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An open-source web-based tool to perform spatial multicriteria analysis

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Abstract
Spatial multicriteria analysis (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. Decision making can include identifying risk levels, uncertainty, developing prioritization maps, site selection, habitat suitability models. This model is being widely because it allows the planners to make a balanced decision based on multiple parameters. We have built an open source web-based tool to run SMA which can be accessed at https://www.prioritymaps.com/. This web based tool is user friendly and people from all backgrounds can use it to make decision based models.

Keywords: Spatial multicriteria analysis; decision making; habitat suitability; web-based applications; geographical data

1. Introduction

Spatial multicriteria analysis (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) [2]. Decision making can include identifying risk levels (Thapa & Prasai, 2022; Rincón *et al*., 2018) [19, 18], uncertainty (Adhikari *et al*., 2021; Thapa *et al*., 2020) [1, 20], developing prioritization maps (Prasai, 2021) [1], site selection (Rikalovic *et al*., 2014; Malczewski & Jankowski, 2020) [17, 9], habitat suitability models (Prasai *et al*., 2021) [1]. We can develop decision models based on various potential factors 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) [11]. 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) [5]. This model is being widely because it allows the planners to make a balanced decision based on multiple parameters (Pradhan & Kim, 2016) [11].

We have built an open source web-based tool to run SMA (https://www.prioritymaps.com/). It is based on google earth engine and uses the datasets available in the google earth engine. This web based tool is user friendly and people from all backgrounds can use it to make decision models.

1.1. Conceptual framework

Prioritymaps.com has a web-client as the front-end and GEE as computing back-ends. The front end is the graphical user interface (GUI) web client where the users can specify the algorithms, date range, filter the datasets and send requests to run the analyses (Figure 1). We used Ipywidgets a python based library, HTML and CSS to design GUI/front end of this application. Since all storages and computing operations are made on the cloud (GEE), the web-client can be accessed from any browser supporting device such as mobile, laptop or desktop computing devices. However, the framework is developed mainly with PC environments in mind and thus it is not optimized for mobile applications. The back end uses GEE to access satellite data, conduct the analyses and use Google's cloud computing capabilities (Prasai *et al*., 2021) [1]. We used Python API to interact with GEE backend. Current version of this tool has 8 predictors/covariates used in the model development. Users can select the shapefiles of any protected areas or draw the region of their interest using the rectangle/polygon icon available on the left side of the map. They can also download the time series charts and data in .csv format for the annual tree cover data from 2000-2020 for any locations.

