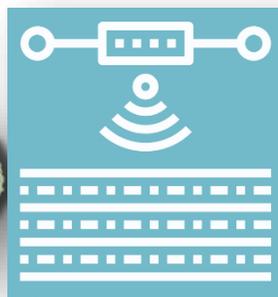
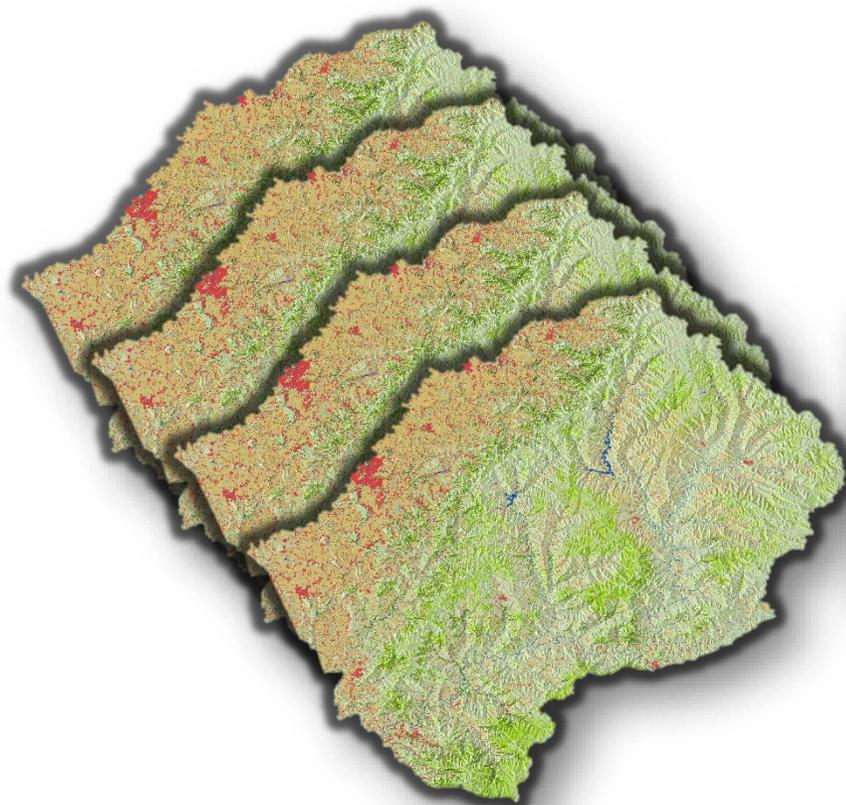




Food and Agriculture
Organization of the
United Nations



ANNUAL LAND COVER PRODUCTION IN GOOGLE EARTH ENGINE

Workflow in Google Earth
Engine to produce an annual
land cover map

February 2021 (Lesotho)

Lorenzo De Simone, FAO

William Ouellette, FAO



European Union



german
cooperation

DEUTSCHE ZUSAMMENARBEIT

Implemented by
giz
Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH



renoka

STEP 1: REFERENCE DATA CLEAN-UP

Reference data (partly) loses its **validity over time** due to changes on the ground

Workbench takes reference data from the baseline year (2021) and runs a **sanity check** on the data to make sure the data is still “valid”

Possibility to use 2021 reference data for all years, but the more years pass, the less viable this becomes, due to this “**decay**” in reference data validity (see slide 5)

Land cover year	Number of reference samples
2017	2 875
2018	2 881
2019	2 908
2020	2 959
2021	3 290 (2 931 if clean-up applied)



