ACADEMIA | Letters

Spatial Multicriteria Analysis Using a Google Earth Engine Based Web Tool

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1. Introduction

Application of Google earth engine (GEE) in remote sensing based research is growing due to its high computation power and capacity to process large scale datasets (Prasai, 2022 a; Prasai, 2022 b). We have developed a GEE based web tool to run the spatial multicriteria analysis (SMA) (Figure 1-3). The tool can be accessed at (https://www.prioritymaps.com/). SMA is an analysis technique that uses geographical data and value judgements to provide a systematic analytical approach which can be used for making a decision (Balasubramaniam & Voulvoulis, 2005). This model can be applied in wide range of decision making projects such as identifying risk levels (Thapa & Prasai, 2022; Rincón et al., 2018), uncertainty (Adhikari et al., 2021; Thapa et.al., 2020), developing prioritization maps (Prasai, 2021), site selection (Rikalovic et al., 2014; Malczewski & Jankowski, 2020), habitat suitability models (Prasai et al., 2021). We can develop decision models based on various potential factors (Table 1) and weigh/rank those factors providing scores/choices (Boggia et al., 2018). The first step to start making these models is identifying the factors or criteria that are potentially influential in our research project (Figure 1). Selection of the factors depend on the context of the problems to be identified or objectives (Pradhan & Kim, 2016). Then the second step is collecting the geographical data related to those factors and weighting their priority in the model (Gonzalez & Enríquez-de-Salamanca, 2018). This model is being widely used because it allows the planners to make a balanced decision based on multiple parameters (Pradhan & Kim, 2016).

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1.1. Conceptual framework

Criteria/Attributes

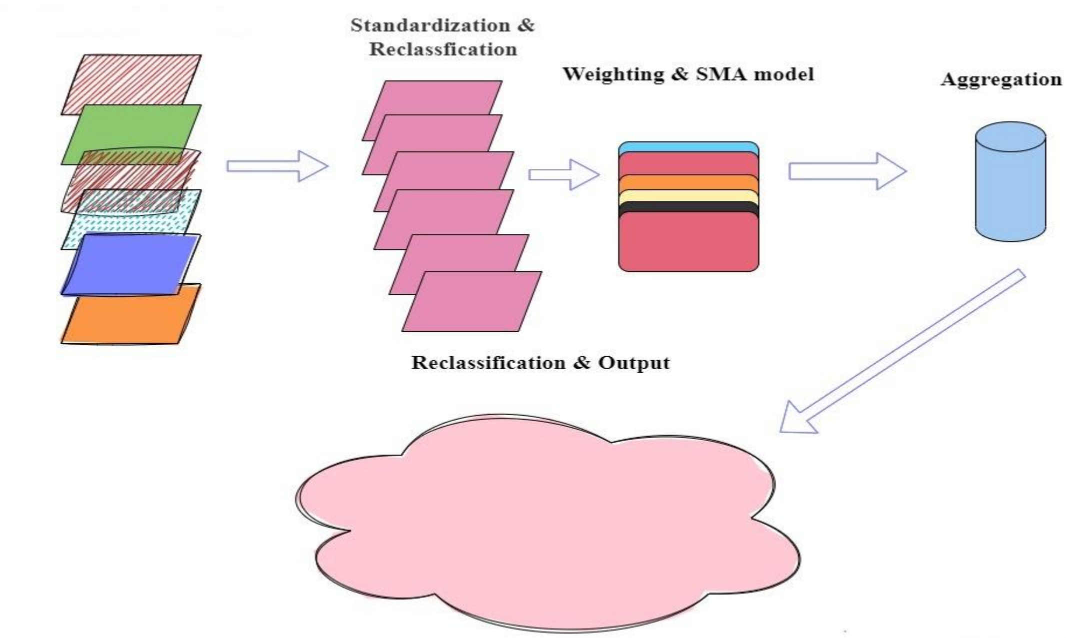

Figure 1: Steps in building spatial multicriteria analysis model (SMA)

