3; 4,3,2; 4,3,2,5 and 2,3,4,5,6,7 have been tried. Train and test processes were carried out separately for each band combination. After the train and test processes were completed, a probability result consisting of values between 0-1 was obtained. Then, a threshold value was used. Thus, binary results consisting of 0 and 1 values were obtained. Three different values were preferred for the threshold: 0.1, 0.5 and 0.9. Thus, the effect of threshold value selection on the test results was examined. The prediction results were evaluated using the masks. For this, general accuracy, recall, precision, F1-score and Jaccard score metrics were used. Recall, precision, and F1-score values were calculated for both burned areas and unburned areas. In addition, minimum, maximum, mean, and standard deviation values were calculated for each metric. When the results are examined, it is seen that the model gives better results when the threshold value is 0.1 and 0.5. Among the band combinations, it is seen that the 7,5,4 combination gave better results than the others. For this band combination, the highest mean accuracy is 0.9743 with the 0.5 threshold value. For this threshold mean recall, mean precision and mean F1-score for burned areas are 0.7203, 0.8411 and 0.7601, respectively. And Jaccard score is 0.6328.

1. INTRODUCTION

Forest fires can be defined as a type of disaster that arises from natural or man-made causes, burns all living and non-living beings in it. All over the world, forest fires harm both nature and living things. Damage after fires should be determined because assessment of damaged areas, planning and reforestation are important for future and future planning.

In addition to terrestrial methods, remote sensing technologies are also used to detect burned areas resulting from forest fires. Considering that collecting data from the land with terrestrial methods will take a lot of time and will be very costly, and even considering that it may not even be possible to reach the burned area after the fire, remote sensing becomes attractive (Sabuncu and Özener, 2019). Remote sensing allows to be examined the changes occurring over large areas of the earth in a short time by recording the energy reflected and emitted through the objects on the relevant platforms without any physical contact. Thanks to the developments in remote sensing technologies, more data can be accessed easily and quickly. From the past to the present, satellites collect a lot of data to meet various purposes. However, classical methods are insufficient in analysing this big data. For this reason, the use of deep learning techniques, which are stated to give better results in the analysis of big data, has become popular recently.

Deep learning is a method based on the functioning of the brain. The expression "deep" refers to the number of layers in the network. Deep learning provides various advantages such as learning through representations of data (Şeker et al. 2017), and having many hidden layers (Sarıyıldız, 2021). Although deep learning is a machine learning method, there are some disadvantages in machine learning such as the inclusion of complex rule sets and the need for feature extraction from raw data (Brand and Manandhar, 2021). However, feature extraction is automatic in deep learning. Because of the advantages it provides, deep learning has become a preferred method in the field of remote sensing and in the detection of burned areas, as it is used in many image processing problems.

The aim of this paper is detecting burned areas with U-Net deep learning algorithm. For this purpose, various band combinations of Landsat-8 images were used. Their effects of them were examined. In addition, different threshold values were used for the test results and their effects were also examined.

2. MATERIAL AND METHOD

2.1 Data Set

The dataset which is provided by Prabowo et al. (2022b) is used. The dataset is called "Dataset of Deep Learning from Landsat-8 Satellite Images for Estimating Burned Areas in Indonesia". It includes burned areas in Indonesia. Figure 1 shows some examples from this dataset.

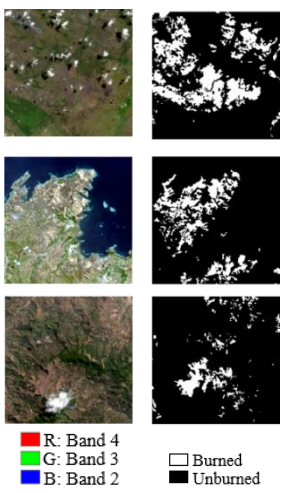

Figure 1. Examples of three images and mask of the dataset

The dataset consists of Landsat-8 satellite images. It has 227 images and corresponding binary masks with the size of 512x512xn and n is the number of the bands. The binary masks have single band and multispectral images have 8 bands in the dataset. These bands are coastal/aerosol, blue, green, red, near infrared, short wave infrared-1, short wave infrared-2 and cirrus bands (Prabowo et al., 2022a; Prabowo et al., 2022b). Table 1 shows the bands, their wavelength and resolution information.