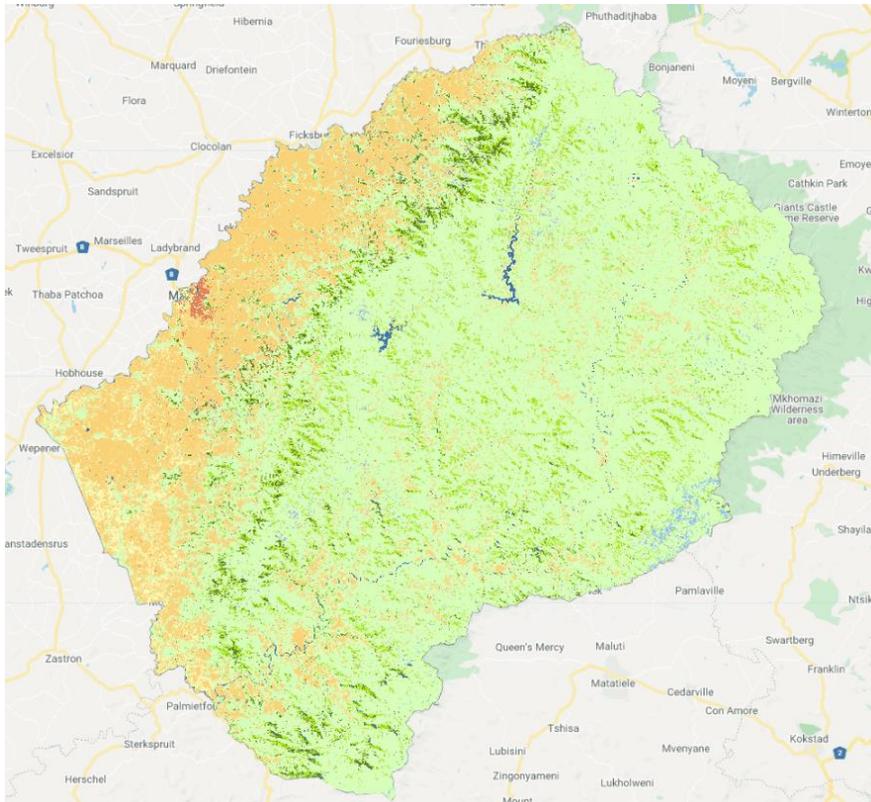
STEP 2: RANDOM FOREST CLASSIFICATION

The screenshot displays the Google Earth Engine web interface. At the top, the search bar contains the URL: `Link d0b0b89d78d6a869f3ff842fa51463e7`. The left sidebar shows a project structure under 'Owner (6)' with folders for 'users/soilwatch/biodiversityApp', 'users/soilwatch/functions', 'users/soilwatch/lrpmApp', and 'users/soilwatch/miscellaneous'. The main editor window shows a JavaScript script for Random Forest Classification. The script includes comments and code for setting parameters like `ALGO`, `CLASS_NAME`, `AGG_INTERVAL`, `S2_BAND_LIST`, and `S1_BAND_LIST`. A dictionary `year_dict` is defined for years 2017 through 2022. The bottom of the interface shows a map of Lesotho with a satellite-style overlay of the classified land cover. A legend on the left side of the map lists various land cover types with corresponding color swatches: Built-up (red), Cropland (orange), Degraded Cropland (yellow), needleleaf (dark green), broadleaf (medium green), Water Body (blue), Wetland (light blue), River Bank (dark blue), Shrubland (light green), Grassland (yellow-green), Degraded Grassland (pale yellow), and Bare Surfaces (white). The right sidebar contains the 'Tasks' panel, which lists 'UNSUBMITTED TASKS' with buttons to 'RUN' each task: 'feature_importance_2021', 'errorMatrix_2021', and 'RF_lesotho_s2_60_10bands...'. Below the tasks, it states 'No tasks loaded from server'.

