Deforestation Prediction due to expansion of roads and cities

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***Abstract*— Construction of roads and highway serves as the major concern for deforestation, which has a direct implication on the wildlife, environment and natural resources. We have proposed a solution using ArcGIS, where we have used Oregon State forest and road layer. We have used ArcGIS library to accurately measure the forest covered by proposed road through making polyline, polygon, and line, etc. on the map. We calculate the amount of deforestation occurred using our web based application and determine whether the proposed project is passed or not based on the given threshold set by the forest department of the state. We have developed this system for state forest department and urban planners/analysts to give an estimate that whether the proposed construction can proceed or not.**

Keywords: ArcGIS, Node.JS, MongoDB, GeoJSON.

I. INTRODUCTION

Every year 15 billion trees are cut and in response, only 5 billion trees are grown in the world. According to the 79 case studies conducted by United States forest service (USFA), it was found out that in 61% cases the major cause of deforestation is conducted by the construction of roads. Construction of road can have a massive impact on wild animals and it can be a major cause of global warming. Natural reserves and basin can get impacted by construction of roads passing through the forest. There is always a tradeoff between the construction of road and deforestation because the construction of the road enhances economic development by connecting the rural area with a major city, but the construction of road should be done judiciously up to certain extent.

Figure. **1.1** Deforestation

To avoid a high amount of deforestation, state forest department and urban analyst should have the clear understanding of their proposed construction. In order to help them, we have used ArcGIS toolkit to create a web-based application that can provide the urban planner the estimate of deforestation occurred by their proposed road. Our application provides results showing whether their proposed construction is approved or not based on the threshold set by the government. We have used the dataset of Oregon State which consist of the forest cover and existing roads. Given figure shows the forest in green color and the highway roads in yellow lines.

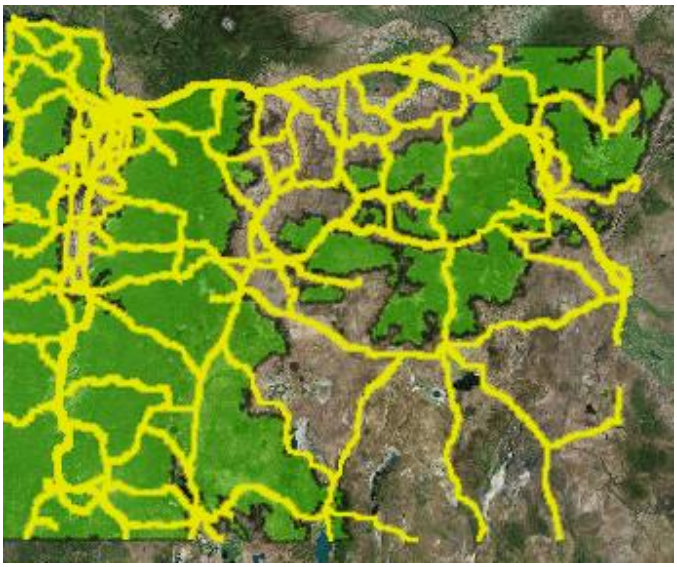

Fig 1.2 Roads

II. ARCHITECTURE

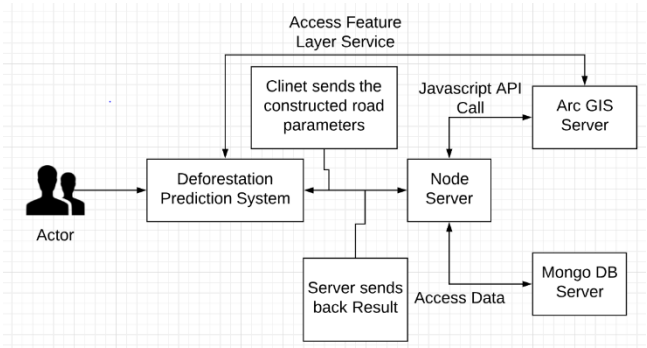

Figure 2.1 Architecture

As shown in the above figure, our deforestation system interacts with the node server for its functioning. The client submits the road construction parameters to the system. The node server then makes a API call to the Arc GIS server and stores the data in mongo DB server. The feature layer data is also stored with the Arc GIS server. After the successful calculation of the deforestation percentage, the server sends back the result to the system.