Band Number	Band Name	Wavelength (µm)	Resolution (m)
1	Coastal/Aerosol	0.43 - 0.45	30
2	Blue	0.45 - 0.51	30
3	Green	0.53 - 0.59	30
4	Red	0.64 - 0.67	30
5	Near Infrared	0.85 - 0.88	30
6	Short Wave Infrared-1	1.57 - 1.65	30
7	Short Wave Infrared-2	2.11 - 2.29	30
8	Cirrus	1.36 - 1.38	30

Table 1. Band information of Landsat-8

2.2 Model

U-Net, one of the deep learning methods, was used for detecting burned areas. U-Net model has a U-shaped design, and it is developed by Ronneberger et al. (2015). It is preferred because of its advantages such as having a small structure, having the purpose of giving good results with limited data and keeping the location information. U-Net is a fully convolutional network, and it doesn't have fully connected layers (Sivri, 2019). Figure 2 shows the U-Net model.

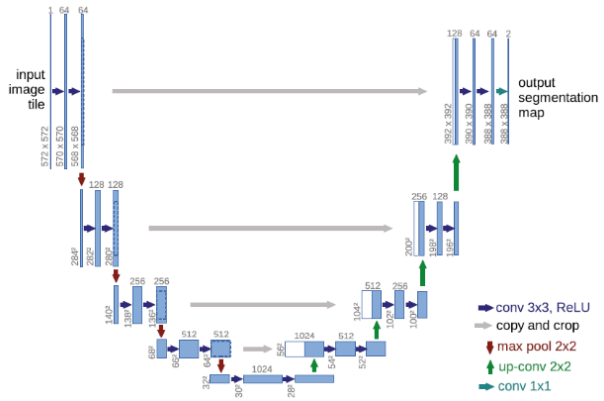

Figure 2. U-Net model (Ronneberger et al., 2015)

U-Net has 23 convolutional layers in total. It consists of two different sides. It's left side is called contracting path and right side is called expansive path. The contracting path consist of 3x3 convolutions followed by ReLU and 2x2 maximum pooling operation. The expansive path consists of 2x2 convolutios, correspond cropped feature map from the contracting path and 3x3 convolutions followed by ReLU. Last layer consist of 1x1 convolution (Ronneberger et al., 2015).

2.3 Platform

Some parts of the process were carried out through computer, and some parts of them were carried out through Google Colaboratory (Colab). The computer is used via Anaconda Spyder for dividing the dataset for suitable sizes and splitting the dataset as train, validation, and test. It is Lenovo Legion Y530 and it has Intel® Core™ i7-8750H CPU @ 2.20GHz, NVIDIA GeForce GTX 1050 Ti 4 GB. Train and test process were carried out through Google Colab and Google Colab Pro, a cloud service offered by Google. Python programming language was preferred. Keras with TensorFlow backend was used as the deep learning framework.

2.4 Preparing Dataset

All images and corresponding binary masks used in this study were splitted into three parts as train, validation, and test dataset. For this purpose, the test data set was created by randomly taking 10% of the images and corresponding binary masks. Then, among the remain parts of the dataset, another 10% of the images and corresponding binary masks are taken for creating the validation dataset. Rest part of the dataset is used as train dataset. After the train, validation and test datasets are created, every image and corresponding mask are divided into 256x256xn. As a result, train dataset consists of 736, validation dataset consists of 80 and test dataset consists of 92 images and masks. Finally, the images were created in the band combinations of 7,5,4; 5,3,7; 5,4,3; 4,3,2; 4,3,2,5 and 2,3,4,5,6,7 to be used as input in the model.

2.5 Hyper Parameter Settings

Input image and mask size was 256x256xn. Batch size was 8. Learning rate was one of the values 0.001, 0.0001 or 0.00001 which gives the best result with the related model. The number of epochs was 100. The optimization algorithm was Adam. As the activation function, sigmoid was used in the last layer and ReLU was used in the other layers.