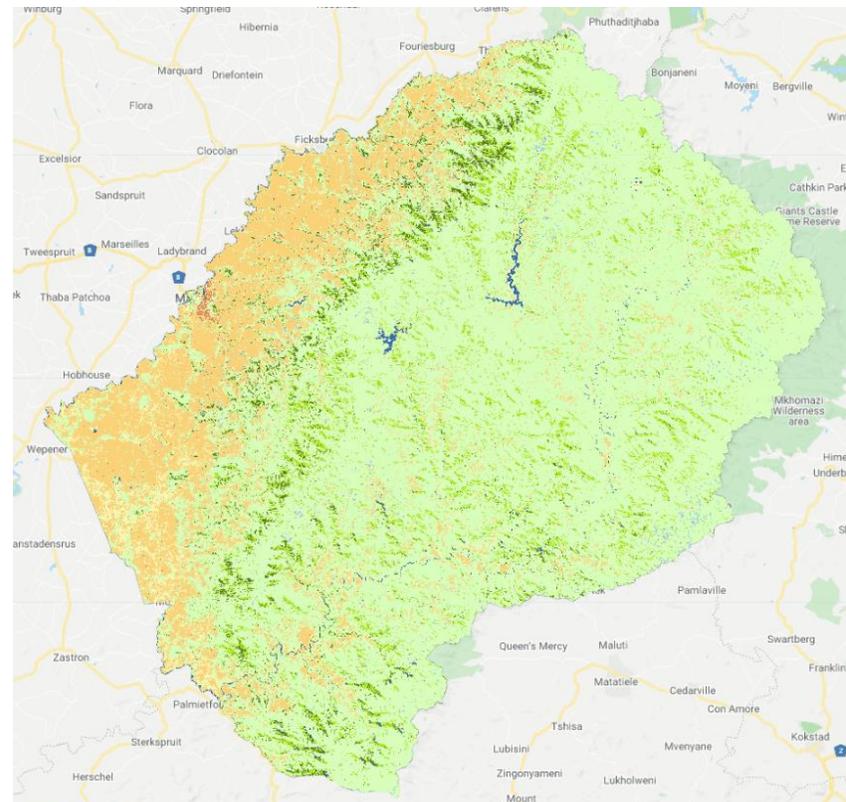
SOURCE: Earth engine app, 2021. [online].
[Cited 25 February 2022].
<https://www.earthengine.app/>

STEP 3: LAND COVER TIME SERIES HARMONIZATION

Harmonization is necessary to ensure that the land cover change information derived is interpretable



Raw



Harmonized

SOURCE: Earth engine app, 2021. [online].
[Cited 25 February 2022].
<https://www.earthengine.app/>

STEP 3: LAND COVER TIME SERIES HARMONIZATION

List of rules:

Three-consecutive-year rule: if middle pixel is different than previous and following year, and previous and following year are the same class, it is converted to that class

1. Applied for built-up, agriculture (assumption is that 1-year fallows are too uncommon), forest, wetland, grassland, bare soil
2. This does not apply for water (dam water extent fluctuates yearly)

Impossible transitions:

1. Water to built-up
2. Built-up to agriculture
3. Bare Soil to Agriculture (the degradation level makes it close to impossible unless a commercial/irrigated agriculture comes along)
4. Any class to forest aside from wetland and shrubland
5. Any class to wetland aside from grassland and cropland
6. Any class to shrubland aside from wetland grassland and forest
7. Any class to grassland aside from bare soil, cropland and wetland
8. Built-up to bare soil

STEP 3: LAND COVER TIME SERIES HARMONIZATION

The screenshot displays the Google Earth Engine interface. The top navigation bar includes the Google Earth Engine logo, a search bar, and the user name 'fao-eostat-review'. The left sidebar shows the 'Assets' panel with a tree view of the user's assets, including a folder named 'users/ocsgeospatial' containing a sub-folder 'Lesotho' with various datasets like 'temp_indicators', 'FAO_JCM_Wetland_TD_2021', and 'RF_lesotho_s2_60_10bands_2018'. The main panel shows a script titled '3-LandCoverHarmonization' with the following code:

```
1 // ..... //
2 // ..... //
3 // ..... //
4 // This workbench performs the land cover harmonization across the produced land cover years
5 // ..... //
6 // ..... //
7 var lcdb2017 = ee.Image('users/ocsgeospatial/Lesotho/RF_lesotho_s2_60_10bands_kfold_2017');
8 var lcdb2018 = ee.Image('users/ocsgeospatial/Lesotho/RF_lesotho_s2_60_10bands_kfold_2018');
9 var lcdb2019 = ee.Image('users/ocsgeospatial/Lesotho/RF_lesotho_s2_60_10bands_kfold_2019');
10 var lcdb2020 = ee.Image('users/ocsgeospatial/Lesotho/RF_lesotho_s2_60_10bands_kfold_2020');
11 var lcdb2021 = ee.Image('users/ocsgeospatial/Lesotho/RF_lesotho_s2_60_10bands_kfold_2021');
12
13 // Initialize the years backwards, because we take 2021 to be the baseline year
14 var lc_timeseries = [lcdb2021, lcdb2021, lcdb2020, lcdb2019, lcdb2018, lcdb2017, lcdb2017];
15 // Buffer the list with double the year 2021 and double the year 2017 so all years have a previous and a next neighbour
16 var years = ['2021', '2021', '2020', '2019', '2018', '2017', '2017'];
17 // ..... //
18
```

