



# FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

# Session 4: Surveillance Tools for Early Warning Systems

## PART 1: FORECASTING

Current and Emerging Threats to Crops: A Practical Course  
Day 2: Surveillance and Diagnostics/Assessment of Threats to Crops



**USAID**  
FROM THE AMERICAN PEOPLE



PennState



PlantVillage

**MICHIGAN STATE**  
UNIVERSITY



# FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

## PANELIST BIOS

### **Daniel Njapit (PlantVillage)**

- Research Extension Officer at Dream Team Kenya under Plant Village. A graduate of Agriculture and Biotechnology

### **Dave Hodson (CIMMYT)**

- Dr Dave Hodson is a Principal Scientist with CIMMYT, currently based in Mexico. For the last 15 years he has worked on developing and coordinating a Global Wheat Rust Monitoring System. He also coordinates a surveillance system for Maize Lethal Necrosis (MLN) in Eastern and Southern Africa.



**USAID**  
FROM THE AMERICAN PEOPLE



PennState



PlantVillage

**MICHIGAN STATE**  
UNIVERSITY



# FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

## OUTLINE

- Why surveillance & forecasting is important
- Examples of surveillance tools
  - Nuru, PlantVillage
  - ODK
- Importance of Diagnostics in surveillance
- Linking surveillance to early warning / forecasting
- Forecasting examples (rust, blast)



**USAID**  
FROM THE AMERICAN PEOPLE



PennState



PlantVillage

**MICHIGAN STATE**  
UNIVERSITY



# FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

## AN INCREASING THREAT – TRANSBOUNDARY PATHOGENS & PESTS

- **Rate of spread, appearance in new areas, detection of new races (new diseases) is increasing**

Drivers: Globalization (trade, travel), climate change, Selection pressure (uniform cropping systems)



Stem Rust



Yellow Rust



Wheat Blast



Maize Lethal  
Necrosis



Fall Army  
Worm

**Pathogen Surveillance & Monitoring Systems increasingly needed**



**USAID**  
FROM THE AMERICAN PEOPLE



**PennState**



**PlantVillage**

**MICHIGAN STATE**  
UNIVERSITY



## SURVEILLANCE TOOLS FOR EARLY WARNING SYSTEMS

- These are tools that are used to monitor factors that affect agricultural production in crops
- These tools help farmers and researchers to in decision making which is critical for farming
- An early warning system is a system that helps to predict and monitor different factors that affect farming before they happen
- An early warning system has four major components hazard detection, monitoring and forecasting; risk analysis and incorporation of risk information in emergency planning and warnings; dissemination of timely and authoritative warnings; and community planning and preparedness with the ability to activate emergency





# FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

## WHY DO WE NEED SURVEILLANCE?

- Understand what is happening in farmer fields
- Early detection and early warning
- Which diseases are present
- When and where diseases are occurring + spread over time
- Collect samples to understand pathogen changes – inform breeding programs
- (Understand role of alternate hosts)
- Monitor changes over time
- Detect hot-spots of disease occurrence
- Basis for informing control and mitigation



**USAID**  
FROM THE AMERICAN PEOPLE



PennState



PlantVillage

**MICHIGAN STATE**  
UNIVERSITY



# FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

## SURVEILLANCE TOOLS

- Electronic survey tools permit the collection of near real-time data
- Quality control of data at collection
- Integration of AI / ML

