Development of Automated Methods for Using Satellite Imagery to Monitor Changes in Vegetative Communities

Report for Quarter 3/Task 7 in 2022

Submitted to: St. Johns River Water Management District

By

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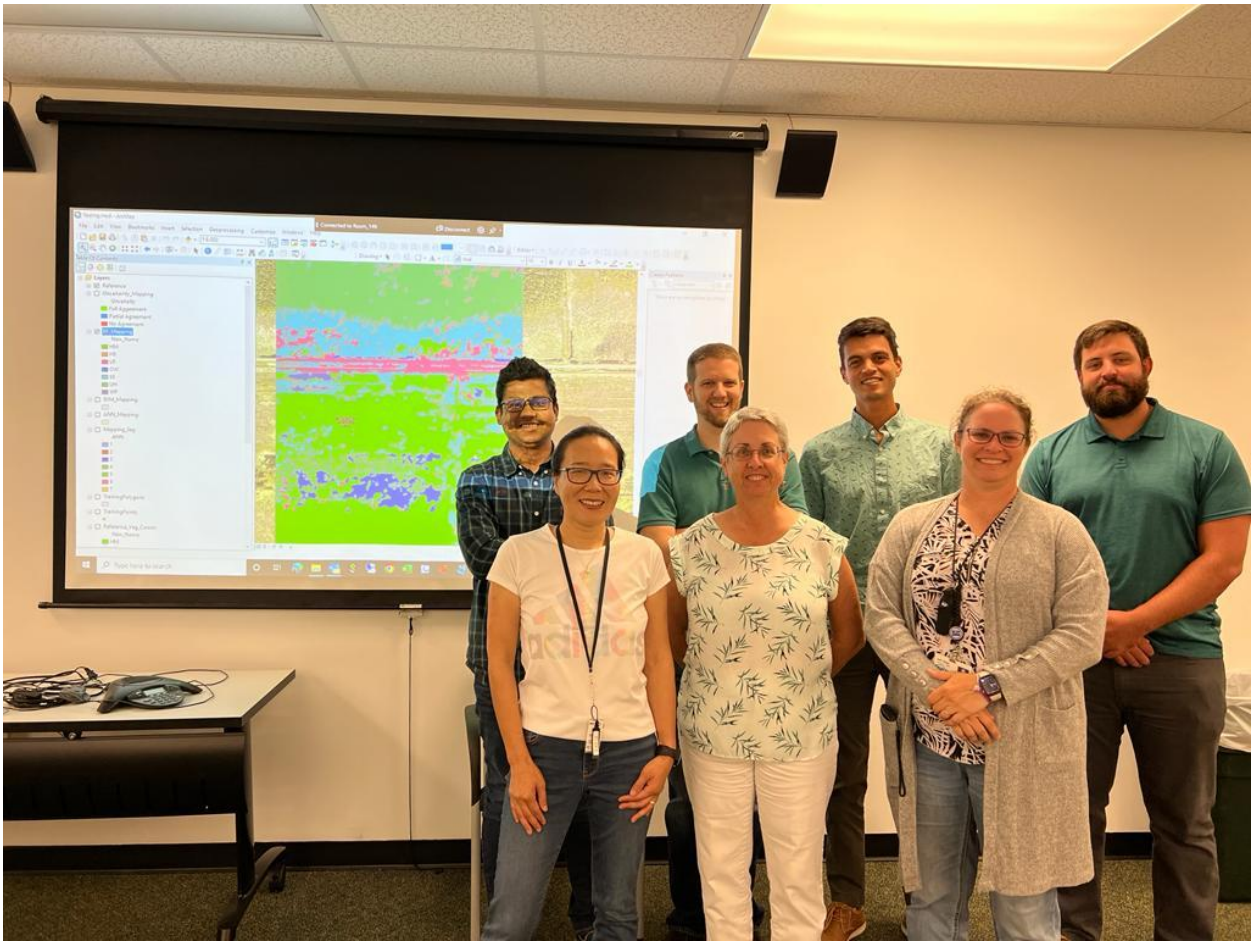

On-site training for using machine learning techniques to map wetland communities at the St. Johns River Water Management District: District Headquarters in Palatka, 22 June 2022. Front (left to right): Caiyun Zhang at FAU, Dianne Hall and Jodi Slater (District); Back (left to right): Mizanur Rahman (FAU), Andy Canion, Ali Simpson, and Randy Fink (District).

