



Global Yield
Gap Atlas

Technology Extrapolation Domains (TEDs)

Tools tutorial

UNIVERSITY OF
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TED justifications

- Traditional agricultural research is mostly conducted at specific locations.
- It's a challenge to interpret results and upscale them to larger spatial scales
- TEDs classify sites based on key climate and soil factors that govern crop yield.
- TEDs have been developed for the United States (US) and sub-Saharan Africa.

TED applications

- If you are a farmer:

View results of product trials to see if trials were conducted in regions with similar climate and soils to yours.

- If you conduct ag research:

You might want to consider conducting research in a variety of TEDs to capture varying climate and soil conditions and represent well the main crop producing areas and/or those where your product is expected to deliver the largest impact.

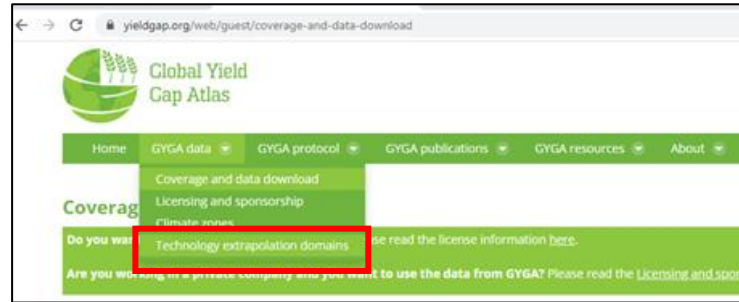
TED interactive tools website

<https://www.tooled.org/>

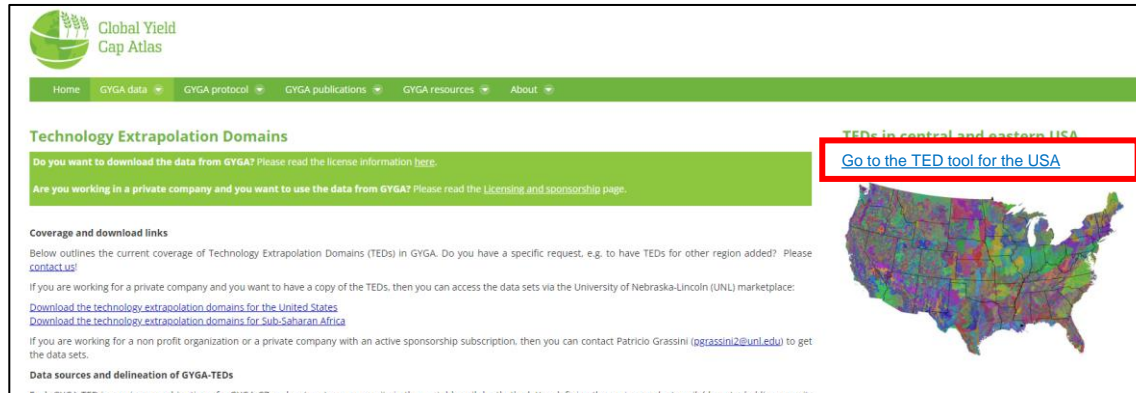
- Africa: <https://www.tooled.org/africa/>
- USA: <https://www.tooled.org/usa/>

Access TED interactive tools via GYGA

From GYGA Homepage, click on GYGA data -> Technology extrapolation domain



Click on the link that will direct to TED tool

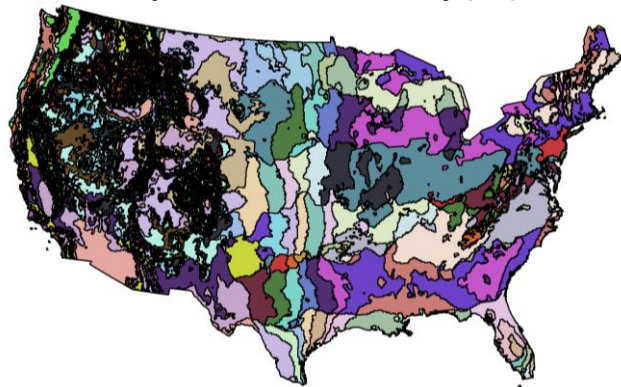


Components of TEDs

$$\text{Unique TED} = \text{CZ} + \text{RZWHC}$$

Climate Zones (CZ)

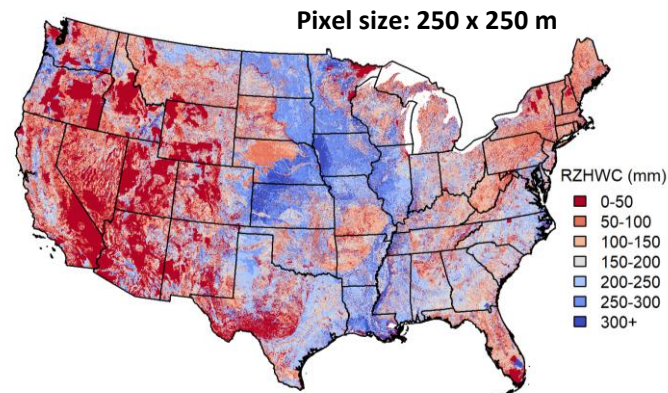
- Growing degree days (GDD)
- Aridity index (AI)
- Temperature seasonality (TS)



Source: van Wart et al.(2013)

Soil water storage capacity

- Root-zone water holding capacity (RZWHC)



Source: gSSURGO, USDA-NRCS

Values of TEDs based on components

$$\text{TED} = \text{CZ} + \text{RZWHC}$$

Each number is a code associated with a specific range of climatic and soil conditions.

Example TED value: **604803**

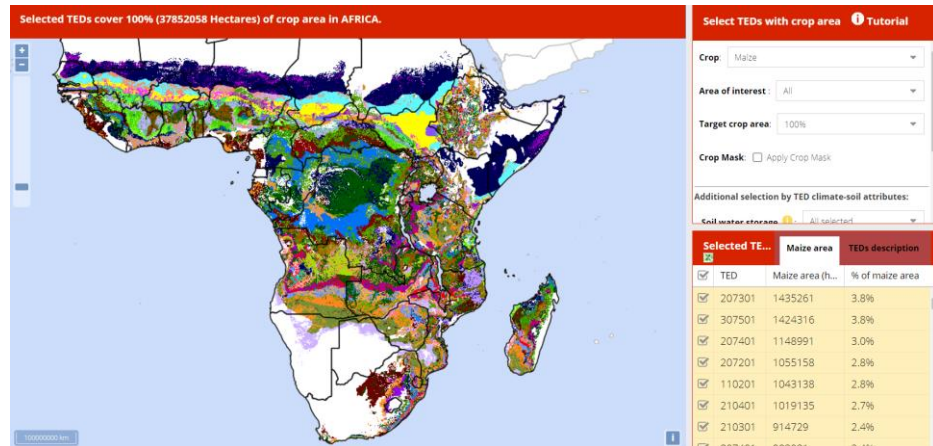
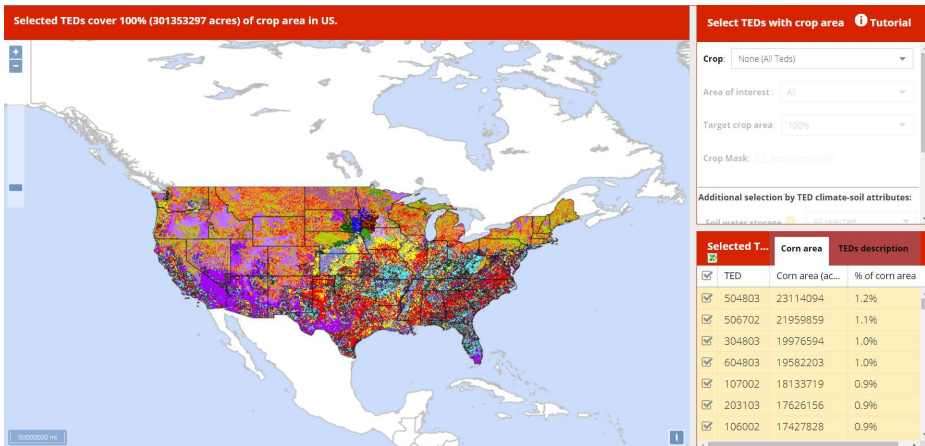
Diagram illustrating the components of the TED value 604803:

- 6**: RZWHC (Soil conditions)
- 0**: GDD (Growing Degree Days)
- 4**: AI (Aridity Index)
- 8**: TS (Temperature Seasonality)
- 0**: CZ (Climate Zone)
- 3**: AI (Aridity Index)

TED interactive tools

USA: <https://www.tooled.org/usa/>

Africa: <https://www.tooled.org/africa/>

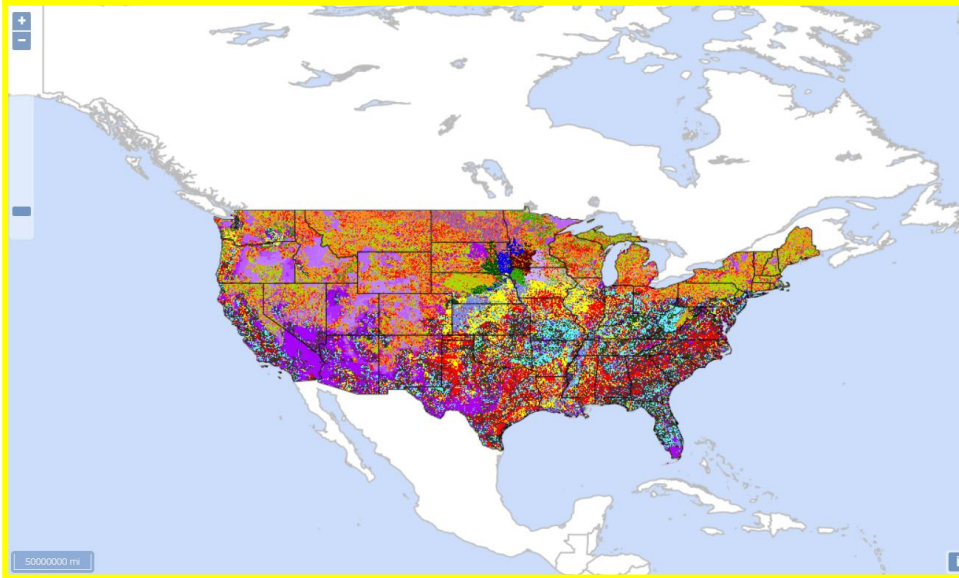


One tool for each region. Same functionalities

TED Tools layout

map
header

Selected TEDs cover 100% (301353297 acres) of crop area in US.



interactive map

TED selection menu

Select TEDs with crop area [Tutorial](#)

Crop: None (All TEDs)

Area of interest: All

Target crop area: 100%

Crop Mask: Apply Crop Mask

Additional selection by TED climate-soil attributes:

Soil water storage: All color-coded

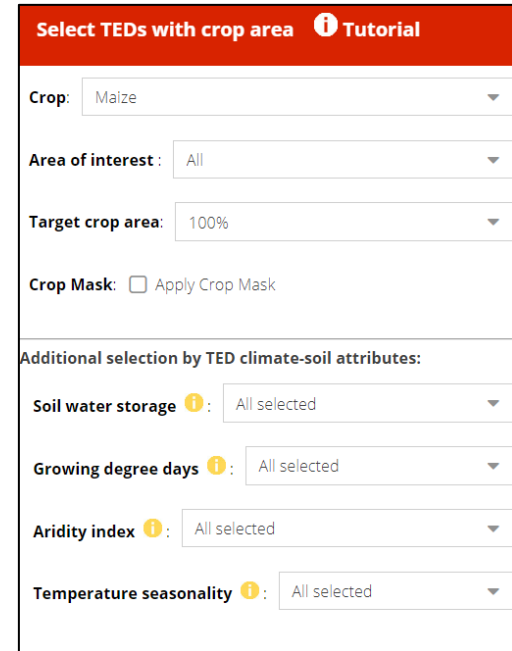
Selected TEDs	Corn area	TEDs description
<input checked="" type="checkbox"/>	TED	Corn area (ac... % of corn area
<input checked="" type="checkbox"/>	504803	23114094 1.2%
<input checked="" type="checkbox"/>	506702	21959859 1.1%
<input checked="" type="checkbox"/>	304803	19976594 1.0%
<input checked="" type="checkbox"/>	604803	19582203 1.0%
<input checked="" type="checkbox"/>	107002	18133719 0.9%
<input checked="" type="checkbox"/>	203103	17626156 0.9%
<input checked="" type="checkbox"/>	106002	17427828 0.9%

Selected
TEDs
table

TED selection menu

For each crop, users can select areas to display based on:

1. Crop
2. Area of interest
3. Target crop area
4. Actual crop producing areas (crop mask)
5. TED climate-soil attributes
 - Soil water storage
 - Growing degree days
 - Aridity Index
 - Temperature seasonality



The screenshot shows a web interface titled "Select TEDs with crop area" with a "Tutorial" icon. It features several dropdown menus and a checkbox. The "Crop" dropdown is set to "Maize". The "Area of interest" dropdown is set to "All". The "Target crop area" dropdown is set to "100%". There is a checkbox for "Apply Crop Mask" which is currently unchecked. Below these, there is a section for "Additional selection by TED climate-soil attributes:" with four dropdown menus, each set to "All selected": "Soil water storage", "Growing degree days", "Aridity index", and "Temperature seasonality".

1. Select Crop

The first step is crop selection. This enables other selection options.

USA

Select TEDs with crop area ⓘ Tutorial

Crop: None (All Teds)

Area of Interest: Corn

Target: Rice

Crop Model: Sorghum

Additional Crops: Soybean

Soil Water: Wheat *

Africa

Select TEDs with crop area ⓘ Tutorial

Crop: None (All Teds)

Area of Interest: Maize

Target: Legumes #

Crop Model: Sorghum

Additional Crops: Cassava

Soil Water: Millet

Additional Crops: Rice

Soil Water: Wheat

Current version includes 5 (USA) and 7 (Africa) major crops

*In the USA, wheat includes winter wheat, spring wheat, and durum wheat.

