CS 452 – Systems Analysis and Design Team Project

Erosion Management

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Introduction

Erosion is a natural process which is usually made by rock and soil being loosened from the erosion earth's surface at one location and moved to another. Erosion changes landscape by wearing down mountains, filling in valets, and making rivers appear and disappear.

Erosion has long-term consequences for soil quality and short-term consequences on individual crops. Off-site environmental effects are increasing and becoming more unacceptable to those affected as well as the public at large.

Repeated erosion reduces the fertility of the soil by:

- removing top soil which is rich in nutrients and organic matter;
- reducing the depth of soil available for rooting and for storing water available for crop growth; and
- reducing infiltration of water into soil and increasing run off.

Short-term damage and increased costs can result from:

- loss of seeds, seedlings, fertilisers and pesticides, and the need to repeat field operations;
- soil being washed from the roots;
- young plants being blasted with sand during wind erosion; and
- the need to level out eroded surfaces by extra cultivations.

Damage to the off-farm environment takes the form of:

- deposition of sediment onto roads, neighbouring properties and in roadside drains;
- damage to the quality of watercourses, lakes and coastal waters though excess inputs of nitrogen, phosphorus and pesticides;
- sediment in rivers damaging the spawning grounds of fish; and
- increased run off and deposition of sediment causing a greater flood hazard downstream.

In Turkey, in the past 50 years 59 percent of agricultural land, 64 percent of pastures and 54 percent of forest lands experienced erosion. Turkey need 700 years to protect 57.6 million hectares from the threat of erosion. Globally, $42 billion is being lost because of erosion and countries spend $2.4 billion to fight against erosion.

Aim of this project is to detect the regions having potential risk of erosion.

Business Drivers

1. With the new modeling tool, proactively and more accurately predict the potential erosion areas and take necessary precautions in advance of occurrence of any land loss due to erosion

2. Reduce amount of land lost due to erosion and its negative impact on economy

3. With help from better prediction, take necessary actions to avoid erosion in a more cost-effective way

4. Optimize the costs by planting trees in the correct areas to slow down erosion

5. Optimize the costs for building structures (drainage, irrigation, dams, etc) controlling water flow to manage the erosive power of water.

Feasibility Analysis

System Request— Erosion Management

Project sponsor**:** Yaşar Çakıroğlu, Head of Erosion Management Department at Ministry of Forestry and Waterworks.

Business Need**:** This project has been initiated to improve the fight against erosion and provide a more precise solution to prevent this natural disaster.

Business Requirements:

• NDVI capable cameras that will fit into the existing drones.

• Installing Rain measurement sensors on selected fields.

• Streamlining the static data in the CSV files.

• Data analysis and tracking capabilities.

•Ability to predict where erosion is going to happen.

Business Value:

The system will provide information about the areas that are prone to erosion in order to calculate where erosion is going to happen. These predictions will allow the ministry to take proactive actions resulting in preservation of the environment and farmable areas that can potentially generate massive amounts of income as long as they are farmed.

Special Issues or Constraints:

• Increased staffing will be needed to operate the new system from business operations aspect. The new staff is trained or professionals are hired in order to maintain and use the drones, maintain and install the database and to perform other necessities of the system.

Technical Feasibility

The project size is considered large because it will be applied to the whole country therefore the scope is large. However, the implementation of this project carries a low-level risk due to availability of drones and rain measurement sensors. So, the IT department has well defined subsystems. The IT department needs to create a way to use these systems together. With this current approach, they only start planting trees once erosion has made an observable impact. Trees take many years to mature, so erosion continues during that period. Also, the IT department need to acquire NDVI cameras that will fit into their existing drones and install rain measurement sensors on selected fields to understand if their rainfall estimations correct. They also need to figure out a way to streamline the static data in the CSV files.

Organizational Feasibility

From organizational perspective, this project has medium risk. Scale of the project creates this the risk. The goal of the system is to enhance the erosion prediction and decrease the erosion risk in all of the country. The project has a project sponsor who is one of the department heads in the Ministry, he is also considered to be the project champion because this system was his idea. With this support IT department can get required information about erosion and its causes. With offering a decrease in erosion, this project

can be accepted if it can pass through the complex approval process of the required permits with the help of an experienced professional at this field(bureaucracy).

Requirements Analysis

Non-functional Requirements

1. Operational Requirements

1.1 NDVI capable camera should capture snapshots of the target area including both visible and non-visible near infrared spectrums.

1.2 NDVI capable camera should store the images in its physical storage(SD and internal).

1.3 Sensors should send the rainfall data to the database via a private network

1.4 System should collect these data and check whether there is erosion risk or not.

1.5 The software will operate in Windows environment.

1.5 A third party image processing software should convert the raw image format to NDVI.

2. Performance Requirements

2.1 NDVI capable camera should scan the area in every 2 second in order to achieve %70 overlaid images for most consistent NDVI images.

2.2 The camera should use its own battery in order to not draw power from the drone for the maximum flight time and area coverage.

2.3 The SD card of the camera must be fast enough write the data in time (less than 2 seconds)

2.4 The drone should fly at 10 m/s to allow best overlay of captured images.

3. Security Requirements

3.1 Only the responsible professionals can import/export the data.

3.2 System is activated with password.

3.2 Physical security of the hardware must be provided.

4. Cultural and Political Requirements

4.1 The organization of the ministry and its attachments are complex. The approval process of the project will require certain permits from different small organizations with specific authority. These issues should be handled by an experienced professional regarding appliance and approval of required permits

Key Performance Indicators

1. Internal Performance Indicators

1.1 Rainfall intensity measurement at the target areas with a low error margin.

1.2 Accurate periodic measurements of slope steepness of a target area

1.3 Being able to train and hire experts to analyze geospatial erosion models

1.4 Ability to utilize Revised Universal Soil Loss Equation (USLE, RUSLE2D, RUSLE3D)

1.5 Ability to cross check concurrent soil detachment calculations with relevant periodic backups

2. External Performance Indicators

2.1 Ability to predict erosion with a time margin big enough to allow proactive action

2.2 Availability of the system in the targeted areas

2.3 Practical deployment for the extension systems

2.4 Compensating the annual system costs with generating indirect tangible values regarding soil loss

Database Selection and Design

While trying to determine the database selection and design, there are a number of conditions to consider. In this case, there will be three types of data that will be collected and analyzed.