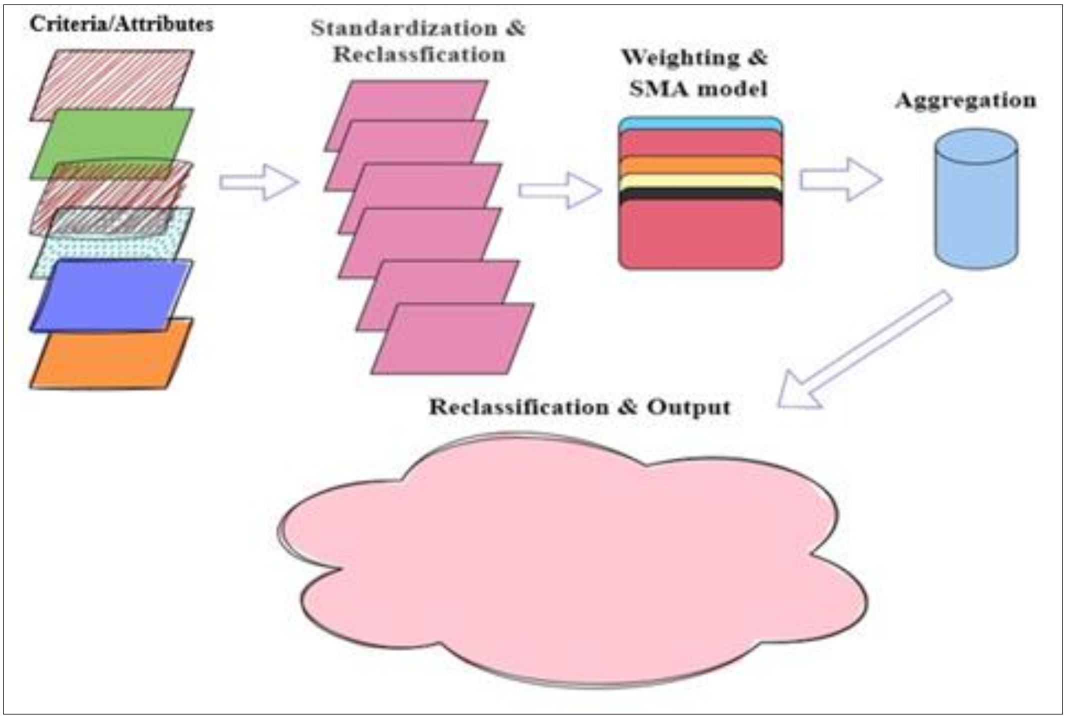


Fig 1: Steps in building spatial multicriteria analysis model (SMA).