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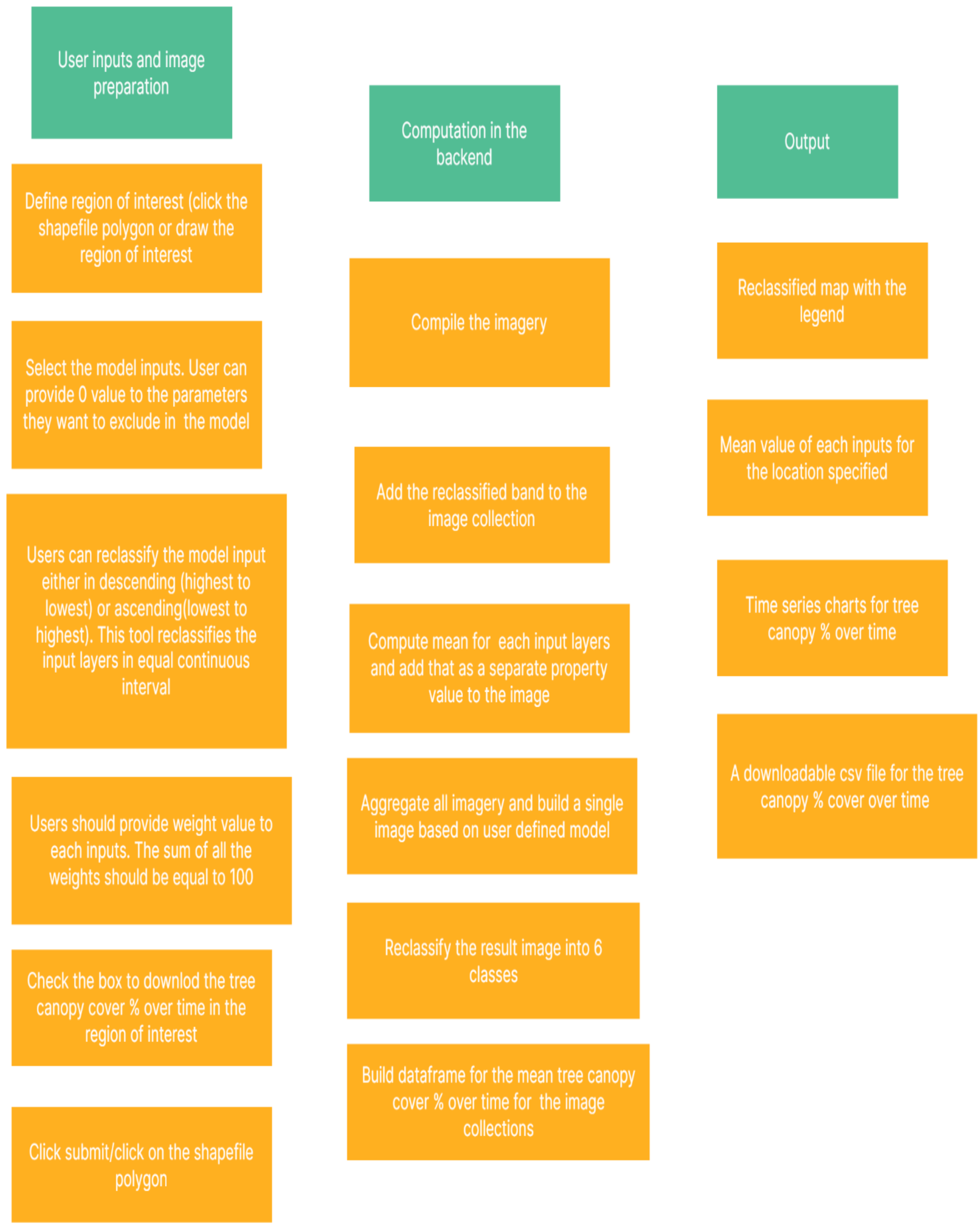