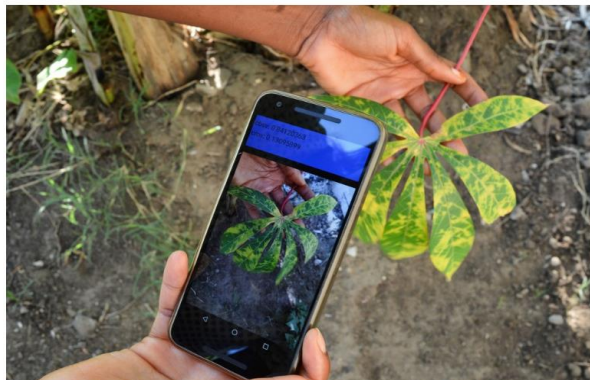


Photo: IITA / Penn State Plant Village



**USAID**  
FROM THE AMERICAN PEOPLE



**PennState**



**PlantVillage**

**MICHIGAN STATE**  
UNIVERSITY





# FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

## PLANT VILLAGE NURU APP

- PlantVillage Nuru is a publically supported, and publically developed application that uses a digital assistant to help farmers diagnose crop disease in the field, without an internet connection.
- During the locust outbreak in the horn of Africa Plant Village Nuru app elocust3m which successfully helped managed the crisis
- The app is also now being used for it's AI features to scan different crop diseases
- Most notable is it has successfully helped in the management of cassava diseases in Busia and Bungoma Kenya .

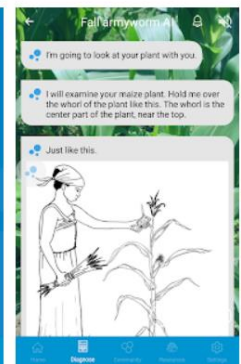
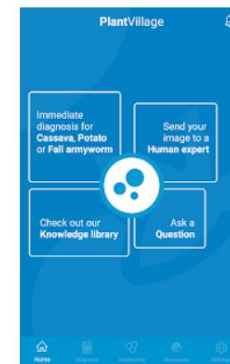


PlantVillage Nuru

PlantVillage Education

1 PEGI 3

Add to Wishlist



**USAID**  
FROM THE AMERICAN PEOPLE



PennState



PlantVillage

**MICHIGAN STATE**  
UNIVERSITY





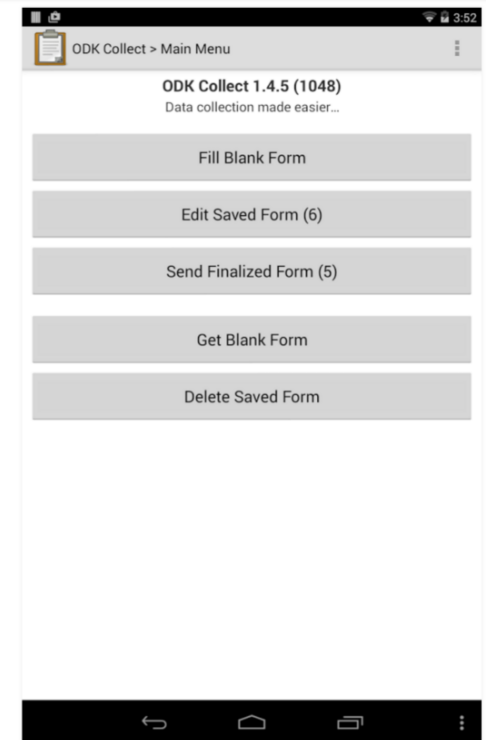
# FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

## ODK

- Free, open-source software
- Simple, custom form design (Images, barcodes, pick lists etc)
- Used for numerous surveys, including wheat rusts and wheat blast
- Download ODK collect