#In Africa, legumes includes bean, chickpea, cowpea, groundnut, pigeonpea, and soybean

2. Area of interest

Select TEDs with crop area Tutorial

Crop:

Area of interest:

Target crop area:

Crop Mask: Apply Crop Mask

Additional selection by TED climate-soil attributes:

Soil water storage :

Growing degree days :

Aridity index :

Temperature seasonality :



All

All

State (click on a state)

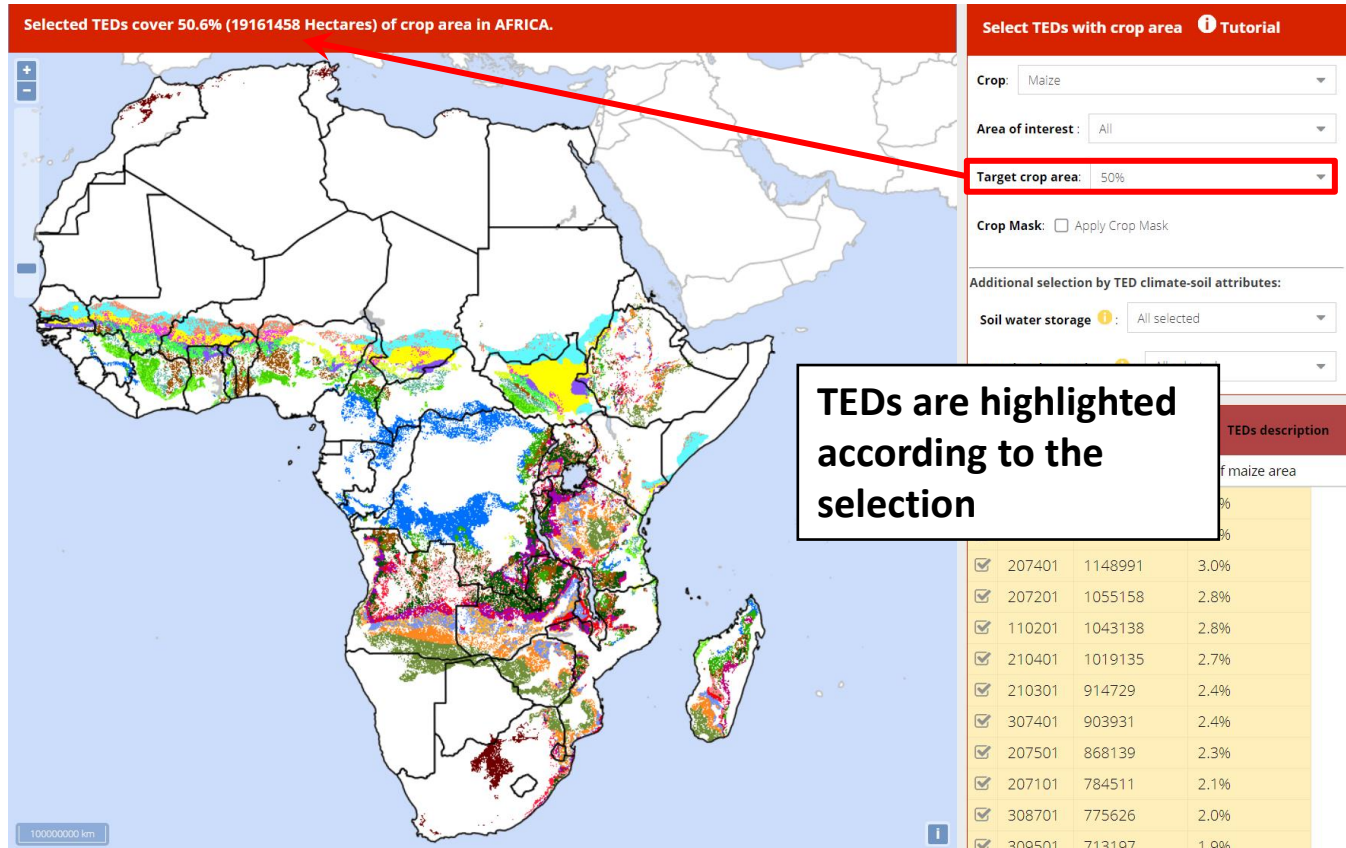
User-defined area (draw a rectangle)

Specific sites (enter GPS coordinates)

The default Area of Interest is the entire region.
Other options are explained in subsequent slides.

3. Target crop area

Selected TEDs cover 50.6% (19161458 Hectares) of crop area in AFRICA.



Select TEDs with crop area **Tutorial**

Crop: Maize

Area of interest: All

Target crop area: 50%

Crop Mask: Apply Crop Mask

Additional selection by TED climate-soil attributes:

Soil water storage: All selected

TEDs are highlighted according to the selection

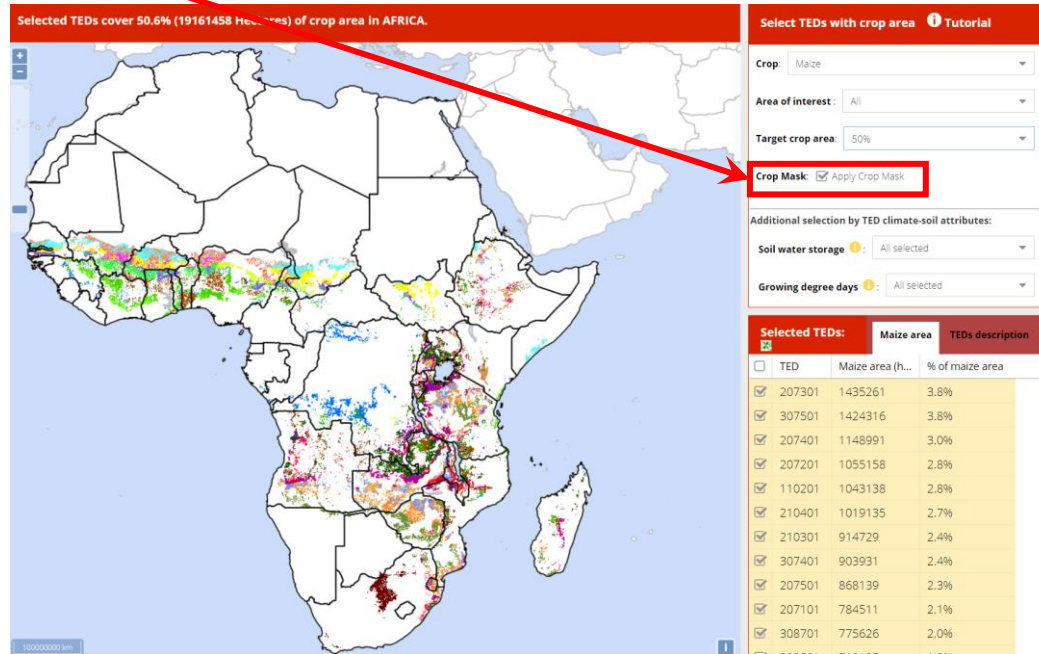
	TEDs description	f maize area	
<input checked="" type="checkbox"/>	207401	1148991	3.0%
<input checked="" type="checkbox"/>	207201	1055158	2.8%
<input checked="" type="checkbox"/>	110201	1043138	2.8%
<input checked="" type="checkbox"/>	210401	1019135	2.7%
<input checked="" type="checkbox"/>	210301	914729	2.4%
<input checked="" type="checkbox"/>	307401	903931	2.4%
<input checked="" type="checkbox"/>	207501	868139	2.3%
<input checked="" type="checkbox"/>	207101	784511	2.1%
<input checked="" type="checkbox"/>	308701	775626	2.0%
<input checked="" type="checkbox"/>	309501	713197	1.9%

