Chapter 4

Result and Conclusion

The U-Net model is used for the classification of the LISS – III multispectral space-born images. Figure 4.1 represents the training logs of the model U-Net, applied on dataset -1 which contains a total of 1490 images out of which 1225 images are used for training and the remaining 265 images are for testing. Adam optimizer was used and the model achieved a very good accuracy of 81%.

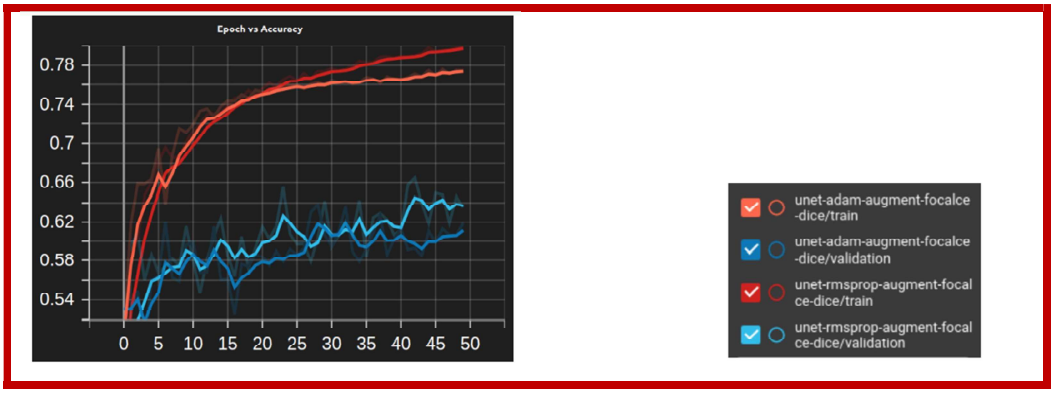
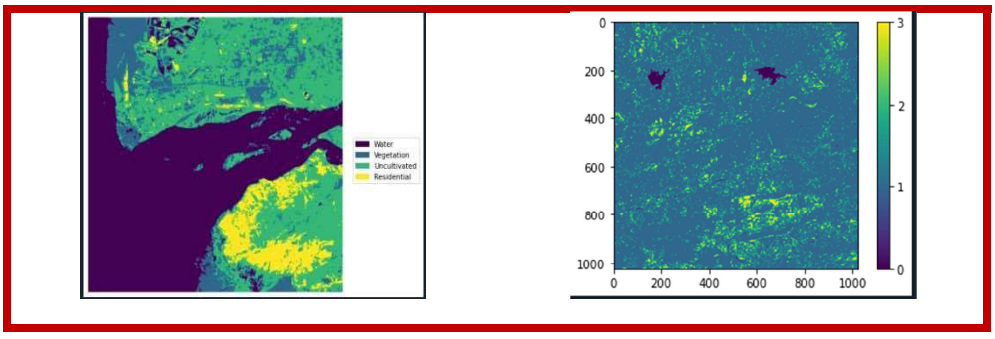


Figure 4.1: Training logs U-Net, Dataset - 1

Figure 4.2(a) and Figure 4.2(b) show the outcome or result predicted by the model (U-Net). The model identifies a total of 4 classes water body, vegetation, uncultivated land, and residential successfully with very good accuracy. In Figure 4.2(b) X represents FCC images, Y PRED represents the image predicted by the model and Y TRUE represents the ground truth mask image. Figure 4.2 (c) shows the quantification for each class in the resulting image.



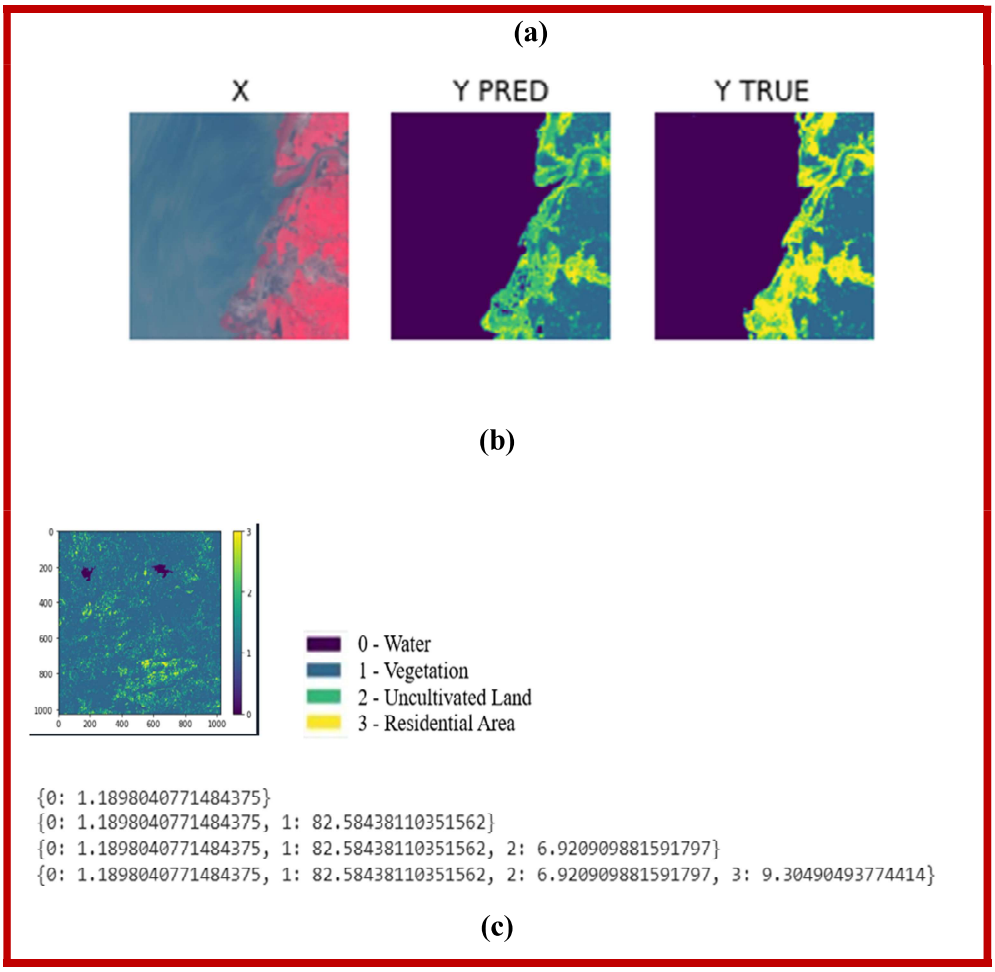


Figure 4.2: Result Predicted by the Model

Figure 4.3 represents the training logs for the U-Net model applied to dataset -1. The U-Net model was applied with a change in the optimizer. RMSprop optimizer was used with the model for the classification on dataset -1 (1490 images). The model achieved an accuracy of 79 % and Figure 4.4 represents the outcome generated by the model.