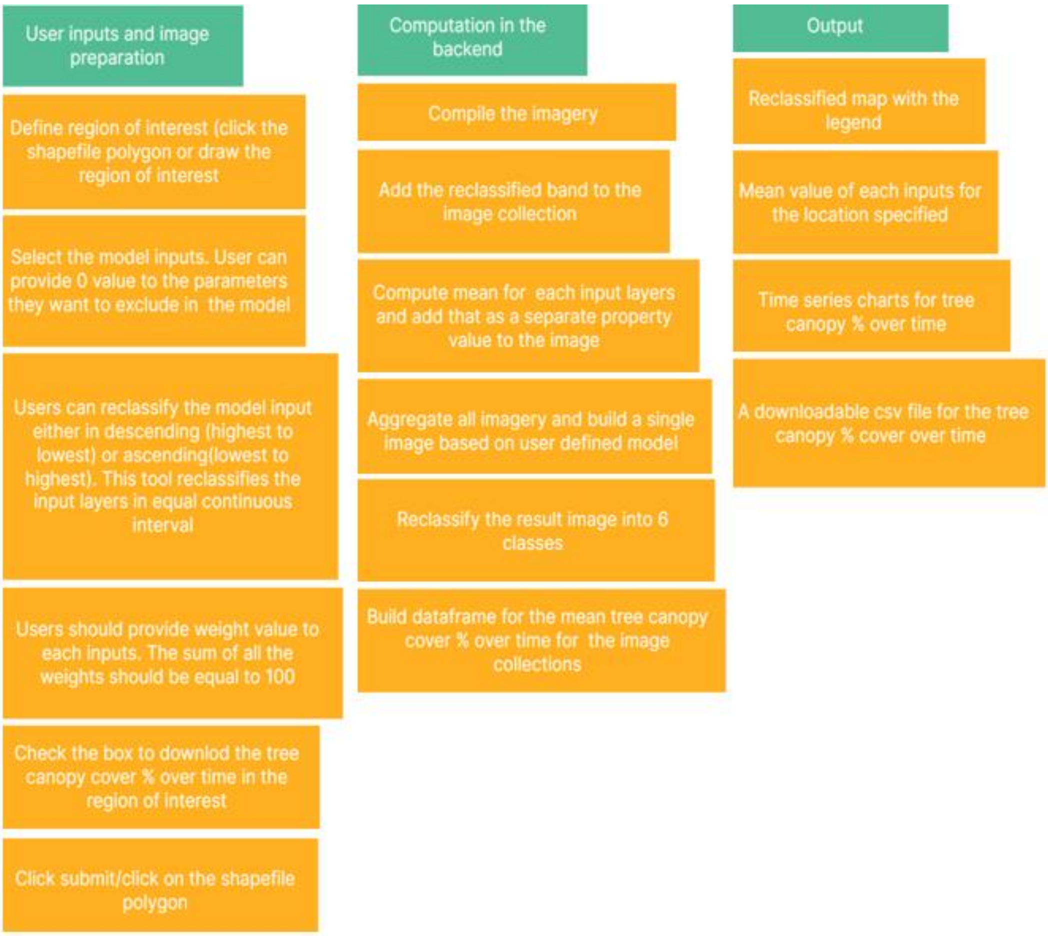
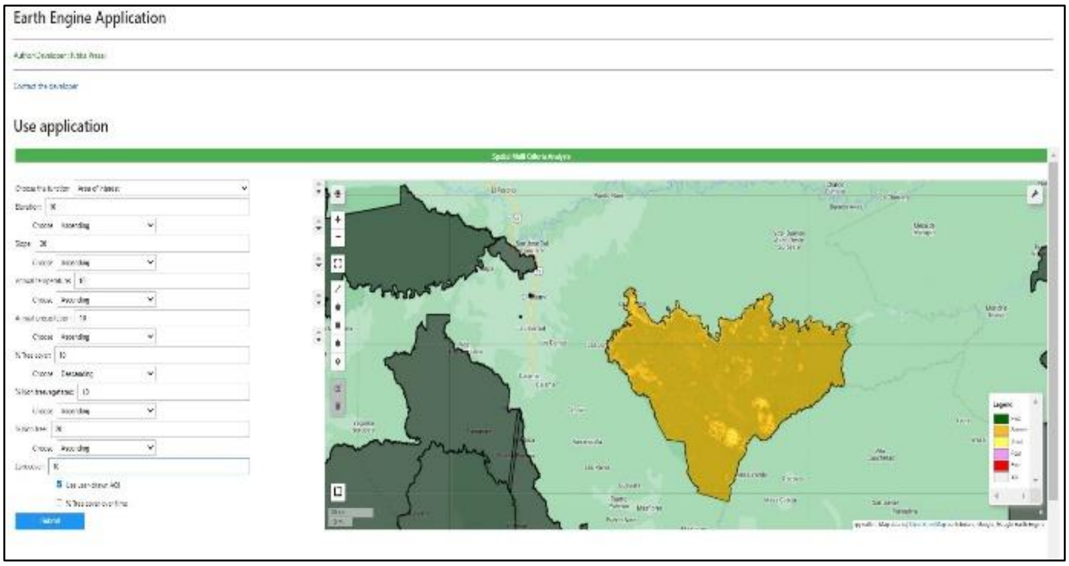