TED selection in the USA – Important notes

- When the tool first loads, it shows all TEDs in the region (US or Africa)
- The user can choose to view any % of crop area up to 100%. In the USA, when many TEDs are selected (e.g., those that cover 70% of all corn area), each TED cannot be represented by a unique color, and the selection includes many TEDs with very small crop area.
- To better visualize the extent of each TED when the area of interest is the entire USA, we recommend selecting a crop area of 50% or less

4. Actual crop production (corn mask)

Checking “apply crop mask” further filters areas where the selected crop is produced

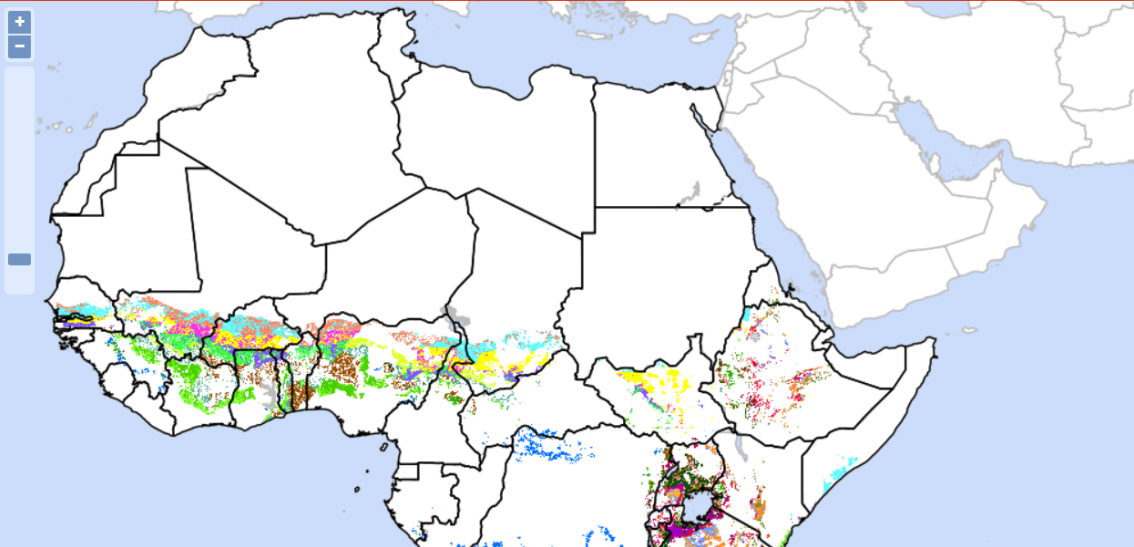


Crop masks are based on 2008-2021 USDA-NASS cropland data layers for the USA and SPAM 2017 v2 for Africa.

4. TED climate-soil attributes

You can select by combination of the 4 attributes defining TEDs

Selected TEDs cover 50.6% (19161458 Hectares) of crop area in AFRICA.



Select TEDs with crop area [Tutorial](#)

Crop:

Area of interest:

Target crop area:

Crop Mask: Apply Crop Mask

Additional selection by TED climate-soil attributes:

Soil water storage [?](#):

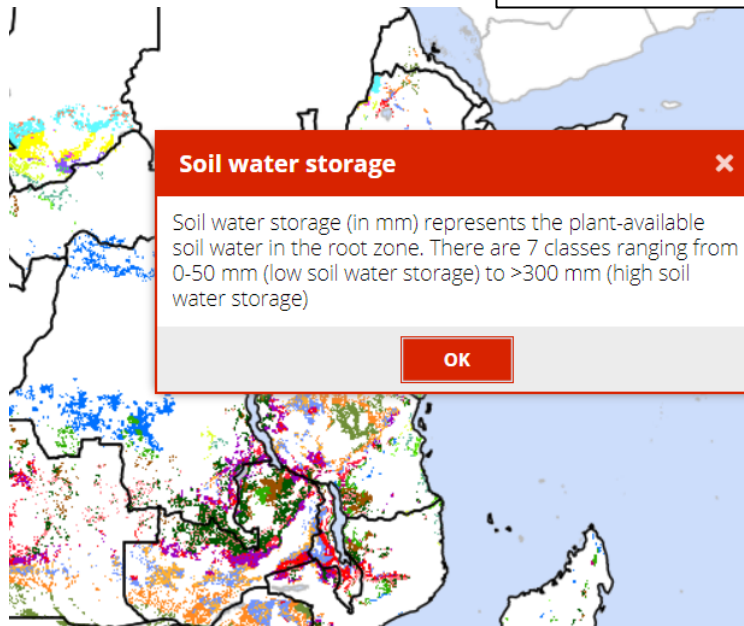
Growing degree days [?](#):

Aridity index [?](#):

Temperature seasonality [?](#):

4. TED climate-soil attributes

Click on the icon to show the definition of each attribute



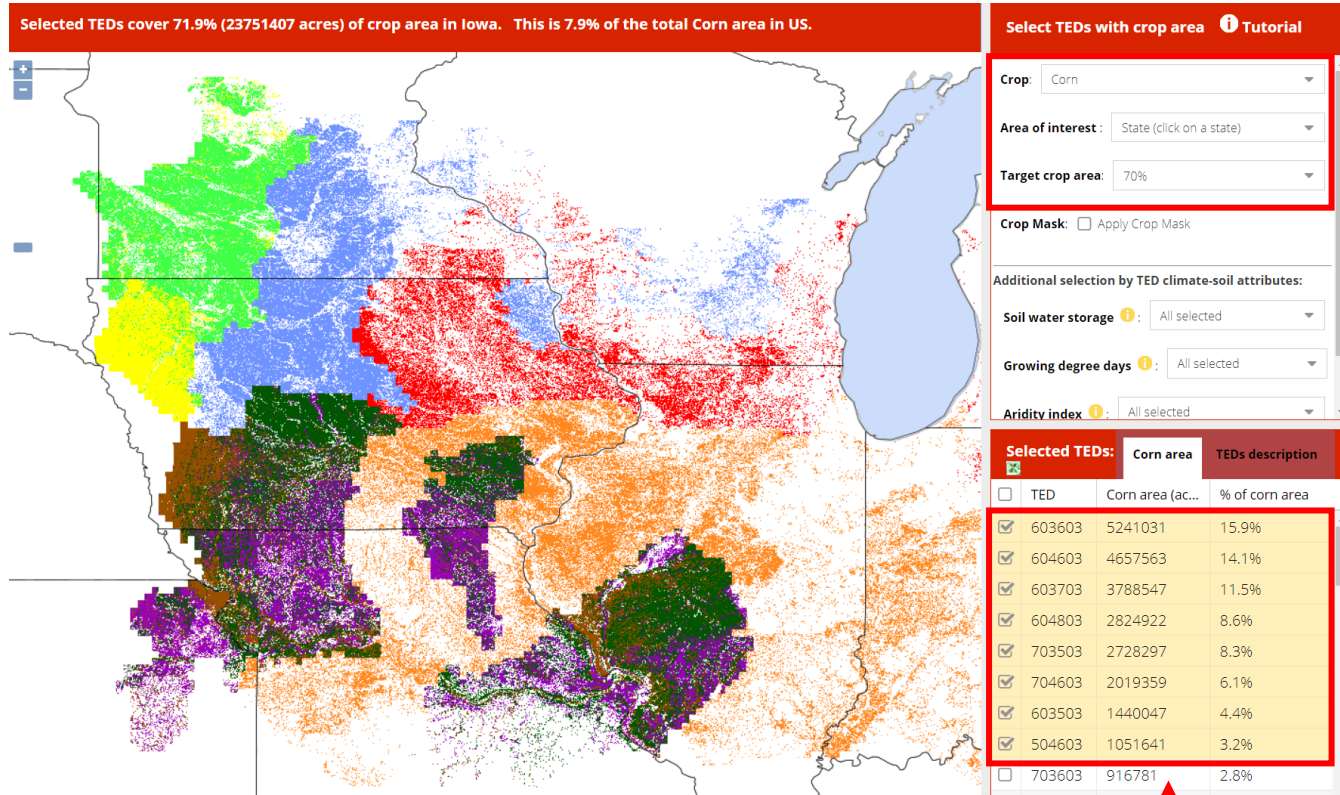
Additional selection by TED climate-soil attributes:

Soil water storage ⓘ: All selected [v]

Growing degree days ⓘ: All selected [v]

Selected TEDs:		Maize area	TEDs description
<input type="checkbox"/>	TED	Maize area (h...	% of maize area
<input checked="" type="checkbox"/>	207301	1435261	3.8%
<input checked="" type="checkbox"/>	307501	1424316	3.8%
<input checked="" type="checkbox"/>	207401	1148991	3.0%
<input checked="" type="checkbox"/>	207201	1055158	2.8%
<input checked="" type="checkbox"/>	110201	1043138	2.8%
<input checked="" type="checkbox"/>	210401	1010135	2.7%

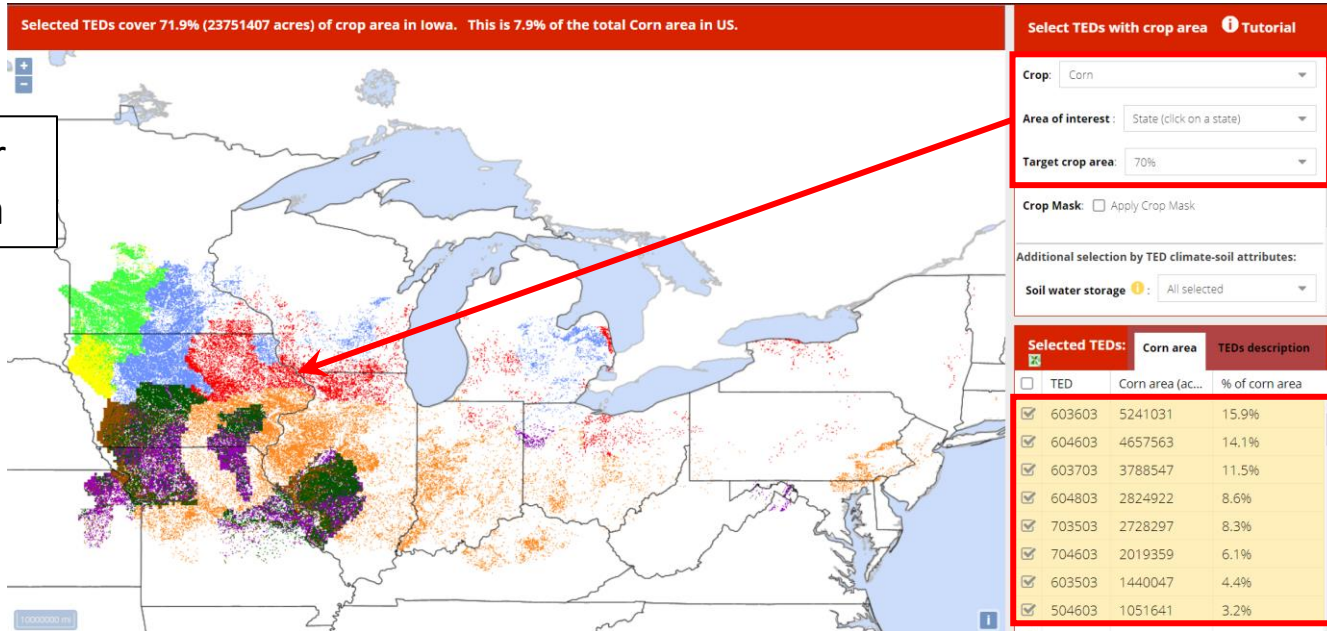
2.b. Area of interest: Select by State/Country



Example: user selected **70%** of corn in Iowa

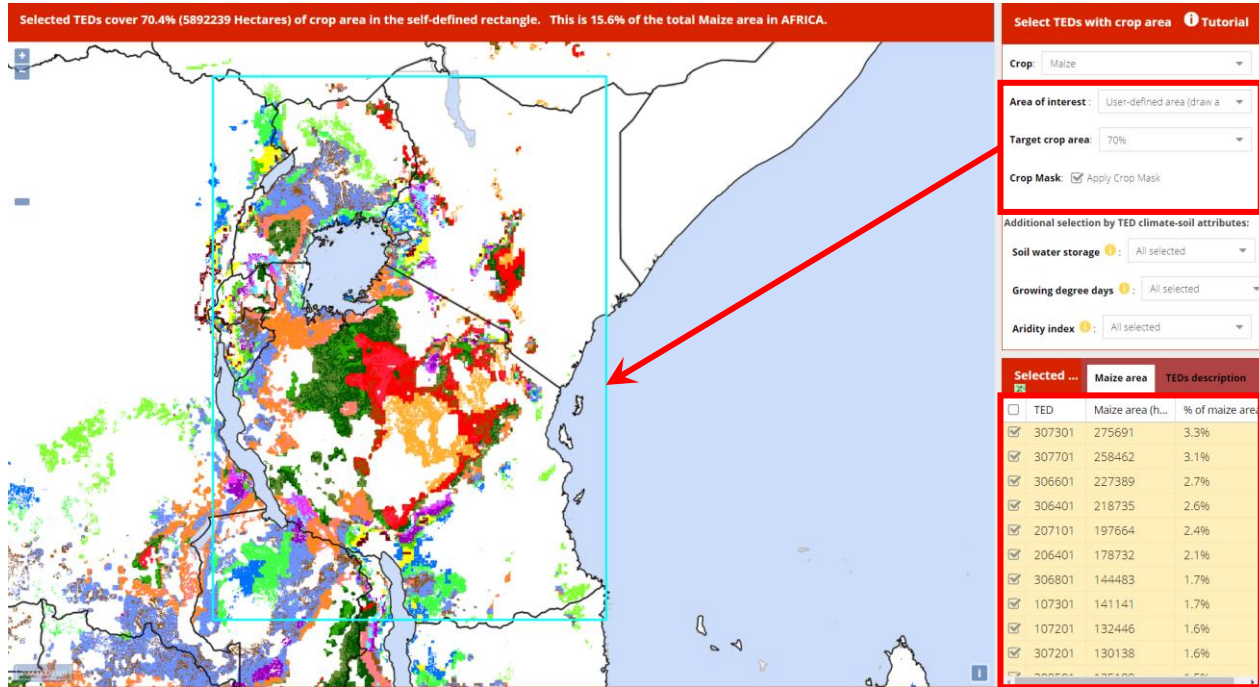
Each color corresponds to one TED. In the case of Iowa, production areas were categorized into **eight TEDs**. Zooming out, the TED tool will show other areas where the same eight TEDs are found (*see next slide*).