<https://play.google.com/store/apps/details?id=org.odk.collect.android&hl=en>



**USAID**  
FROM THE AMERICAN PEOPLE



PennState



PlantVillage

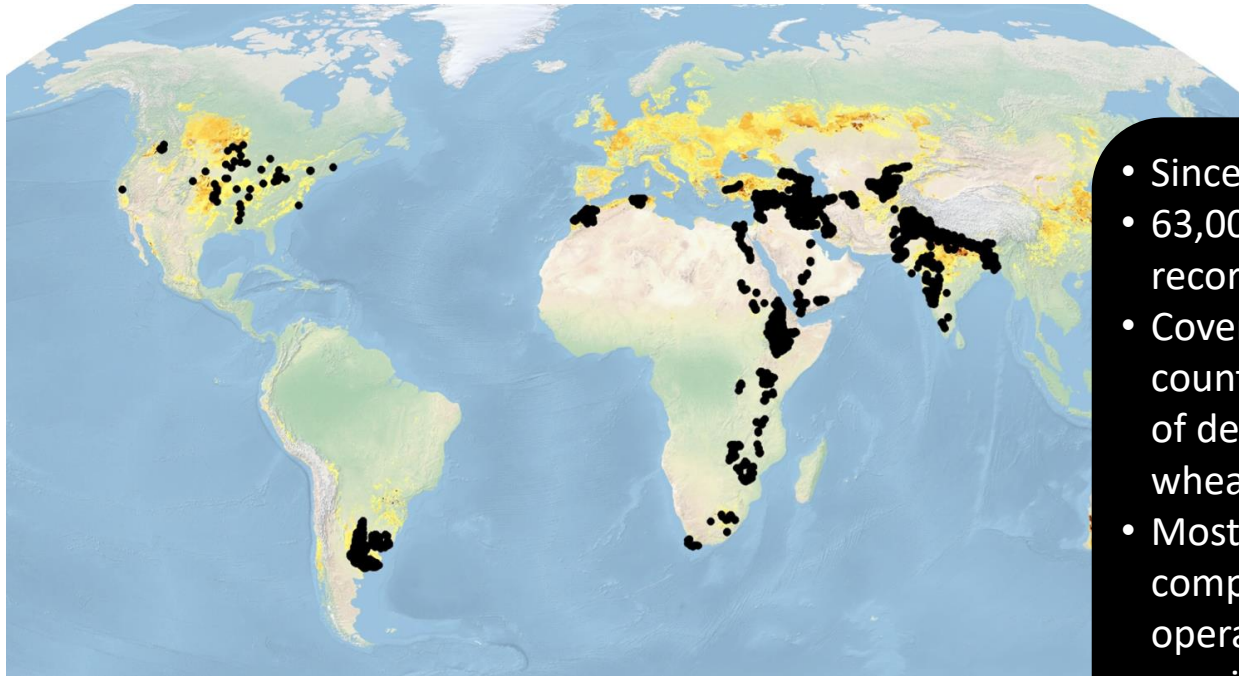
**MICHIGAN STATE**  
UNIVERSITY



# FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

## SURVEILLANCE EXAMPLE: WHEAT RUSTS



- Since 2018
- 63,000+ survey records
- Covers 40+ countries: large % of developing world wheat
- Most comprehensive, operational monitoring system for major crop diseases



**USAID**  
FROM THE AMERICAN PEOPLE



PennState



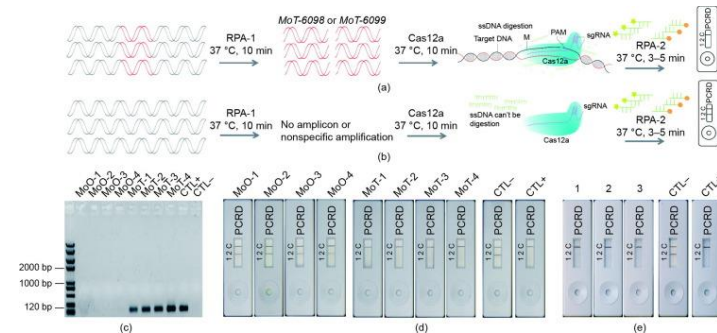
PlantVillage

**MICHIGAN STATE**  
UNIVERSITY



## SAMPLING + DIAGNOSTICS

- Critically important to determine new strains / specific pathogens
- Rapid diagnostics & new tools
- New strains / new pathogens usually the most damaging
- Rapid detection & forecasting increasingly important