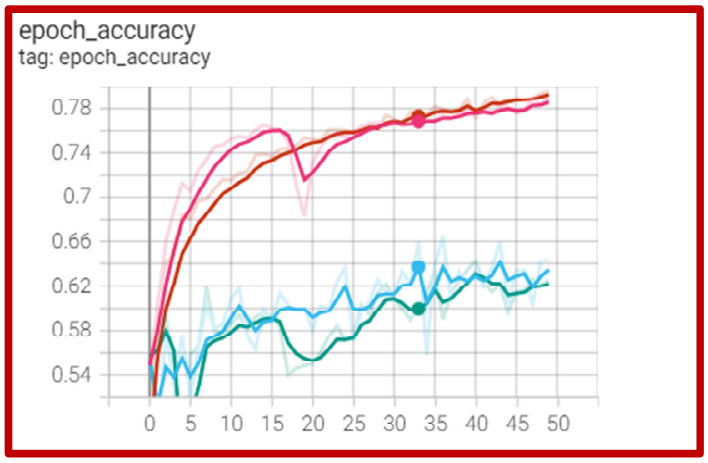


Figure 4.3: Training logs U-Net, RMSprop, Dataset -1

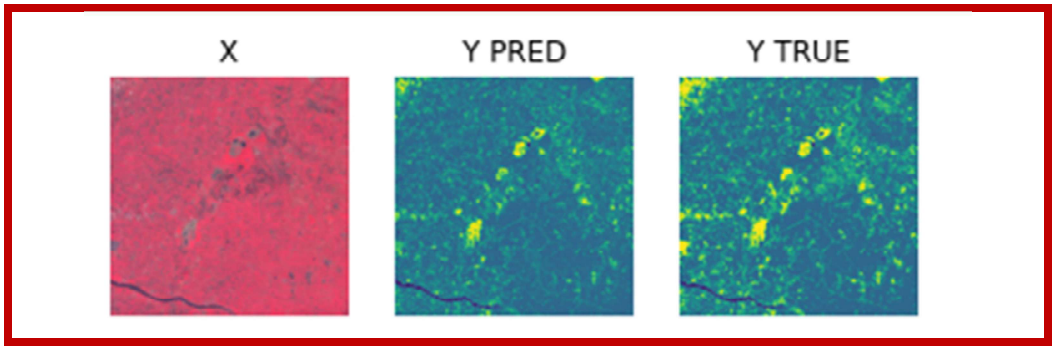


Figure 4.4: Result Predicted by the Model

Figure 4.5 represents the training logs for the U-Net model applied on the dataset – 3 with Adam optimizer. Dataset -3 contains a total of 960 images out of which 800 images were used for training and 160 images were used for validation. The model achieved an accuracy of 89 % and Figure 4.6(a) represents the outcome generated by the model and Figure 4.6(b) represents the quantification class-wise.

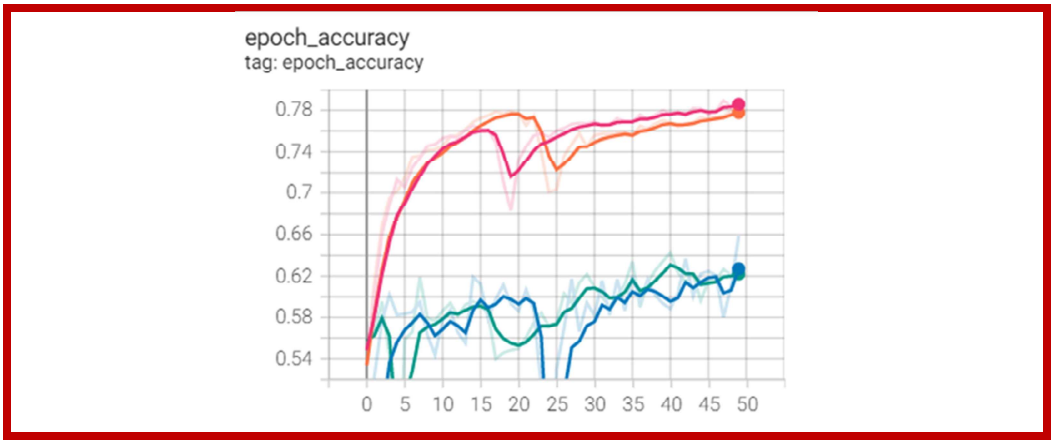


Figure 4.5: Training logs

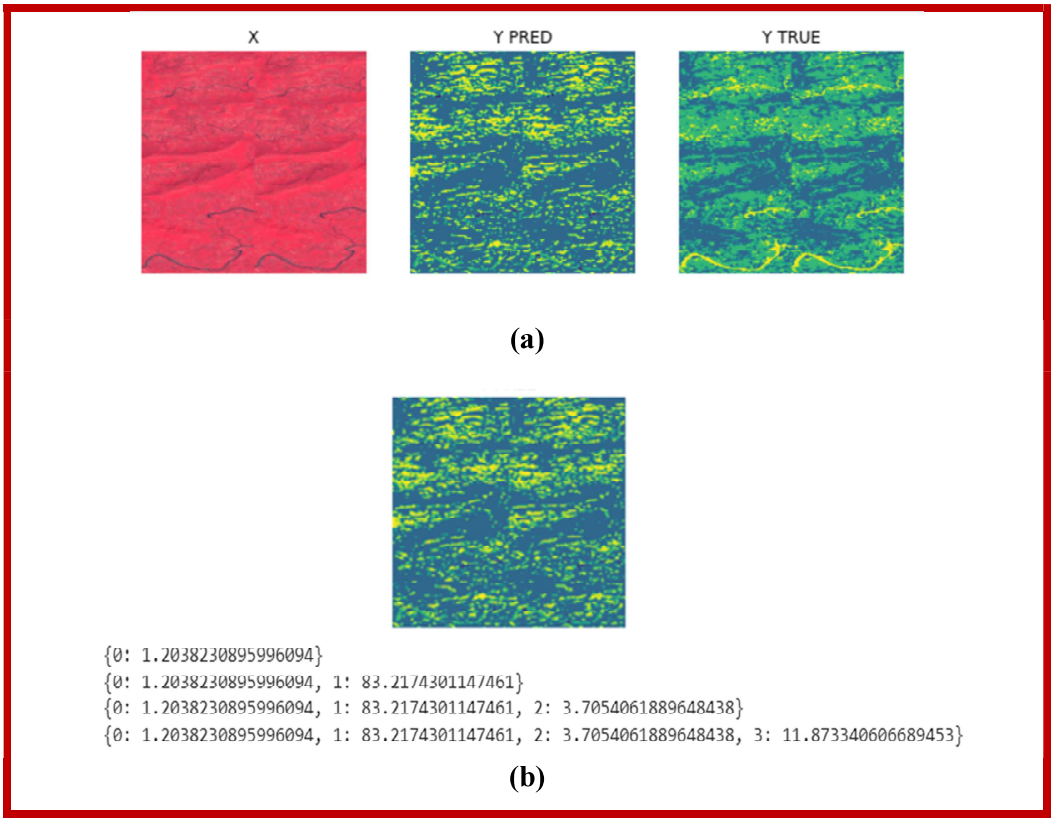


Figure 4.6: Result Predicted by the Model

Figure 4.7 shows the training logs for the Deeplabv3+ model applied on the dataset – 1 with Adam optimizer. The model achieved low accuracy of 31 % and Figure 4.8(a) shows the outcome generated by the model and Figure 4.8(b) represents the quantification class-wise.