2.6 Accuracy Assessment

After the training process was completed, the test process was carried out. As a result, a probability result consisting of values between 0-1 was obtained. Then, a threshold was used. By using a threshold value, the results higher than the specified threshold became 1 and the results less than the specified threshold became 0. Thus, binary results consisting of 0 and 1 values were obtained. Three different values were preferred for the threshold: 0.1, 0.5 and 0.9. The prediction results were evaluated using the masks. For this, general accuracy (eq. 1), recall (eq. 2), precision (eq. 3), F1-score (eq. 4) and Jaccard score (eq. 5) metrics were used. Recall, precision, and F1-score values were calculated for both burned areas and unburned areas. In addition, minimum, maximum, mean, and standard deviation values were calculated for each metric.

$$\text{Accuracy} = \frac{TP + TN}{TP + FP + TN + FN}, \quad (1)$$

$$\text{Recall} = \frac{TP}{TP + FN}, \quad (2)$$

$$\text{Precision} = \frac{TP}{TP + FP}, \quad (3)$$

$$\text{F1-Score} = \frac{2 * (\text{Precision} * \text{Recall})}{\text{Precision} + \text{Recall}}, \quad (4)$$

$$\text{Jaccard Score} = \frac{TP}{TP + FP + FN}, \quad (5)$$

where TP, FP, TN and FN are the number of true positives, false positives, true negatives and false negatives, respectively.

3. RESULTS AND DISCUSSION

Various band combinations have been tried using these images and masks. These are the combinations of 7,5,4; 5,3,7; 5,4,3; 4,3,2; 4,3,2,5 and 2,3,4,5,6,7. Thus, the effect of different band combinations on the detection of burned areas was examined. Table 2 shows the input band combinations and corresponding learning rate values.

No.	Band Combinations	Learning Rate
1	7,5,4	0.001
2	5,3,7	0.001
3	5,4,3	0.0001
4	4,3,2	0.00001
5	4,3,2,5	0.001
6	2,3,4,5,6,7	0.00001

Table 2. Training Settings

After the train, test was implemented. Figure 3 shows examples of two test images used in this study.

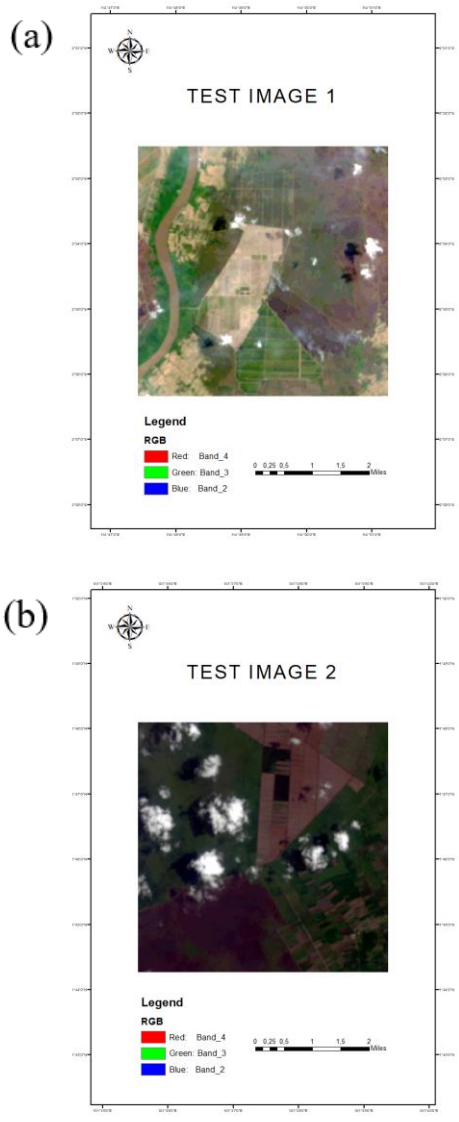

Figure 3. Examples of a) Test image 1 and b) Test image 2

Visual and metric results were presented below for each band combination. For the visual results, the images in Figure 3 were presented. For metric results, minimum, maximum, mean, and standard deviation values for each metric were presented.

Figure 4 shows the visual results for the band combination 7,5,4. According to the results, the road in image 1 and the agricultural area in image 1 weren’t classified as burned area.