Kang et al., 2021

<https://doi.org/10.1016/j.eng.2020.07.016>



# FEED THE FUTURE

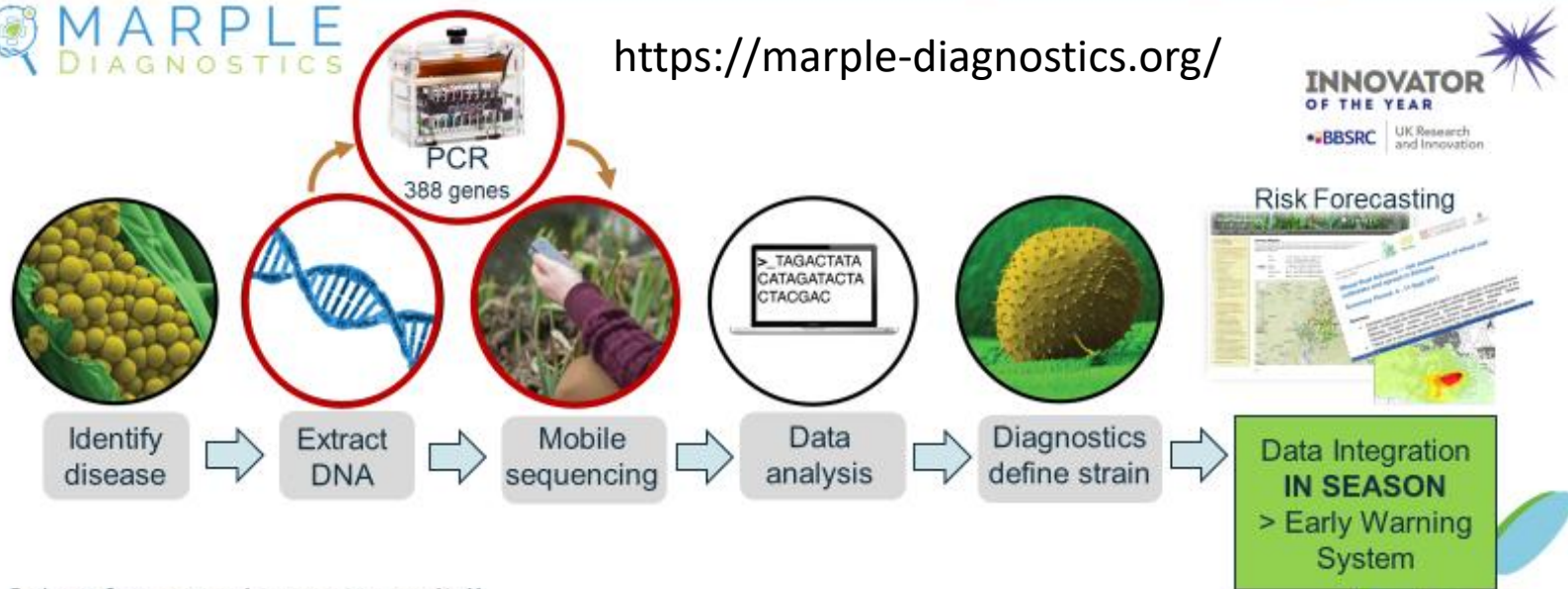
The U.S. Government's Global Hunger & Food Security Initiative

## MARPLE DIAGNOSTICS

Mobile And Real-time PLant disEase (MARPLE) diagnostics



<https://marple-diagnostics.org/>



2 days from sample prep to results!!