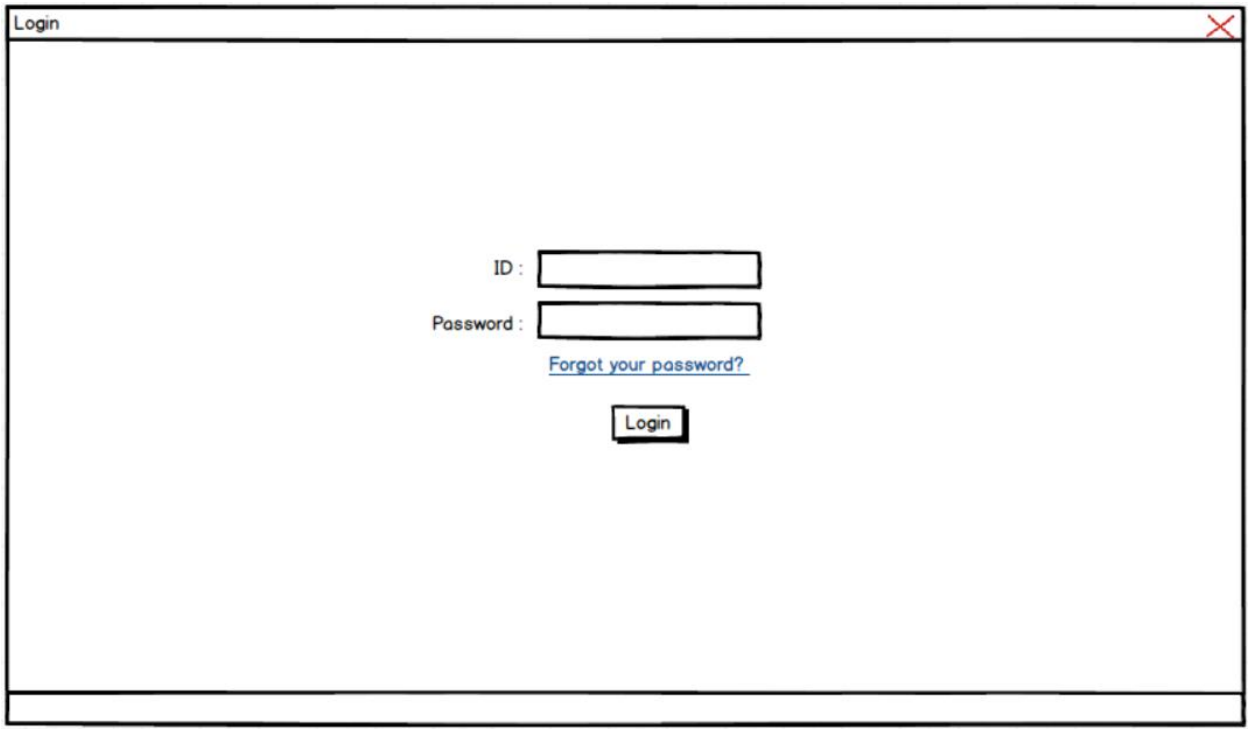
- CSV files that are going to be downloaded from the FTP server.
- The data that is going to be acquired by cameras placed on drones at target regions.

- The data of the rain measurement sensors that are placed on specific regions.

The CSV data that will be acquired from Ministry of Environment is not very reliable as it does not concern the targeted areas directly. However; it still has importance so, it will be used. For this reason, the database that will be chosen should be able to integrate these files into its system. The data that comes from cameras and sensors does not have a specific format as the format will be given various types according to need as it is processed by the software and data created in it. Therefore; these data are transmitted directly to the database. At the start, it is considered that the data comes from very different places, their size is really high and data will be very detailed so the data is complex and it would be sensible to use a NoSQL database for this reason in order to handle this situation better than relational databases. However; the incompliance of both ministries makes this hard; considering it especially in terms of CSV files. There are also some ways for no-sql databases to streamline the data of CSV files. For example, for MongoDB, there are some platforms with extra cost that automates CSV files to MongoDB like FME software. However; RDBMS is decided to be used because it is easy to use also it is easy to insert CSV files to SQL tables because with MySQL, the CSV files can directly be converted into tables so the data can be changed in tables and does not require a paid third-party software.

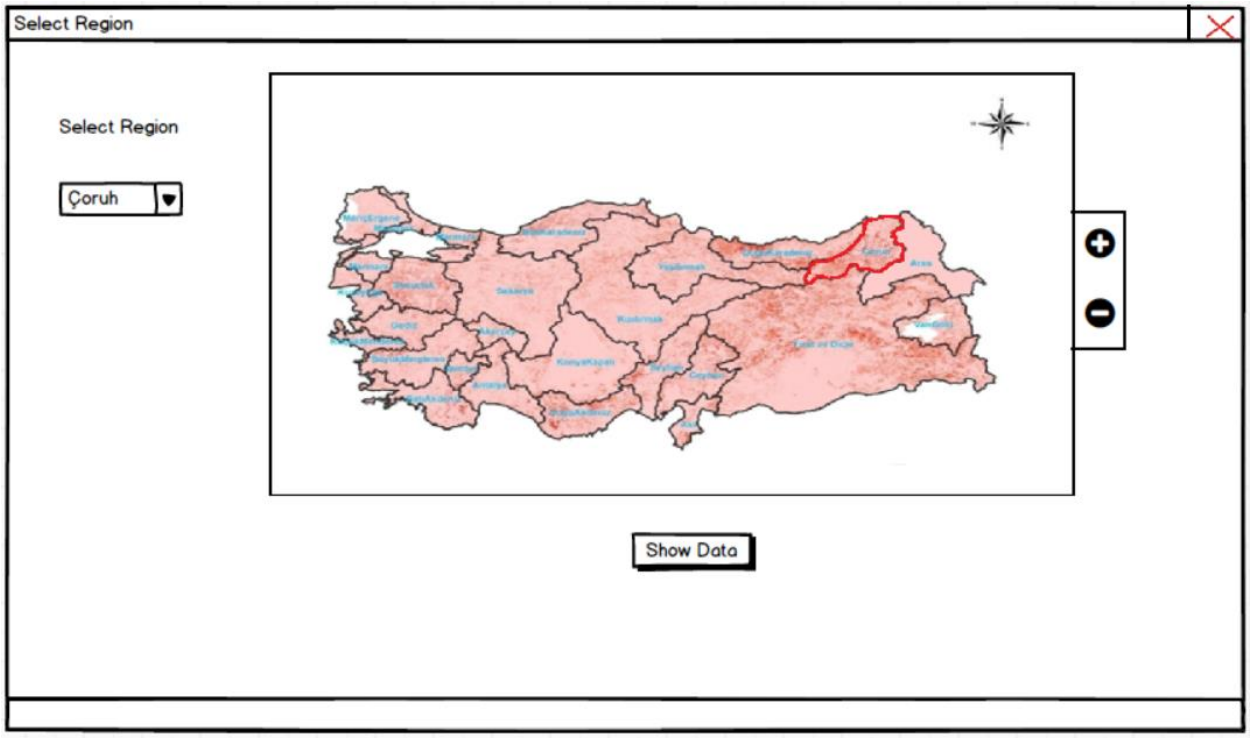
UI Design

1. Login Screen



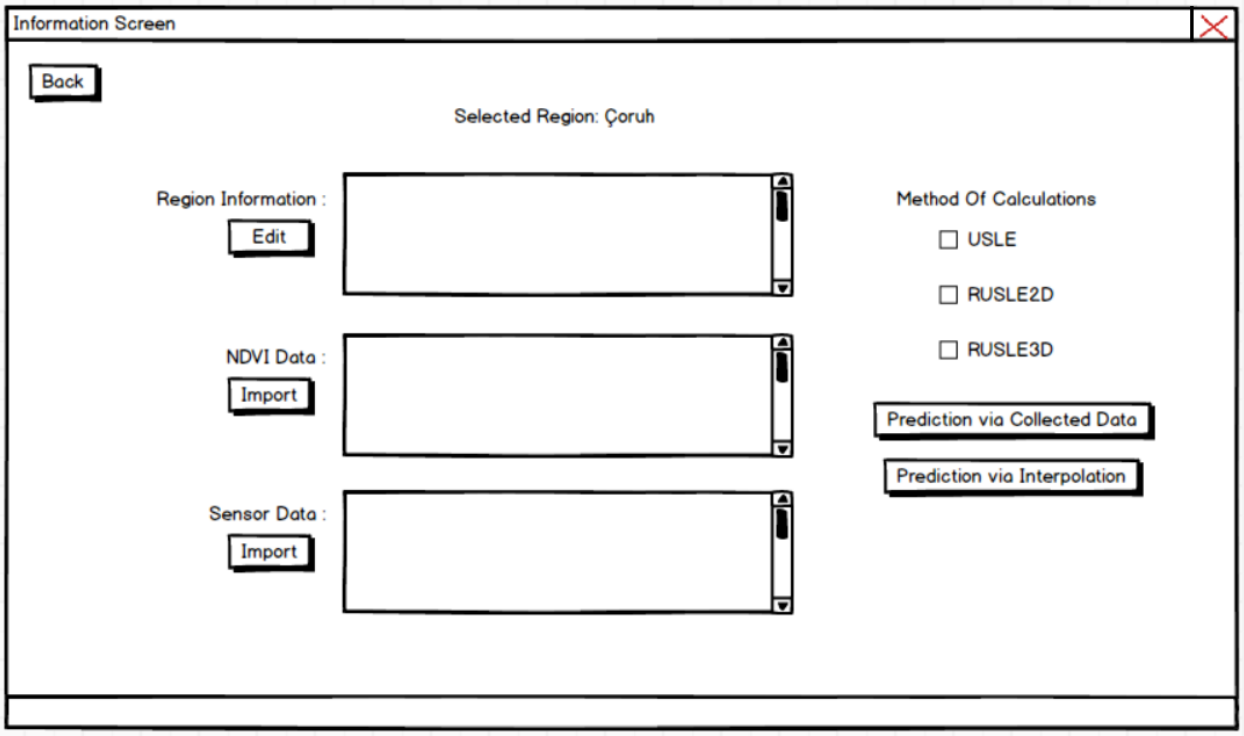
To login the system authorized person has to enter his/her personal ID and password. After entering ID and password he/she can access the system with pushing the “Login” button. If the user forgot his/her password, he/she clicks the “Forgot your password?” link. And he/she can change the password from this link.