Contents

In this Quarter, we focused on improving the developed tutorials including the entire mapping tutorial and R script tutorial. We also prepared testing datasets for the on-site training and met with the District's project manager Dr. Dianne Hall to discuss the on-site training plan. Details are provided below.

1. Tutorial Improvement and Update

Major updates of the tutorial include:

1) Replacement of the ArcPro part with ArcMap for NDVI and DEM addition in the segmentation file. Due to limited licenses of ArcPro, as suggested by the District, we revised the original NDVI calculation and DEM part to utilize ArcMap. Now the entire mapping procedures can be completed using ArcMap, eCognition, WEKA, and R.
2) Segmentation export part in eCognition. For the export part, eCognition does not name each selected feature in a reasonable manner, we thus need to manually put in a reasonable name such as B1 for band 1, STD_B1 for standard deviation of band 1. This will help during the variable importance analysis when we run each classifier to select optimal features for classifications.
3) Training sample selection. During the on-site training, Jodi Slater suggested that the class code number be assigned first and then the edited points will automatically have the assigned number and there is no need to assign the class codes to the points afterwards. This made the training point editing part easier. We have updated this part of the tutorial accordingly.
4) Addition of R script part for ensemble analysis and McNemar test. WEKA does not have a method for conducting the McNemar test or doing ensemble analysis. Consequently, we wrote R scripts to process the outputs from WEKA to produce the McNemar test results, and the ensemble analysis.

The updated tutorial is sent in a separate file (Mapping Tutorial_V6.docx).

2. On-site Training Plan

We met the District's project manager Dr. Dianne Hall on line on 12 May 2022 to discuss the on-site training plan. We discussed the following points and plans:

1) Potential training date
   June 21-22, 2022 (District will find the most common date District staff can attend)
2) Number of District attendants
   Around 6 District staff including an IT guy to provide IT support.
3) Number of FAU attendants
   2-3, PI Zhang and PhD students
4) Software packages and PC/Laptops
   District will prepare PCs/laptops with required software packages for District staff, and FAU will prepare software and PC/laptop required by FAU personnel. Software packages include:
   - ArcMap: we will use ArcMap 10.7 or higher version in the entire procedure, and no ArcGIS Pro is required
   - eCognition Developer 10.0 or above version

- Excel: Microsoft Excel
- WEKA: open source, can be download at https://waikato.github.io/weka-wiki/downloading_weka/. We need Windows 64-bit.
- R and RStudio: open source
  R is from https://cran.r-project.org/bin/windows/base/
  RStudio is from: https://www.rstudio.com/products/rstudio/download/
- Notepad++: open source, from https://notepad-plus-plus.org/downloads/v8.4.1/, 64-bit

5) Demonstration data preparation
   FAU will prepare a smaller dataset for the training because a large dataset will require many hours to complete the segmentation and export procedures in eCognition. We will identify a subset of the imagery that eCognition can finish in 30 minutes. The imagery subset will have a reasonable number of communities and adequate training samples. This prepared dataset will be uploaded to District server before on-site training starts. FAU will also prepare the West Apopka result for each step in the training.
6) Tutorial revision
   The District will complete the second review of the mapping tutorial and the first review of the R script tutorial ASAP and send back to FAU. FAU will work on the revision, especially the part concerning the use of ArcGIS Pro, which will be replaced by ArcMap. The revised tutorial will be sent to the District before the on-site training.
7) Serving on FAU graduation dissertation committee
   District Dr. Dianne Hall is allowed to serve on the dissertation research committee of FAU PhD student Mizanur Rahman who will develop his dissertation based upon this project. Dr. Hall is supervising this project and is knowledgeable in wetland mapping and ecology. The inclusion of Dr. Hall's expertise to this dissertation research is valuable. FAU will work on the paperwork for this and needs a CV of Dr. Hall for the paperwork at FAU.
8) Potential further collaboration
   District may have the opportunity to collaborate with FAU on satellite wetland mapping projects in the future.

