Food and Agriculture Organization of the United Nations

UNITED NATIONS
Office for Outer Space Affairs

Agricultural Drought Monitoring System in Ethiopia

The Next Generation ASIS

November 18, 2021

"Space-based Solutions for Disaster Management in Africa: Networks and Information Technologies in times of crisis."

FAO-Agriculture Stress Index System (ASIS)

Global Information and Early Warning System on Food and Agriculture (GIEWS)

http://www.fao.org/giews/earthobservation

ASIS

Agricultural
Stress **I**ndex
System

ASIS is an information system developed by **FAO** to support individual countries to monitor and manage agricultural drought and the risks it entails, with the use of satellite data updated every 10 days.

What is Country-level ASIS ?

https://www.youtube.com/watch?v=QIW6qowJlU8

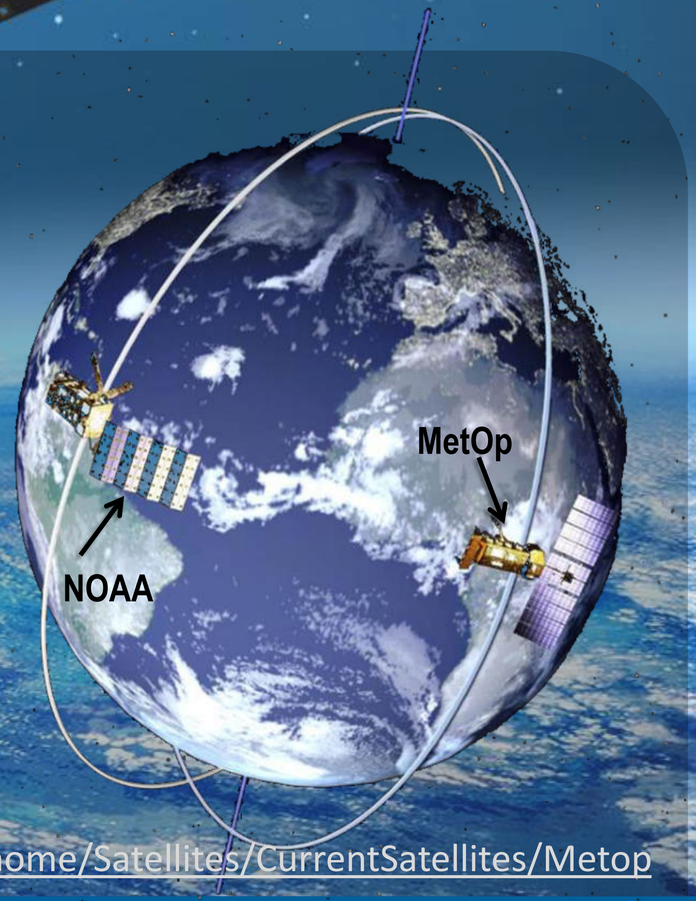
What is Country-level ASIS ?

- Same satellite data source than Global ASIS: MetOp/AVHRR (1 Km) since 1984
- Same methodological principles of Global ASIS, based on vegetation health
- Adapted and calibrated to the particular conditions of a country
- Installed and managed by goverment institutions
- Completely automated through the ASIS Web Application

What are the input data of Country-level ASIS?

- MetOp Program
  - Between EUMETSAT and ESA
  - 3 satellites: MetOp A, MetOp B y MetOp C
  - AVHRR sensor

- Satellite data MetOp-AVHRR and NOAA-AVHRR
  - MetOp: every 10 days, pixel 1 Km, since 2007
  - NOAA: weekly, pixel 16 Km, since 1984



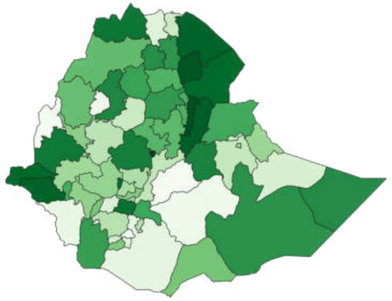
https://www.eumetsat.int/website/home/Satellites/CurrentSatellites/Metop

What are the input data of Country-level ASIS?

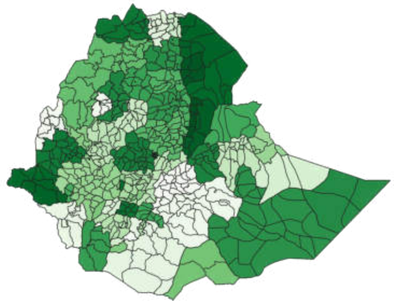
I. Administrative units

Level 0:
Regions

Level 1:
Zones



Level 2:
Woredas



II. Land cover/ Crop maps

Belg season

Meher season

1. wheat
2. maize
3. sorghum
4. barley
5. teff

III. Phenology data

Crop sowing dates
by geographical area and season

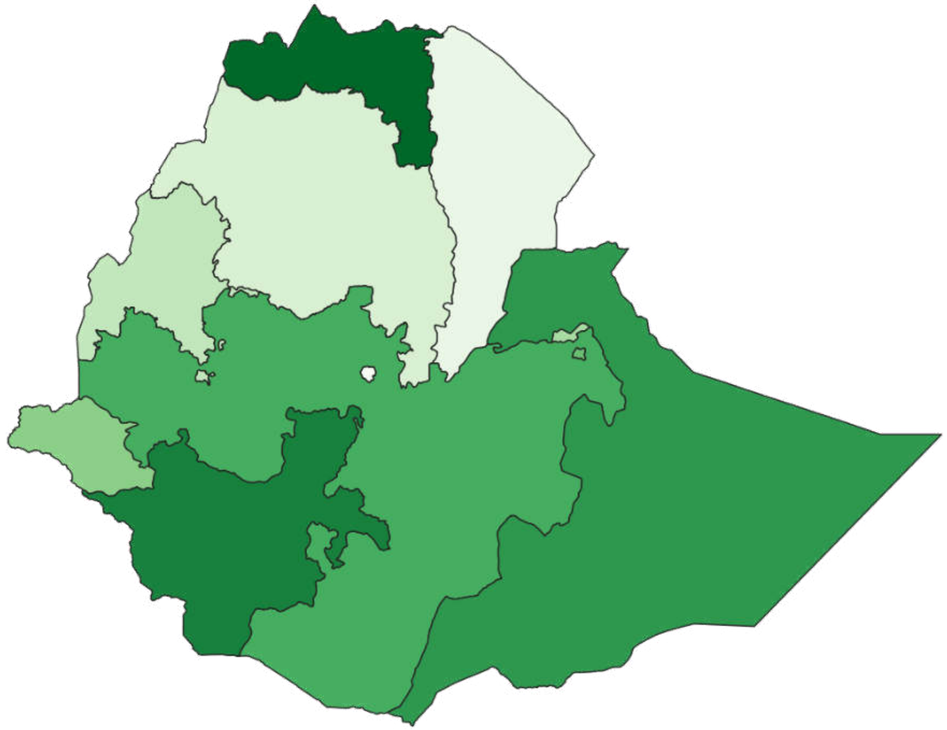
- ✓ dates expressed in dekads
(10 days period: 1 a 36 in a year)
  - Start of season - SOS
  - Maximum of season – MOS (max NDVI)
  - End of season – EOS (physiological maturity)