2. Region Selection Screen



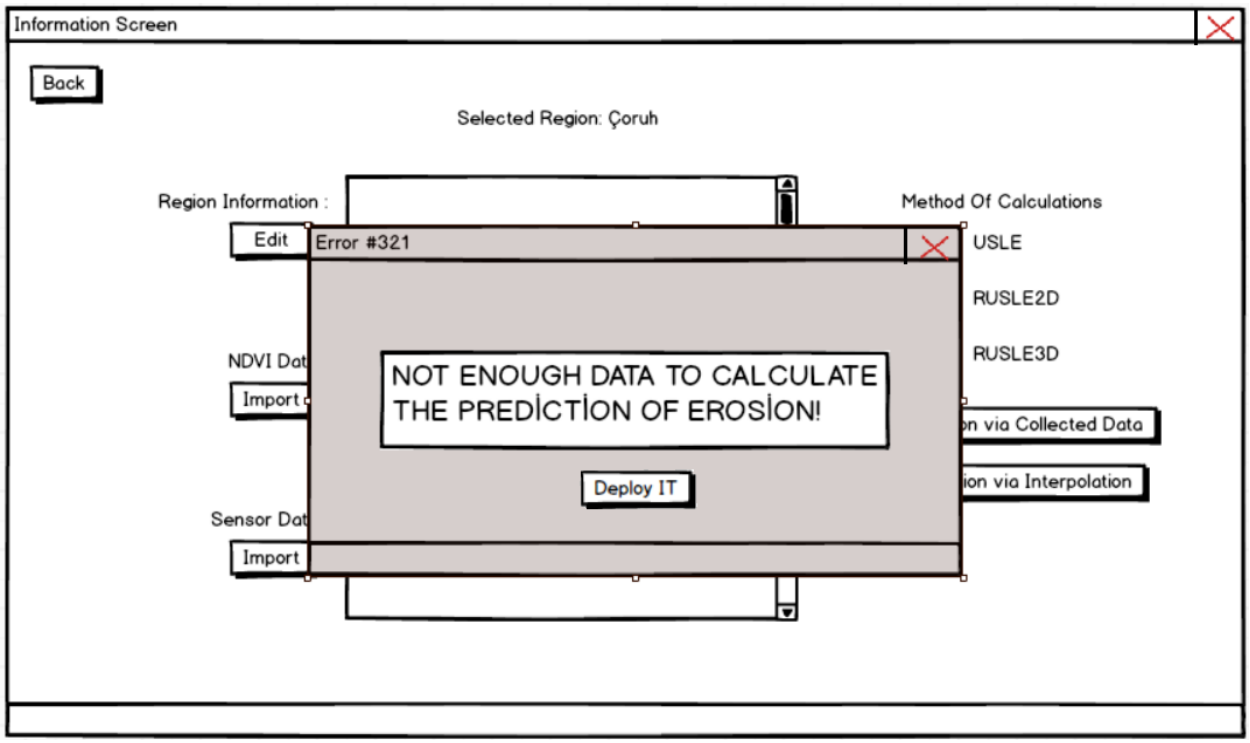
The authorized person can select the area from combo box. Also, he/she can look at the map more detailed with using zoom buttons. When he/she select the region, the region's frame will be highlighted. After that to look at the data about this specific region, the authorized person can click the "Show Data" button.

3. Information Screen



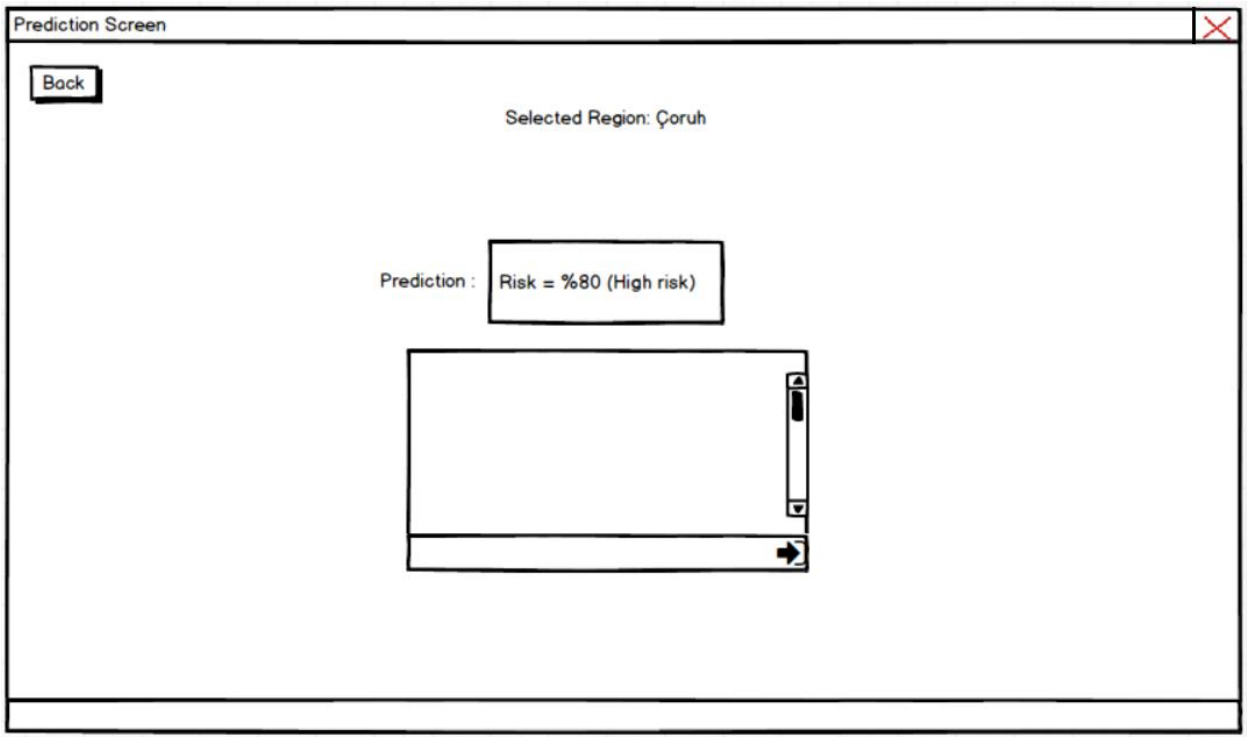
After the “Show Data” button is clicked, the information screen will come. The authorized person can look at the region information’s, NDVI camera data and sensor data in this screen. The region information data and NDVI data will be updated with clicking the “Edit” and “Import” buttons under them. Sensor data will be updated from the database. If this process fails it is possible to update the data manually with clicking the “Import” button under the Sensor data. To see the erosion predictions, he/she must select the calculation type with checking one of the check boxes with calculation methods, then he/she pushes the “Prediction via Collected Data” button or “Prediction via Interpolation” button. To go back to previous screen he/she can click the “Back” button.