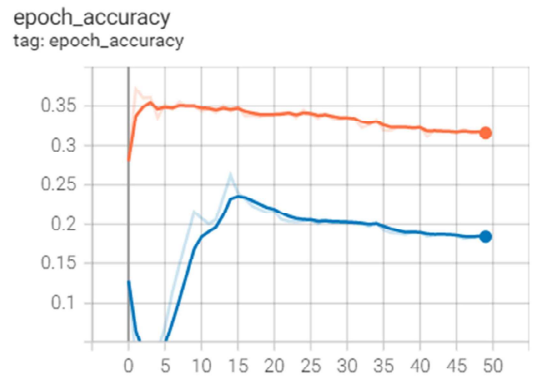
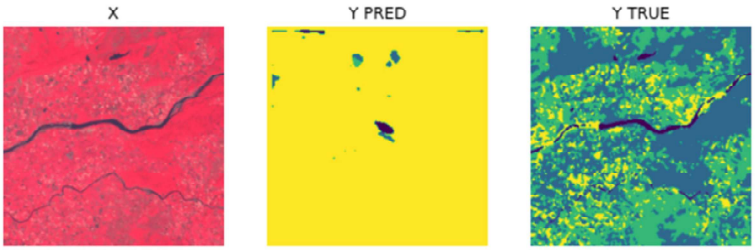
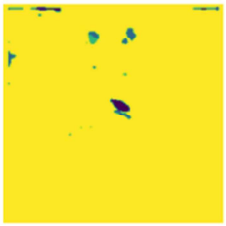


Figure 4.7: Training logs Deeplabv3+, Dataset – 1



(a)



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{0: 1.9480705261230469}
{0: 1.9480705261230469, 1: 15.830612182617188}
{0: 1.9480705261230469, 1: 15.830612182617188, 2: 1.4016151428222656}
{0: 1.9480705261230469, 1: 15.830612182617188, 2: 1.4016151428222656, 3: 80.8197021484375}
```

(b)

Figure 4.8: Result Predicted by the Model

Figure 4.9 shows the training logs for the Deeplabv3+ model applied on dataset – 2 with Adam optimizer. The model secured a very low accuracy of 25 % and Figure 4.10(a) shows the outcome generated by the model and Figure 4.10(b) represents the quantification for each class.

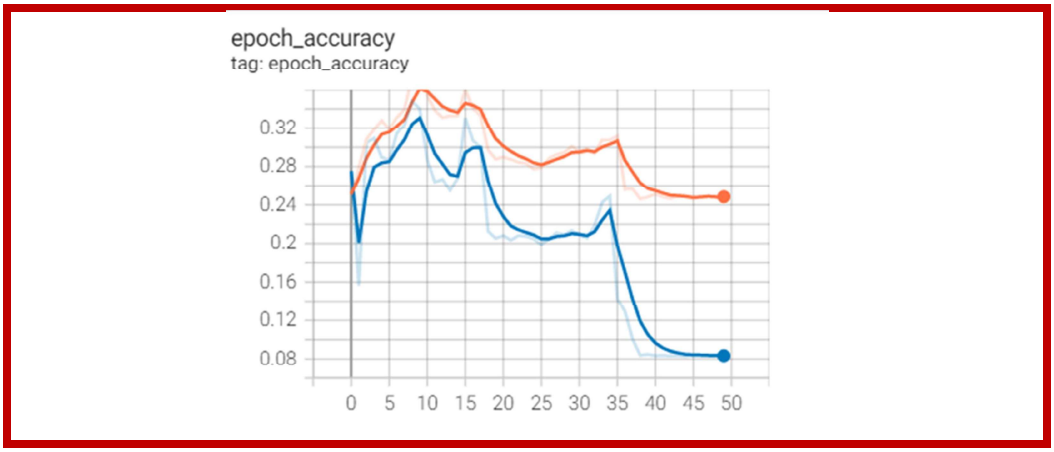


Figure 4.9: Training logs DeepLabv3+, Dataset -2

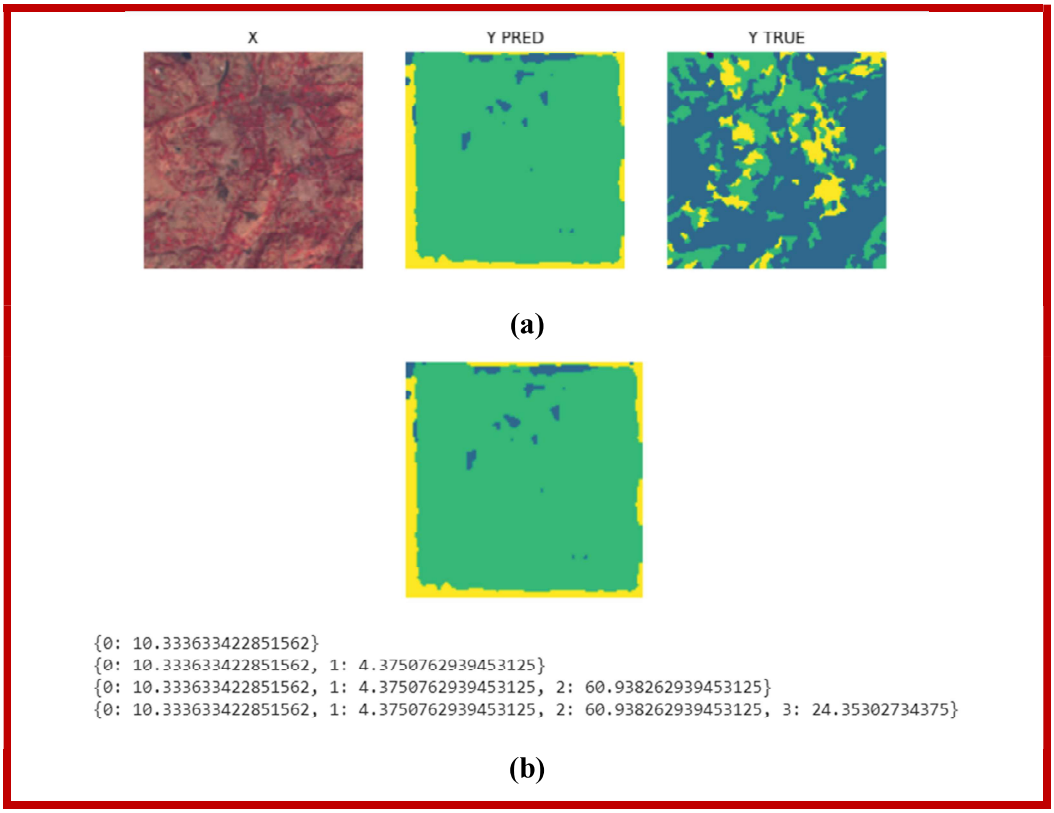


Figure 4.10: Result Predicted by the Model

Figure 4.11 represents the training logs of the model U-Net, applied on the dataset – 2 which contains a total of 13500 images out of which 11250 images were used for training and the remaining 2250 images are for testing. Adam optimizer was used and the model achieved a very good accuracy of 84%.

Figure 4.12(a) shows the outcome or result predicted by the model (U-Net). Figure 4.12(b) shows the quantification for each class in the resulting image.

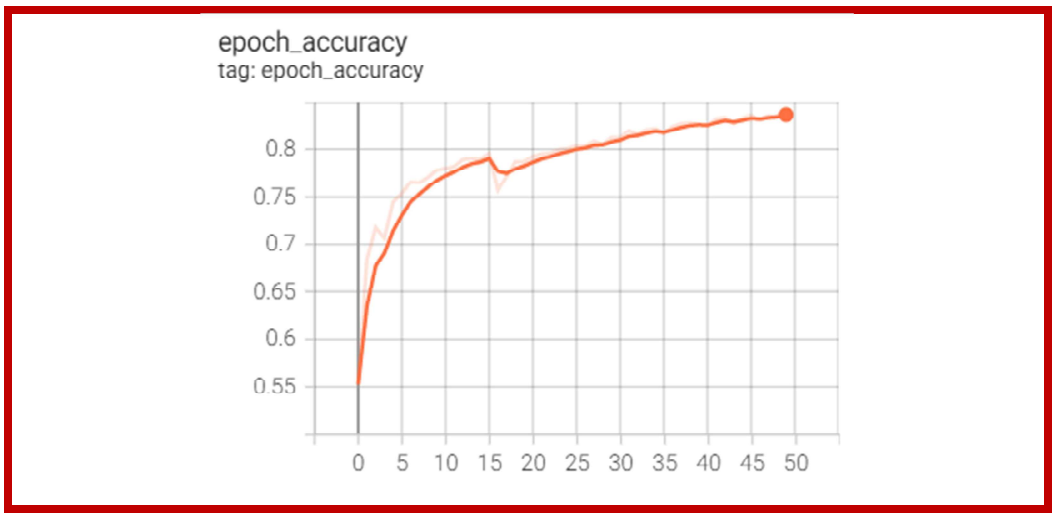
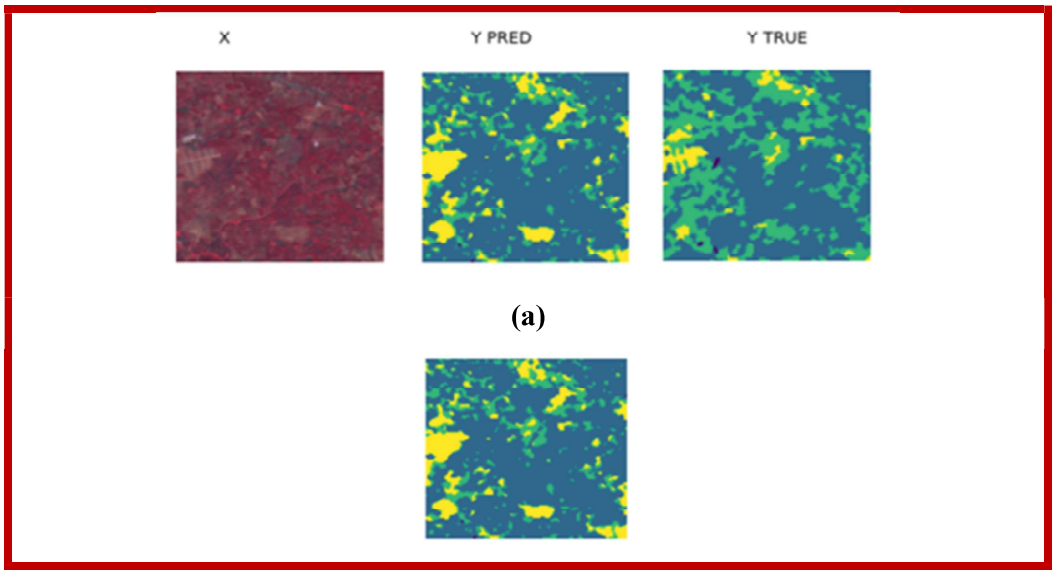


Figure 4.11: Training logs U-Net, Dataset -2



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{0: 0.279998779296875, 1: 44.03648376464844, 2: 23.249053955078125, 3: 32.43446350097656}
```