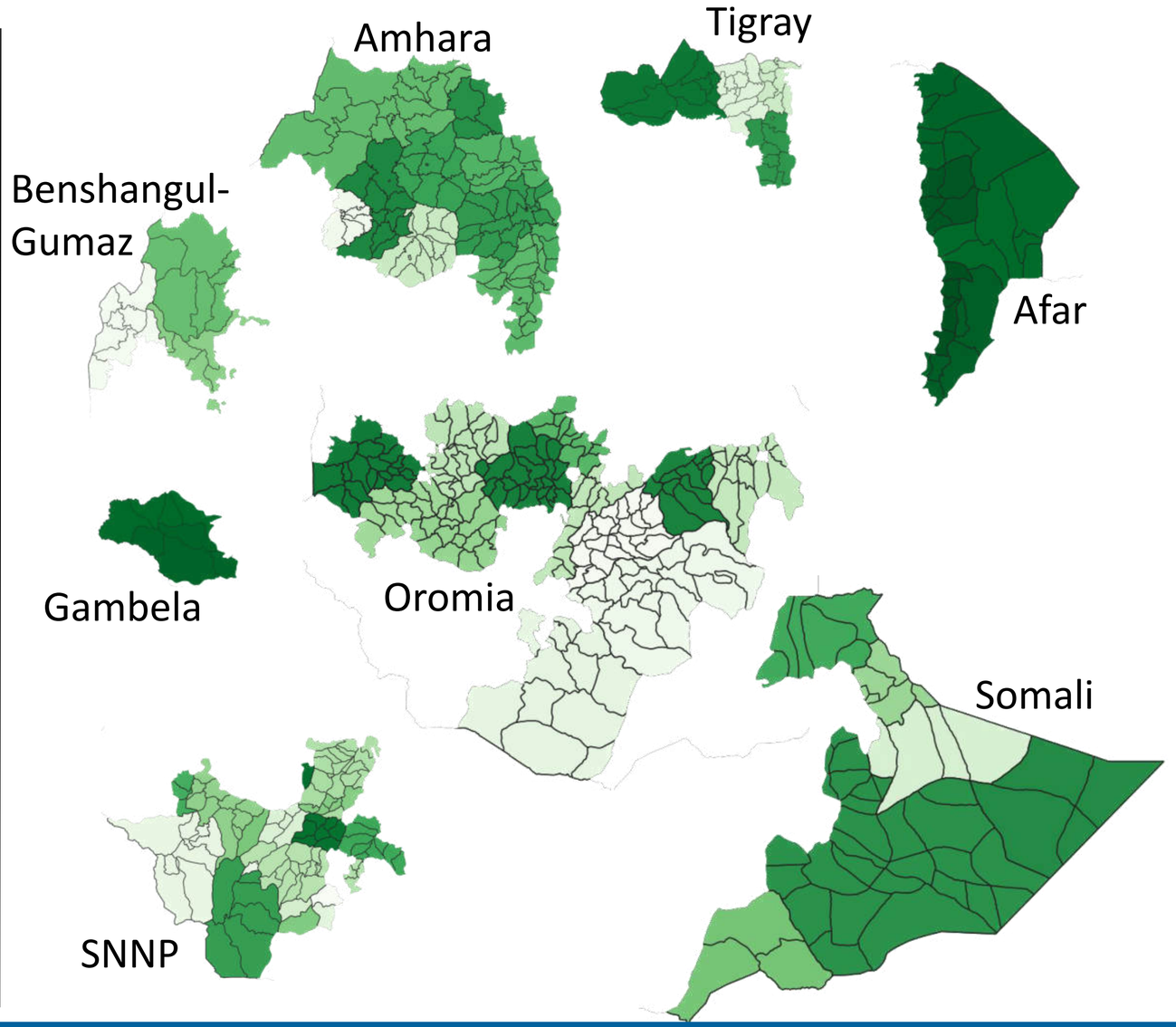
- ✓ Kc, crop coefficient

Geographical framework and levels

Subnational

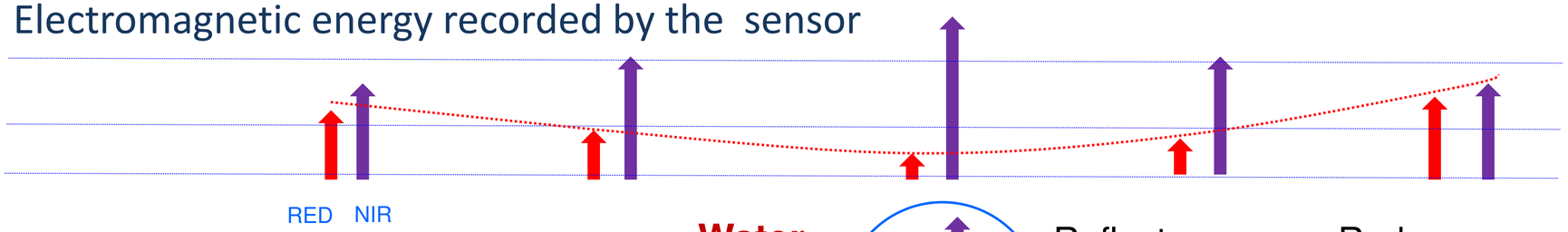
Regions



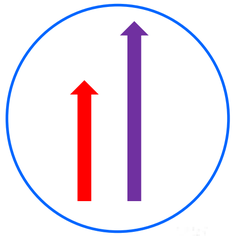


How does the plant react to water stress?

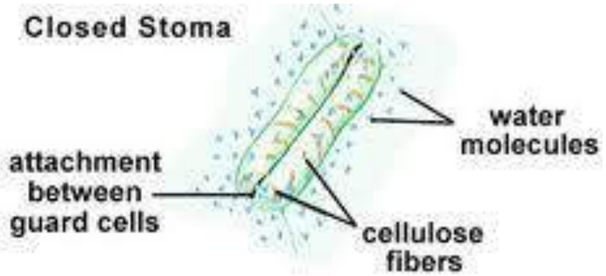
Electromagnetic energy recorded by the sensor

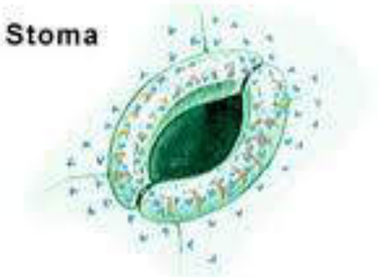


Water Stress



Reflectance + en Red
Reflectance – en Infrared





ASIS is based on vegetation health

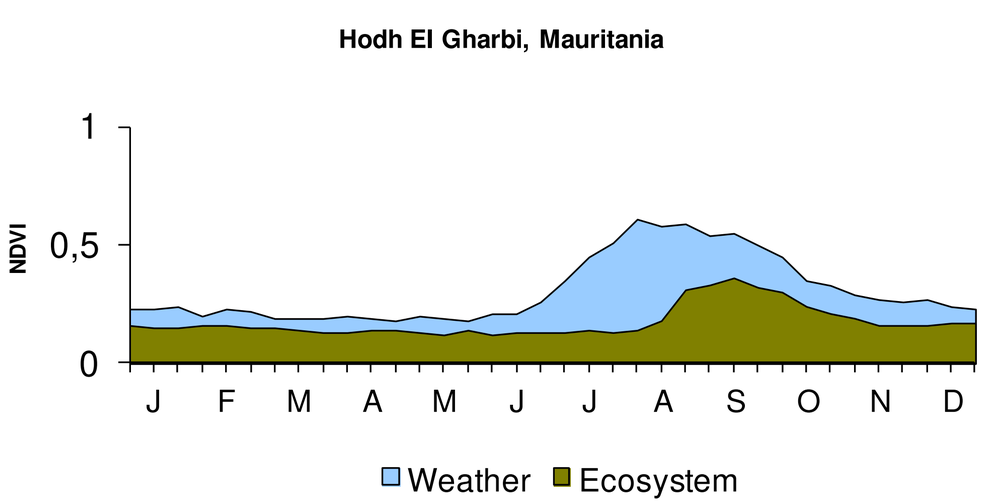
Healthy vegetation

VEGETATION REFLECTANCE
50% NIR 8% RED

VEGETATION REFLECTANCE
40% NIR 30% RED

Stressed vegetation

Methodological basis of ASIS
Vegetation health measured by Earth observation



Source: Kogan, F. 1995. Droughts of the late 1980s in the United States as derived from NOAA polar-orbiting satellite data. Bulletin of the American Meteorological Society vol.76, No. 5 655-668 pp.

Vegetation Condition Index

$$VCI_i = \frac{NDVI_i - NDVI_{\min}}{NDVI_{max} - NDVI_{min}}$$

Temperature Condition Index

$$TCI_i = \frac{BT_{max} - BT_{\mathrm{i}}}{BT_{max} - BT_{min}}$$

Vegetation Health Index

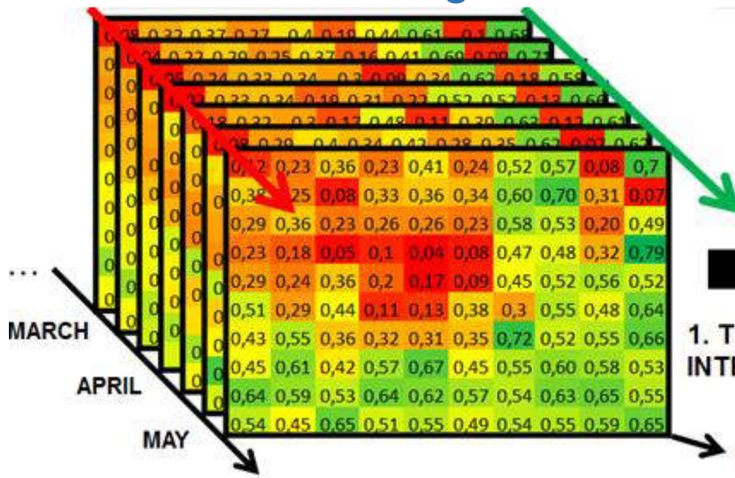
VHI = a*VCI + (1-a)* TCI

- The variation between the minimum and the maximum is due to the weather factor.
- A long series of at least 30 years is needed to study the climatic variability of precipitation.
- The increase in temperature and the progressive decrease in rainfall produces an effect on the health of the vegetation

How does ASIS work?
Temporal Integration

Temporal Integration (dekad and anual summary)