4. Not Enough Information Pop-up



After the authorized person clicks one of the prediction buttons, if there is not enough data to predict erosion risk, the error screen pops up. When the authorized person clicks the “Deploy IT” button, the system send an email to the IT department for installment of material to this specific area.

5. Prediction Screen



The authorized person reads the erosion risk prediction in this screen. Also, he/she can comment about the prediction and see the previous comments from comment box. With clicking the “Back” button he/she can back to the previous page.

Security Measures

Security is an important key factor for project. In this project several security conditions should be provided to prevent different risk factors.

First of all, security of the drone controller program must be established to prevent the drone from being hyjacked. Secondly, NDVI camera provides some data about land where we control whether there is a risk about erosion or not. Essentially, database security should preserve these data from individuals outside of the project. There should be also an armed security guard for IT people responsible for the hardware that worths thousends of dollars at the time of field exploration and data measurement.

Hardware Selection

The hardware this project requires can be divided into two categories:

- Project specific erosion prediction related hardware
- Computing and data storage related hardware

1. Project Specific Erosion Prediction Related Hardware:

In order to collect data for erosion management Ministry of Forestry and Waterworks needs to obtain cameras with sensors capable of capturing data at “near-infrared” band. These data from the sensor then can be converted to a NDVI image. To give these cameras as much coverage as possible their logistics will be provided by the existing drones of the ministry (SenseFly eBee).

The camera chosen for the project is Parrot Sequoia. This camera is made by the same company as the drones of the ministry and they have a multispectral sensor that will provide very accurate NDVI data. To integrate these camera to the drones there is a kit provided by

the company so the integration will be straightforward and the camera will be secure completely compared to other integration options (gimbals and compatible goPro mounts).

Parrot Sequoia has an SD card slot and 64gb internal memory and the expected period of snapshots of the areas are about 2 seconds. The files will be in raw format therefore it is possible to max out the internal storage in mid-flight. Since the maximum flight time of eBee drones are about 50 minutes, in order to not bottleneck the drone's capabilities, we will utilize both internal and external memory of the camera. We will need and SD card that is capable of writing data at high speeds because after 2 second there will be a new snapshot. We will purchase Samsung SD Pro+ U3 C10 (Class 10) cards with 64gb of storage and 95MB/s writing capacity.

Product	**Number (For each expansion unit)**	**Price(MSRP)**
Parrot Sequoia	1	3500$
Sequoia integration kit for eBee	1	350$
Samsung SD Pro+ U3 C10 (Class 10) 128Gb	1	129$(on sale for 99$)
Total	-	3949$

2. Computing and Data Storage Related Hardware:

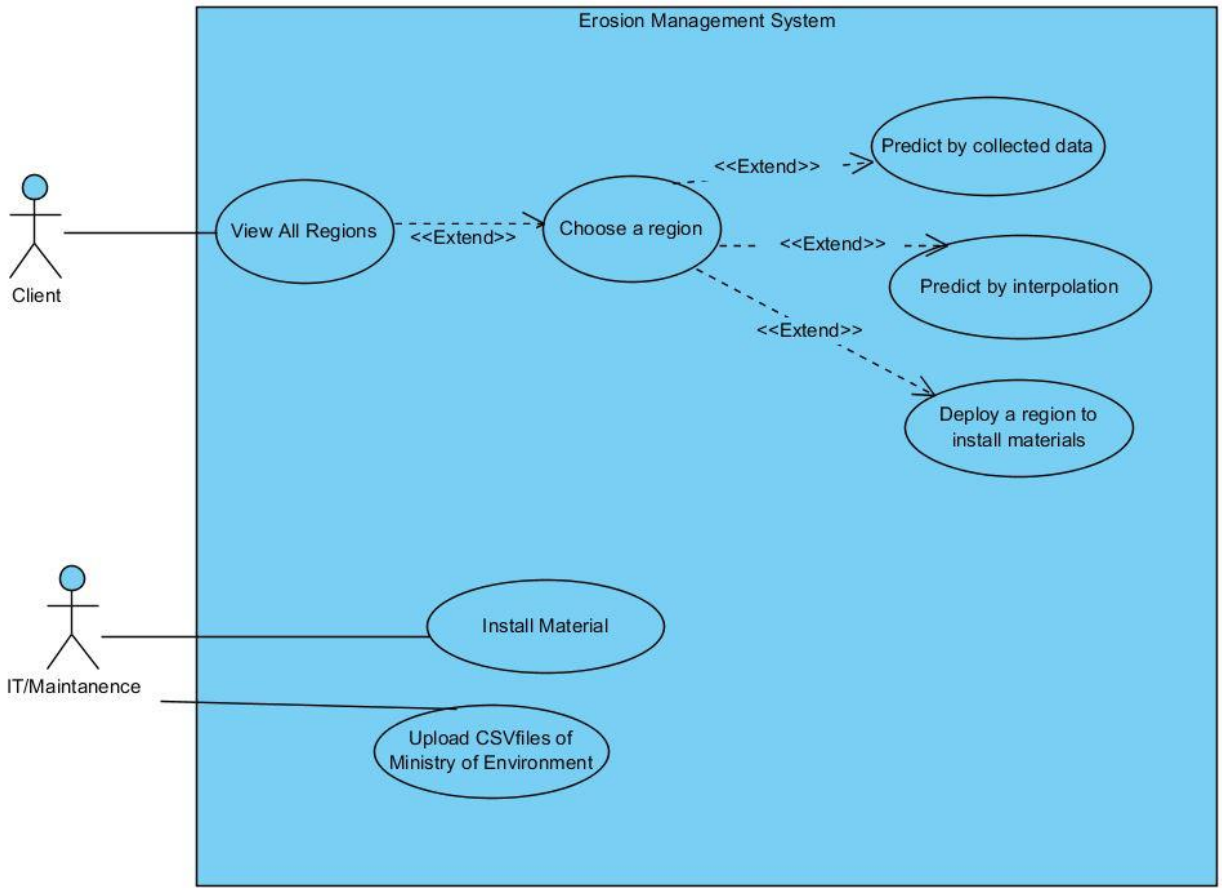
The ministry already has a datacenter in order to store their project and other functions like Geo Data. The database that this project requires can be at the same physical space within the ministry's It at their Ankara cite. The servers that will hold this projects data do not have any special requirements because the project essentially aims to collect data without doing complex calculations. Therefore, hardware choices of the project are focused on storage capacities and reliability rather than raw computing power. Since the drones will collect new data in weekly periods and this data will fit in the cameras total memory as explained above our data size will be around a gigabyte for each facility within a month. Therefore, our storage system will use a standard RAİD 5 configuration and a single 6u server with 20Tb storage consisting of 40x500gb hard drives.