Figure 2: Flowchart describing the overall application design

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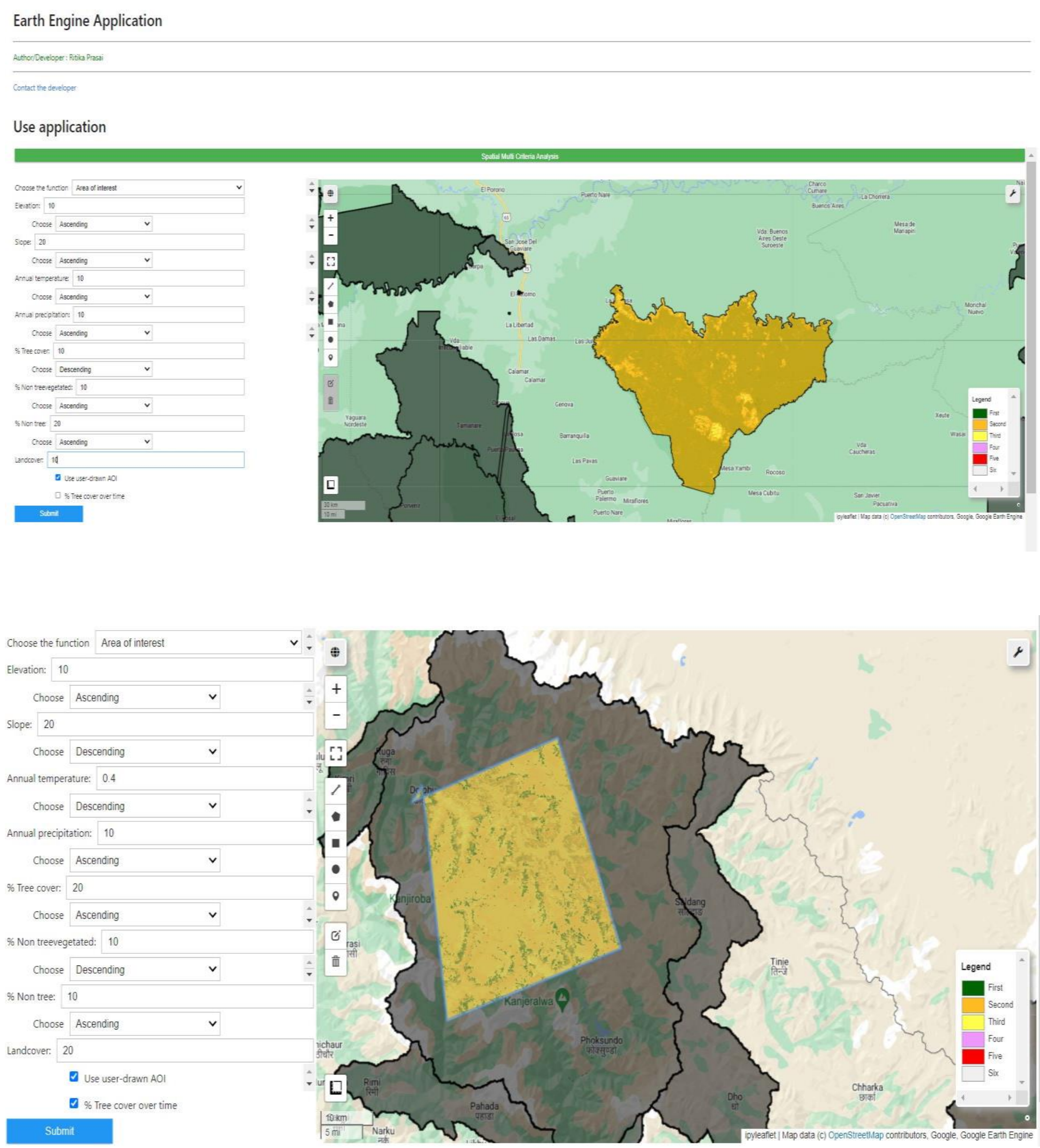

Figure 3: Graphical user interface of the application

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Table 1: Parameters/covariates selected to build a spatial multicriteria analysis model in the web based tool

S. N.	Parameters/covariates used	Explanation
1.	Elevation	Shuttle Radar Topography Mission (SRTM) digital elevation data which provides elevation of 1 arc-second (approximately 30 m) (SRTM Quick Guide.)
2.	Bioclimatic variables	WorldClim V1 Bioclim datasets that are derived from the monthly temperature and rainfall (https://developers.google.com/earth-engine/datasets/catalog/WORLDCLIM_V1_BIO).
3.	Land use land cover	Global land cover data of 2020 at 10 m resolution based on Sentinel-1 and Sentinel-2 data. It has 11 land cover classes (https://developers.google.com/earth-engine/datasets/catalog/ESA_WorldCover_v100).
4.	Vegetation dataset	Percent tree cover, percent non-tree cover, and percent bare derived from Terra MODIS Vegetation Continuous Fields (VCF) (https://developers.google.com/earthengine/datasets/catalog/MODIS_006_MOD44B).
5.	Shapefile	Global protected areas