Dekadal VHI images

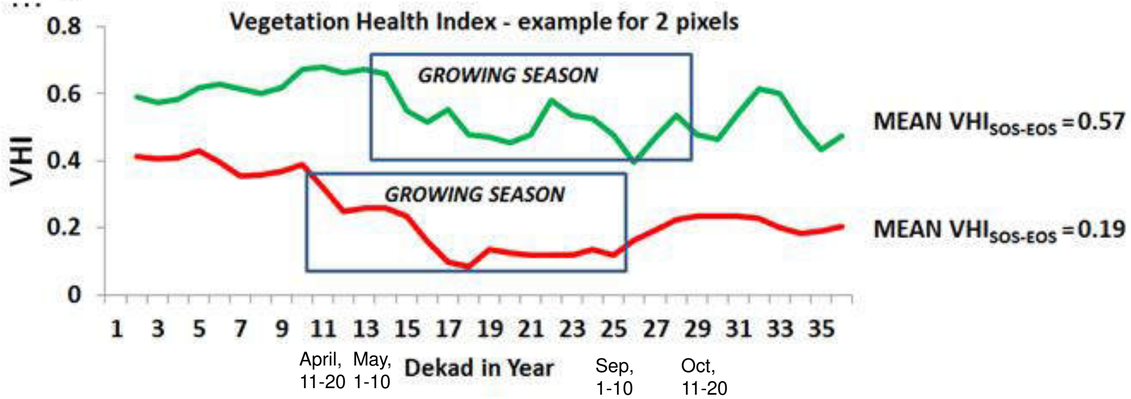


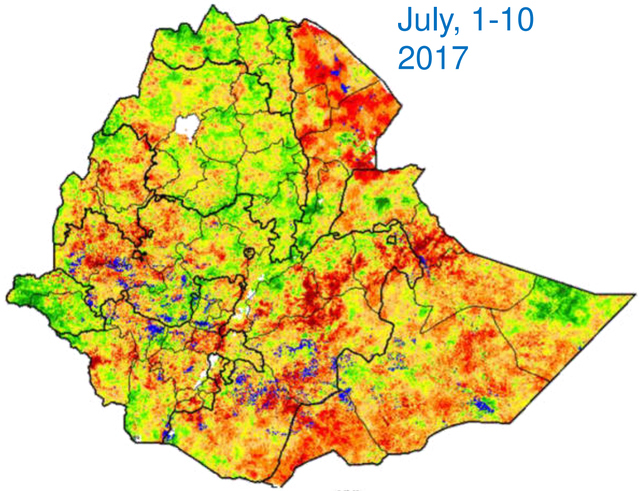
Mean VHI over the crop season (μVHI)

0,19	0,24	0,33	0,18	0,34	0,1	0,34	0,54	0,05	0,57
0,29	0,23	0,01	0,27	0,34	0,32	0,57	0,6	0,25	0,05
0,24	0,3	0,21	0,21	0,22	0,17	0,52	0,43	0,16	0,45
0,31	0,16	0,03	0,07	0,03	0,06	0,37	0,46	0,25	0,76
0,26	0,19	0,34	0,16	0,09	0,03	0,44	0,50	0,50	0,42
0,39	0,27	0,34	0,07	0,07	0,35	0,26	0,50	0,45	0,60
0,38	0,48	0,30	0,26	0,21	0,28	0,69	0,44	0,51	0,58
0,40	0,60	0,41	0,48	0,57	0,43	0,54	0,59	0,50	0,46
0,50	0,52	0,51	0,57	0,52	0,51	0,45	0,54	0,58	0,54
0,43	0,44	0,56	0,46	0,52	0,46	0,46	0,48	0,56	0,55

1. TEMPORAL INTEGRATION

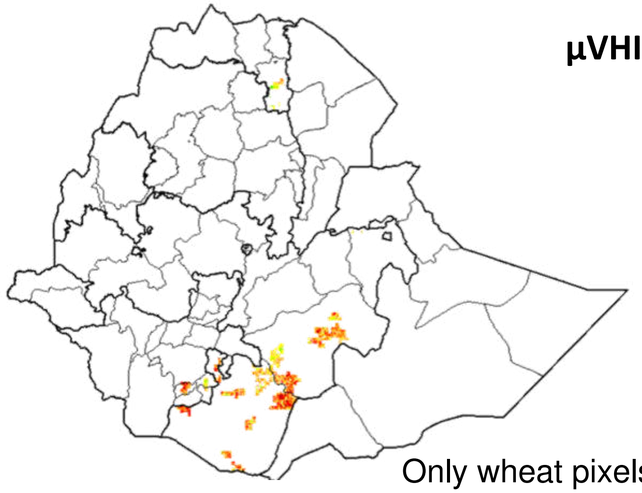
Fictive GAUL REGION (10 x 10 pixels)





July, 1-10 2017

VHI
- < 0.15 vegetación estresada
- 0.15 - 0.25
- 0.25 - 0.35
- 0.35 - 0.45
- 0.45 - 0.55
- 0.55 - 0.65
- 0.65 - 0.75
- 0.75 - 0.85
- >= 0.85 vegetación sana



μVHI during the crop season
- < 0.15
- 0.15 - 0.25
- 0.25 - 0.35
- 0.35 - 0.45
- 0.45 - 0.55
- 0.55 - 0.65
- 0.65 - 0.75
- 0.75 - 0.85
- >= 0.85

Only wheat pixels

How does ASIS work? Spatial Integration

Mean VHI over the crop season

0,07	0,24	0,33	0,18	0,34	0,10	0,34	0,54	0,06	0,66
0,29	0,23	0,01	0,27	0,34	0,32	0,57	0,6	0,25	0,05
0,24	0,30	0,21	0,21	0,22	0,17	0,52	0,43	0,16	0,45
0,31	0,16	0,03	0,07	0,03	0,06	0,37	0,46	0,25	0,76
0,26	0,19	0,34	0,16	0,09	0,03	0,44	0,50	0,50	0,42
0,39	0,27	0,34	0,07	0,07	0,35	0,26	0,50	0,45	0,60
0,38	0,48	0,30	0,26	0,21	0,28	0,69	0,44	0,51	0,58
0,40	0,60	0,41	0,48	0,57	0,43	0,54	0,59	0,50	0,46
0,50	0,52	0,51	0,57	0,52	0,51	0,45	0,54	0,58	0,54
0,43	0,44	0,56	0,46	0,52	0,46	0,46	0,48	0,56	0,55

(1)

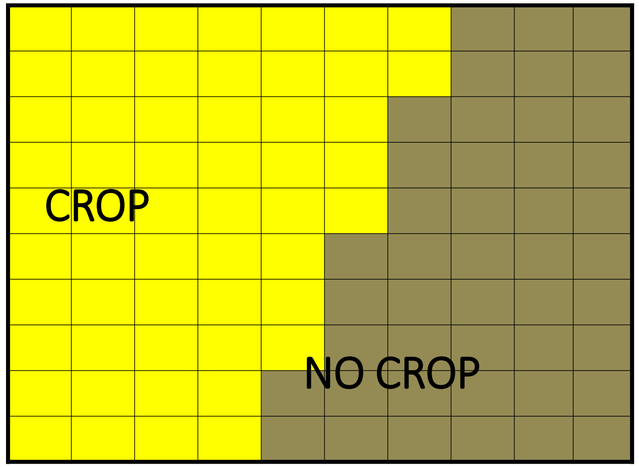
THRESHOLD

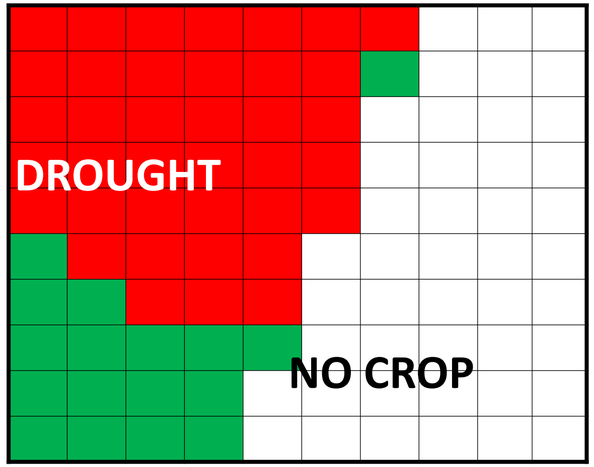
Pixels with µVHI < 0.35

0,07	**0,24**	**0,33**	**0,18**	**0,34**	**0,10**	**0,34**	0,54	**0,06**	0,66
0,29	**0,23**	**0,01**	**0,27**	**0,34**	**0,32**	0,57	0,60	**0,25**	**0,05**
0,24	**0,3**	**0,21**	**0,21**	**0,22**	**0,17**	0,52	0,43	**0,16**	0,45
0,31	**0,16**	**0,03**	**0,07**	**0,03**	**0,06**	0,37	0,46	**0,25**	0,76
0,26	**0,19**	**0,34**	**0,16**	**0,29**	**0,03**	0,44	0,50	0,50	0,42
0,39	**0,27**	**0,34**	**0,07**	**0,07**	**0,34**	**0,26**	0,50	0,45	0,60
0,38	0,48	**0,3**	**0,26**	**0,21**	**0,28**	0,69	0,44	0,51	0,58
0,40	0,60	0,41	0,48	0,57	0,43	0,54	0,59	0,50	0,46
0,50	0,52	0,51	0,57	0,52	0,51	0,45	0,54	0,58	0,54
0,43	0,44	0,56	0,46	0,52	0,46	0,46	0,48	0,56	0,55