Software/Systems Construction Plan

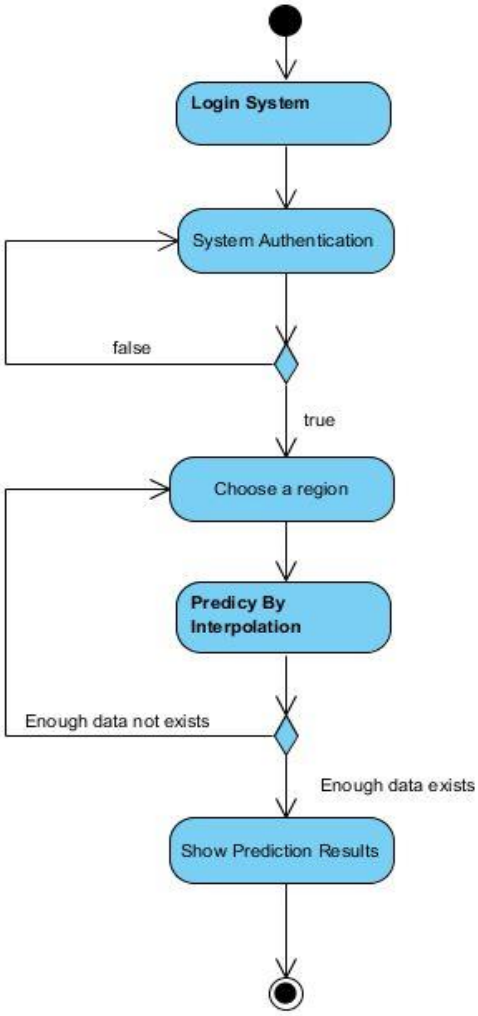
- Programming tasks will be assigned in terms of UI related classes, entity related classes and controller related classes.
- There will be meetings in every 2 weeks.
- Resources will be divided into three areas; development, testing and production. Development areas will take approximately %75 of the resources, testing will take %15 and production will take %10 of the resources.
- %10 error margin will be set into due dates.
- Risk assessments will be made for possible scope creep cases and delays from assigned dates and the ones with high risk will not be tolerated.
- There will be no cultural issues expected to happen.
- The development stage will be made sure by project manager that it will be done according to object oriented systems development.
- Documentation will be done by developers; UI developer and the developers that develop entity and controller classes.