The right sidebar shows the 'Task Manager' panel, which lists 'UNSUBMITTED TASKS' with a table of tasks and their status:

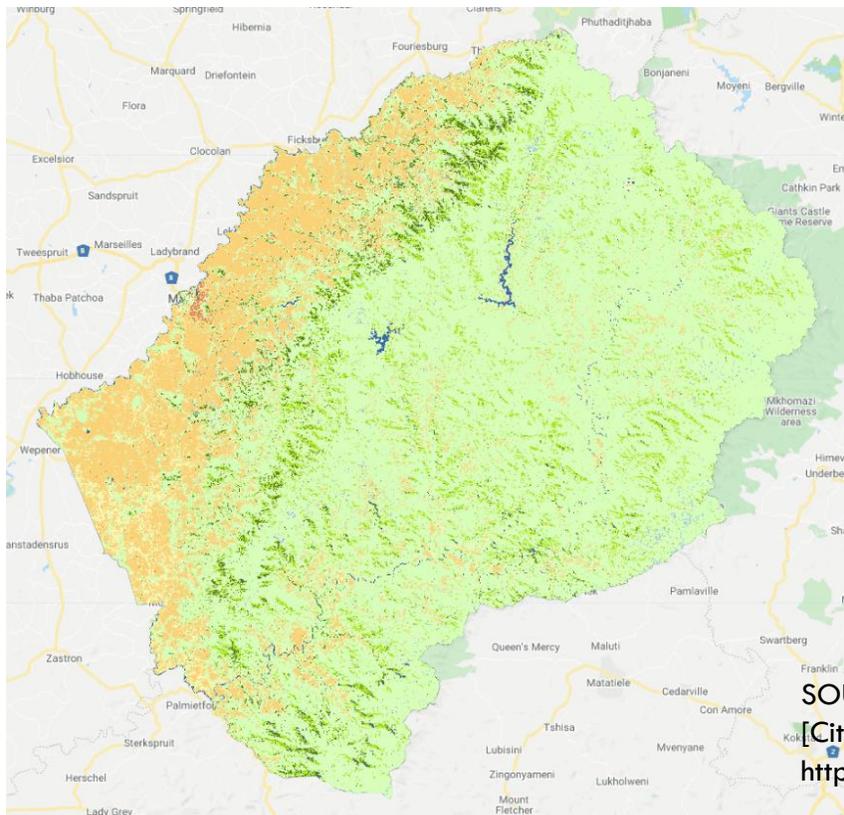
Task Name	Status
rf_lesotho_s2_60_2020_harmonized	RUN
rf_lesotho_s2_60_2021_harmonized	RUN
rf_lesotho_s2_60_2018_harmonized	RUN
rf_lesotho_s2_60_2019_harmonized	RUN
rf_lesotho_s2_60_2017_harmonized	RUN
rf_lesotho_s2_60_2021_harmonized...	2h

The bottom panel shows a map of Lesotho with a land cover time series visualization. The map includes labels for various towns and cities such as Kimberley, Bloemfontein, and Durban. The land cover is represented by a color-coded overlay, with green indicating forest and yellow/orange indicating other land cover types.