DROUGHT

(2) ONLY CROP AREA



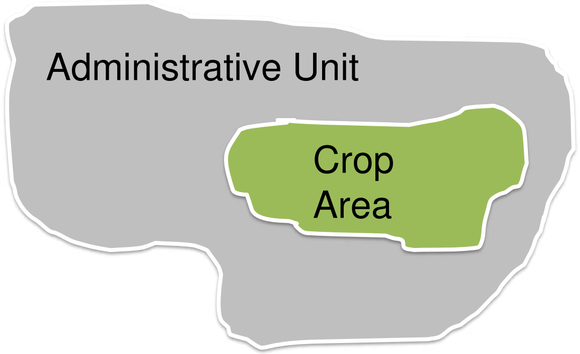


(3) PIXEL COUNTING

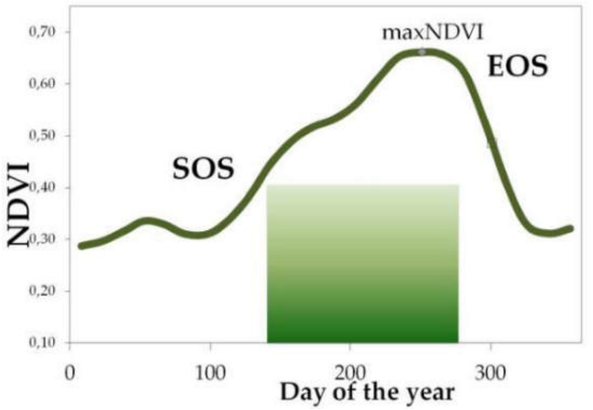
Agricultural Stress Index
ASI = 70%

$$\frac{\#\text{drought pixels (38)}}{\#\text{total crop pixels (55)}} = \pm 70\% \text{ of crop area affected by drought}$$

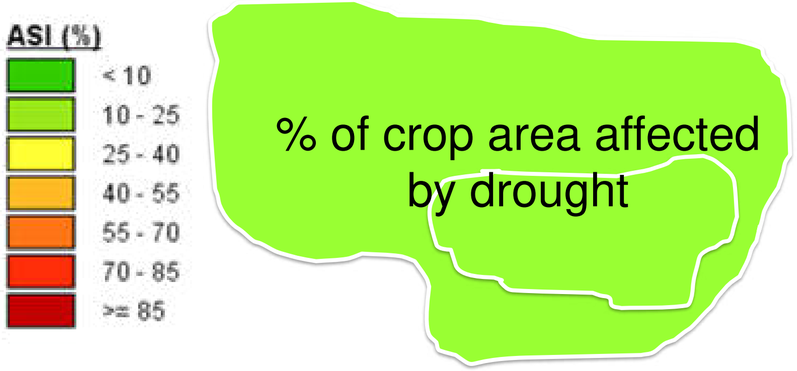
ASIS assesses the severity of the drought

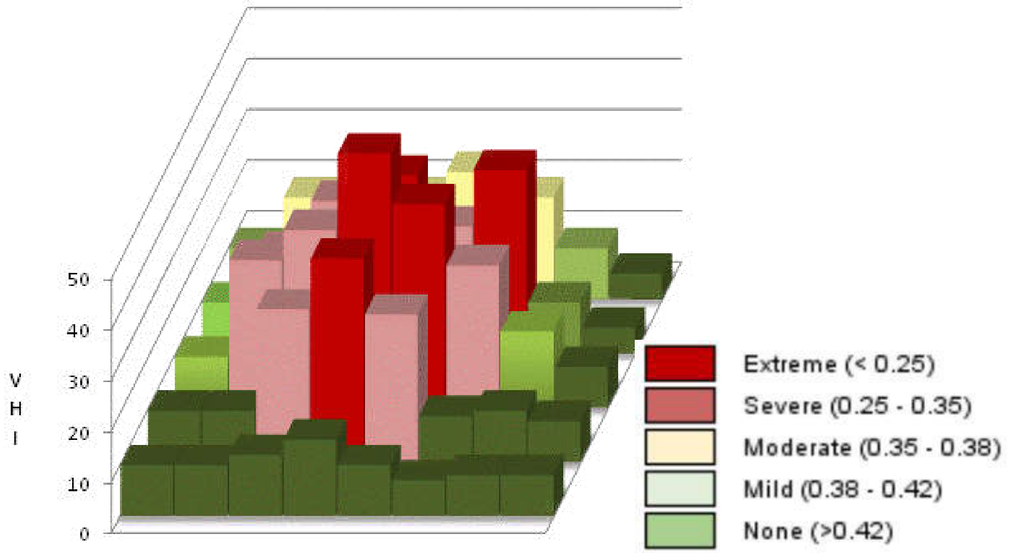


Intensity
Duration
Geographic extent



Porcentaje de la área agrícola afectada por sequía (VHI<35)





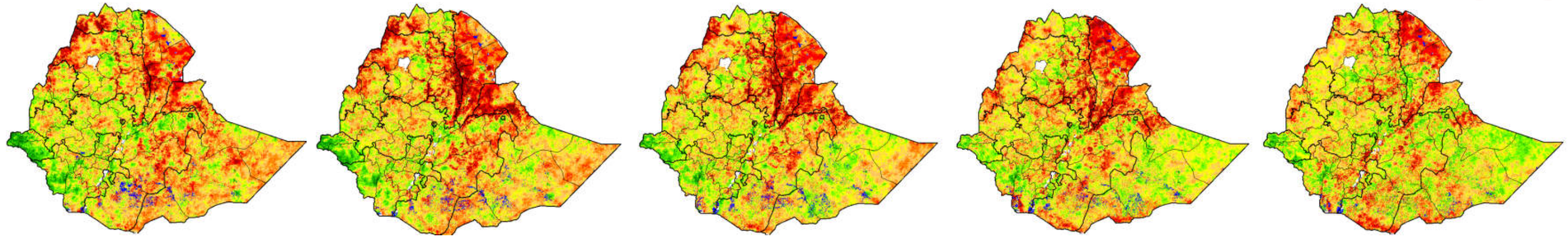
How does ASIS work?
Monitoring and early warning every 10 days

Country: Ethiopia

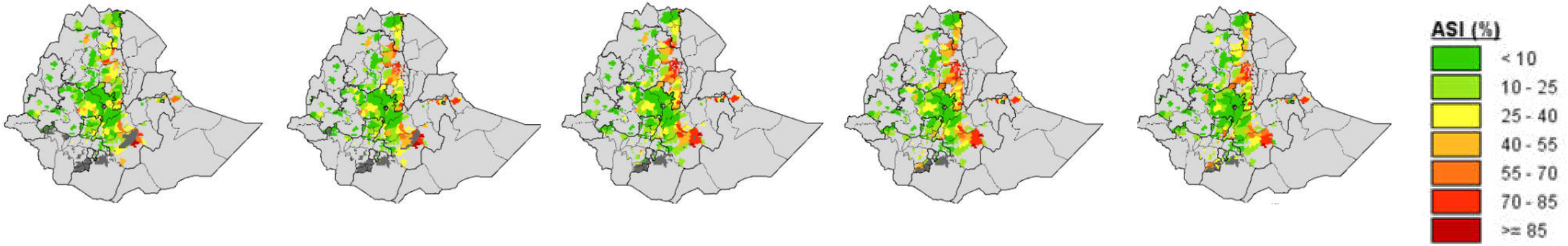
How is the development of the crop going?

VHI – Vegetation Health Index

2015



July, 11-10 | Jul, 21-31 | Aug, 1-10 | Aug, 11-20 | Aug, 21-30



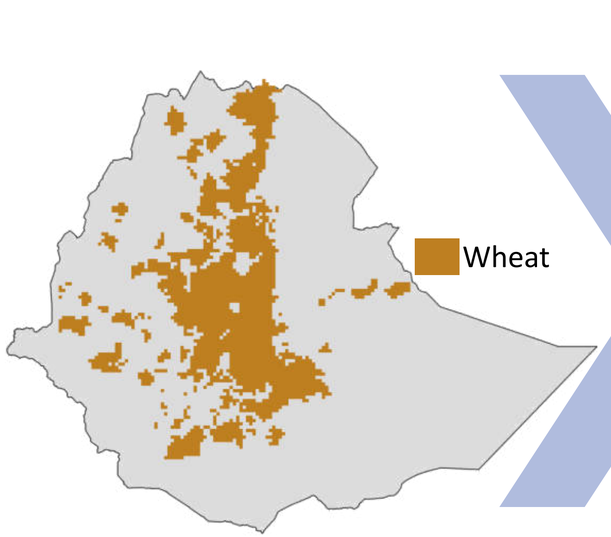
ASI - Agricultural Stress Index, percentage of wheat area affected by drought by administrative unit

ASI integrates VHI over time from the start of season to the dekad of analysis, concentrating on the areas where the crops are located

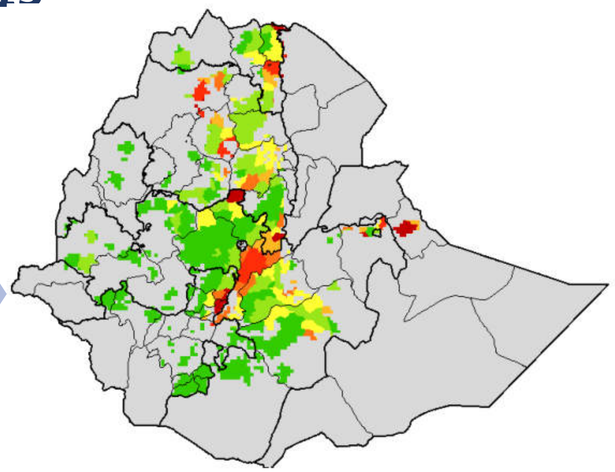
What does ASIS offer?
Agricultural Drought Monitoring and Early Warning System