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2. Example case studies using the web based tool

2.1. Site selection for the tree plantation project

Lets assume we are looking for a suitable location inside Dallas, Texas, USA to plant trees for our project. We choose the Use user-drawn AOI option in the web tool to draw the boundary of our study area in the map. We search for Dallas location through the search icon on the map and draw the rectangle covering our study area. The tool records the study area (Wu, 2020)

2.1.1. Design a SMA model

We consider annual precipitation, annual temperature, % tree cover, % non tree vegetated, % non tree as the suitable covariates for prioritizing sites for the plantation project (Table 2 and Table 3). We ignored elevation and slope because Dallas has a flat landscape and relatively consistent elevation. Then we provide the weights to each covariates selected and decide whether the descending or ascending range values of those covariates impact in our plantation project (Table 3).

Table 2: Parameter/covariates selected for the case study 1

S.N.	Parameters/covariates	Explanation
1.	Annual temperature	Temperature increases when % tree canopy cover in a place is low. We predicted that with increase in temperature, site needs more plants/trees. Therefore we selected decreasing option (from highest to lowest) of annual temperature to reclassify the temperature range in the web tool

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2.	Annual precipitation	Precipitation is higher in areas with vegetation . Therefore we concluded that the areas having lower precipitation require more trees. Therefore we selected the increasing option of precipitation range to reclassify our annual precipitation range
3.	% Tree cover	Our goal was to plant trees in the areas with less tree cover. Therefore we selected the increasing option of % tree cover to reclassify the % tree cover ie the areas with less % tree cover as the most prioritized area
4.	% Non tree vegetated	We gave higher priority to the areas with higher values of % non tree vegetated and selected the decreasing option of % non tree to reclassify the % non tree vegetated range values.
5.	% Non tree	We gave higher priority to the areas with higher values of % non tree and selected the decreasing option to reclassify the % non tree range values.

Table 3. Scores provided to the parameter/covariates selected for the case study 1

S.N.	**Parameters/covariates**	**Scores**
1	% Tree cover	30
2	% Non tree	20
3.	Annual temperature	20
4.	Annual precipitation	20
5.	% Non tree vegetated	10
		Total scores=100

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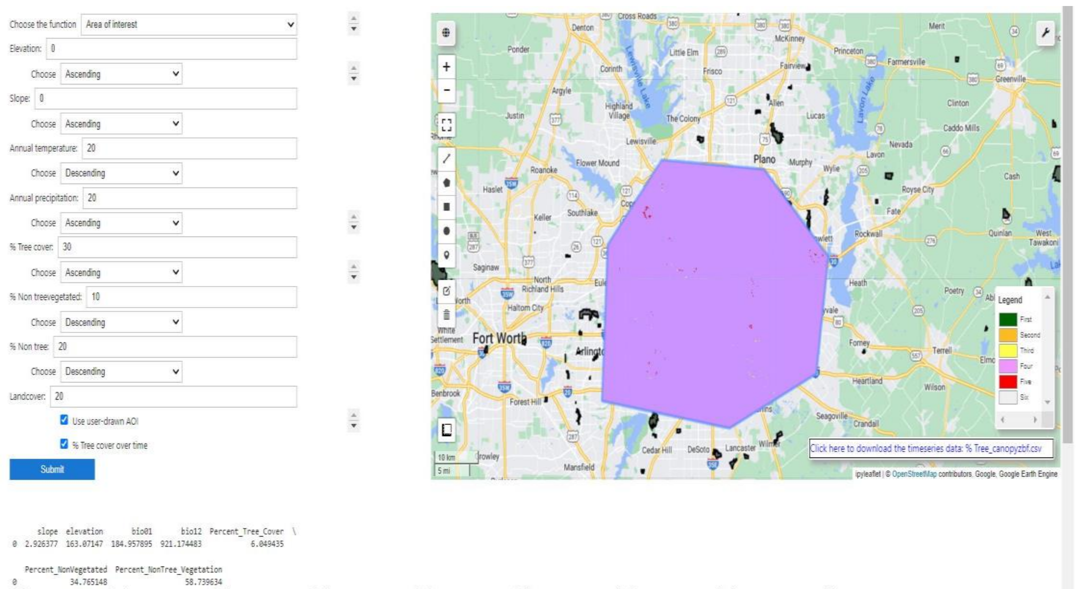
We gave 0 value to other covariates present in the web-based tool to ignore those covariates in the model. Then we ran the model using the submit button.