3. On-site Training Data Preparation

We prepared a small dataset covering around 300 acres in LANS for the on-site training (Figure 1). The small dataset takes less time and is more appropriate for demonstrating each step. The WorldView-2 imagery was collected in 2021. We prepared corresponding datasets for the small areas including:

AerialPhoto.tif: aerial photography in 2017

DEM.tif: 2-m resolution DEM

Reference_Veg_Comm.shp: reference map in 2017

ROI.shp: region of interest

WV2.tif: WorldView-2 imagery of 2021

All these datasets were uploaded to District's FTP a week before the on-site training.

Figure 1. The location of a small sample area with corresponding datasets used in the on-site training.

We also prepared all datasets including inputs and outputs for the west LANS to demonstrate each step (Figure 2), including:
1_WV-2_WestApoka.tif: Original WorldView 2 imagery to be used for mapping
2_DEM_WestApoka.tif: Original input DEM file
3_Veg_Original: original vegetation map in 2017
4_AOI: Original input Area of Interest
5_Original segmentation from eCognition: Output segmentation file from eCognition
6_Clipped out segmentation file: Clipped out segmentation file
7_Segmentation file with NDVI and DEM: Segmentation file with NDVI and DEM included
8_Training points: collected training points
9_Training_Polygons: Identified training polygons
10_Veg_Code_WestApopka.txt: created text file with vegetation name, class code, and abbreviations
11_Training.csv: exported csv file to be used in WEKA

12_InputForPediction.csv: exported csv text for prediction in WEKA
13_Prediction_ANN_SVM_RF.shp: final segmentation file with SVN, ANN, RF prediction included
14_Final_Map_ANN: final dissolved ANN mapping file
14_Final_Map_SVM: final dissolved SVM mapping file
14_Final_Map_RF: final dissolved RF mapping file
14_Final_Map_Uncertainty: final dissolved uncertainty mapping file
16_NDVI.tif: NDVI of the WV-2 imagery