III. PERSONAS, FUNCTIONAL AND NON- FUNCTIONAL REQUIREMENTS

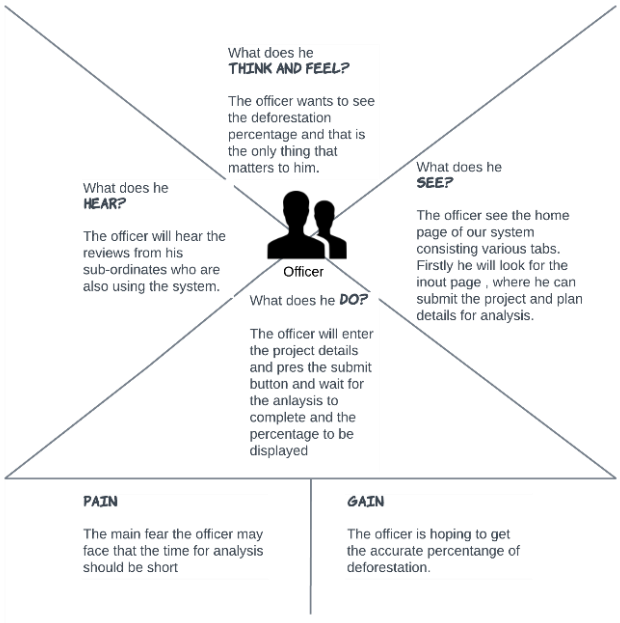

Figure 3.1 User Personas

The persons of our system would be:

- An officer at the environment department of the Federal Highway Administration (FHA) who looks at the environmental aspects of Highway construction projects.

Functional Requirements:

In this section we present you the functional requirements of our system:

- The user successfully logs into the system using the Google Sign-in feature by clicking the sign in button.
- If the user does not have an account with our system, the user registers himself by completing a registration form and the user will get the credentials to access the system.
- After a successful log in the user should see the home page of our system which will contain the information about deforestation phenomenon, it's causes and impact.
- The user should click on the submit tender tab on the left side of the screen and a new page should open
- The user enters the name of the company and the name of the road to be constructed.
- The user should select any one drawing tool from the left panel and also enter a number in the buffer column which will represent the width of the road.
- The user should be able to draw the desired road on the map.
- The user should see the buffer area, total forest area and intersection area on the left pane.
- The user should click on a "generate report "button on the left pane, and a report should be generated.

- After all the above steps, when the user clicks on the "Submit Button", a new page should open which should show the result of the tender, i.e. the tender is passed or failed along with the deforestation area and deforestation percentage.

Non-Functional requirements:

- Testability: The system should be testable with all the possible inputs and desires output should be achieved.
- Security: The system should be secure enough to avoid illegal access.
- Scalability: The system should be scalable enough such that it should scale up and down according to the load.
- Flexibility- The system should be made incorporated with changes at any time according to user needs and requirements.
- Accessibility- The system should support multiple platforms and devices, so the users can access it from anywhere.

IV. Our Solution

Details of Algorithm

Inputs:

1. Base Map
2. Feature Layers
   - Forest Layer of the state of Oregon
   - Roads Layer (Primary and Secondary Highway Roads)

Note: Co-ordinate system of Base Map should match with the Forest Layer and Roads Layer. (Projection should be same.)