(b)

Figure 4.12: Result Predicted by the Model

Figure 4.13 represents the training logs of the model Deeplabv3+, applied on the dataset – 3 which contains 940 images. Adam optimizer was used and the model achieved 25% accuracy. Figure 4.14(a) shows the outcome or result predicted by the model and Figure 4.14 (b) shows the quantification for each class in the resulting image.

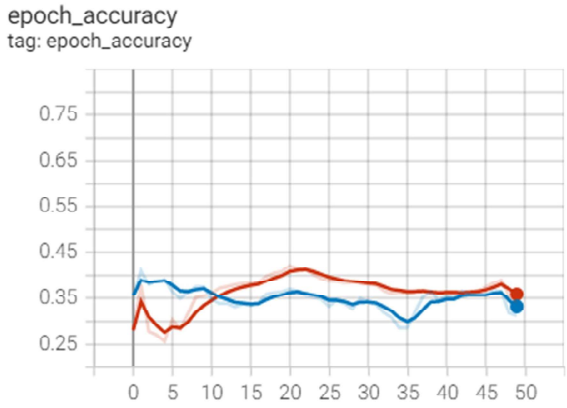
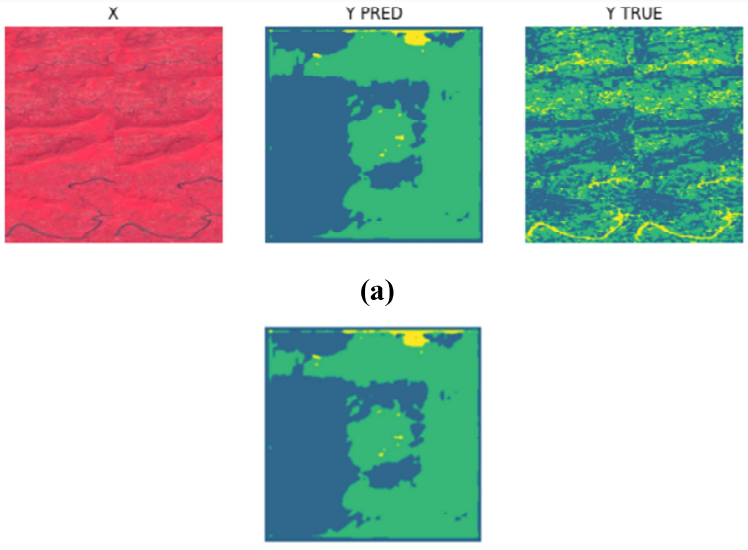


Figure 4.13: Training logs Deeplabv3+, Dataset -2



(a)