Slide: Dr. Diane Saunders, JIC

John Innes Centre

Radhakrishnan et al & Saunders (2019) BMC Biology



Platform for  
Big Data  
in Agriculture

BILL & MELINDA  
GATES foundation



Biotechnology and  
Biological Sciences  
Research Council



**USAID**  
FROM THE AMERICAN PEOPLE



PennState



PlantVillage

**MICHIGAN STATE**  
UNIVERSITY



# FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

## FORECASTING



**USAID**  
FROM THE AMERICAN PEOPLE



**PennState**



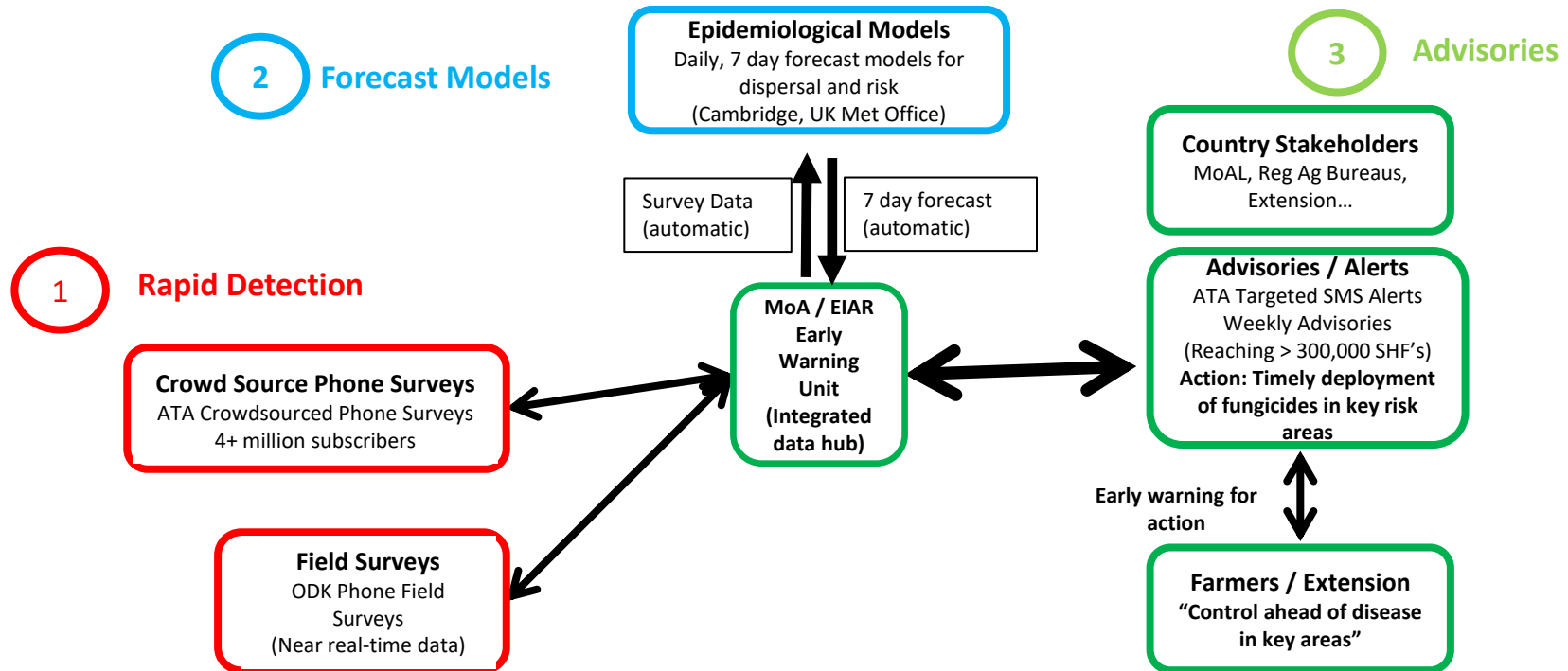