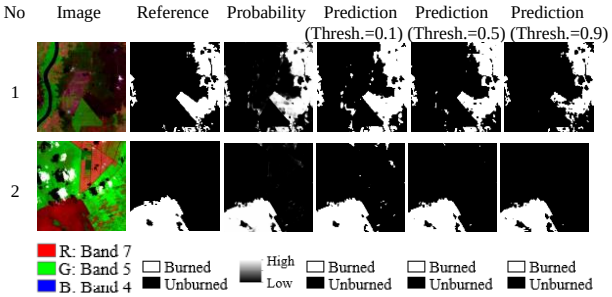

Figure 4. Examples of two test images with reference mask, probability and prediction results for bant combination 7,5,4

Table 3 shows the metric results for the band combination 7,5,4. The highest values in the average rows are marked in bold. According to the mean results, the highest accuracy was achieved with 0.9743, when the threshold value was 0.5.

Metrics	Statistic	Threshold		
		0.1	0.5	0.9
Accuracy	Min.	0.7919	0.7401	0.6572
	Max.	1.0000	1.0000	1.0000
	Mean	0.9741	**0.9743**	0.9609
	Std.	0.0339	0.0411	0.0599
Recall 0.0*	Min.	0.7290	0.9229	0.9784
	Max.	1.0000	1.0000	1.0000
	Mean	0.9749	0.9924	**0.9985**
	Std.	0.0412	0.0134	0.0033
Recall 1.0*	Min.	0.0000	0.0000	0.0000
	Max.	1.0000	0.9768	0.9192
	Mean	**0.8364**	0.7203	0.5268
	Std.	0.2771	0.2612	0.2644
Precision 0.0*	Min.	0.7674	0.6792	0.4963
	Max.	1.0000	1.0000	1.0000
	Mean	**0.9878**	0.9728	0.9527
	Std.	0.0323	0.0557	0.0822
Precision 1.0*	Min.	0.0000	0.0000	0.0000
	Max.	0.9682	0.9994	1.0000
	Mean	0.7047	0.8411	**0.9366**
	Std.	0.2745	0.2579	0.2002
F1-Score 0.0*	Min.	0.8161	0.7974	0.6595
	Max.	1.0000	1.0000	1.0000
	Mean	0.9809	**0.9818**	0.9730
	Std.	0.0327	0.0353	0.0514
F1-Score 1.0*	Min.	0.0000	0.0000	0.0000
	Max.	0.9734	0.9765	0.9536
	Mean	0.7509	**0.7601**	0.6382
	Std.	0.2654	0.2467	0.2626
Jaccard Score	Min.	0.0000	0.0000	0.0000
	Max.	0.9482	0.9541	0.9113
	Mean	**0.6399**	0.6328	0.4788
	Std.	0.2717	0.2815	0.2888

* 0.0 and 1.0 represents unburned and burned areas, respectively.

Table 3. Evaluation metrics results with different thresholds for bant combination 7,5,4

Figure 5 shows the visual results for the band combination 5,3,7. According to the results, the road in image 1 and the agricultural area in image 1 weren’t classified as burned area.

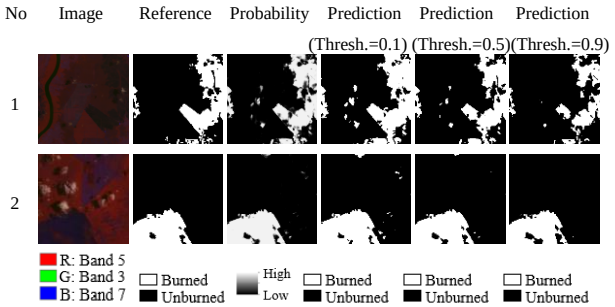

Figure 5. Examples of two test images with reference mask, probability and prediction results for bant combination 5,3,7

Table 4 shows the metric results for the band combination 5,3,7. The highest values in the average rows are marked in bold. According to the mean results, the highest accuracy was achieved with 0.9722 when the threshold value was 0.5.