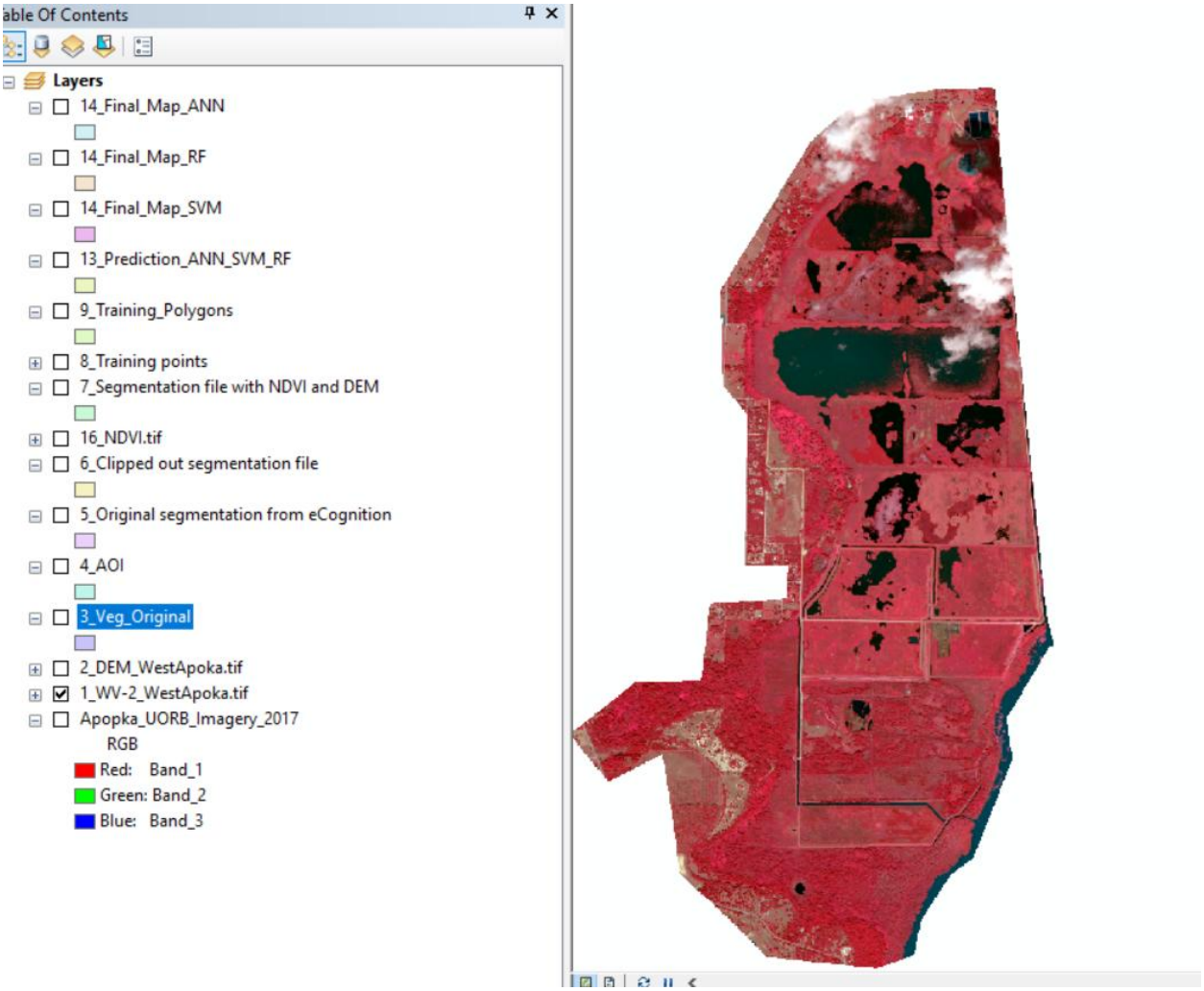

Figure 2. West LANS demonstration datasets for on-site training.

4. On-site Training

On-site training was conducted 21-22 June 2022 at District's Headquarter as planned. FAU crew (Zhang, and two PhD students David Brodylo, Mizanur Rahman) arrived on June 20 and visited the training room and checked all software packages. Dr. Dianne Hall at the District introduced us to the District environment, showed us around, and prepared name plates to be used during training. District staff Dianne Hall, Jodi Slater, Andy Canion, Ali Simpson, and Randy Fink attended the training. Lissa Strohecker from District's communications department was present

during part of the first day of training to take pictures and report on this research and training event. The agenda is below.

Day 1: June 20, FAU crew arrived Palatka in the afternoon. Dr. Dianne Hall showed us the training room, ensured the FAU laptop could connect to the overhead projector and discussed the training schedule for the next day (e.g., starting at 8 am, lunch time: 12-1 PM, and ending at 4 PM) Pictures were taken in Building 1 with help from the front desk (Figure 3).

Day 2: June 21, we completed the tutorial for using ArcMap, eCognition and WEKA to produce the plant community maps.

Day 3: June 22, we completed the tutorial for using the R script, in place of WEKA, to produce the plant community maps and discussed other questions the District had concerning mapping plant communities using satellite imagery. FAU crew got back to Boca Raton around 5 PM.

