Foresight Crops

Insect Swarm Modelling & Prediction

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The Problem

- Insect swarm activity causes devastation to farms and crops all around the world.
- Locusts are one example.
- They affect Africa, Middle East, Asia, Australia.
- They eat crops such as rice, millet, maize, barley, as well as, cash crops such as sugar cane, cotton, date palms and many more.

The Problem

- In Madagascar alone more than US$37 million was spent in 2015 to deal with locust swarms.
- In 2010 locusts damage cost billions to Agriculture in Australia. With an estimated $2 billion in the state of Victoria alone.
- Many other insects which cause crop damage include the green beetle, army worms, weevil and aphids.

The Problem

Army worms (**Spodoptera frugiperda**)

- In Zambia army worms causes significant damage to crops in particular the staple crop maize. They are leaf eating caterpillars and outbreaks are influenced by environmental conditions.
- In 2012 & 2014 an outbreak of army worms caused major damage to maize, sorghum, cassava and rice.
- The ministry of agriculture distributes pesticides to the farmers however the free supply is usually insufficient to address the need.
- The Zambian National Farmers Union is calling for early warning systems to prevent future severe outbreaks.

The Problem

- Local food shortages.
- Loss of income/financial loss.
- Environmental impact due to pesticide overuse.
- Instability of food prices.
- Global Food Security
  - There are currently over 800 million people in the world without access to good nutritious food.
  - With global population expected to rise to 9 billion and increased urbanisation, the demand for food is set to increase, growing by 40% by 2030 and 70% by 2050.

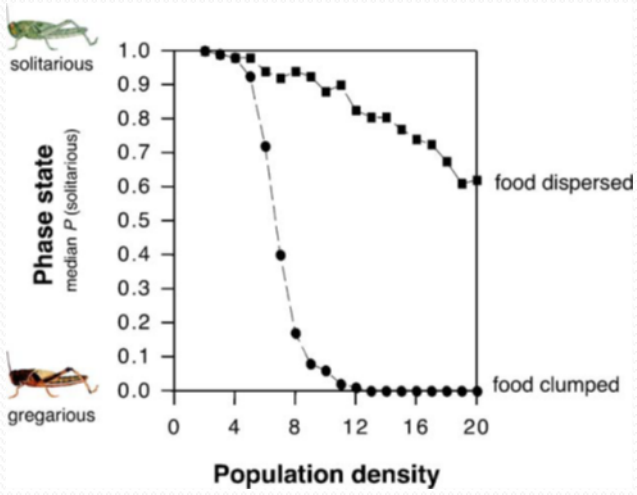

WWW. FAO.org

Foresight Crops

- Geospatial intelligence for agricultural resource management.
- A predictive analytics platform based on satellite data.
- Use satellite data to model and predict the causal factors and triggers for insect swarm activity.
- Combining the latest satellite data with crowdsourced ground data and observations to track the real time movements of the swarm.

An Example: Locust Swarms

- Forming factors are:
  - eggs in sandy soils and on the sea coasts;
  - heavy rainfall in Nov-Feb;
  - Severe dry conditions create overpopulation;
- Weather conditions affected by:
  - temperature;
  - cloud, wind;



Sword et al. (2010)

- Using satellite data to track locations with favorable conditions for breeding and development of the larva, as well as for activating the swarming behaviour.

QGIS 2.8.1-Wien - FAO Locust 2015

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Browser

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- Oracle
- PostGIS
- SpatiaLite
  - Wembley
- OWS
- WCS
- WFS
- WMS