**PlantVillage**

**MICHIGAN STATE**  
UNIVERSITY



# Ethiopia: Wheat Rusts

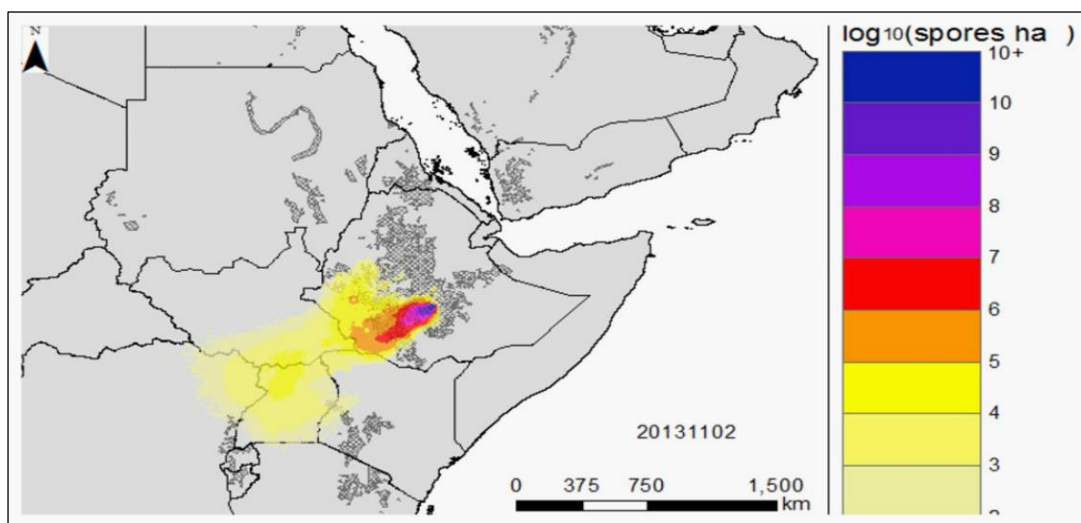
## Early Warning Advisory System



Allen-Sader, et al . (2019) *Environ Res Letters*

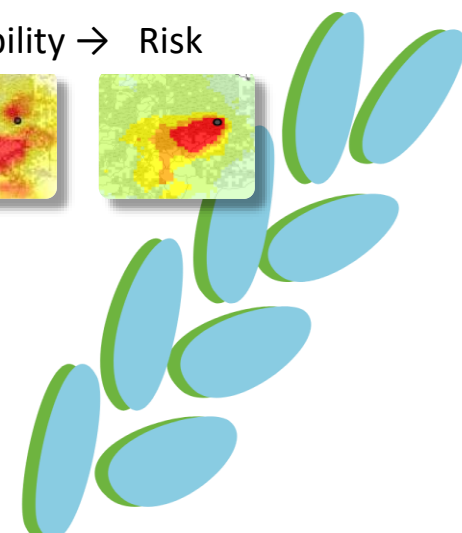
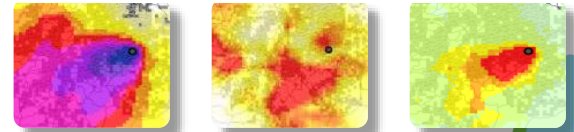


# Spore dispersal and environmental suitability forecasting



- Advanced Spore Dispersal Model (NAME model, UK Met Office)
- 7 day forecast models for dispersal and risk (daily, in-season)
- 3 weeks' warning to prevent epidemics