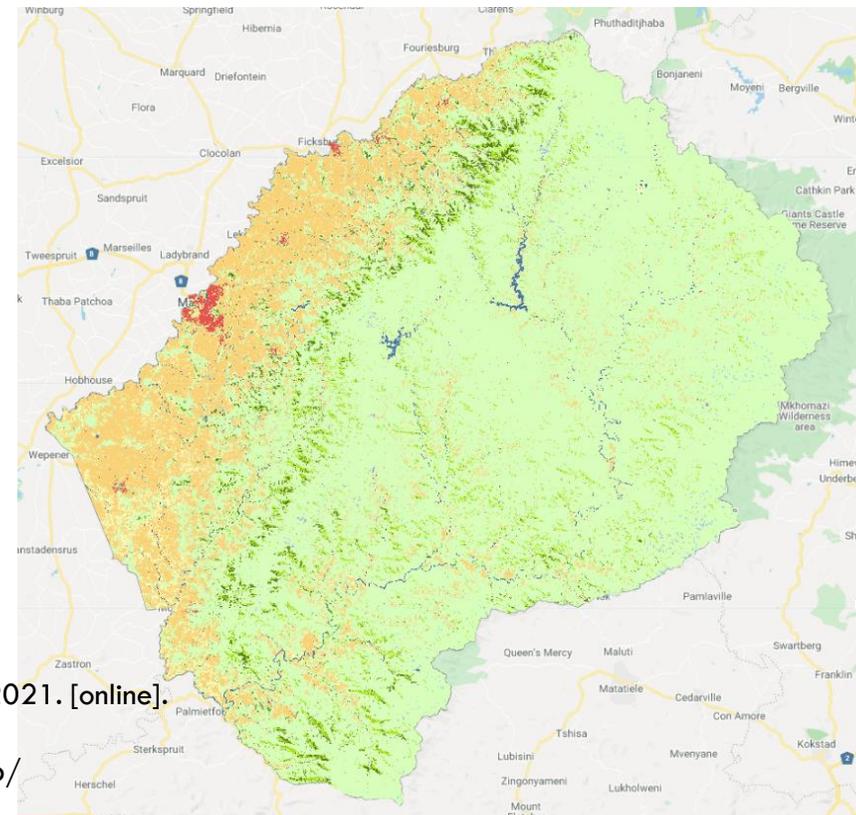
SOURCE: Earth engine app, 2021. [online].
[Cited 25 February 2022].
<https://www.earthengine.app/>

STEP 4: LAND COVER POST-PROCESSING

Post-processing aims to increase the overall quality of the land cover product, both in terms of accuracy and usability



Harmonized



Post-processed

SOURCE: Earth engine app, 2021. [online].
[Cited 25 February 2022].
<https://www.earthengine.app/>

STEP 4: LAND COVER POST-PROCESSING

List of rules:

1. Remove **Cropland** on steep slopes ($> 30^\circ$) to surrounding majority class
2. Remove **Water** on slope ($> 10^\circ$) and Height Above Nearest Drainage (HAND) $> 45\text{m}$ to surrounding majority class
3. **Irrigated Cropland**: Kmeans clustering of cropland (2 clusters), Highest mean NDVI cluster selected, $s2_integral > 0.5$, slope $< 10^\circ$, HAND $< 45\text{m}$, pixel groups > 100 pixels
4. Remove **Wetland** on slope ($> 20^\circ$), HAND $> 90\text{m}$, and within 5 pixels (50m) of built-up areas
5. **Gullies**: GLCM Correlation and contrast of bands 2, 3, 4 and 8, trained a RF model using 1000 sampled gullies pixels from the LCDB2015 dataset, with HAND $< 45\text{ m}$, + Carry over Gullies from previous year
6. Google Open Buildings and World Settlement Footprint 2015-2019 burnt in as **Built-Up**

STEP 4: LAND COVER POST-PROCESSING

The screenshot displays the Google Earth Engine web interface. The top navigation bar includes the Google Earth Engine logo, a search bar, and the user profile 'fao-eostat-review'. The left sidebar shows a file explorer with folders for 'users/ocsgeospatial/functions', 'users/ocsgeospatial/Kmeans_Berea', and 'users/ocsgeospatial/Lesotho'. The 'LandCoverPostProcessing' script is selected and its code is visible in the main editor. The code includes comments and variable declarations for land cover classification in Lesotho. The right sidebar contains the 'Inspector', 'Console', and 'Tasks' panels. The 'Tasks' panel shows a list of 'UNSUBMITTED TASKS' with 'RUN' buttons for each. The bottom panel shows a map of Lesotho with a land cover classification legend.

```
LandCoverPostProcessing
Imports (1 entry)
var geometry: MultiPoint, 0 vertices
1 // ===== 4. Land Cover Post-Processing Workbench - Lesotho ===== //
2 // ===== //
3 // ===== //
4 // This workbench picks up the harmonized landcover time series, and further processes it using a ruleset that aims to
5 // reduce the commission errors of certain classes on the basis of external datasets (e.g. WSF, Google Open Buildings)
6 // Moreover, the irrigated croplands and gullies are produced as part of this workbench and integrated into the land cover
7 // ===== //
8 // ===== //
9 var CLASS_NAME = 'LC_Class_1'; // Property name of the feature collection containing the crop type class attribute
10 var AGG_INTERVAL = 364/6; // Number of days to use to create the temporal composite for 2020
11 var S2_BAND_LIST = ['B2', 'B3', 'B4', 'B5', 'B6', 'B7', 'B8', 'B8A', 'B11', 'B12', 'NDVI']; // S2 Bands to use as DTW input
12 // ===== //
13 // ===== //
14 // A dictionary that will be iterated over for multi-year land cover mapping.
15 // Comment out the years you do not wish to produce.
16 // First element of the dictionary value is the collection name, Second element the irrigate agriculture cluster to select
17 var year_dict = { // 2017: ['COPERNICUS/S2', 1],
18 // 2018: ['COPERNICUS/S2', 2],
19 // 2019: ['COPERNICUS/S2', 2],
20 // 2020: ['COPERNICUS/S2', 1],
21 // 2021: ['COPERNICUS/S2', 2]
22 };
23
24
25
```