Metrics	Statistic	Threshold		
		0.1	0.5	0.9
Accuracy	Min.	0.7421	0.6854	0.6094
	Max.	1.0000	1.0000	1.0000
	Mean	0.9700	**0.9722**	0.9608
	Std.	0.0408	0.0480	0.0647
Recall 0.0*	Min.	0.7604	0.9064	0.9716
	Max.	1.0000	1.0000	1.0000
	Mean	0.9745	0.9910	**0.9980**
	Std.	0.0370	0.0148	0.0042
Recall 1.0*	Min.	0.0000	0.0000	0.0000
	Max.	1.0000	0.9886	0.9299
	Mean	**0.8096**	0.7180	0.5259
	Std.	0.2815	0.2669	0.2723
Precision 0.0*	Min.	0.6944	0.6165	0.4708
	Max.	1.0000	1.0000	1.0000
	Mean	**0.9820**	0.9709	0.9532
	Std.	0.0489	0.0657	0.0860
Precision 1.0*	Min.	0.0000	0.0000	0.0000
	Max.	0.9472	0.9943	1.0000
	Mean	0.6779	0.8247	**0.8998**
	Std.	0.2645	0.2474	0.2509
F1-Score 0.0*	Min.	0.7600	0.7339	0.6342
	Max.	1.0000	1.0000	1.0000
	Mean	0.9778	**0.9798**	0.9729
	Std.	0.0398	0.0426	0.0549
F1-Score 1.0*	Min.	0.0000	0.0000	0.0000
	Max.	0.9653	0.9739	0.9614
	Mean	0.7260	**0.7539**	0.6333
	Std.	0.2613	0.2457	0.2748
Jaccard Score	Min.	0.0000	0.0000	0.0000
	Max.	0.9329	0.9492	0.9257
	Mean	0.6065	**0.6243**	0.4935
	Std.	0.2651	0.2787	0.2831

* 0.0 and 1.0 represents unburned and burned areas, respectively.
Table 4. Evaluation metrics results with different thresholds for bant combination 5,3,7

Figure 6 shows the visual results for the band combination 5,4,3. According to the results, the road in image 1 and the agricultural area in image 1 weren’t classified as burned area.

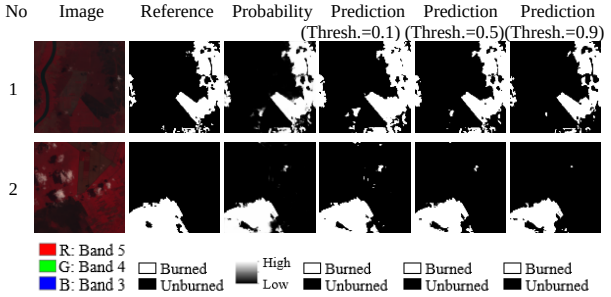

Figure 6. Examples of two test images with reference mask, probability and prediction results for bant combination 5,4,3

Table 5 shows the metric results for the band combination 5,4,3. The highest values in the average rows are marked in bold. According to the mean results, the highest accuracy was achieved with 0.9679 when the threshold value was 0.1.

Metrics	Statistic	Threshold		
		0.1	0.5	0.9
Accuracy	Min.	0.7062	0.6685	0.6141
	Max.	1.0000	1.0000	1.0000
	Mean	**0.9679**	0.9673	0.9577
	Std.	0.0455	0.0499	0.0609
Recall 0.0*	Min.	0.6758	0.8418	0.9384
	Max.	1.0000	1.0000	1.0000
	Mean	0.9746	0.9903	**0.9967**
	Std.	0.0455	0.0209	0.0087
Recall 1.0*	Min.	0.0000	0.0000	0.0000
	Max.	1.0000	0.9913	0.9031
	Mean	**0.7393**	0.5962	0.4399
	Std.	0.2659	0.2786	0.2758
Precision 0.0*	Min.	0.6783	0.6233	0.5438
	Max.	1.0000	1.0000	1.0000
	Mean	**0.9778**	0.9653	0.9505
	Std.	0.0528	0.0657	0.0804
Precision 1.0*	Min.	0.0000	0.0000	0.0000
	Max.	0.9746	1.0000	1.0000
	Mean	0.7145	0.8114	**0.8610**
	Std.	0.2613	0.2700	0.2874
F1-Score 0.0*	Min.	0.6968	0.7277	0.6886
	Max.	1.0000	1.0000	1.0000
	Mean	0.9758	**0.9768**	0.9713
	Std.	0.0468	0.0447	0.0511
F1-Score 1.0*	Min.	0.0000	0.0000	0.0000
	Max.	0.9756	0.9546	0.9439
	Mean	**0.7136**	0.6688	0.5496
	Std.	0.2559	0.2700	0.2876
Jaccard Score	Min.	0.0000	0.0000	0.0000
	Max.	0.9524	0.9131	0.8938
	Mean	**0.5704**	0.5243	0.4029
	Std.	0.2803	0.2865	0.2820