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{0: 0.079345703125}
{0: 0.079345703125, 1: 54.05893325805664}
{0: 0.079345703125, 1: 54.05893325805664, 2: 44.4244384765625}
{0: 0.079345703125, 1: 54.05893325805664, 2: 44.4244384765625, 3: 1.4372825622558594}
```

(b)

Figure 4.14: Result Predicted by the Model

Figure 4.15 shows the training logs for the Tiramisu algorithm applied on dataset -1. Figure 4.16 shows the classified image predicted by the model Tiramisu, applied on the dataset –1. Adam optimizer was used and the model achieved 51% accuracy. Figure 4.16(a) shows the outcome or result predicted by the model and Figure 4.16(b) shows the quantification for each class in the resulting image.

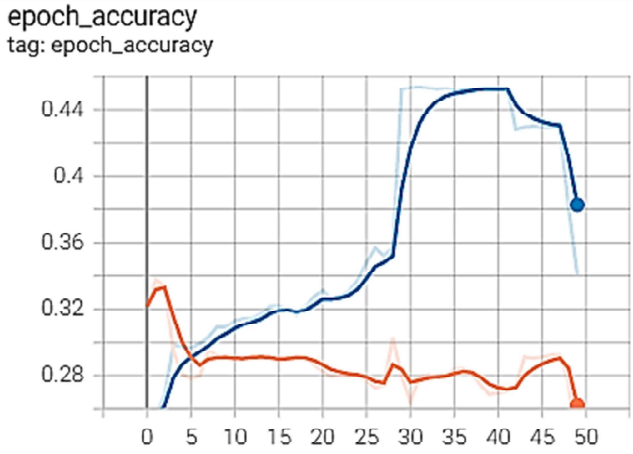
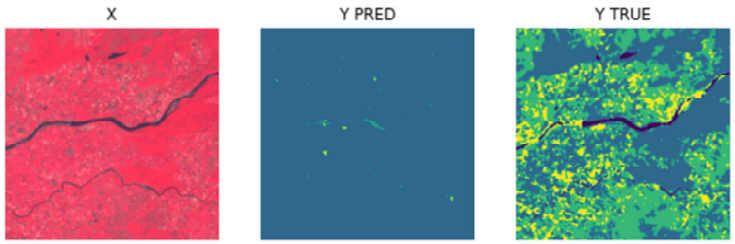


Figure 4.15: Training logs Tiramisu, Dataset – 1



(a)

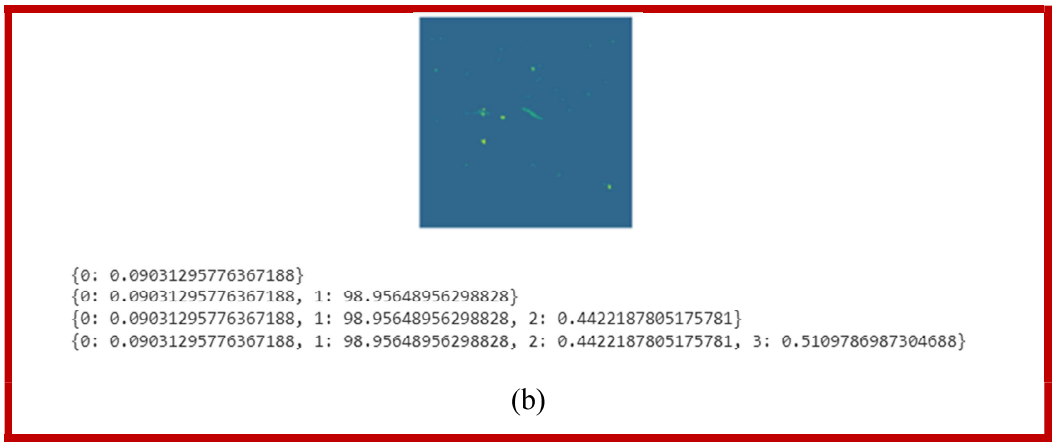


Figure 4.16: Result Predicted by the Model

Figure 4.17 displays the training logs for the Tiramisu algorithm applied to dataset -2. Figure 4.18(a) shows the resultant image predicted by the model Tiramisu, applied on the dataset –2. The model achieved 37 % accuracy. Figure 4.18(b) shows the quantification for each class in the resulting image.

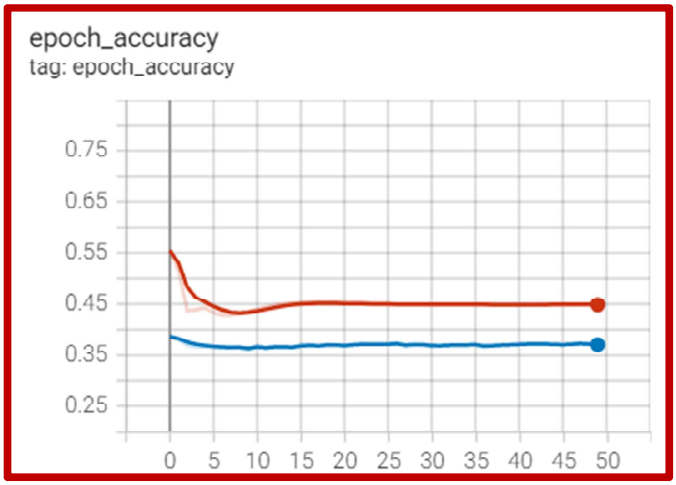


Figure 4.17: Training Logs Tiramisu – Dataset-2

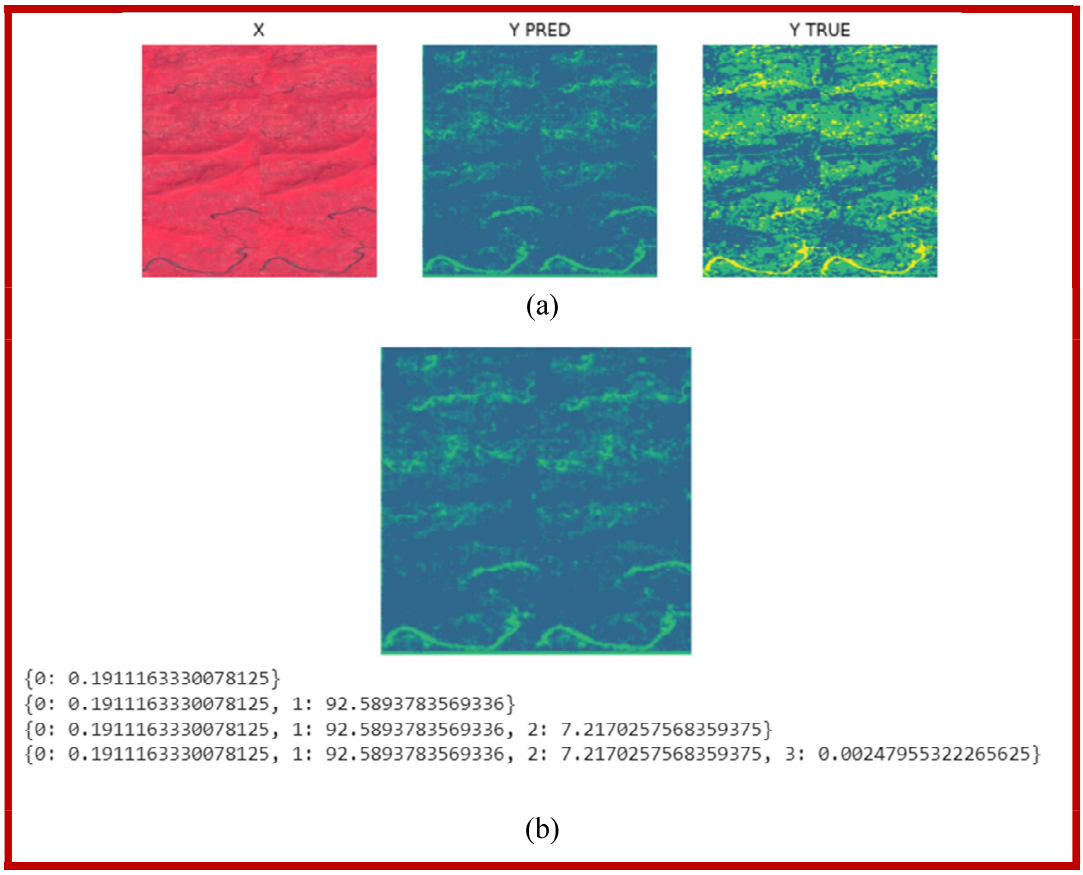
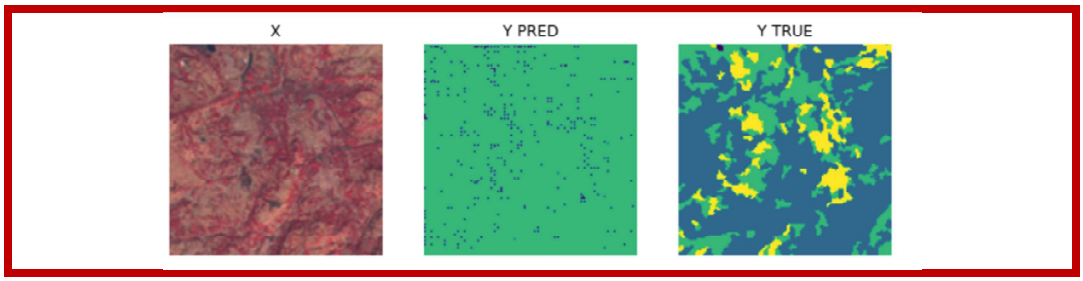
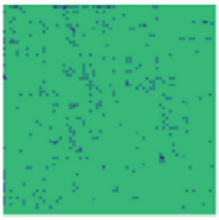


Figure 4.18: Result predicted by the model

Figure 4.19 represents the training logs of the model Tiramisu, applied on dataset – 3. Adam optimizer was used and the model achieved 33 % accuracy. Figure 4.20(a) shows the outcome or result predicted by the model and Figure 4.20(b) shows the quantification for each class in the resulting image.





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{0: 1.639556884765625}
{0: 1.639556884765625, 1: 0.0682830810546875}
{0: 1.639556884765625, 1: 0.0682830810546875, 2: 98.29216003417969}
```

Figure 4.19: Result Predicted by the model

The environment for the experiment is as follows: Windows 11 operating system and Envi 4.7 is used to process the remote sensing information, such as the selection of training sample, generation of masking, etc. The algorithm for classification developed in Fully-Convolutional Network U-Net, DeepLabv3+, and Tiramisu was coded with python + OpenCV.