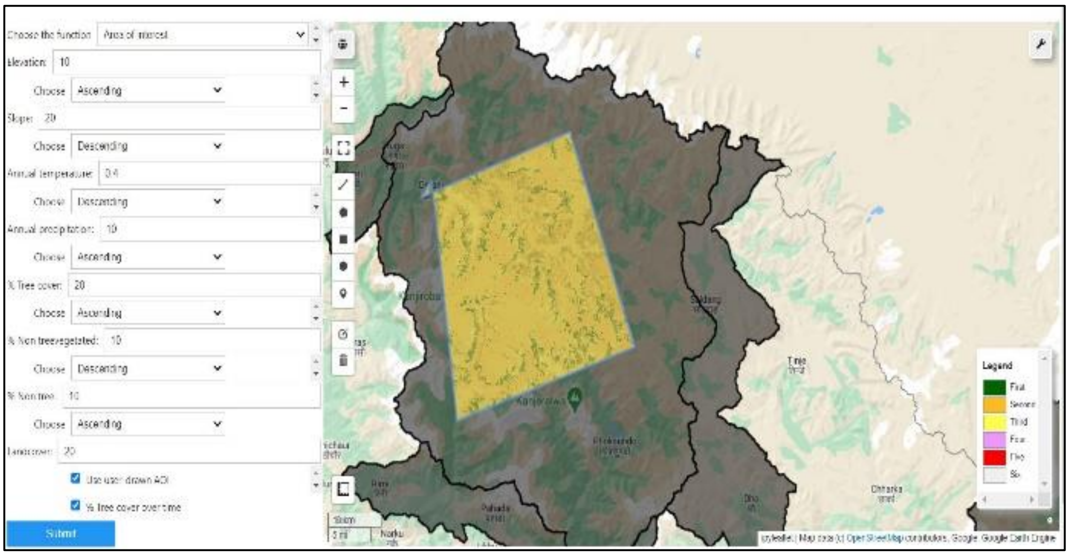
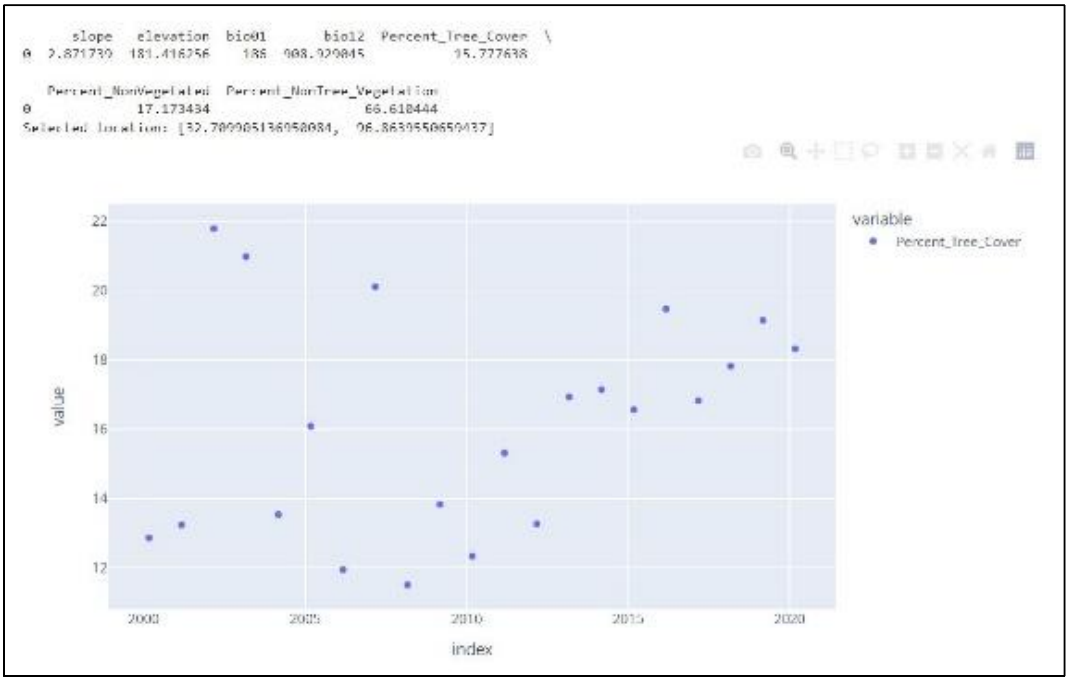