3. Buffer size

Outline of steps**:**

1. Load the feature layers onto the basemap. (host layers as a service in ArcGIS Online, and use it in application)
2. Input the coordinates to reference the begin or end position in the map.
3. Input the buffer size. (usually 3 kms, but the user may decide whatever he/she needs)
4. Draw the Road by using Line, Polyline, or freehand polyline geometry on the map.
5. Perform calculations. [buffer area, Area of intersection, forest area, buffer length]
6. Estimate deforestation. [see below for its logic]
7. Output: Area of deforestation estimated, and percentage of deforestation resulting due to newly proposed road.

Estimation of deforestation:

Basic Idea:

To make this estimate, we first find how much deforestation is associated with existing roads.

To find the percentage, we divide the area of the deforested land by the area of the existing buffered roads layer(obtained by buffering all the roads in Oregon state, buffer size=3 km), and then multiply the result by 100. We have now obtained the percentage of land within 3 kilometers of roads that is deforested. We can use this percentage to estimate the deforestation that a newly proposed road would cause. To find a total area of potential deforestation around the proposed road, we buffer this new road to the same 3 k.m. distance, and intersect it with the Forest layer, so that already existing deforested area within buffer is not accounted. We then multiply this intersected buffer area by the percentage of deforestation observed around existing roads.

Algorithm:

1. **Obtain area of intersection**

```
if(geometryEngine.intersects(geoBuffer, forestLayerGeometry)){
        var intersectGeometry = geometryEngine.intersect(geoBuffer, forestLayerGeometry);
        map.graphics.add(new Graphic(intersectGeometry, buffSymFade));
        console.log(intersectGeometry);
        INTERSECT_AREA = geometryEngine.planarArea(intersectGeometry, bufferAreaUnit);
}
else{
    INTERSECT_AREA = 0
}
```

2. **Calculate Percentage**

```
var percent_of_deforest = (INTERSECT_AREA/FOREST_AREA_SQ_KM)*100;
 percent_of_deforest = percent_of_deforest.toFixed(2);
```

3. **Acceptance Logic**

```
if(percent_of_deforest < 0.3){
   Acceptable
  }
  else{
    Not Acceptable
  }
```

4. **Calculate the estimated area of deforestation by the proposed road**

Deforestation_area = (INTERSECT_AREA X *Threshold_Value*)

Where, *Threshold_Value* is computed by applying **Calculate Percentage** step on the existing roads and forest layer.

In our study, *Threshold_Value = 0.35*

Output variables:
Deforested_area in <square-units>
Percentage_of_deforestation <in %>

V. IMPLEMENTATION

The implementation of our project mainly depends on the ArcGIS layers and the code we did write for it. We made use of multiple technologies for our project to work. These include the following

- ***BootStrap UI***: The UI was made with the help of bootstrap and its efficient classes which help in better styling
- ***Node.js***: This technology works as a backend for our project. We pushed all the logic to the Node.js so that the logic would work at the backend and it would not have the impact on the client side if the logic fails in any-case
- ***ArcGIS with JavaScript***: The most important technology of our project is all about the use of ArcGIS. We did make use of ArcGIS for creating the layers and hosting the service on ArcGIS Online.
- ***MongoDB***: All the information which include the name of the project and details related to the project is pushed to the MongoDB database. We use an online database system named MLab so that it would be easy to host on cloud for further usage.

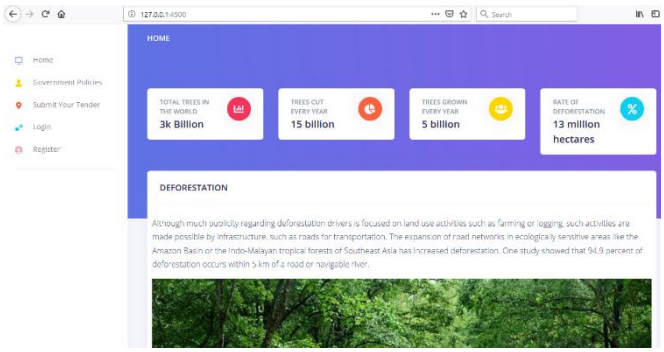

Figure: 5.1 Home Page

The workflow of our project is as follows
The persona of our application is a user who is from the construction department and wants to submit the tender. The user can look at the whole web application but when it comes to the part of submitting the tender, the user needs to register himself. The registration information is stored in the mongodb database and the user is redirected to the login page. The user signs in and then the page is redirected to the submit your tender your page. Now the user needs to enter the Project name and Company Name.