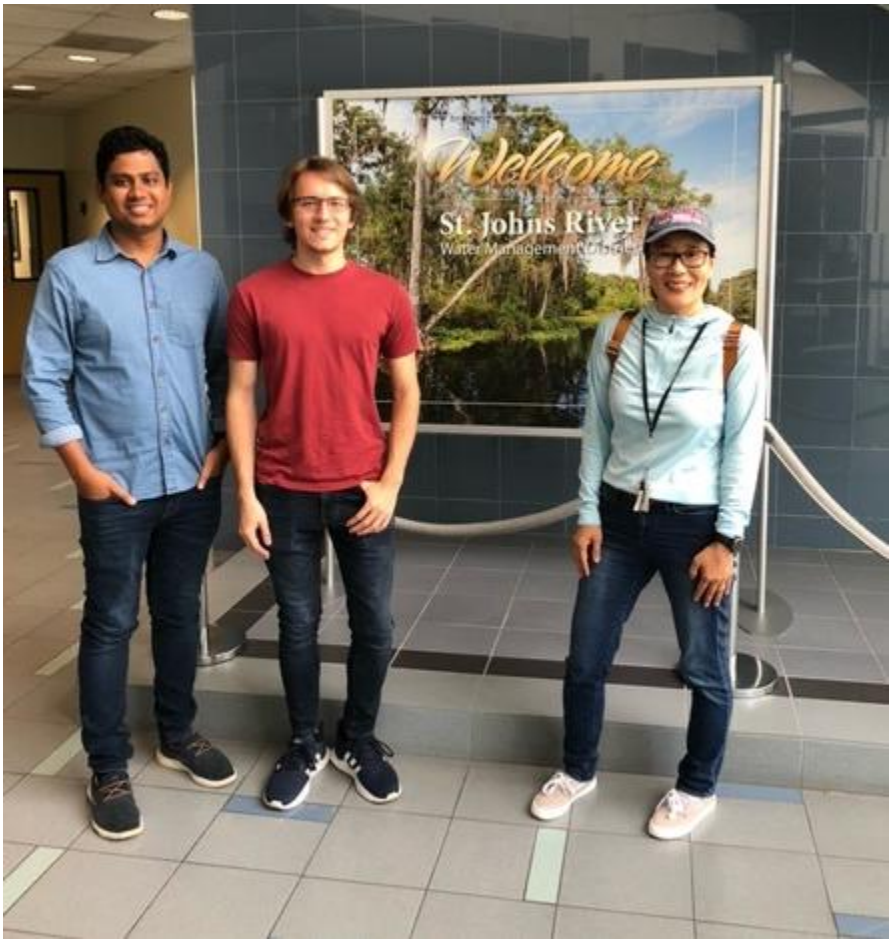

Figure 3. FAU crew arrived District Headquarters in Palatka on 20 June 2022. Left to right: Mizanur Rahman, David Brodylo, Caiyun Zhang.

Figure 4. Training on Day 2.