2.1.2. Results



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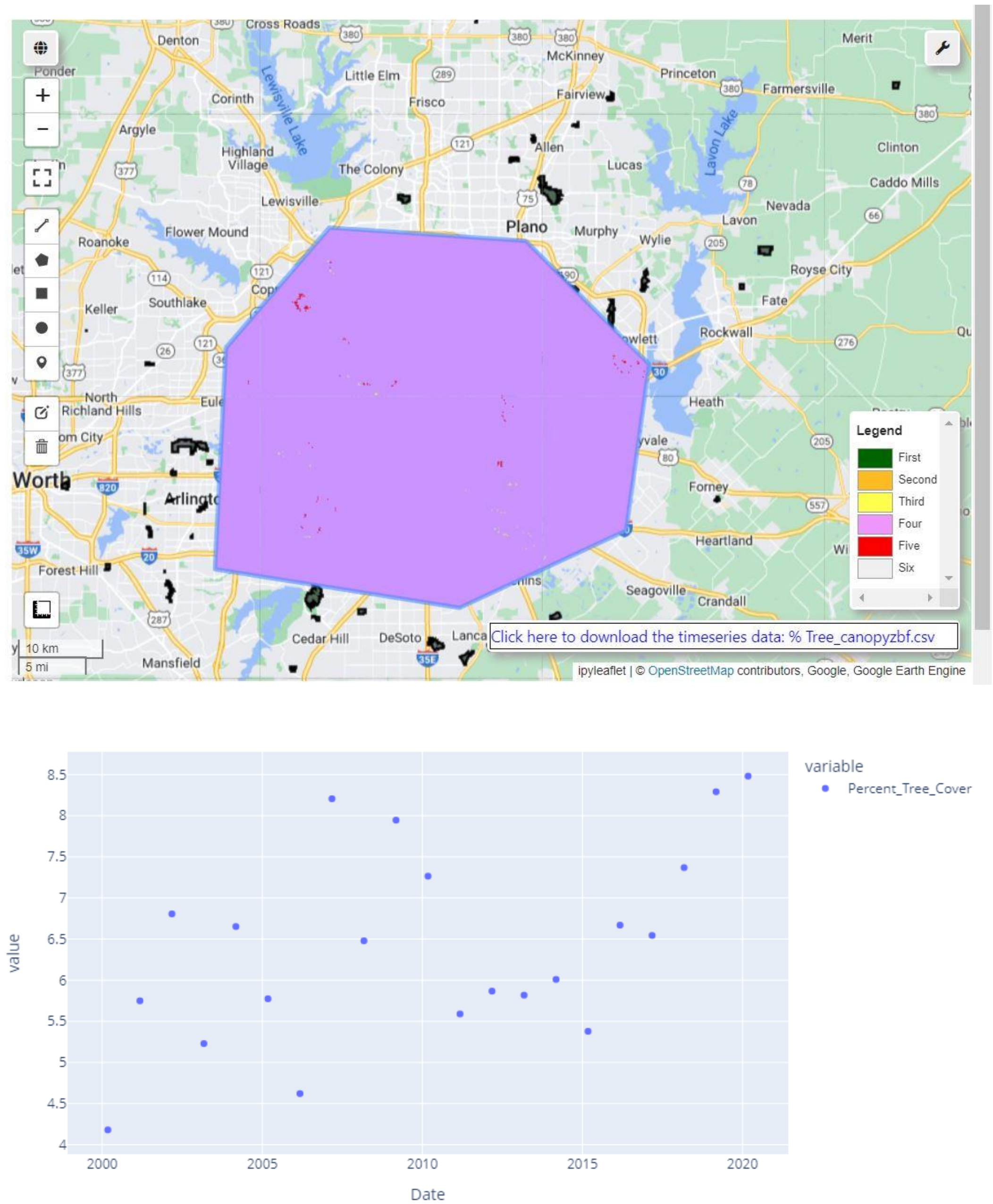