* 0.0 and 1.0 represents unburned and burned areas, respectively.
Table 5. Evaluation metrics results with different thresholds for bant combination 5,4,3

Figure 7 shows the visual results for the band combination 4,3,2. According to the results, the road in image 1 and the agricultural area in image 1 were misclassified. They were classified as burned areas.

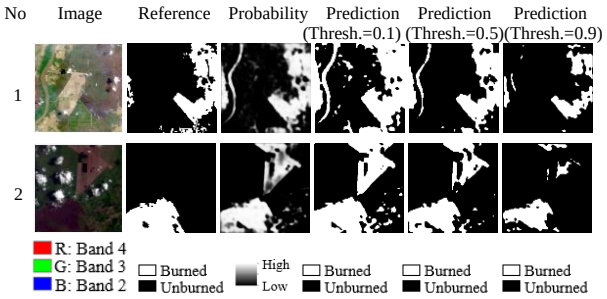

Figure 7. Examples of two test images with reference mask, probability and prediction results for bant combination 4,3,2

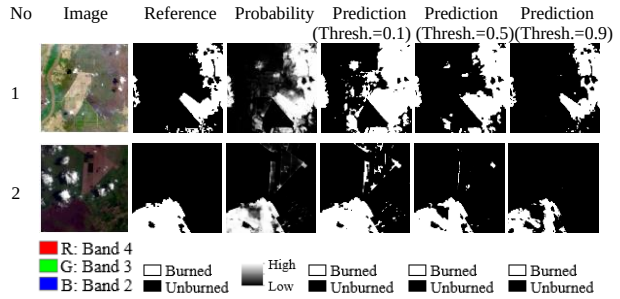

Figure 8. Examples of two test images with reference mask, probability and prediction results for bant combination 4,3,2,5

Table 6 shows the metric results for the band combination 4,3,2. The highest values in the average rows are marked in bold. According to the mean results, the highest accuracy was achieved with 0.9518 when the threshold value was 0.5.

Metrics	Statistic	Threshold		
		0.1	0.5	0.9
Accuracy	Min.	0.7041	0.6819	0.5337
	Max.	1.0000	1.0000	1.0000
	Mean	0.9436	**0.9518**	0.9302
	Std.	0.0660	0.0594	0.0891
Recall 0.0*	Min.	0.4276	0.7474	0.9410
	Max.	1.0000	1.0000	1.0000
	Mean	0.9444	0.9833	**0.9970**
	Std.	0.0941	0.0392	0.0097
Recall 1.0*	Min.	0.0000	0.0000	0.0000
	Max.	0.9911	0.9340	0.7397
	Mean	**0.6297**	0.4249	0.1997
	Std.	0.3374	0.3167	0.2212
Precision 0.0*	Min.	0.7534	0.6151	0.3396
	Max.	1.0000	1.0000	1.0000
	Mean	**0.9757**	0.9522	0.9222
	Std.	0.0443	0.0711	0.1119
Precision 1.0*	Min.	0.0000	0.0000	0.0000
	Max.	0.9185	1.0000	1.0000
	Mean	0.5177	**0.6962**	0.6904
	Std.	0.2865	0.3366	0.4409
F1-Score 0.0*	Min.	0.5760	0.6748	0.4994
	Max.	1.0000	1.0000	1.0000
	Mean	0.9575	**0.9666**	0.9543
	Std.	0.0672	0.0527	0.0752
F1-Score 1.0*	Min.	0.0000	0.0000	0.0000
	Max.	0.9485	0.9375	0.8389
	Mean	**0.5396**	0.4882	0.2782
	Std.	0.2996	0.3206	0.2784
Jaccard Score	Min.	0.0000	0.0000	0.0000
	Max.	0.9021	0.8823	0.7224
	Mean	**0.4233**	0.3650	0.1786
	Std.	0.2692	0.2885	0.2129

* 0.0 and 1.0 represents unburned and burned areas, respectively.