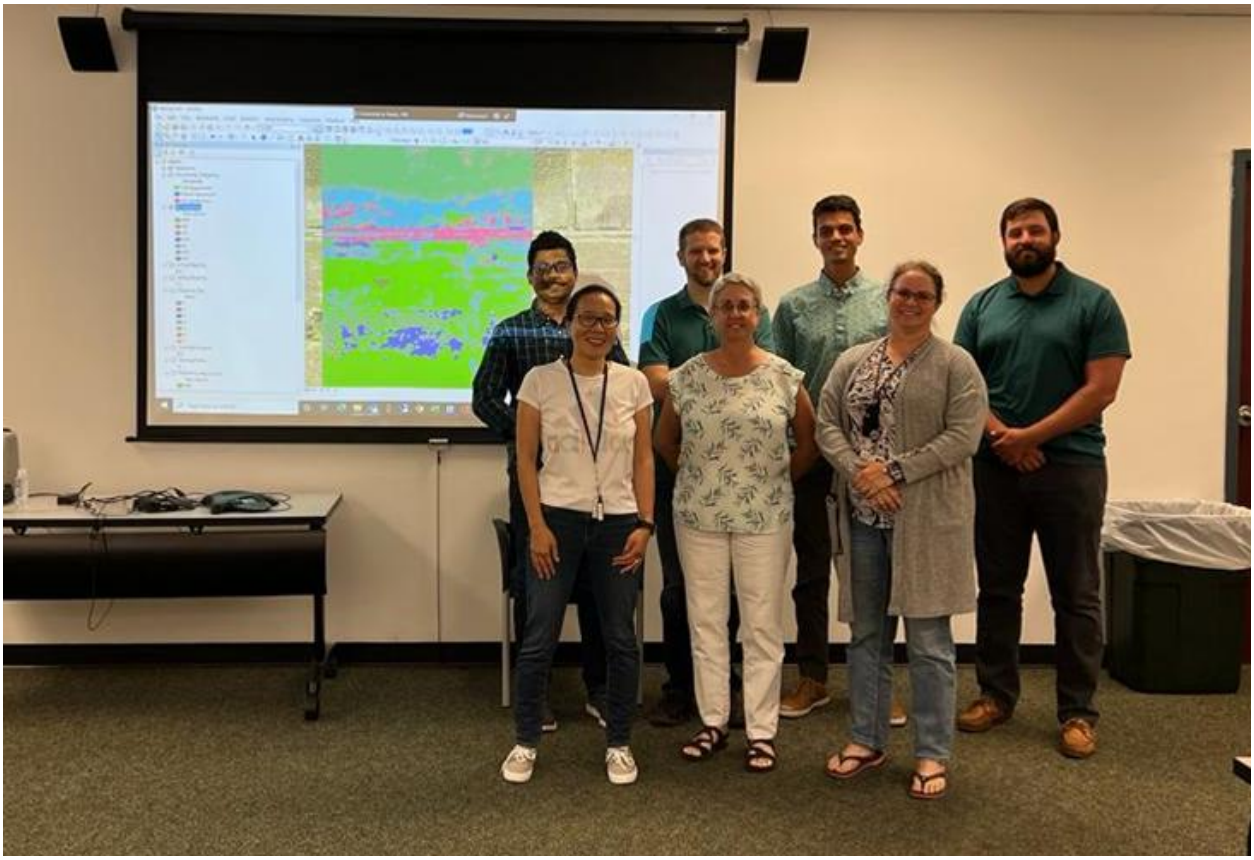

Figure 5. Completion of training on Day 2 with the classification map shown behind.

The on-site training was successful without any technical issues. We generated classification maps and R script outputs, as shown below.

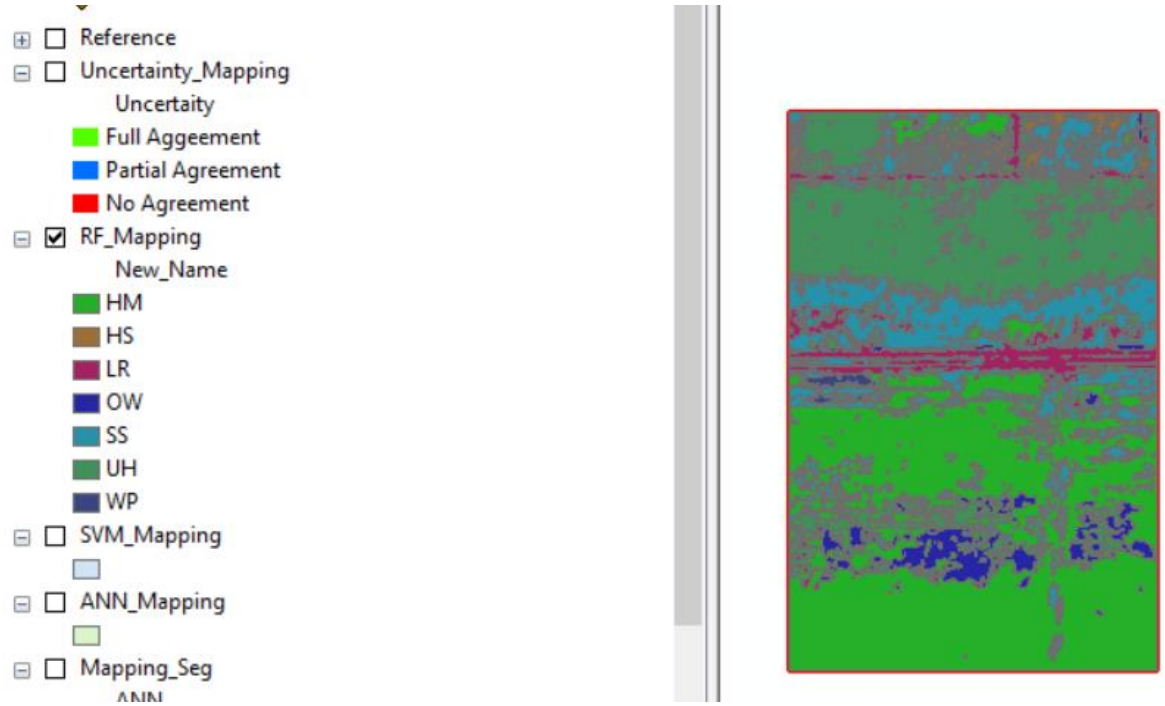

Figure 6. Example of RF classification map for the testing area.