Country:
Ethiopia

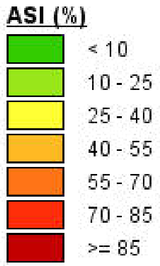
Example
Season 2
2015

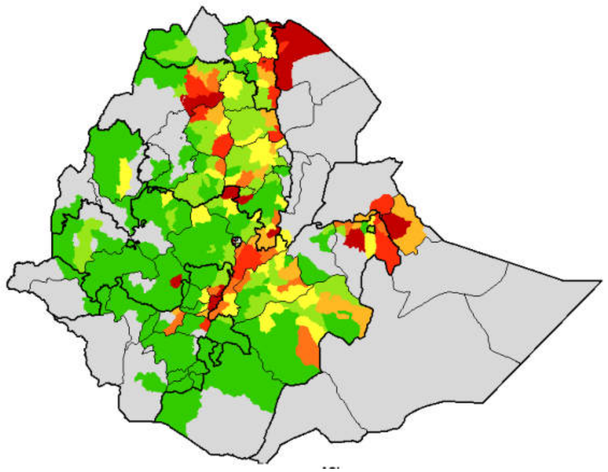


Wheat land cover
Second season (Meher)

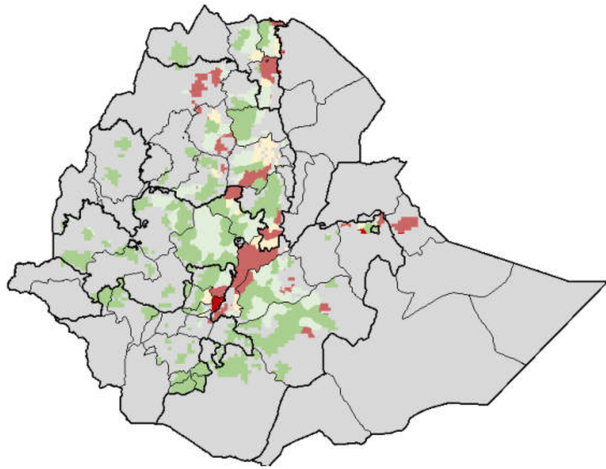


Percentage of wheat area affected by drought (pixel)





Percentage of wheat area affected by drought
(administrative unit- zone)