Legend

- Urban
- Cropland
- Degraded Cropland
- needleleaf
- broadleaf
- Water Body
- Wetland
- River Bank
- Shrubland
- Grassland
- Degraded Grassland
- Bare Surfaces
- Mines
- Irrigated Cropland
- Gullies

Tasks

Manage tasks.

Search or cancel multiple tasks in the Task Manager.

UNSUBMITTED TASKS

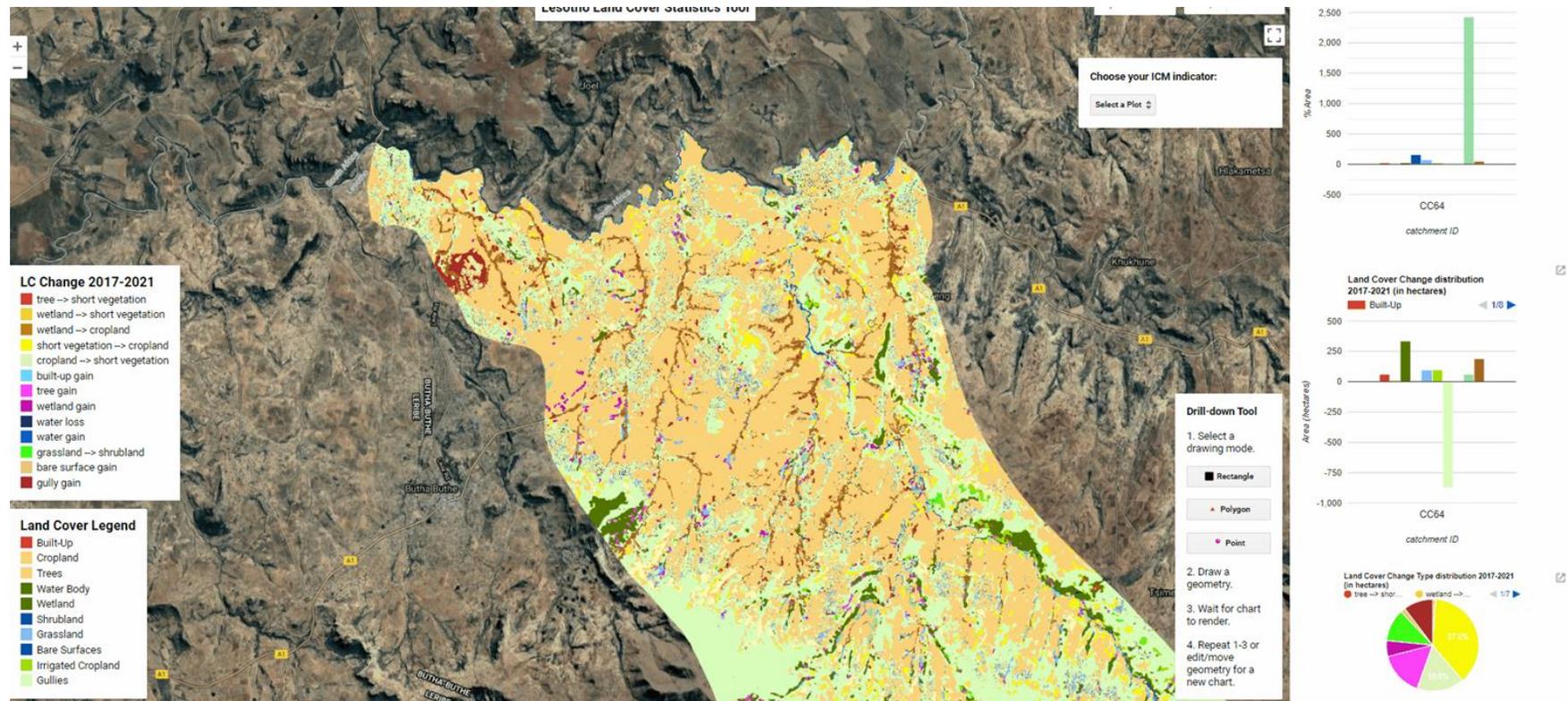
Task Name	Status	Time
errorMatrix_2021	RUN	
rf_lesotho_s2_60_10bands_kfold_20...	RUN	
rf_lesotho_s2_60_2021_harmonized...	3h	
rf_lesotho_s2_60_2020_harmonized...	3h	
rf_lesotho_s2_60_2019_harmonized...	18m	
rf_lesotho_s2_60_2018_harmonized...	✓ 3h	
rf_lesotho_s2_60_2017_harmonized...	✓ 2h	
errorMatrix_2021	✓ 7m	
errorMatrix_2020	✓ 5m	