	Optimizer	**EPOCH Trained**	**Dataset**	**Accuracy (%)**
U-net	Adam	50	Dataset – 1	81
U-net	RMSprop	50	Dataset – 1	79
U-net	Adam	50	Dataset - 2	84
U-net	Adam	50	Dataset - 3	77
Deeplabv3+	Adam	50	Dataset - 1	31
Deeplabv3+	Adam	50	Dataset - 2	26
Deeplabv3+	Adam	50	Dataset - 3	25
Tiramisu	Adam	50	Dataset - 1	51
Tiramisu	Adam	50	Dataset - 2	37
Tiramisu	Adam	50	Dataset - 3	33

Table – 4.1: Experiment result

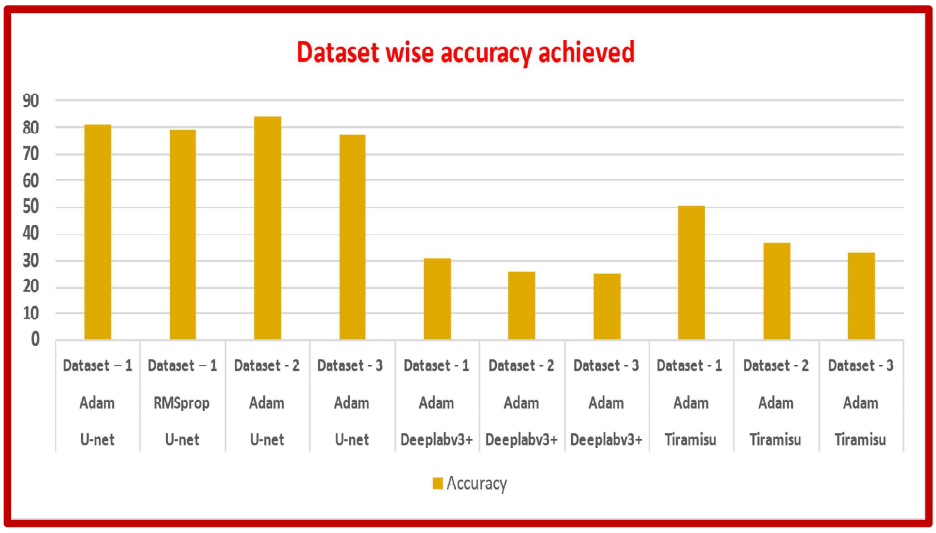
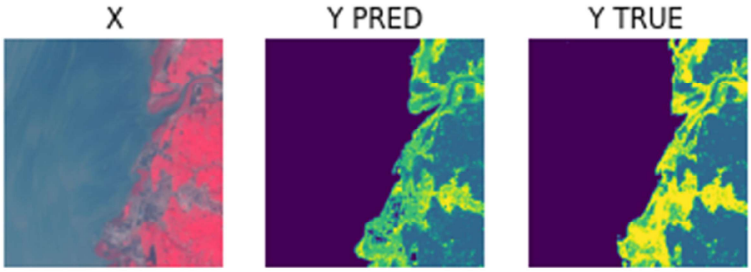


Figure 4.20: Dataset-wise accuracy

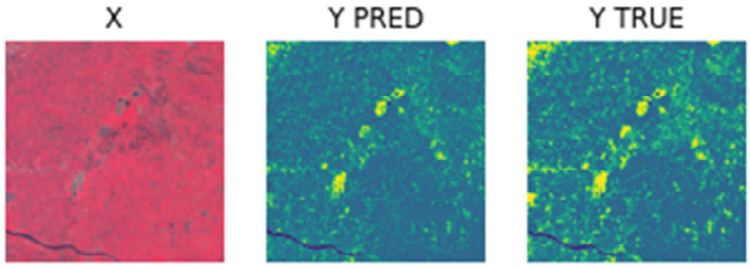
Experiment figured out the best fine-tuning parameters for U-net, Deeplabv3+, and Tiramisu with RGB bands of the dataset of LISS- III multispectral remote sensing images. The parameters which give vast performance are used to develop the final model. The model also used data augmentation. Table – 4.1 shows the experiment results and accuracy with different epochs. And from the outcomes, it was detected that U-net gives better results in classifying land use land cover classes. Figure 4.20 shows the dataset-wise accuracy of different models.

An FCC image is a combination of Band - 4, Band - 3, and Band - 2 of LISS -III multispectral images processed using tools of ENVI 4.7, in which the class Water Bodies are in blue, class Vegetation is in red, class Uncultivated Land in light red color, and class Residential Area is in white.

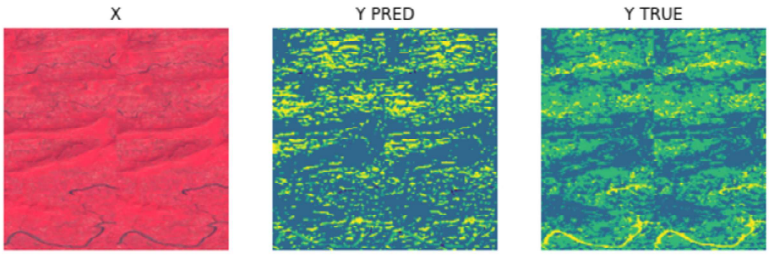
Figure 4.21 shows the land cover land use classification results in the south Gujarat region, India using U-Net, Deeplabv3+, and Tiramisu algorithms. The resultant figure contains a total of three figures X, Y PRED, and Y TRUE where X is an FCC input image, Y PRED is an image predicted by the model and Y TRUE is a ground truth mask that is used for the validation of the predicted output. The ground truth mask is generated via the maximum likelihood classifier.