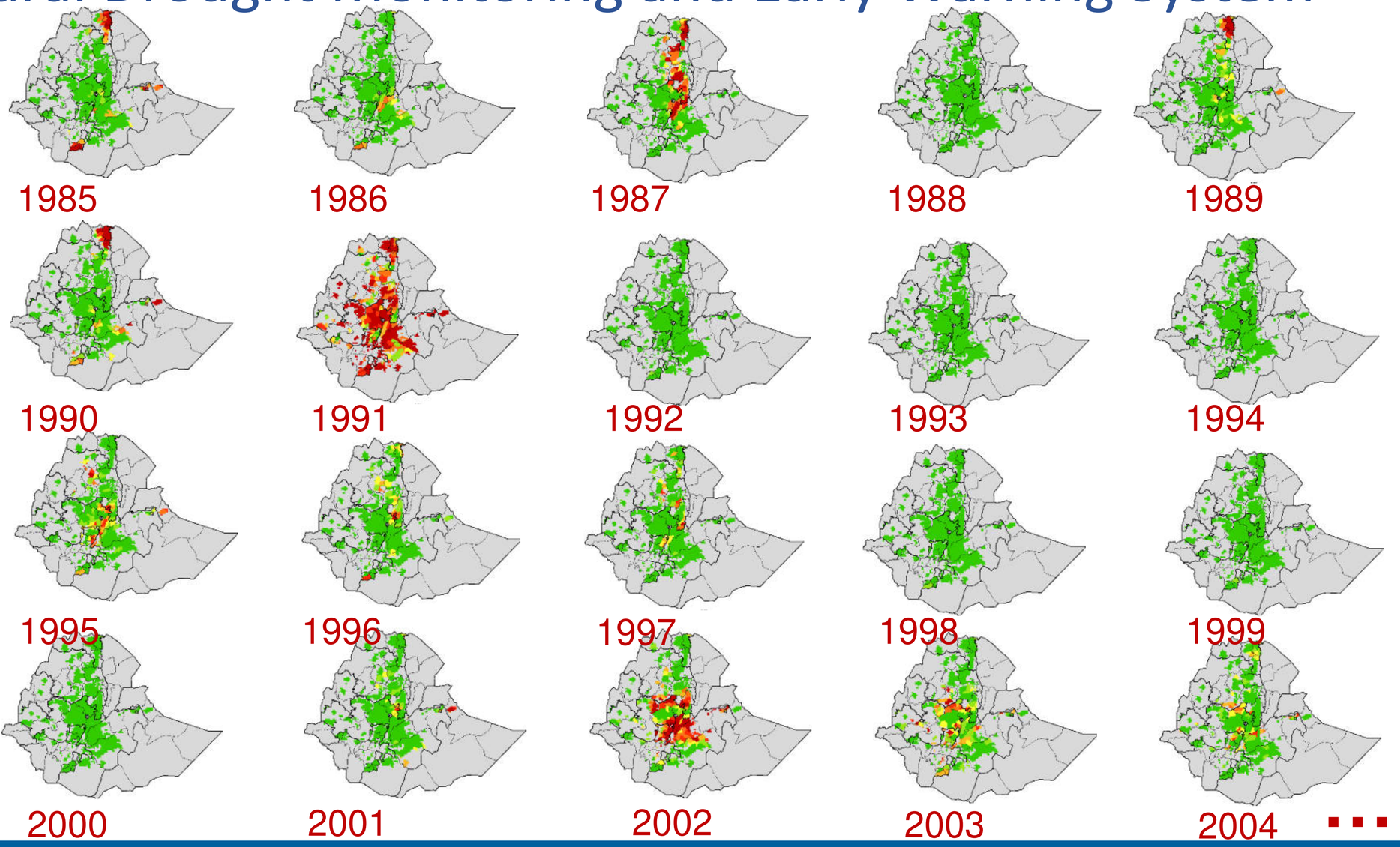
Drought categories

By crop type and season

What does ASIS offer?
Agricultural Drought Monitoring and Early Warning System

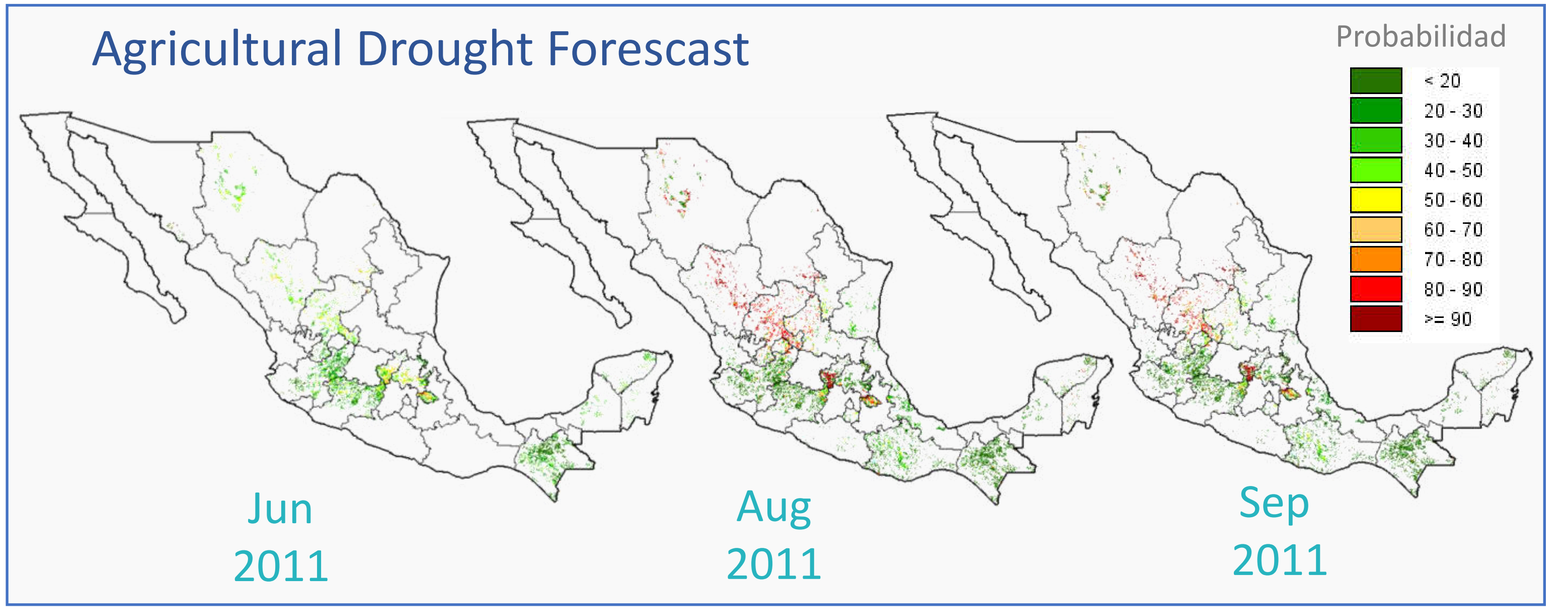
Country:
Ethiopia

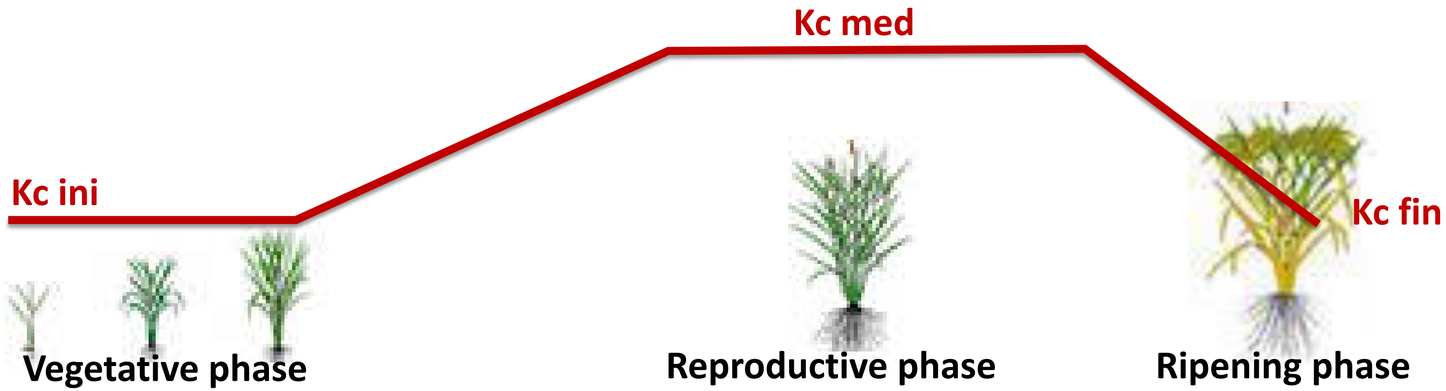
Database of annual average agricultural drought hot spots starting in 1985



What does ASIS offer?
Agricultural Drought Forecast

Meroni, M. et al. 2014.



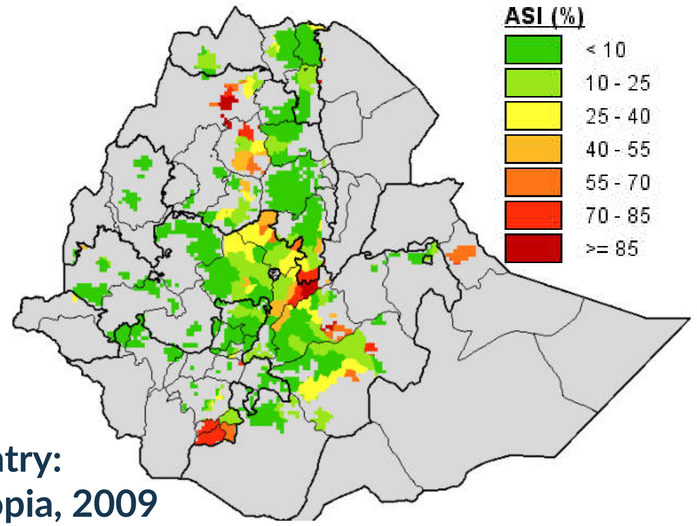


VHI

No drought pixel

Probability of ocurrence

Drought pixel



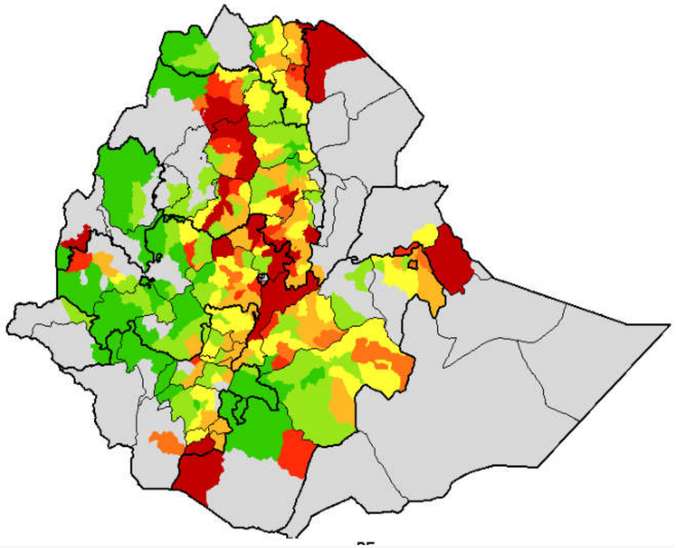
Country: Ethiopia, 2009
Meher wheat crop

What does ASIS offer?

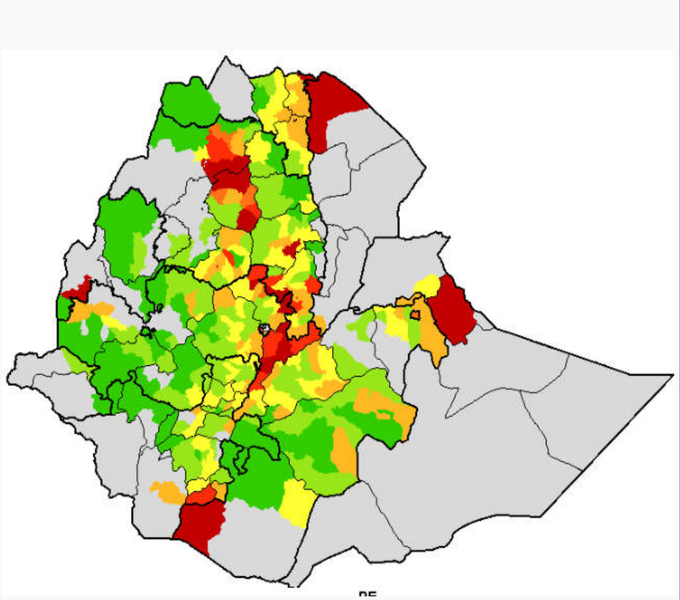
Historical agricultural drought probability based on 30+ years

Country :
Ethiopia

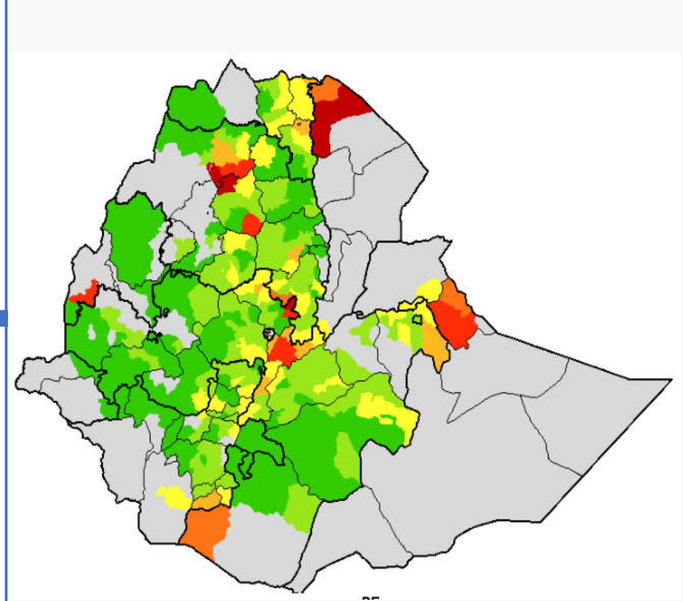
Meher crop season (wheat)



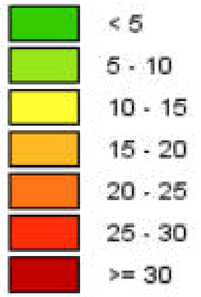
>20%
Maize area affected by drought



>30%
Maize area affected by drought



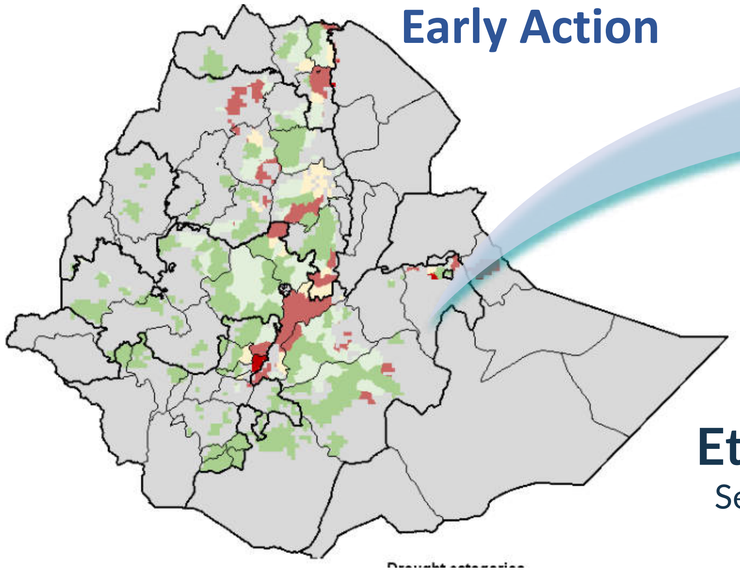
>50%
Maize area affected by drought



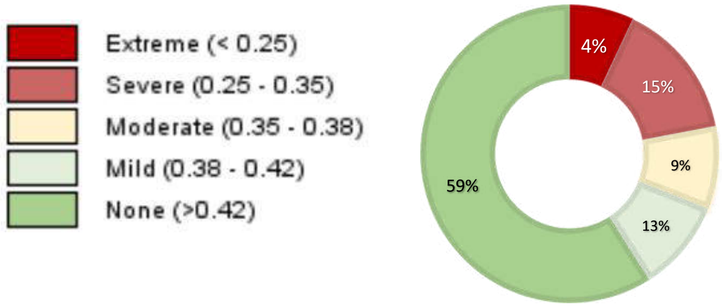
Knowing the administrative units with highest probability of drought (1984-2020) allows to guide the **public investments** and prepare **financial proposals** for the development of district/municipalities.