SOURCE: Earth engine app, 2021. [online]. [Cited 25 February 2022]. <https://www.earthengine.app/>

STEP 5: INTEGRATION OF NEW DATA TO DASHBOARD

The **dashboard** is powered by the land cover data produced

Additional **temporal indicators** support the interpretation of the land cover change

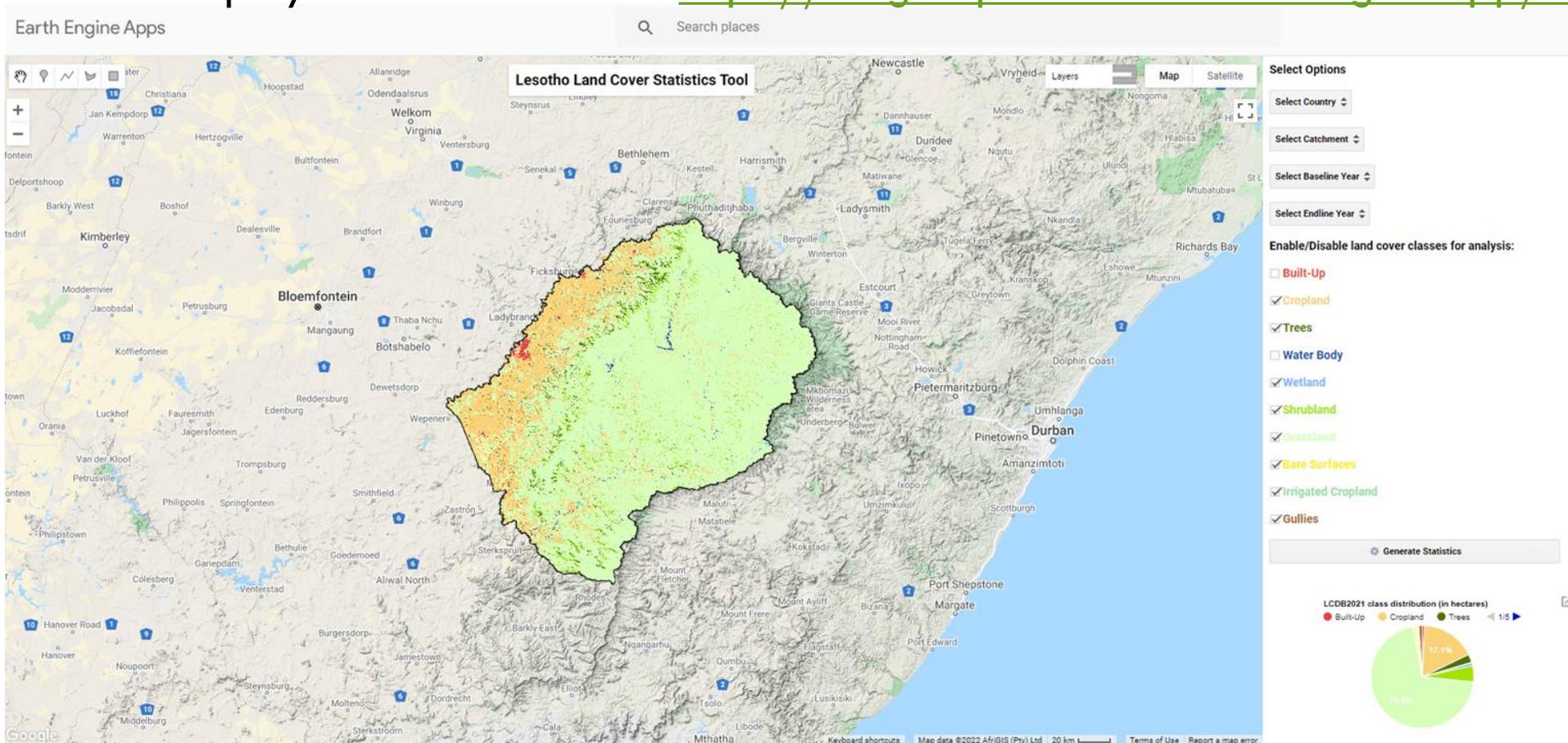


SOURCE: Earth engine app, 2021. [online].
[Cited 25 February 2022].
<https://www.earthengine.appspot.com/>

STEP 5: INTEGRATION OF NEW DATA TO DASHBOARD