Fig 2: Flowchart describing the overall application design


Earth Engine Application
Use application
Submit


Choose the function
Area of interest
Elevation: 10
Choose Ascending
Slope: 20
Choose Descending
Annual temperature
Choose Descending
Annual precipitation: 10
Choose Ascending
% Tree cover: 20
Choose Ascending
% Non treevegetated: 10
Choose Descending
Choose Ascending
Use user drawn AOI
% Tree cover over time
Submit
Legend


slope elevation bio01 bio12 Percent_Tree_Cover \
Percent_NonVegetated Percent_NonTree_Vegetation
0 17.173434 66.618444
Selected location:
variable
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value
index
22
20
18
16
14
12
2000
2005
2010
2015
2020

	A	B	C
1	Date	Percent_Tree_Cover	
2	3/4/2000	12.86092914	
3	3/5/2001	13.23738051	
4	3/5/2002	21.79275448	
5	3/5/2003	20.98875152	
6	3/4/2004	13.53600197	
7	3/5/2005	16.09037759	
8	3/5/2006	11.94400377	
9	3/5/2007	20.11675852	
10	3/4/2008	11.5058328	
11	3/5/2009	13.82817522	
12	3/5/2010	12.33476019	
13	3/5/2011	15.31411633	
14	3/4/2012	13.26637355	
15	3/5/2013	16.93345961	
16	3/5/2014	17.14623706	
17	3/5/2015	16.56853024	
18	3/4/2016	19.47843985	
19	3/5/2017	16.82425022	
20	3/5/2018	17.82412029	
21	3/5/2019	19.14971075	
22	3/4/2020	18.3249682	
23			
24			
25			

Fig 3: Graphical user interface (GUI) of the web-based tool

2. Data and Methods

2.1 Elevation

We have used Shuttle Radar Topography Mission (SRTM) digital elevation data which provides elevation of 1 arc-second (approximately 30 m) in our model. We have used global data so that users can filter the location of their interest and build the model. For more information about this dataset please visit SRTM Quick Guide.

2.2 Bioclimatic variables

We have used WorldClim V1 Bioclim datasets that are derived from the monthly temperature and rainfall in our model (https://developers.google.com/earth-engine/datasets/catalog/WORLDCLIM_V1_BIO). This dataset can be used to study annual temperature and precipitation trends, seasonality. We have used only two bioclimatic variables in our model (i): bio 1: annual temperature in °C. Minimum temperature is -290 and maximum temperature is 320 °C. (ii): Annual precipitation in mm. The lowest value is 0 and the highest is 11401 mm.

2.3 Land use land cover

We have used global land cover data for 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).

2.4 Vegetation datasets

We used The Terra MODIS Vegetation Continuous Fields (VCF) to derive a gradation of three surface cover components: percent tree cover, percent non-tree cover, and percent bare. These products are generated yearly, the VCF product is produced using monthly composites of Terra MODIS 250 and 500 meters. Land Surface Reflectance data, including all seven bands, and Land Surface Temperature (https://developers.google.com/earthengine/datasets/catalog/MODIS_006_MOD44B).

2.5 Shape files

This web-tool consists of shape files of global protected areas. This file is uploaded in developer's google earth engine private account and shared in the application.

2.6 Model development

We used only raster as the input layers/covariates in our models. We resampled the covariates to match the resolution, cell size, extent of all the covariates. We used fuzzy logic to reclassify the priority of covariates before using them in the final model. Using our web-tool user can reclassify the covariates either in ascending (increasing values/lowest to highest) or descending (highest to lowest) to feed in their model based on the requirement of the projects. Then the model gives the output based on weighted overlay sum approach. The sum of all the weights/scores should be equal to 100 (Chen, 2014) [4]. We provide scores based on varying levels of 'importance' or weights to the different input layers (Pradhan & Kim, 2016) [11].

2.7 Legend

Legend on the right side provides the color code which can be matched with classified map to figure out the priority of the location based on the model developed. First describes the highest prioritized region/area and the vice versa.

3. Conclusion

This tool is intended to give a generalized road map to the environmental decision process (Gorelick *et al*., 2017; Prasai, 2021) [6, 1]. 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. This tool can be used to develop a preliminary map/prioritization maps for any locations based on the users interest therefore it can be used for all regions and for any models. It allows us to consider many different solutions to make a decision allowing users to pick the best model. Then these models help in making a decision model about a research project. This open-source web-based tool will benefit spatial multicriteria analysis projects throughout the world especially where access to commercial image processing software packages and remote sensing data is limited (Boggia *et al*., 2018; Prasai *et al*., 2021) [1].

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Conflict of Interest: None

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