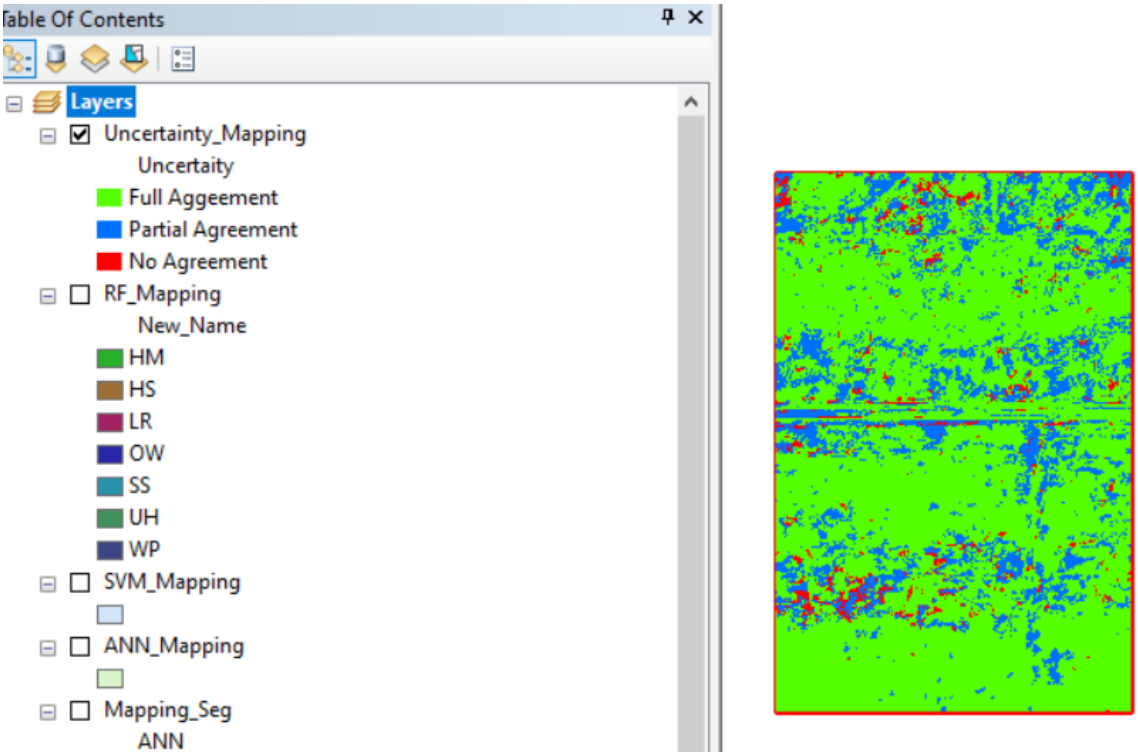

Figure 7. The uncertainty map for the testing area.

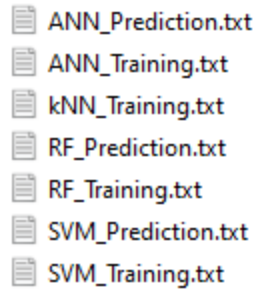

Figure 8. WEKE training and prediction output files.

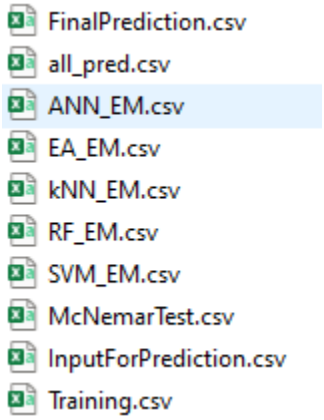

Figure 9. R script input and output files.