Figure 4: Results obtained after running the spatial multicriteria model using the web based tool for the case study 1

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The color code in the legend helps to rank the places inside our study area that needs plantation to meet our goal (Figure 4). As there is no green color and we only have yellow, purple and red in our study area map, our model does not have the highest prioritized area based on the parameters/covariates and scores we selected. However, the places with yellow mark are the highest ranked places for our tree plantation project, purple with the second and red are the least prioritized areas based on our model. The tool also provides the percent tree cover of our study area from 2000-2020 and we can see the increase in % tree cover in our study area.

2.2. Site selection for species focused research

Lets assume we are interested in selecting the best site for our species specific (species distribution) preliminary visit (Figure 5). Our targeted species is found in Dhorpatan Hunting Reserve, Nepal. It is a protected area therefore, the web tool has the shapefile of this area. We click in shapefile to record it as our study area.

2.2.1. Design a SMA model

Our targeted species prefers higher elevation, sloppy land, high rainfall, high precipitation, low temperature, dense forest. We use these parameters/covariates in our model and provide the scores based on the influence of each of these parameters/covariates (Table 4 and Table 5) .

Table 4: Parameters/covariates selected for the case study 2

S.N.	Parameters/covariates	Explanation
1.	Elevation	Targeted species prefers the highest elevation. Therefore we selected the decreasing option (highest to lowest) of elevation to reclassify the elevation range to provide the highest rank to the highest elevation
2.	Slope	Targeted species prefers sloppy land. Hence we selected the decreasing option (highest slope to lowest slope) to reclassify the slope range values in our model
3	Annual temperature	Targeted species prefers lower temperature. Hence we selected the increasing option to reclassify the temperature range values to prioritize areas with lower

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		temperature in our model
4.	Annual precipitation	Targeted species prefers higher precipitation. Therefore, we selected the decreasing option to prioritize the areas with higher precipitation in our model
5	% Tree cover	Targeted species prefers the dense forest. Hence we selected the decreasing (highest % tree cover to lowest % tree cover) option and prioritized the area with the highest % tree cover
6	% Non tree	Targeted species prefers the dense forest. Therefore we selected the increasing option with this covariate to reclassify and prioritize the areas with low % Non tree.
7.	Landcover	Targeted species prefers dense forest so we included the landcover in our model

We did not include % Non tree vegetated in our model as it is less influential to our targeted species distribution.

Table 5: Scores provided to the parameters/covariate selected for the case study 2

S.N.	**Parameters/covariates**	**Scores**
1	Elevation	25
2	% Tree cover	20
3	Slope	15
4	Landcover	15
5	Annual temperature	10
6	Annual precipitation	10
7	% Non tree	5
		Total scores=100