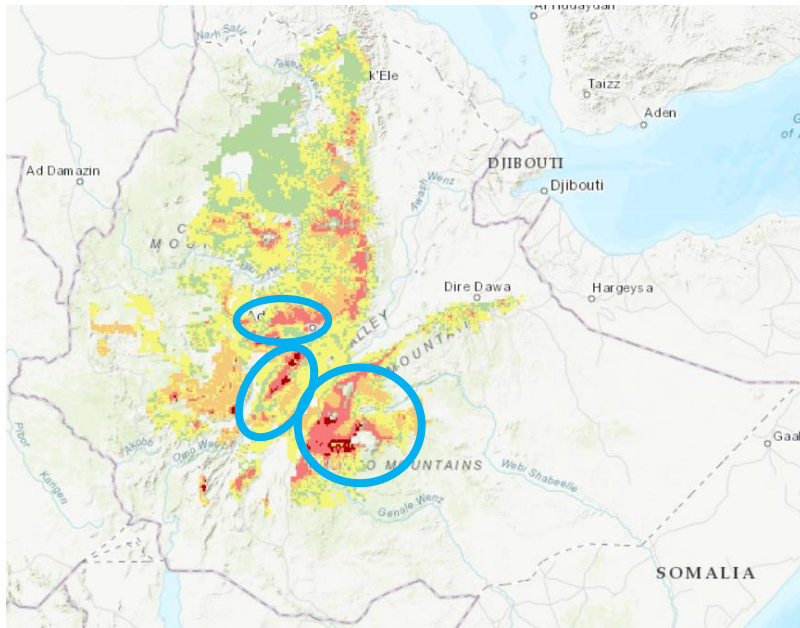
Dispersal + Suitability  $\rightarrow$  Risk



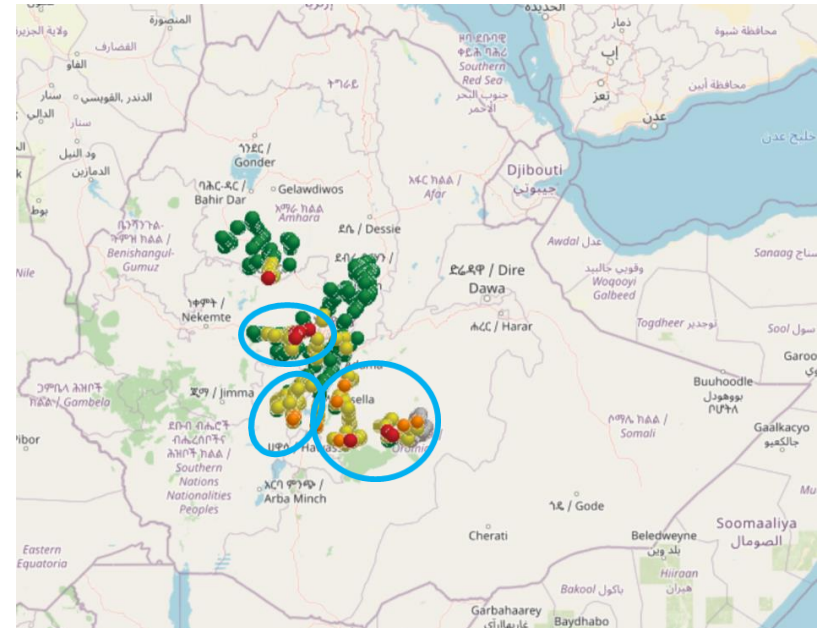
# Vulnerability Mapping Tool

- Host x Pathogen x Environment ➡ Vulnerability / Risk
- Ethiopia – 2021: Pre-season risk information for PstS16

VMT – Risk PstS16 July



2021 YR Severity September



Accurate, early prediction of risk areas = Valuable planning information



# FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

## SUMMARY

- Large-scale and long-term surveillance increasingly important
- Electronic survey tools increasingly used and AI providing new opportunities
- Advanced, in-season early warning and advisory systems operational in Ethiopia, Nepal, Bangladesh + starting in Kenya.
- Early warning systems showing impact e.g., Ethiopia 2021
- Vulnerability tool providing advance warning of risk from new races
- MARPLE diagnostics expanding + other new diagnostic tools in development



**USAID**  
FROM THE AMERICAN PEOPLE



PennState



PlantVillage

**MICHIGAN STATE**  
UNIVERSITY



# FEED<sup>THE</sup>FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

[www.feedthefuture.gov](http://www.feedthefuture.gov)



**USAID**  
FROM THE AMERICAN PEOPLE



**PennState**



**PlantVillage**

**MICHIGAN STATE**  
UNIVERSITY