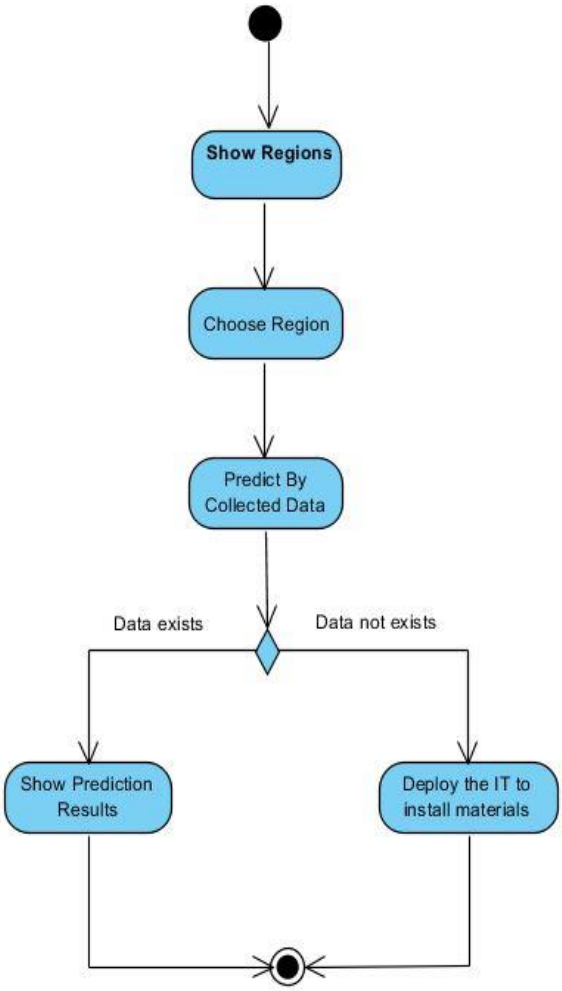
Functional Modelling

1. Use Case Diagram

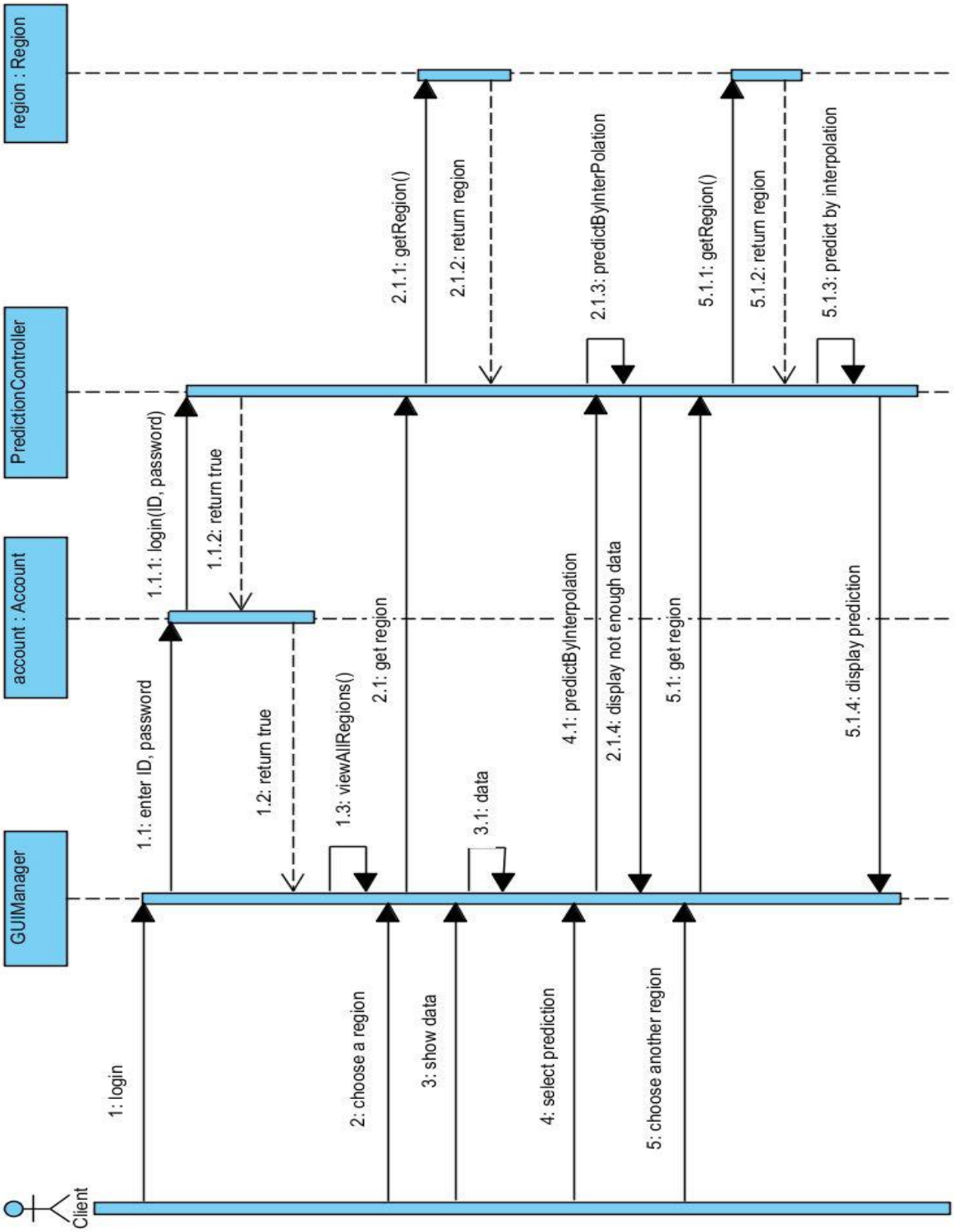


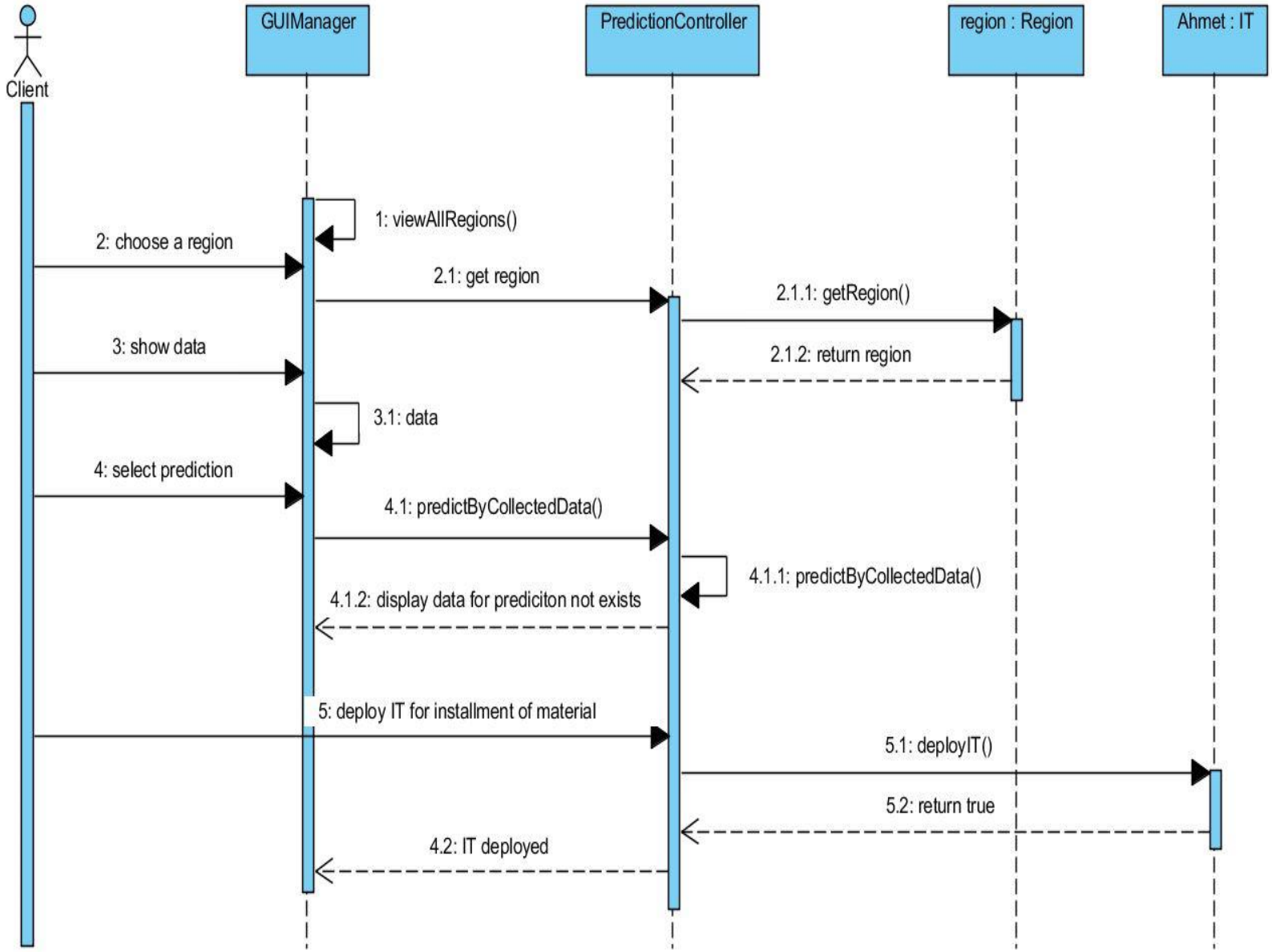
2. Activity Diagrams



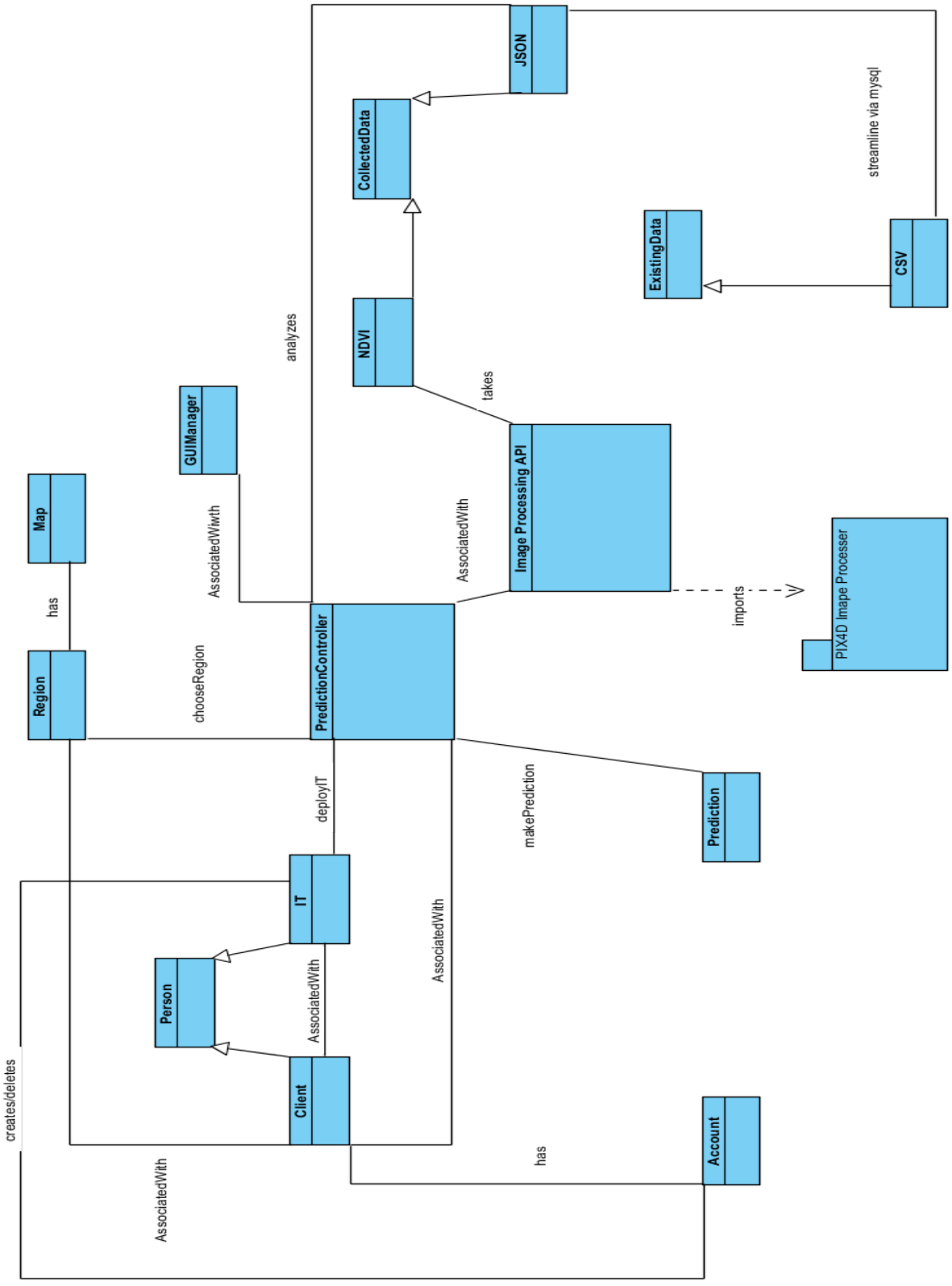


Behavioral Modelling




Client
GUIManager
PredictionController
region : Region
Ahmet : IT
1: viewAllRegions()
2: choose a region
2.1: get region
2.1.1: getRegion()
3: show data
2.1.2: return region
3.1: data
4: select prediction
4.1: predictByCollectedData()
4.1.1: predictByCollectedData()
4.1.2: display data for prediciton not exists
5: deploy IT for installment of material
5.1: deployIT()
5.2: return true
4.2: IT deployed