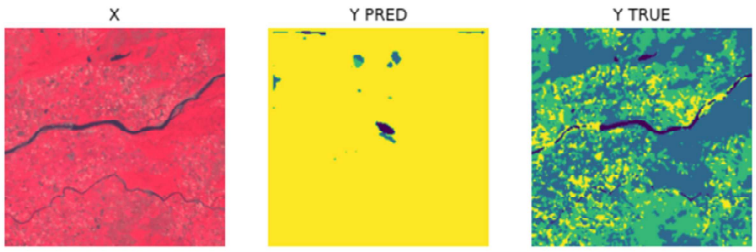
U-Net dataset -1, Adam



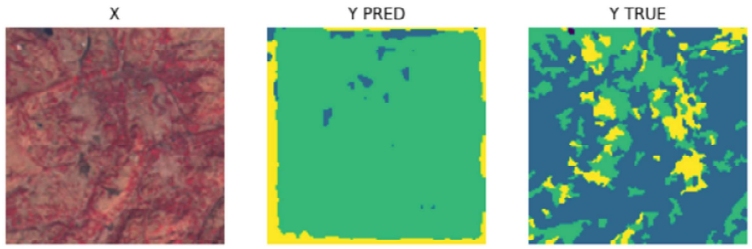
U-Net dataset – 1 RMSProp



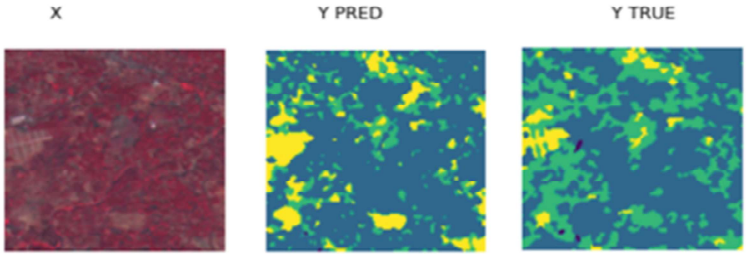
U-Net, Dataset -3



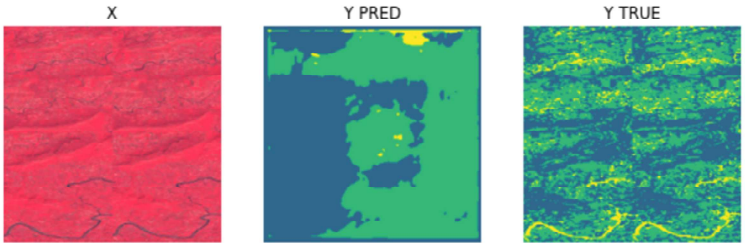
Deeplabv3+, dataset -1



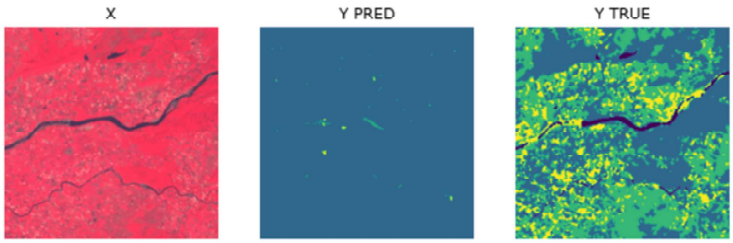
Deeplabv3+ dataset - 2



U-Net dataset – 2



Deeplabv3+ dataset – 3



Tiramisu, dataset – 1

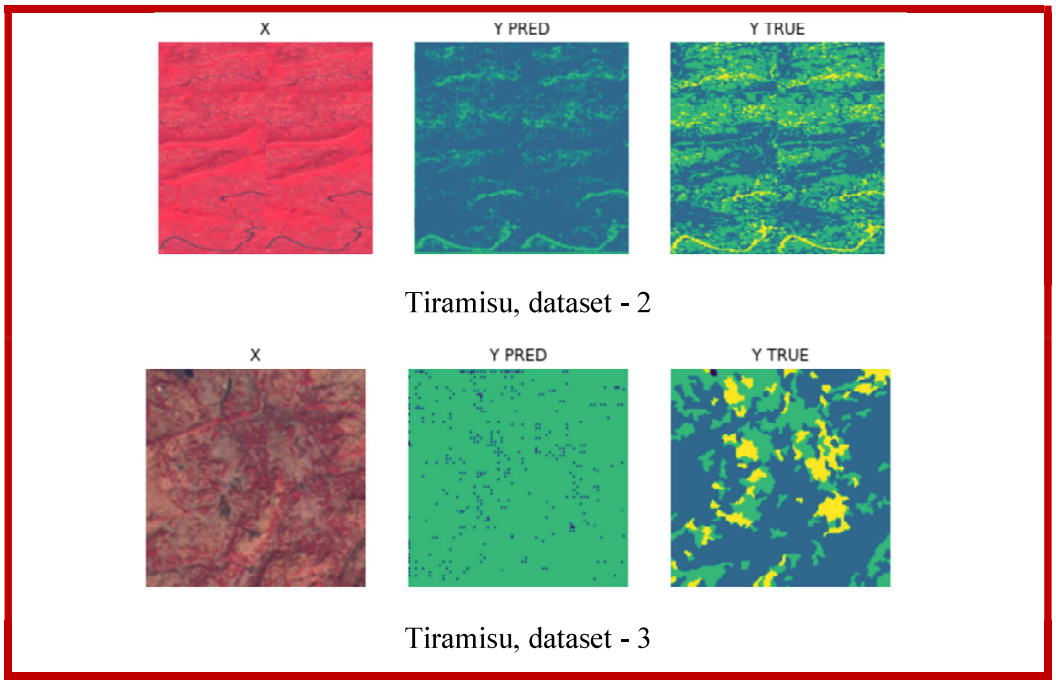


Figure 4.21: Classification of land use land cover with different classifiers

Table 4.2 shows the experiment performed on dataset-1 with different models. Figure 4.22 shows the model-wise accuracy with dataset -1.

	Optimizer	Dataset	Accuracy	EPOCH Trained
U-net	Adam	Dataset – 1	81	50
U-net	RMSprop	Dataset – 1	79	50
Deeplabv3+	Adam	Dataset – 1	31	50
Tiramisu	Adam	Dataset – 1	51	50

Table 4.2: Experiment result for dataset - 1

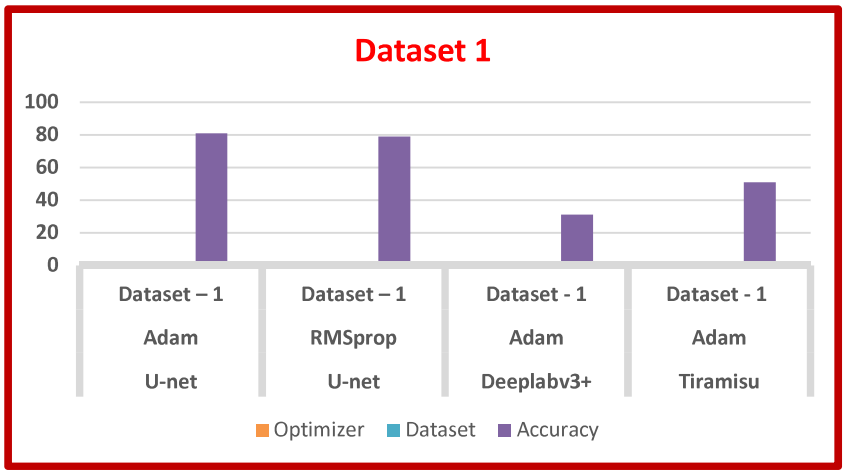


Figure 4.22: Model-wise accuracy with dataset -1

Tables 4.3 and 4.4 show the experiment performed on dataset-2 and dataset – 3 respectively with different models. Figure 4.22 and Figure 4.23 shows the model-wise accuracy with dataset - 2 and dataset-3.

	Optimizer	Dataset	Accuracy	EPOCH Trained
U-net	Adam	Dataset - 2	84	50
Deeplabv3+	Adam	Dataset - 2	26	50
Tiramisu	Adam	Dataset - 2	37	50

Table 4.3: Experiment result for dataset - 2

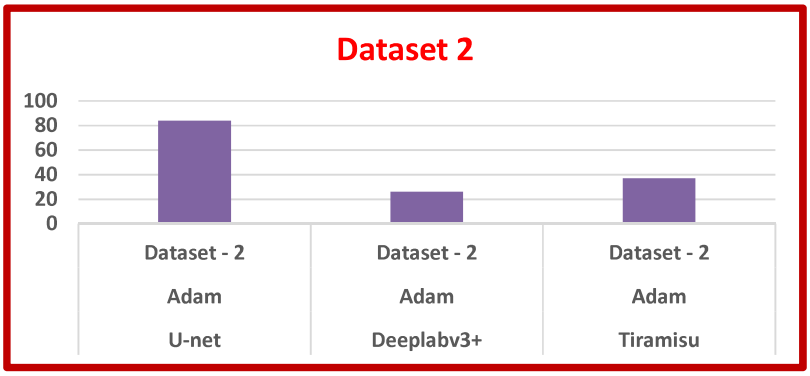


Figure 4.23: Model-wise accuracy with dataset – 2

	Optimizer	Dataset	Accuracy	EPOCH Trained
U-net	Adam	Dataset - 3	77	50
Deeplabv3+	Adam	Dataset - 3	25	50
Tiramisu	Adam	Dataset - 3	33	50