TEDs in Iowa extends to other states



Each color corresponds to TED. In case of Iowa, production area were categorized into **eight TEDs**

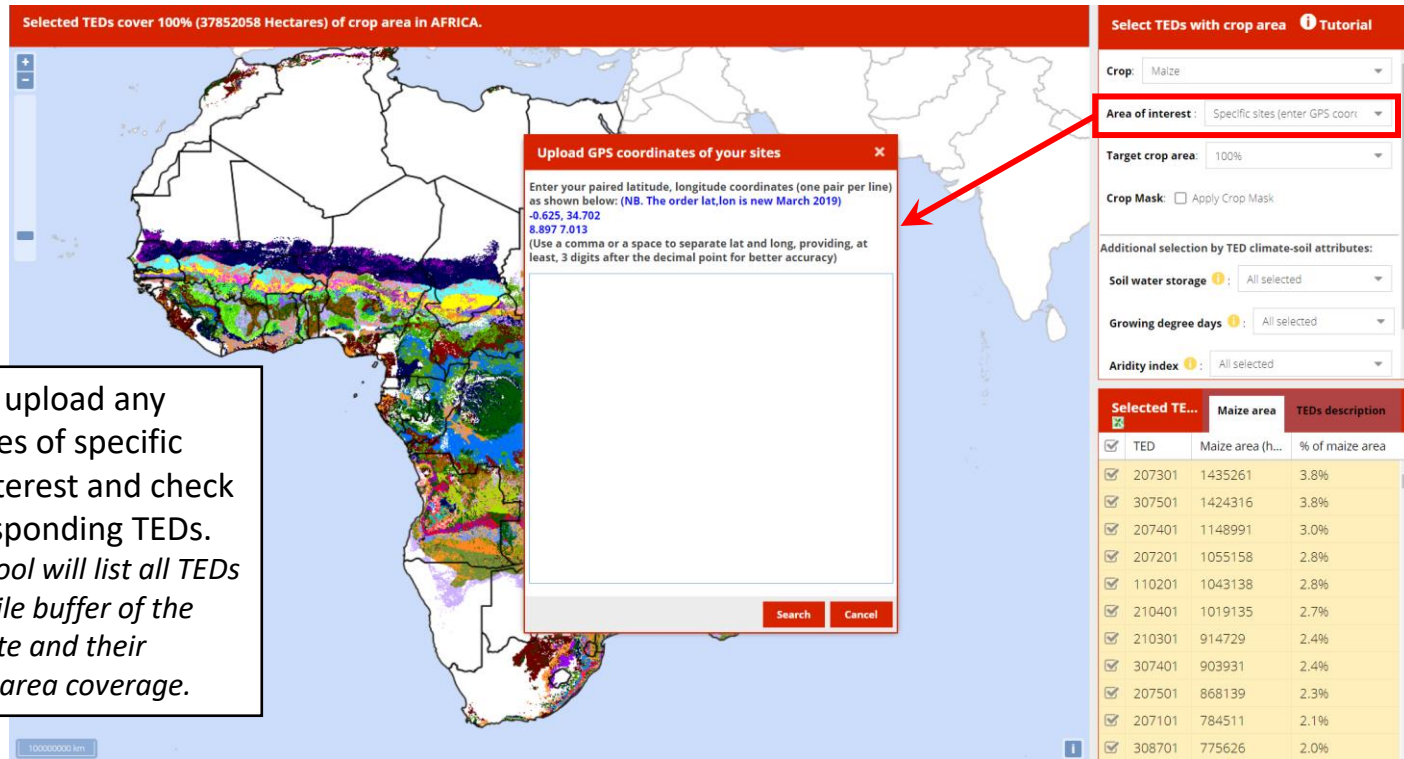
2.c. Area of Interest: User-defined rectangle



User defined a rectangle in East Africa and selected TEDs that cover 70 % of all maize in the self-defined rectangle. This selection represents twenty **TEDs**. Those TEDs extend beyond the limits of the rectangle.

2.d. Area of interest: Specific sites (GPS coordinates)

Selected TEDs cover 100% (37852058 Hectares) of crop area in AFRICA.

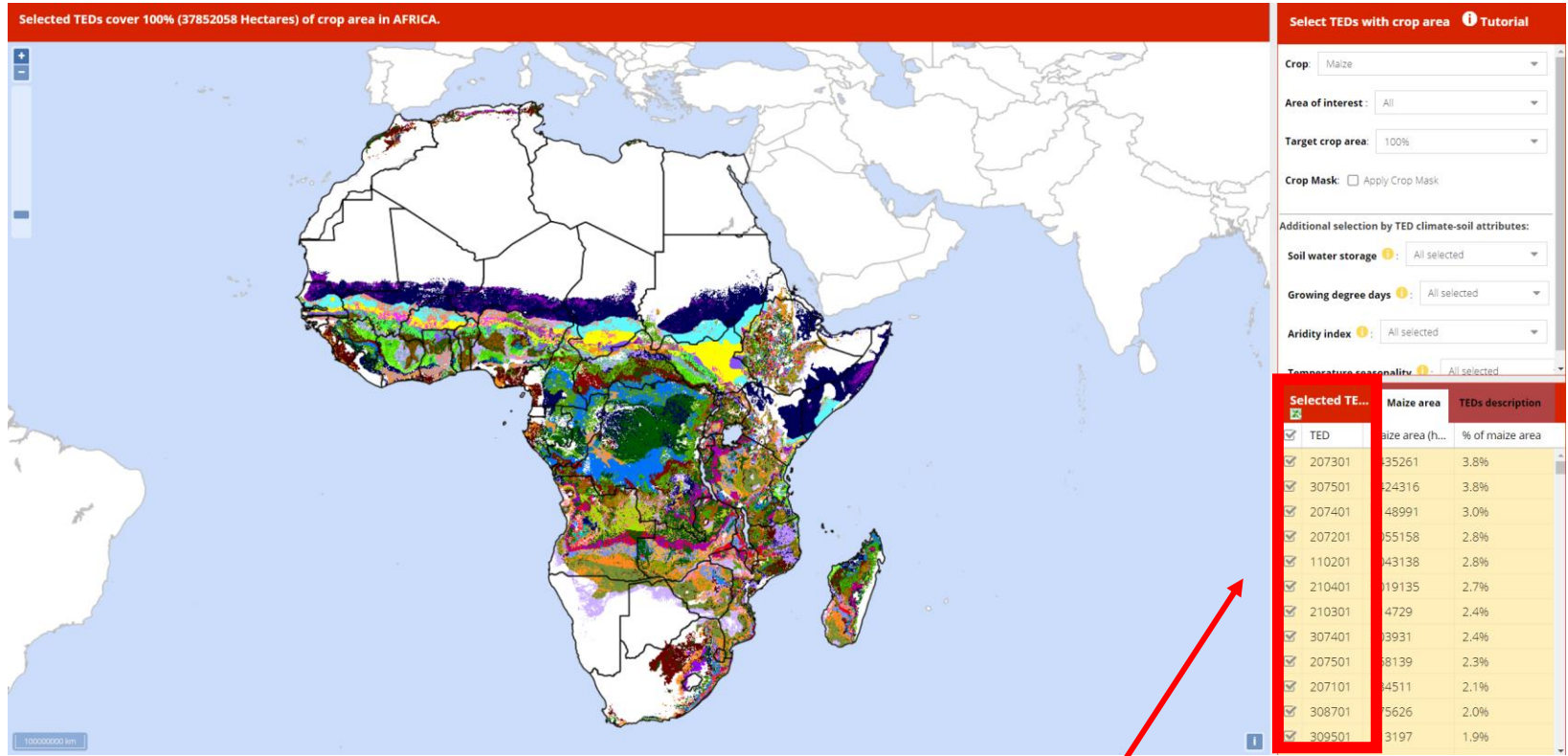


The screenshot displays the Global Yield Gap Atlas interface. At the top, a red banner states "Selected TEDs cover 100% (37852058 Hectares) of crop area in AFRICA." Below this is a map of Africa with a colored overlay representing TEDs. A dialog box titled "Upload GPS coordinates of your sites" is open, prompting the user to enter paired latitude and longitude coordinates. To the right, a sidebar titled "Select TEDs with crop area" contains several filters: "Crop" (Maize), "Area of interest" (Specific sites [enter GPS coord]), "Target crop area" (100%), "Crop Mask" (Apply Crop Mask), and "Additional selection by TED climate-soil attributes" (Soil water storage, Growing degree days, Aridity index, all set to "All selected"). At the bottom right, a table lists the selected TEDs with their IDs, Maize area in hectares, and the percentage of the total Maize area.