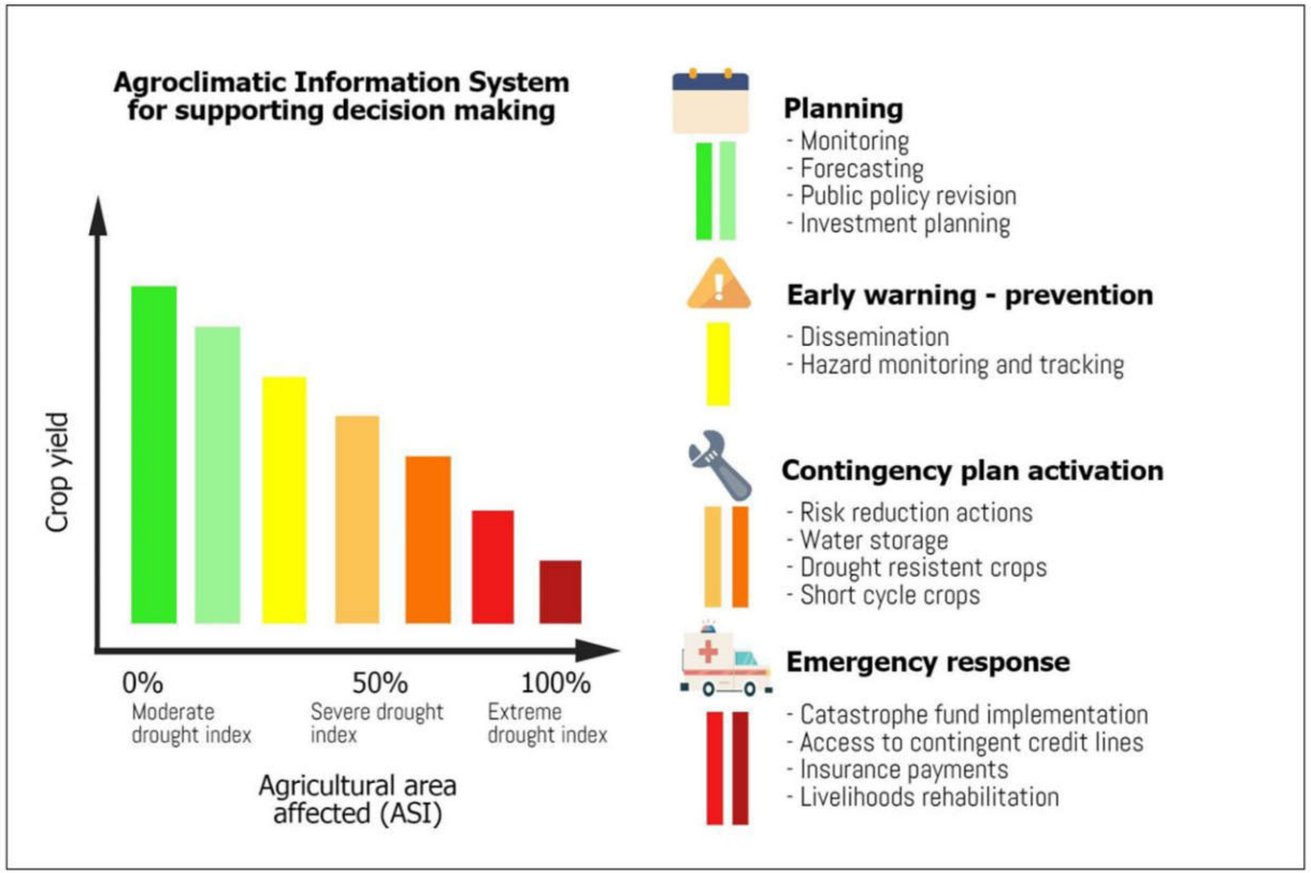
What does ASIS offer?
Integration of ASIS with National Plan of Drought

Integration of ASIS with National Plan of Drought Mitigation and Early Action



Ethiopia, 2015
Second crop season
Wheat

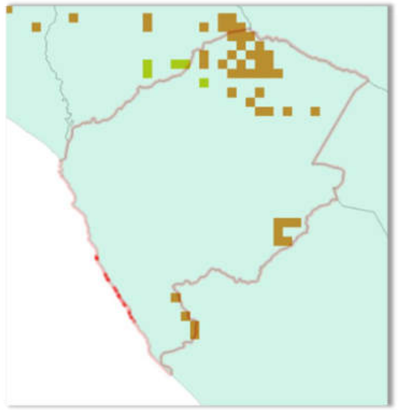


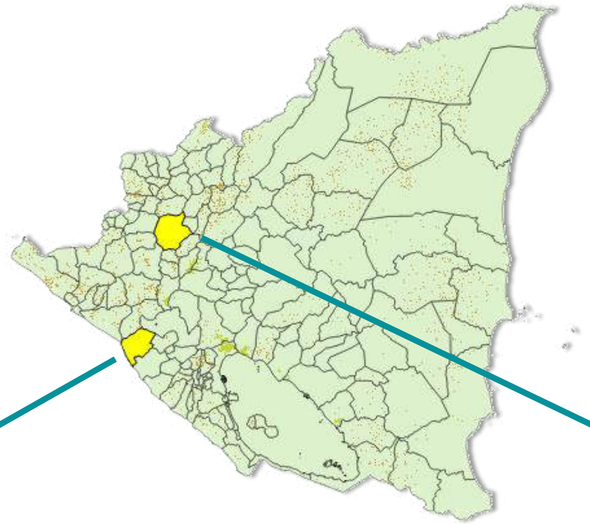


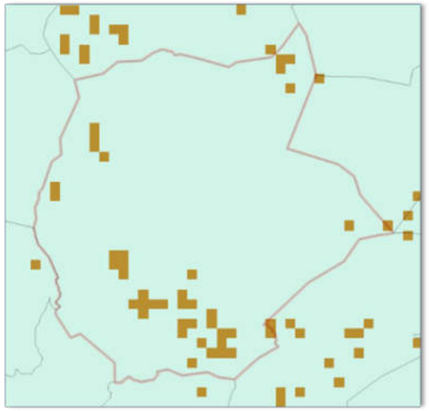
PRACTICAL GUIDELINES FOR EARLY WARNING – EARLY ACTION PLANS ON AGRICULTURAL DROUGHT

What does ASIS offer?

Trigger for an indexed crop insurance based on geospatial data (1984-2020)

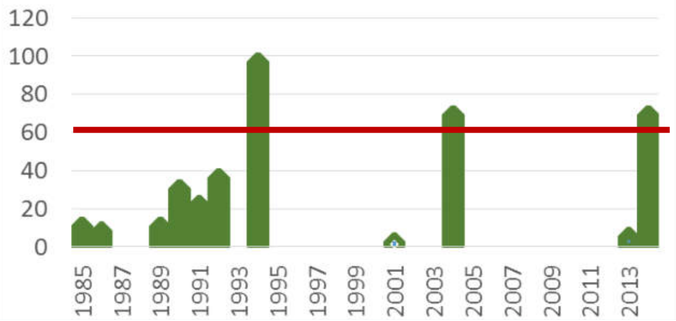




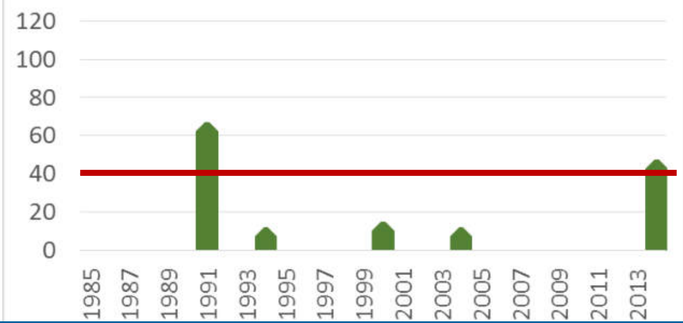


Fuente: INETER, 2017

Nagarote, León, Nicaragua

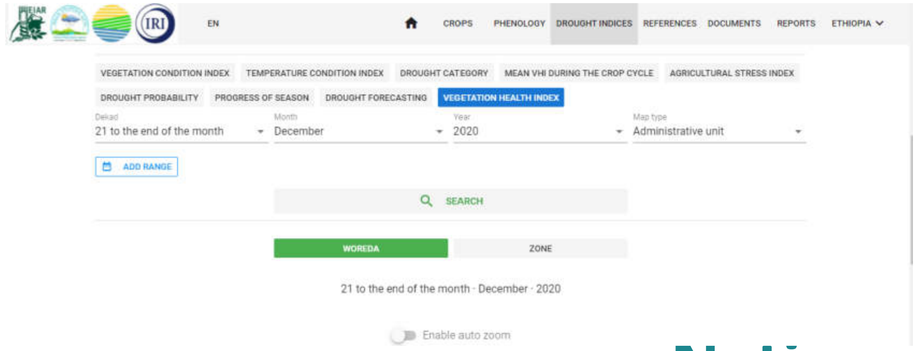


Estelí, Estelí, Nicaragua



What does ASIS offer?