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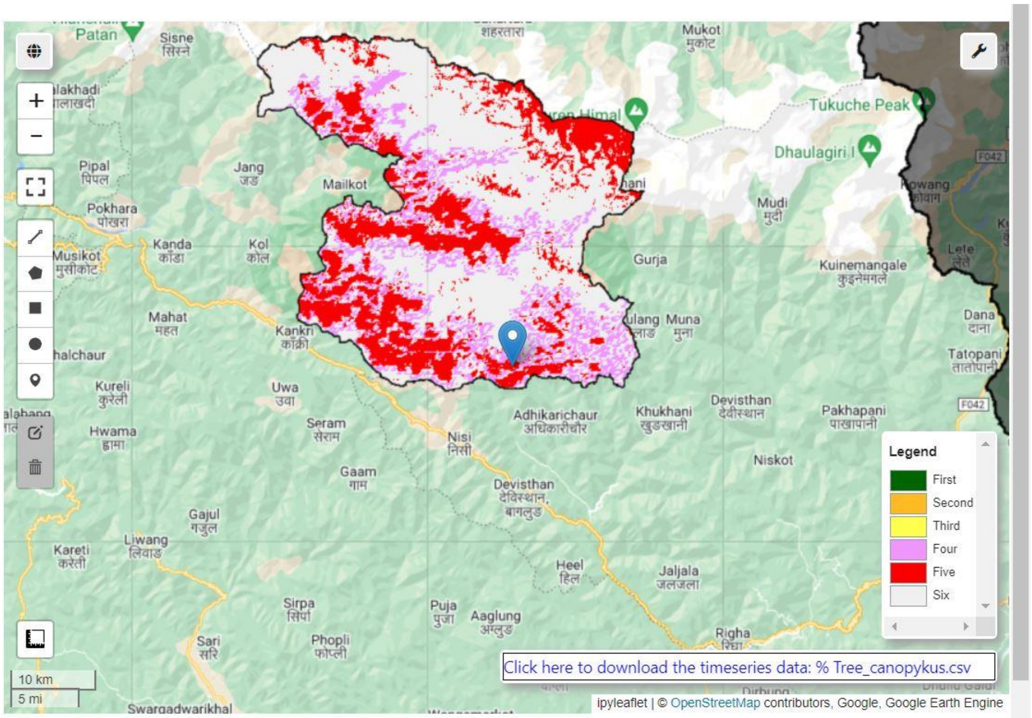
2.2.2. Results



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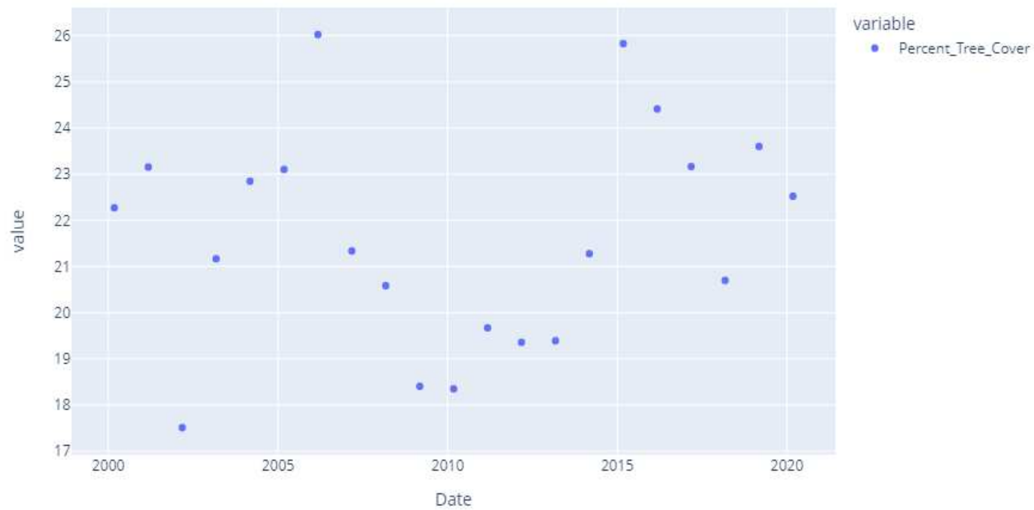

Figure 5: Results obtained after running the spatial multicriteria model using the web based tool for the case study 2

The color code in the legend helps to rank the places inside our study area which is favorable for the species distribution or the likelihood of the species to be distributed based on the parameters/covariates we selected (Figure 5). As there is no green color and we only have purple, red and white spots on the study area, our study area does not have the excellent/top habitat for the targeted species. However, the places with purple spots have the highest probability of species distribution, red are the second and the white are the least based on our model. The tool also provides the percent tree cover of our study area from 2000-2020 and we can see the increase in % tree cover in our study area in 2020.

3. Conclusion

This web based tool could be handy to researchers from all background to acquire a preliminary information about the area of interest based on the parameter/covariates of interest (Prasai, 2022 b). This tool avoids the requirements of data acquisition, data preparation and GIS skillsets to make the models making it easily accessible for any environmental advocators, researchers, students and practitioners (Prasai, 2022 b).

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