Table 6. Evaluation metrics results with different thresholds for bant combination 4,3,2

Figure 8 shows the visual results for the band combination 4,3,2,5. According to the results, the road in image 1 weren’t classified as burned area. Some parts of the agricultural area in the image two were misclassified.

Table 7 shows the metric results for the band combination 4,3,2,5. The highest values in the average rows are marked in bold. According to the mean results, the highest accuracy was achieved with 0.9677 when the threshold value was 0.5.

Metrics	Statistic	Threshold		
		0.1	0.5	0.9
Accuracy	Min.	0.7248	0.7191	0.6261
	Max.	1.0000	1.0000	1.0000
	Mean	0.9509	**0.9677**	0.9490
	Std.	0.0601	0.0455	0.0692
Recall 0.0*	Min.	0.4538	0.8097	0.9581
	Max.	1.0000	1.0000	1.0000
	Mean	0.9396	0.9806	**0.9977**
	Std.	0.0941	0.0369	0.0062
Recall 1.0*	Min.	0.0000	0.0000	0.0000
	Max.	1.0000	0.9909	0.8481
	Mean	**0.8131**	0.6391	0.3471
	Std.	0.2983	0.2925	0.2765
Precision 0.0*	Min.	0.7929	0.6348	0.4330
	Max.	1.0000	1.0000	1.0000
	Mean	**0.9900**	0.9730	0.9407
	Std.	0.0282	0.0556	0.0917
Precision 1.0*	Min.	0.0000	0.0000	0.0000
	Max.	0.9960	1.0000	1.0000
	Mean	0.5996	0.7548	**0.8520**
	Std.	0.2781	0.2992	0.3124
F1-Score 0.0*	Min.	0.6034	0.7117	0.6006
	Max.	1.0000	1.0000	1.0000
	Mean	0.9620	**0.9764**	0.9658
	Std.	0.0640	0.0448	0.0594
F1-Score 1.0*	Min.	0.0000	0.0000	0.0000
	Max.	0.9663	0.9708	0.9127
	Mean	0.6721	**0.6764**	0.4513
	Std.	0.2803	0.2854	0.3046
Jaccard Score	Min.	0.0000	0.0000	0.0000
	Max.	0.9347	0.9433	0.8395
	Mean	0.5550	**0.5564**	0.3215
	Std.	0.2725	0.2850	0.2783

* 0.0 and 1.0 represents unburned and burned areas, respectively.

Table 7. Evaluation metrics results with different thresholds for bant combination 4,3,2,5

Figure 9 shows the visual results for the band combination 2,3,4,5,6,7. According to the results, the road in image 1 and the agricultural area in image 1 weren’t classified as burned area.

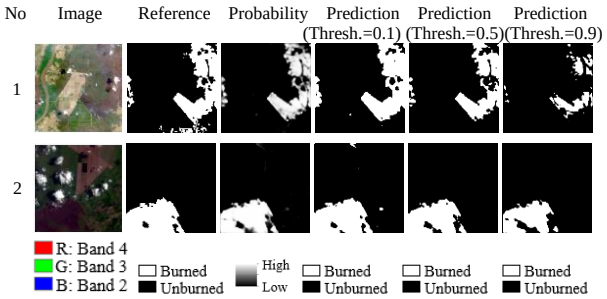

Figure 9. Examples of two test images with reference mask, probability and prediction results for bant combination 2,3,4,5,6,7

Table 7 shows the metric results for the band combination 2,3,4,5,6,7. The highest values in the average rows are marked in bold. According to the mean results, the highest accuracy was achieved with 0.9609 when the threshold value was 0.1.