Structural Modelling



Installation and Operations Plan and Testing for Erosion Management Project

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Document Approval

Name	Role	Date	Signature
<Author>	Author		
	IT		
	Validation		

Document Control

Version	Author	Date	Description
1.0	<Author>	DD-MMM-YYYY	First Version

Introduction

Objective

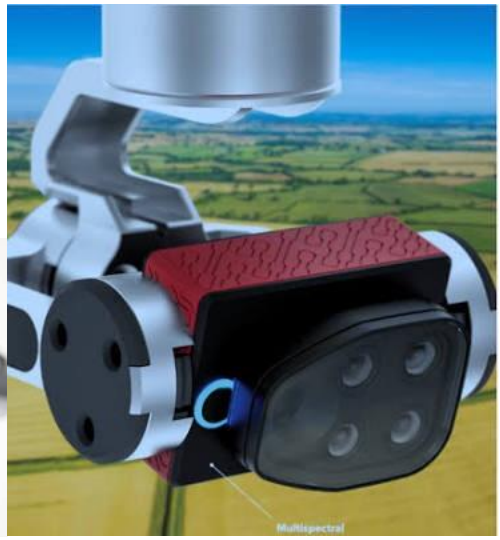
Objective of this document is to provide a plan for installation of the necessary equipment and software for the pilot project for Erosion Control, as well as a plan for operational aspects of the pilot.

Scope

Scope of the installation includes the following:

NDVI Cameras:

- Purchasing the Parrot Sequoia NDVI cameras (5 units + 2 spares)
- Out-of-testing (OBT)
- Installation on Ministry's existing SenseFly eBee drones
- Training of the operators
- Test fly and taking test aerial photos



Rainfall Sensors:

- For pilot project, five rainfall sensors needed (one for each selected location). These sensors will be provided by the Ministry of Environment (MoE). MoE is already using 800 of these sensors in its meteorological stations and is ready to provide 5 from the spares inventory. MoE will do the installation and regular maintenance of these sensors free of charge. MoE will also collect the data from these sensors and will send to the Ministry of Forestry and Waterworks (MoFW) along with other rainfall data in CSV format via an FTP server.


MoE's rainfall data collector

IT Equipment:

- New server and disks necessary for the pilot project will be installed by the IT Department of MoFW.

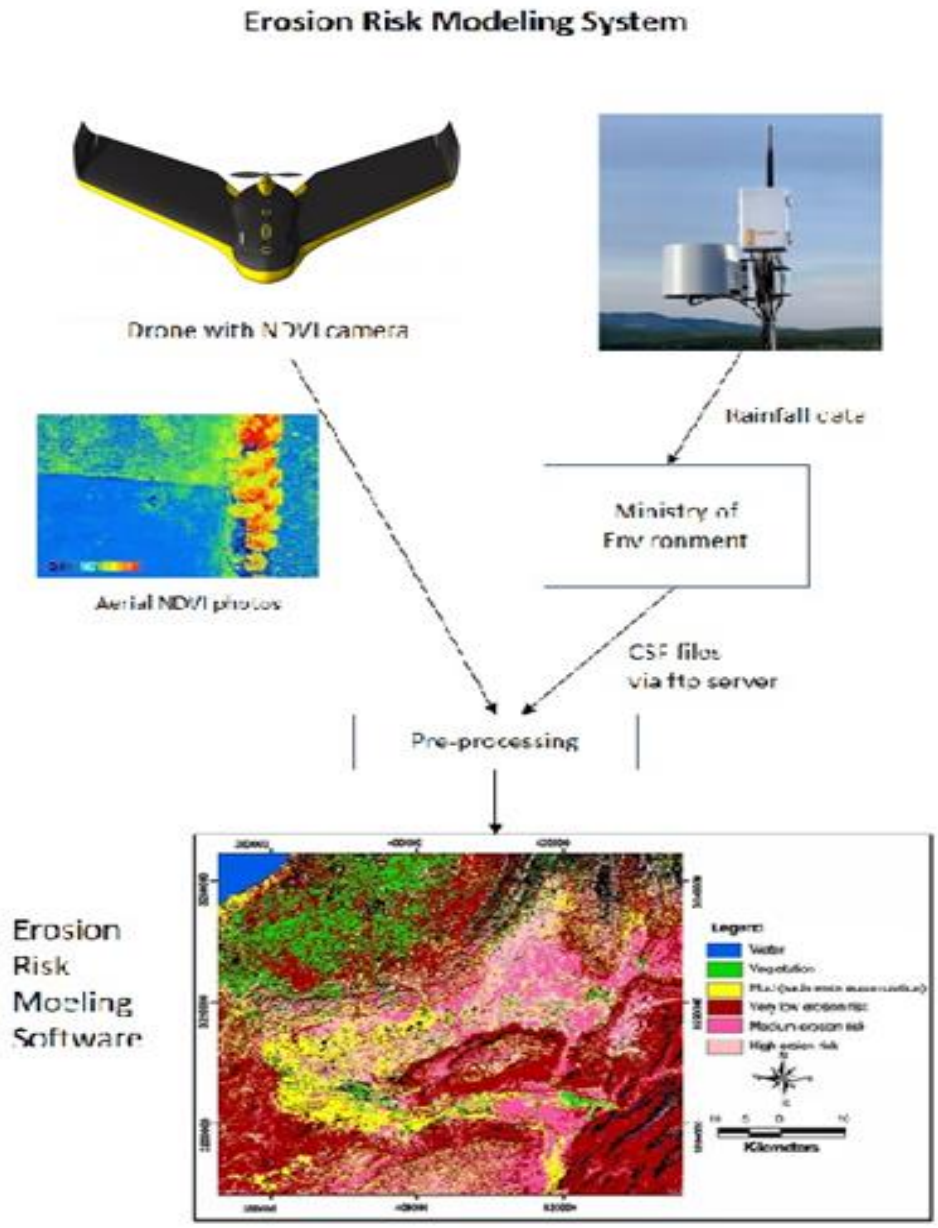
USLE Erosion Risk Modeling Software:

- Until erosion management software is finished by the ministry's IT a third party USLE capable software will be used to test the equipment. After pilot project is completed the system will migrate to the new software.

Supporting Documentation

- Parrot Sequoia Camera Owner's Manual
- SenseFly eBee Technical Manual
- USLE Erosion Risk Modeling Software User's Manual

System Description



Hardware

Parrot Sequoia NDVI cameras (5 + 2 spares)

Rainfall sensors (5 units to be provided by the MoE)

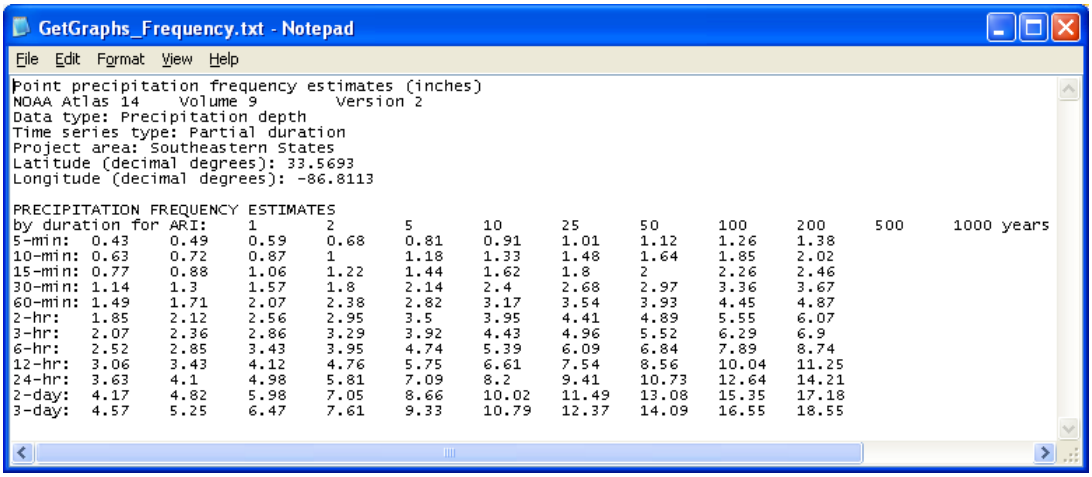
6u Server with 20 TB disk storage

Software

USLE Modeling software version 3.1

Network

No change is needed in the Ministry's current network configuration since there will be no need for on-line, real-time data sharing or transaction processing. Rainfall data (in CSV format) will be transferred from Ministry of Environment via an FTP service.