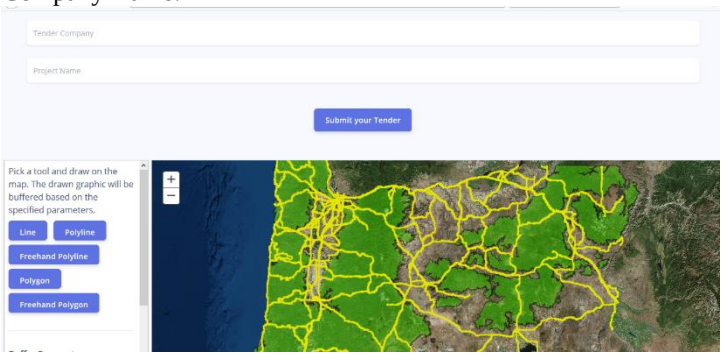

Figure 5.2 Input Tender

User can use the longitude and the latitude of the position from where he wants to start the road. He then can set the buffer size which indicates to the size of the road which would cutoff the area around the road. He then chooses to draw the road by using different drawing tools which include the polyline or the polygon according to the requirements. The intersection part of to be constructed road with the forest area is seen by the user on the map.

Figure 5.3 Drawing Tool

The user then clicks on the Generate report button which takes him to the Results page. Here the user is able to see the whole report: the snapshot of the map, the total area under deforestation and the percentage of the forest cutdown. He is also able to see the Result whether the tender has been accepted or rejected.

Figure 5.4 Generate Report

Whenever a user clicks on a desired page, the request is sent to the node.js backend, the logic is run and the page is redirected as required. Also when a form is submitted as that in the tender submission page, the information is redirected towards the node.js backend. This information is added into the mongodb database and then the information is used for the percentage calculation using the raster and the clipper function of ArcGIS in javascript. The layers which are seen on a map are the Forest layer and the State Highways layer. These layers are hosted on ArcGIS online portal and that service is used on our application. We can add other layers according to the requirements of the persona.

VI. RESULTS

From the below figure we can see that as the deforestation percentage in under the threshold , the tender has been accepted for further approval process.

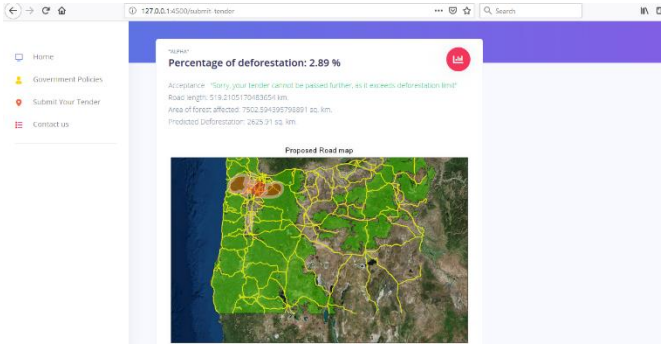

Figure 6.1 Results

VII CONCLUSION

As our proposed solution gives the estimate whether the given construction of road can get a green signal or red signal by calculating the amount of deforestation to be occurred using ArcGIS, it can make the life of forest department and urban planners easy using a simple web application. They can easily find alternative solutions in a few minutes through our application. As a future work, we can add more layers like extinct wildlife, natural reserves, rivers, etc. so that it can provide a more efficient estimate of the impacts of the construction of a road. In addition to that, we can also provide alternative suggestion to the forest department and urban planners if their proposed road is not accepted.

VIII REFERENCES

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