Metrics	Statistic	Threshold		
		0.1	0.5	0.9
Accuracy	Min.	0.5833	0.5663	0.4677
	Max.	1.0000	1.0000	1.0000
	Mean	**0.9609**	0.9525	0.9331
	Std.	0.0722	0.0823	0.0992
Recall 0.0*	Min.	0.8322	0.9410	0.9934
	Max.	1.0000	1.0000	1.0000
	Mean	0.9857	0.9964	**0.9997**
	Std.	0.0299	0.0092	0.0010
Recall 1.0*	Min.	0.0000	0.0000	0.0000
	Max.	0.9918	0.9566	0.8603
	Mean	**0.6071**	0.4637	0.2564
	Std.	0.3540	0.3187	0.2469
Precision 0.0*	Min.	0.5630	0.4596	0.3160
	Max.	1.0000	1.0000	1.0000
	Mean	**0.9649**	0.9474	0.9256
	Std.	0.0800	0.0967	0.1153
Precision 1.0*	Min.	0.0000	0.0000	0.0000
	Max.	1.0000	1.0000	1.0000
	Mean	0.7434	**0.8601**	0.8018
	Std.	0.2813	0.2850	0.3943
F1-Score 0.0*	Min.	0.7079	0.6209	0.4796
	Max.	1.0000	1.0000	1.0000
	Mean	**0.9733**	0.9685	0.9567
	Std.	0.0524	0.0624	0.0772
F1-Score 1.0*	Min.	0.0000	0.0000	0.0000
	Max.	0.9675	0.9690	0.9236
	Mean	**0.6263**	0.5509	0.3501
	Std.	0.3219	0.3275	0.2985
Jaccard Score	Min.	0.0000	0.0000	0.0000
	Max.	0.9371	0.9398	0.8580
	Mean	**0.5208**	0.4088	0.2307
	Std.	0.3116	0.3191	0.2458

* 0.0 and 1.0 represents unburned and burned areas, respectively.

Table 8. Evaluation metrics results with different thresholds for bant combination 2,3,4,5,6,7

When the results are examined, it is seen that the model generally gives better results when the threshold value is 0.1 and 0.5. The results are generally weaker for the threshold value 0.9. Among the band combinations, it is seen that the 7,5,4 combination gave better results than the others. Figure 10 shows the loss and accuracy graphs after training for the band combination 7,5,4.

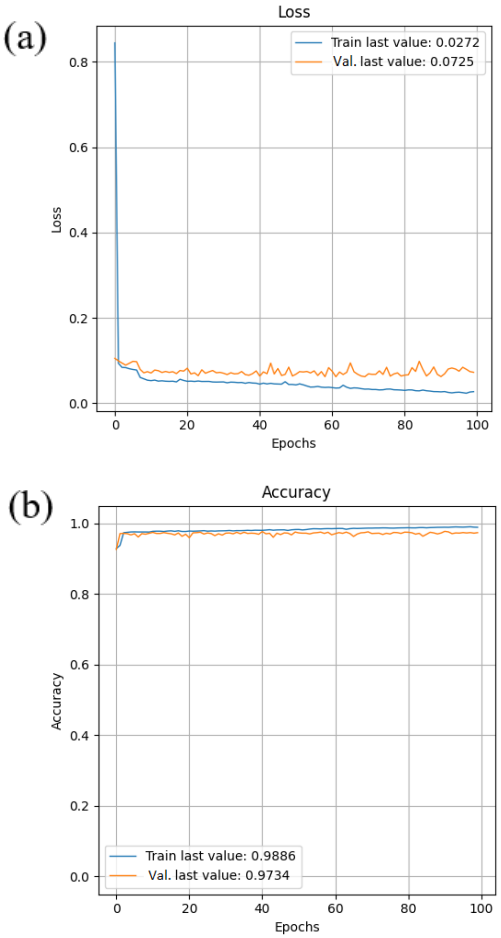

Figure 10. a) Loss and b) Accuracy graphs for band combination 7,5,4

4. CONCLUSIONS

In this study, it was aimed to determine the burned areas by using Landsat-8 satellite images and U-Net deep learning model. Various band combinations have been tried and the effect of different band combinations on the detection of burned areas was examined. In addition, three different threshold values were used for the test results and the effect of threshold value selection on the test results was examined.

According to the evaluation metrics results, among the band combinations, it is seen that the 7,5,4 combination gave the best and 4,3,2 combination gave the worst results. When the threshold values were compared, generally better results were obtained for the threshold values 0.1 and 0.5.

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