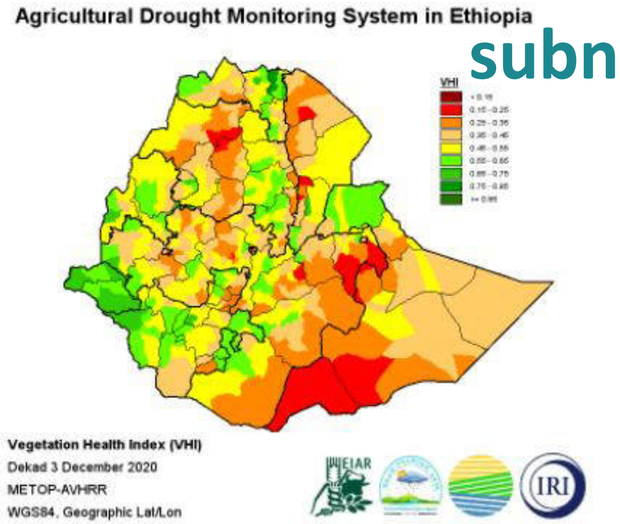
Online data viewing and querying through a web application

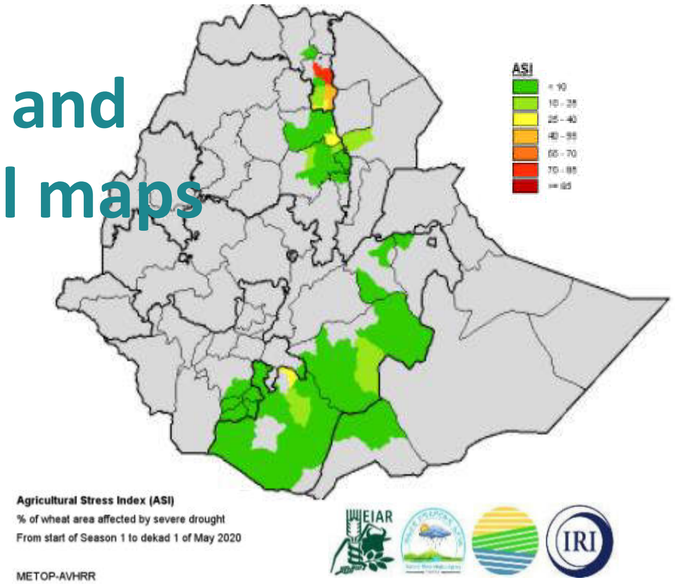


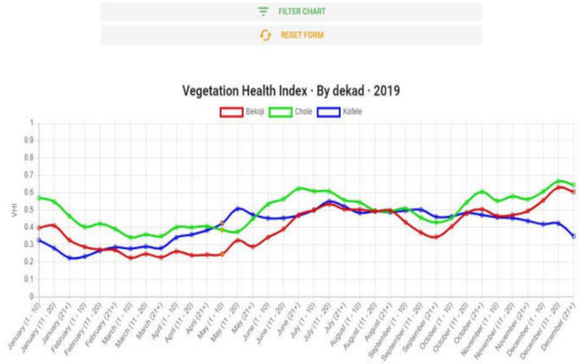
Country:
Ethiopia

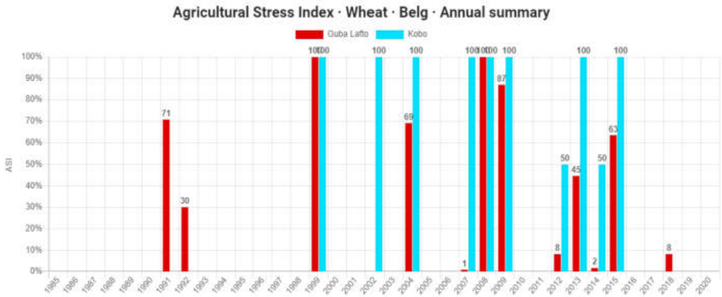
Statistics, graphs, tables

National and subnational maps





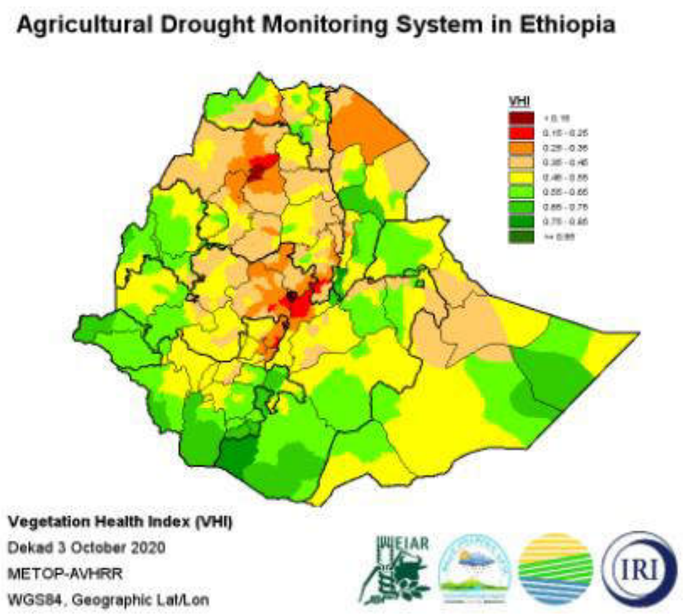




What does ASIS offer?

Integration with other information sources

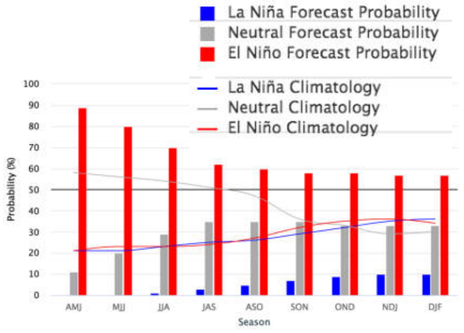
MONITORING OF CONDITIONS EVERY 10 DAYS AT 1 KM OF SPATIAL RESOLUTION

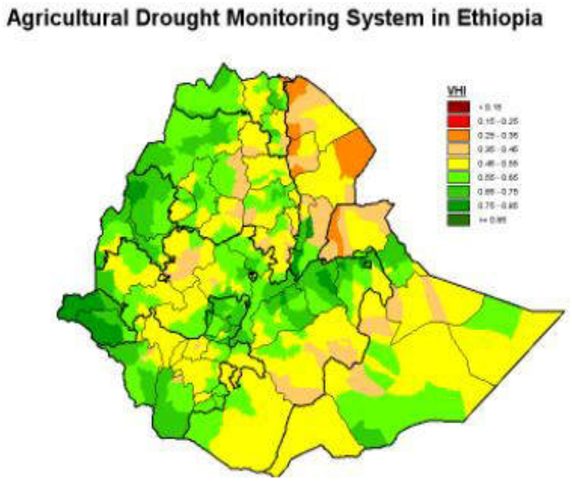


SEASONAL FORECAST, EL NIÑO FORECAST, VEGETATION CONDITIONS

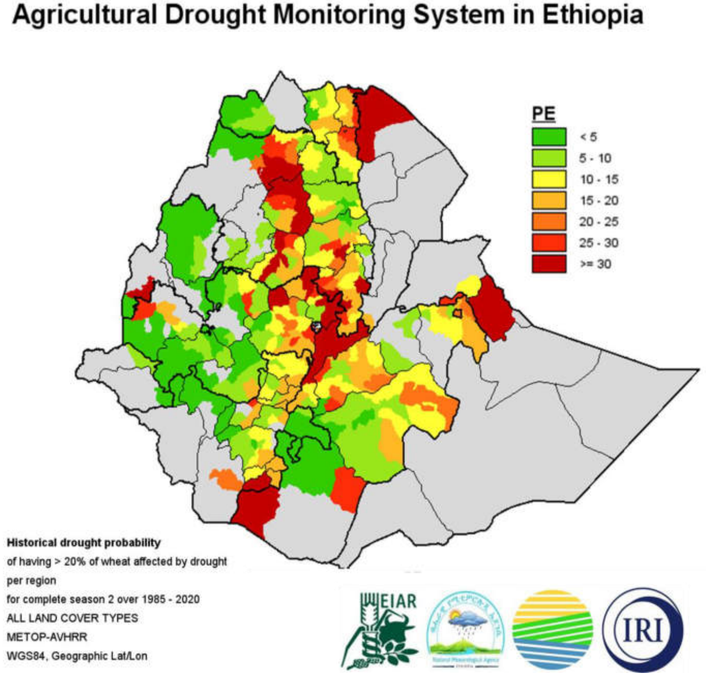
Climate Perpective

(NextGEN Forecast)





HISTORICAL PROBABILITY OF DROUGHT



Food and Agriculture Organization of the United Nations

Contribution of ASIS

1. Automatic-system fed by pre-processed imagery from VITO that guarantee the sustainability of the system

2. Temporal-spatial integration (including Kc), normally not take into consideration for most of the systems on agricultural monitoring based on remote sensing data

3. :Unique time series (>30 years) a 1 km resolution that guarantee the long term memory of the pixel of having an extreme drought event

Thank you

Food and Agriculture Organization
of the United Nations

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