Table 4.4: Experiment result for dataset - 3

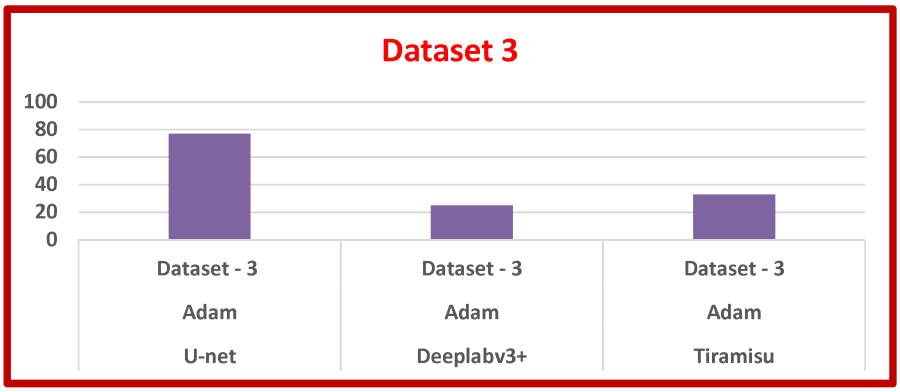


Figure 4.24: Model-wise accuracy with a dataset – 3

	Optimizer	Dataset	Accuracy (%)	EPOCH Trained
U-net	Adam	Dataset – 1	81	50
U-net	RMSprop	Dataset – 1	79	50
U-net	Adam	Dataset - 2	84	50
U-net	Adam	Dataset - 3	77	50

Table 4.5: Experiment result for all datasets using U-Net

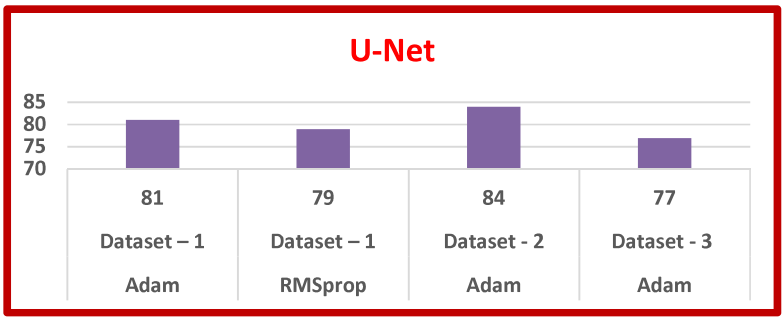


Figure 4.25: U-Net Accuracy on all datasets

	Optimizer	Dataset	Accuracy	EPOCH Trained
Deeplabv3+	Adam	Dataset - 1	31	50
Deeplabv3+	Adam	Dataset - 2	26	50
Deeplabv3+	Adam	Dataset - 3	25	50

Table 4.6: Experiment result for all datasets using DeeplabV3+

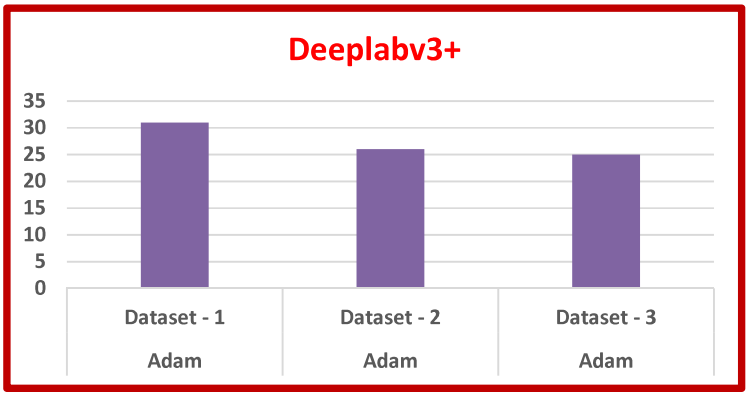


Figure 4.26: Deeplabv3+Accuracy on all datasets

	Optimizer	Dataset	Accuracy	EPOCH Trained
Tiramisu	Adam	Dataset - 1	51	50
Tiramisu	Adam	Dataset - 2	37	50
Tiramisu	Adam	Dataset - 3	33	50

Table 4.7: Experiment result for all datasets using Tiramisu

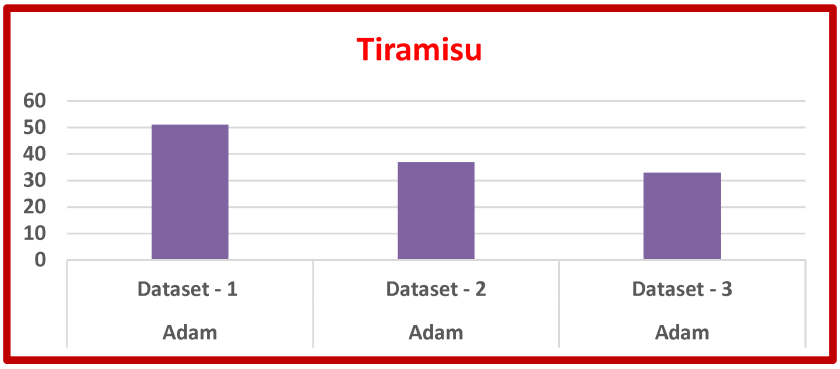


Figure 4.27: Tiramisu Accuracy on all datasets

Table 4.5 shows the experiment performed on all the datasets using the model U-Net. Figure 4.25 shows the accuracy achieved by the U-Net. Tables 4.6 and 4.7 show the experiment performed on all the datasets using the models Deeplabv3+ and Tiramisu. respectively. Figure 4.26 shows the accuracy achieved by the model deeplabv3+ and Figure 4.23 shows the accuracy achieved by the model Tiramisu on all the datasets.

Conclusion

The advantages of using intelligent systems like deep learning for LULC classification becoming more evident. It will provide a cost-effective and time management solution than the visual interpretation or other machine learning techniques currently obtainable today. The aim of the present work is to design algorithm for the classification of IRS LISS-III multispectral images to obtained land use land cover using deep learning approach.The model classified the LISS – III image into 4 classes i.e., Water Bodies, Vegetation, Uncultivated Land, and Residential areas. The U-net classifier gives better performance than Deeplabv3+ and Tiramisu. In this paper, a land-use land cover classification model is presented, built on an FCN classifier which is trained and tested on land use land cover LISS-III multispectral space born image dataset. Experiments show that model able to detect land use land cover classes. The combination of maximum Likelihood for ground truth masking and FCN for classification gives a very good result. The resultant

images predicted by the U-Net are very near to the ground truth mask. This research work was done in the South Gujarat region of country INDIA. And images were taken for the different months and seasons (OCT, JAN, and MAY) respectively. Total 3 datasets were created (dataset -1: 1470, dataset-2 : 13500, dataset-3 : 960 images). U-Net achieves an accuracy of 81% with dataset -1, 84% with dataset -3, and 77% with dataset-2. Model performed better with the dataset- 2 (13500 images).Outcomes confirmed that the FCN classifier holds massive potential for accurate detection of land use land cover classes. The model identifies 4 classes with very good accuracy and successfully works on LISS - III Multispectral indigenous space-born images.