GetGraphs_Frequency.txt - Notepad

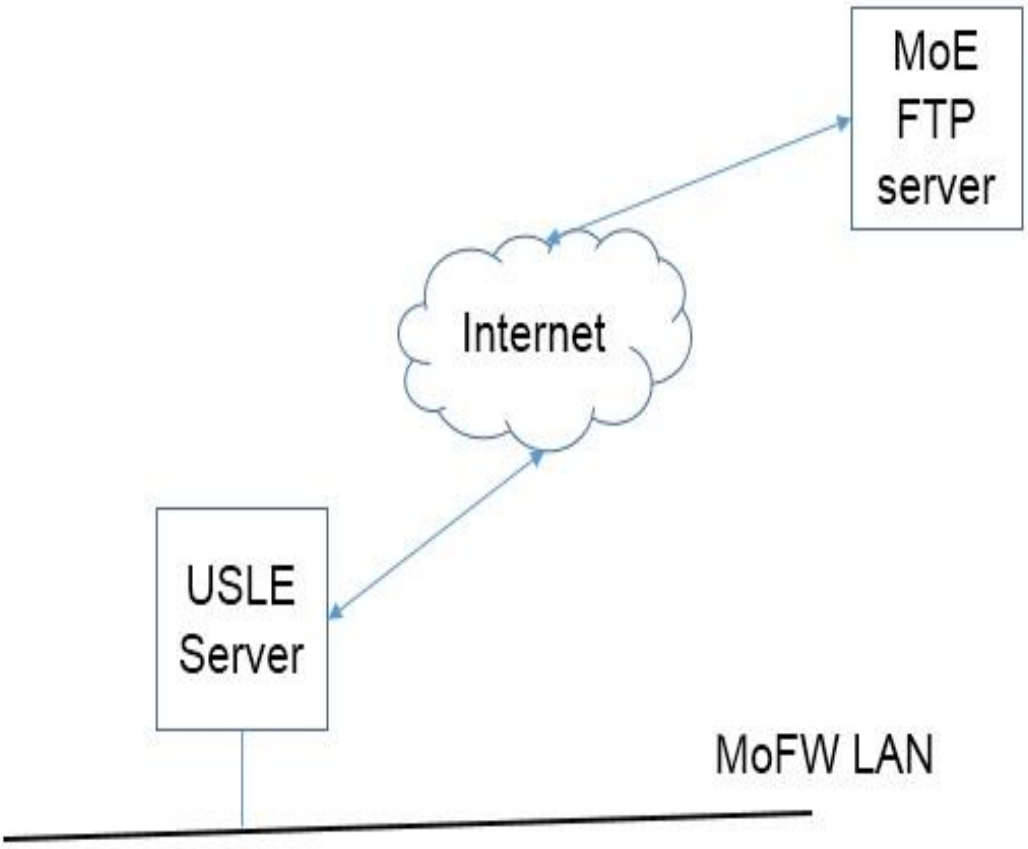
File Edit Format View Help

```
Point precipitation frequency estimates (inches)
NOAA Atlas 14    Volume 9        Version 2
Data type: Precipitation depth
Time series type: Partial duration
Project area: Southeastern States
Latitude (decimal degrees): 33.5693
Longitude (decimal degrees): -86.8113

PRECIPITATION FREQUENCY ESTIMATES
by duration for ARI:     1       2       5       10      25      50      100     200     500     1000 years
5-min:  0.43    0.49    0.59    0.68    0.81    0.91    1.01    1.12    1.26    1.38
10-min: 0.63    0.72    0.87    1       1.18    1.33    1.48    1.64    1.85    2.02
15-min: 0.77    0.88    1.06    1.22    1.44    1.62    1.8     2       2.26    2.46
30-min: 1.14    1.3     1.57    1.8     2.14    2.4     2.68    2.97    3.36    3.67
60-min: 1.49    1.71    2.07    2.38    2.82    3.17    3.54    3.93    4.45    4.87
2-hr:   1.85    2.12    2.56    2.95    3.5     3.95    4.41    4.89    5.55    6.07
3-hr:   2.07    2.36    2.86    3.29    3.92    4.43    4.96    5.52    6.29    6.9
6-hr:   2.52    2.85    3.43    3.95    4.74    5.39    6.09    6.84    7.89    8.74
12-hr:  3.06    3.43    4.12    4.76    5.75    6.61    7.54    8.56    10.04   11.25
24-hr:  3.63    4.1     4.98    5.81    7.09    8.2     9.41    10.73   12.64   14.21
2-day:  4.17    4.82    5.98    7.05    8.66    10.02   11.49   13.08   15.35   17.18
3-day:  4.57    5.25    6.47    7.61    9.33    10.79   12.37   14.09   16.55   18.55
```

Sample CSV file with rainfall (precipitation) data

Configuration



Impact/Dependencies

Installation and operations plan and schedule is dependent on the delivery times of cameras, rainfall sensors (Ministry of Environment) and USLE software. No dependency on the server as hardware since in case of any delay one of the existing back up servers in the ministry's IT department can be used.

Installation and Operational Activities Schedule

Each installation is followed by a check that it has been installed correctly which must be signed and dated by the person performing the installation. Any problems or unusual occurrences during the installation must be recorded in the Problem Resolution Log in Section 5.

Total duration of the pilot project is 14 months. Five locations for erosion risk analysis will be selected for the pilot purposes.

First month will be used for purchasing, delivery, testing of the equipment and training.

From month 2 through 12, rainfall data collection for 12 months (to collect sufficient data covering all seasons). The sensors will temporarily be provided by the Ministry of Environment and will measure rainfall estimates in 5 locations specifically selected for the pilot project. These measurements will be compared with the interpolated values calculated based on the rainfall data coming from already available meteorological stations.

In parallel to accumulating rainfall data, field teams will do the aerial photo capturing of the 5 selected regions.

During month 14 (last) month of the pilot, data collected from 5 selected regions (rainfall data, NDVI photos, etc.) will be input to the USLE erosion risk modelling software, and obtained results will be evaluated by the subject matter experts in the ministry.

	Months													
Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Delivery and installation and testing of cameras														
Installation of USLE server														
Installation of rainfall sensors														
Rainfall data collection														
USLE tmodeling s/w installation														
USLE tmodeling s/w training														
Aerial photography of region 1														
Aerial photography of region 2														
Aerial photography of region 3														
Aerial photography of region 4														
Aerial photography of region 5														
Run modeling software														
Evaluate results														

Installers Specimen Signatures

Immediately prior to installation, all installers and witnesses/authorizers should sign and initial below.

Installer/tester name (block capitals)	Company /group	Role/Position	Signature	Date

Supporting Documentation

Full identity and number of pages of any supporting documentation appended (If none, state “None”, sign and date):-

Title (of Supporting Documentation appended)	**Document’s unique identity (e.g., version no., date, date of signing etc)**	**No. of pages**	**Appended by:- (Signature & date)**

Installation Problem/Resolution Log

This ***must*** be completed if any acceptance criteria are not met in the preceding sections.

Item number	Description of problem encountered	Description of the resolution	Referenced documentation (name date & number of sheets OR "None")	Installer and witness (signature and date)