[HTTPS://CODE.EARTHENGINE.GOOGLE.COM/4A8BC9DF385D91F7158718AE7C648441?NOLOAD=TRUE](https://code.earthengine.google.com/4a8bc9df385d91f7158718ae7c648441?noload=true)

Deployed dashboard link: <https://ocsgeospatial.users.earthengine.app/view/lcstatslesotho>



SOURCE: Earth engine app, 2021.
[online].

[Cited 25 February 2022].

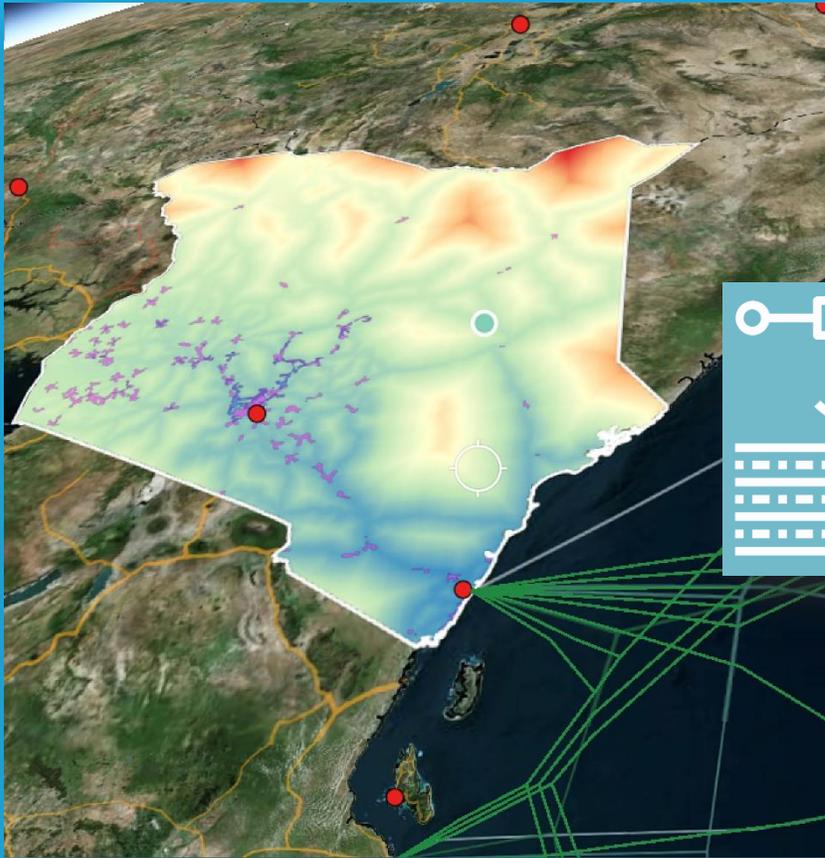
<https://code.earthengine.google.com/4a8bc9df385d91f7158718ae7c648441?noload=true>



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