Selected TEDs	Maize area	TEDs description
<input checked="" type="checkbox"/>	Maize area (h...)	% of maize area
<input checked="" type="checkbox"/> TED		
<input checked="" type="checkbox"/> 207301	1435261	3.8%
<input checked="" type="checkbox"/> 307501	1424316	3.8%
<input checked="" type="checkbox"/> 207401	1148991	3.0%
<input checked="" type="checkbox"/> 207201	1055158	2.8%
<input checked="" type="checkbox"/> 110201	1043138	2.8%
<input checked="" type="checkbox"/> 210401	1019135	2.7%
<input checked="" type="checkbox"/> 210301	914729	2.4%
<input checked="" type="checkbox"/> 307401	903931	2.4%
<input checked="" type="checkbox"/> 207501	868139	2.3%
<input checked="" type="checkbox"/> 207101	784511	2.1%
<input checked="" type="checkbox"/> 308701	775626	2.0%

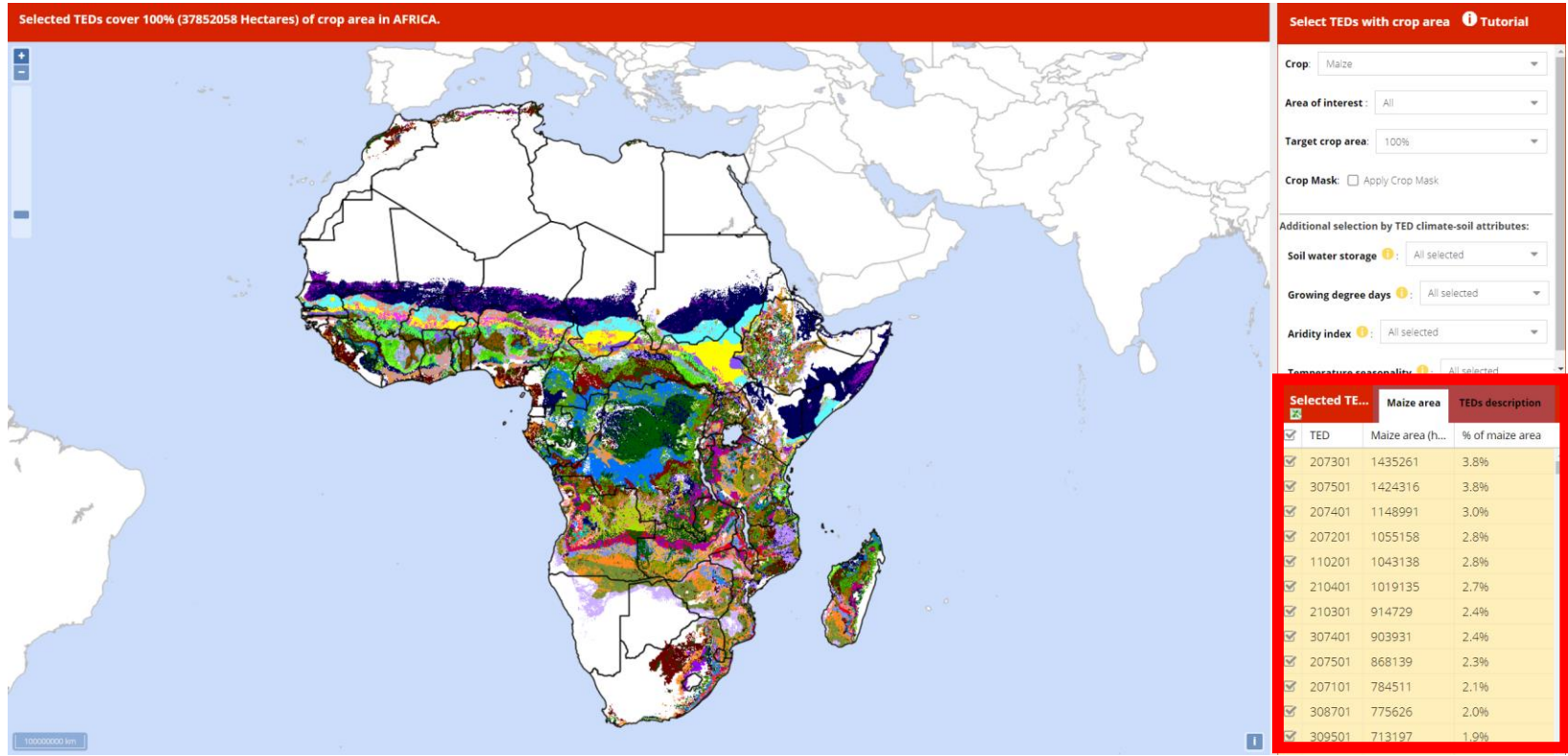
Users can upload any coordinates of specific area of interest and check the corresponding TEDs. *Note: the tool will list all TEDs within 1-mile buffer of the specified site and their associated area coverage.*

List of selected TEDs



Scroll down in the lower right panel to see the full list

Associated crop area for each TED



Crop area (% of total) represented by each TED for the selected crop is shown

Further TED selection

Selected TEDs cover 5% (15084109 acres) of crop area in US.

Click on one TED to display it individually or click on any checkmark to add or remove a TED from the selection

Select TEDs with crop area Tutorial

Crop: Corn

Area of interest: All

Target crop area: 50%

Crop Mask: Apply Crop Mask

Additional selection by TED climate-soil attributes:

Soil water storage: All selected

Growing degree days: All selected

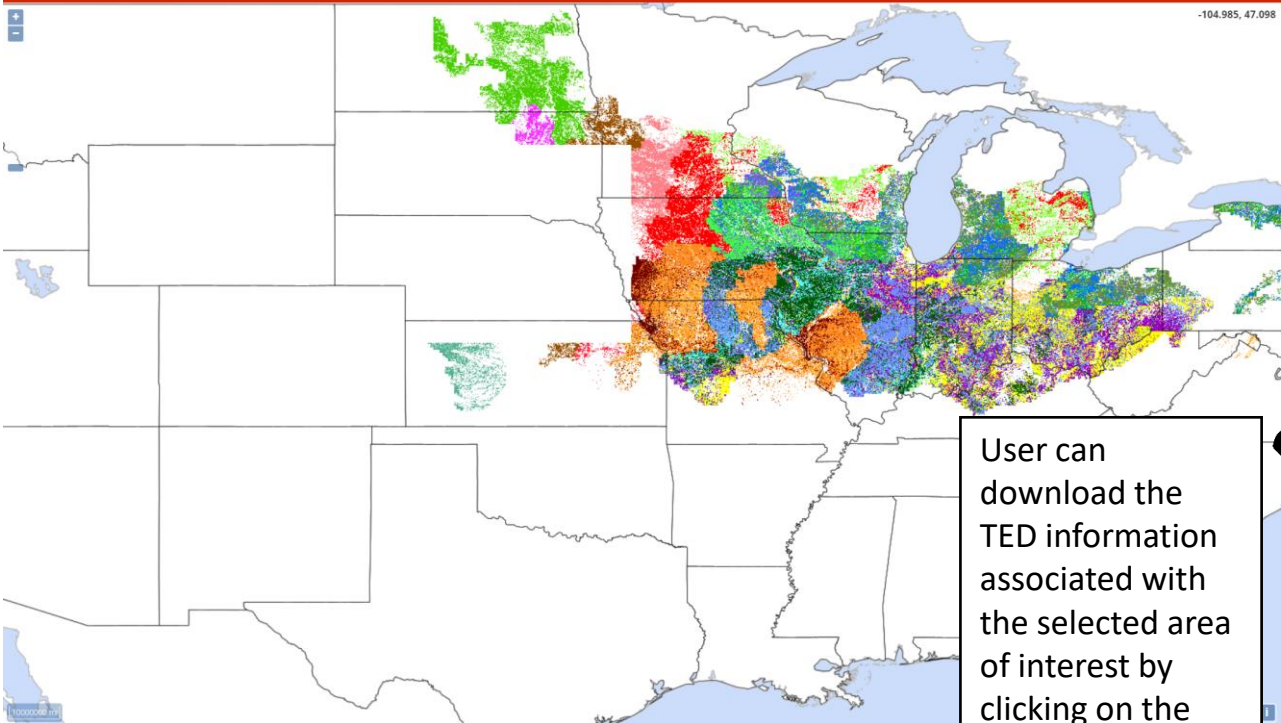
Aridity index: All selected

Temperature seasonality: All selected

Selected TEDs:	Corn area	TEDs description
<input type="checkbox"/> TED	Corn area (ac...)	% of corn area
<input checked="" type="checkbox"/> 504803	15084109	5.0%
<input type="checkbox"/> 603403	10462234	3.5%
<input type="checkbox"/> 603703	10178406	3.4%
<input type="checkbox"/> 603703	8213922	2.7%
<input type="checkbox"/> 603403	7792297	2.6%
<input type="checkbox"/> 603703	7742125	2.6%
<input type="checkbox"/> 404803	7546328	2.5%
<input type="checkbox"/> 603503	7217344	2.4%
<input type="checkbox"/> 303703	6908969	2.3%
<input type="checkbox"/> 403703	6118766	2.0%
<input type="checkbox"/> 602303	5998344	2.0%

Export selected TED information

Selected TEDs cover 50% (150747749 acres) of crop area in US.



Select TEDs with crop area [Tutorial](#)

Crop: Corn

Area of interest: All

Target crop area: 50%

Crop Mask: Apply Crop Mask

Additional selection by TED climate-soil attributes:

Soil water storage: All selected

Growing degree days: All selected

Aridity index: All selected

Temperature seasonality: All selected

Selected TEDs:	Corn area	TEDs description
TED	Corn area (ac...)	% of corn area
15084109	15084109	5.0%
14335531	14335531	4.8%
10462234	10462234	3.5%
303403	10178406	3.4%
<input checked="" type="checkbox"/> 304803	8213922	2.7%
<input checked="" type="checkbox"/> 603403	7792297	2.6%
<input checked="" type="checkbox"/> 603703	7742125	2.6%
<input checked="" type="checkbox"/> 404803	7546328	2.5%
<input checked="" type="checkbox"/> 603503	7217344	2.4%
<input checked="" type="checkbox"/> 303703	6908969	2.3%
<input checked="" type="checkbox"/> 403703	6118766	2.0%
<input checked="" type="checkbox"/> 602303	5998344	2.0%

User can download the TED information associated with the selected area of interest by clicking on the excel icon.

Downloaded file with TEDs and attributes

TED download in csv-format

Thank you for your interest in GYGA TEDs. In case the download doesn't start please click [here](#).

	A	B	C	D	E	F	G
1	ted	corn area in acres	percentage of corn area in US	soil water storage	growing degree days	aridity index	temperature seasonality
2	504803	5340078	6.188	200 - 250 mm	3792 - 4829 Å°C.day	10182 - 12876	High
3	604803	5143672	5.96	250 - 300 mm	3792 - 4829 Å°C.day	10182 - 12876	High
4	603603	4212234	4.881	250 - 300 mm	3170 - 3791 Å°C.day	7786 - 8685	High
5	604603	3672984	4.256	250 - 300 mm	3792 - 4829 Å°C.day	7786 - 8685	High
6	603703	3076609	3.565	250 - 300 mm	3170 - 3791 Å°C.day	8686 - 10181	High
7	603503	2897719	3.358	250 - 300 mm	3170 - 3791 Å°C.day	6589 - 7785	High
8	603403	2743656	3.179	250 - 300 mm	3170 - 3791 Å°C.day	5690 - 6588	High
9	304803	2555125	2.961	100 - 150 mm	3792 - 4829 Å°C.day	10182 - 12876	High
10	404803	2542469	2.946	150 - 200 mm	3792 - 4829 Å°C.day	10182 - 12876	High
11	303703	1838078	2.13	100 - 150 mm	3170 - 3791 Å°C.day	8686 - 10181	High
12	403703	1813672	2.101	150 - 200 mm	3170 - 3791 Å°C.day	8686 - 10181	High
13	604403	1771844	2.053	250 - 300 mm	3792 - 4829 Å°C.day	5690 - 6588	High
14	704803	1734547	2.01	> 300 mm	3792 - 4829 Å°C.day	10182 - 12876	High
15	603303	1717641	1.99	250 - 300 mm	3170 - 3791 Å°C.day	4792 - 5689	High
16	704603	1556922	1.804	> 300 mm	3792 - 4829 Å°C.day	7786 - 8685	High

Note: the csv-file has a UTF-8 encoding. If the file is opened in Excel, a Å symbol will appear before the GDD units.

To avoid that, you can follow the instructions [on this link](#)

Access to TEDs

- TEDs can be accessed via :
 - <https://www.toolted.org>
 - <https://www.yieldgap.org/web/guest/technology-extrapolation-domains>
- The TEDs can be requested for free in the case of non-profit organizations.
- In the case of for-profit organizations, there are two ways to have access to the TEDs:
 1. By purchasing a GYGA sponsorship or commercial license, which provides access to all the data included in the GYGA website: <https://www.yieldgap.org/licensing-and-sponsorship>
 2. By purchasing a license ONLY for accessing the TEDs *via* NUtech ventures:
 - TEDs for the entire United States: <https://marketplace.unl.edu/nutechmarketplace/nutech-teds.html>
 - TEDs for Sub-Saharan Africa: <https://marketplace.unl.edu/nutechmarketplace/nutech-teds-ssa.html>
- If you want to discuss extensions and/or applications of TEDs for other geographic areas or uses, feel free to contact us at: pgrassini2@unl.edu (Professor Patricio Grassini, University of Nebraska-Lincoln).

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