Layers

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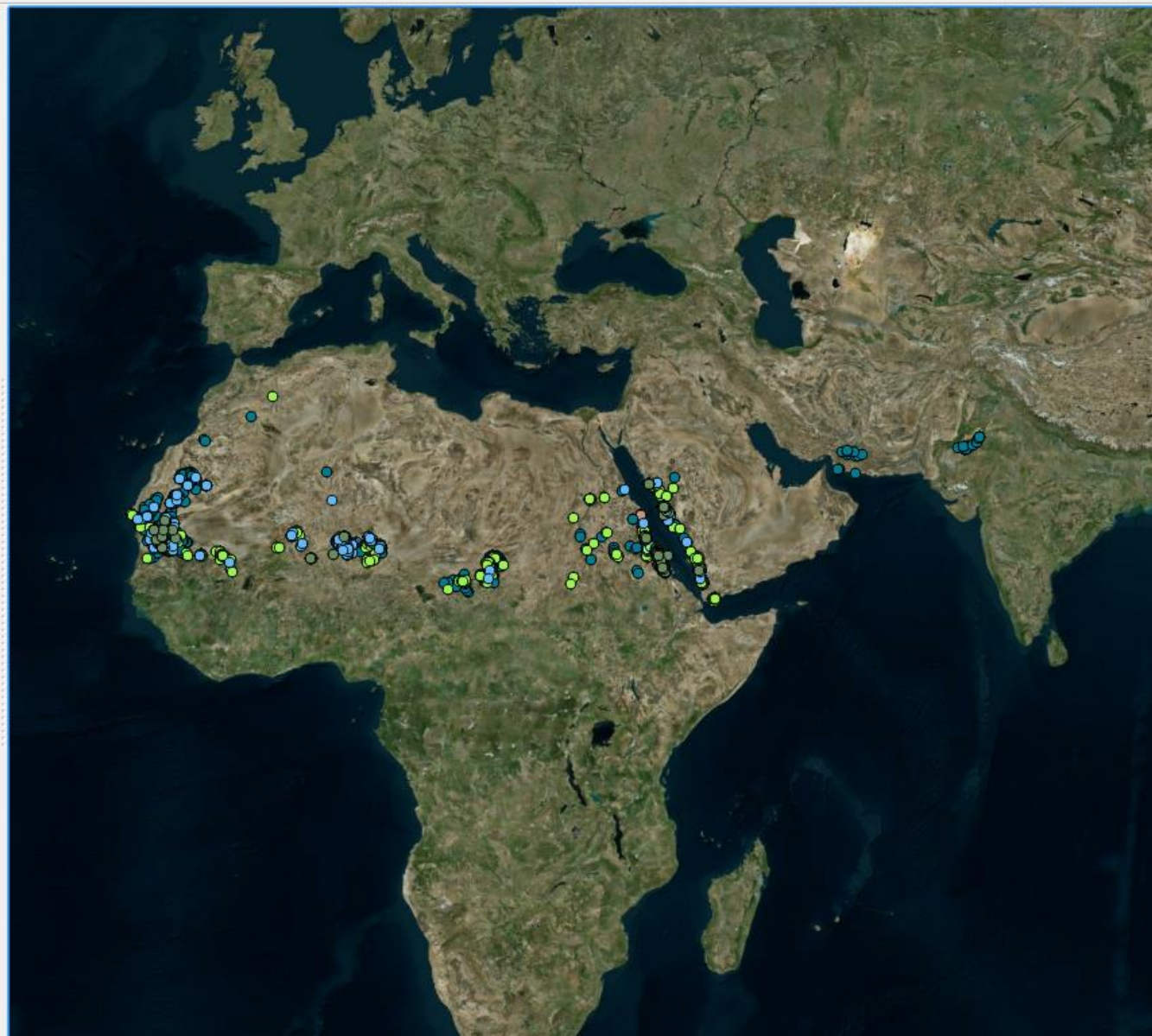
- OpenStreetMap
- Bing Aerial



Foresight Crops

- Utilise satellite earth observation data to compute the differences in indices such as the Normalised Difference Vegetation Index (NDVI) & the Soil Moisture Index (SMI) between peak wet and dry periods. As well as long term changes at different scales.

- This provides an indication of the areas of high risk for triggering swarming activity.

- Analyse historical data from LANDSAT, MODIS together with local historical records on swarm activity to model long term trends in locust swarming patterns. Weather data and crowd sourced observations together with higher resolution Sentinel data will be used for near real-time monitoring of active swarms.

Satellite Data

Normalised Difference Vegetation Index

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

For Sentinel 2:

$$NDVI = \frac{Band\ 8 - Band\ 4}{Band\ 8 + Band\ 4}$$

Moisture Index (MI) and Soil Moisture Index (SMI)

$$MI = \frac{NIR}{Blue}$$

$$SMI = \frac{T_{S_{max}} - T_S}{T_{S_{max}} - T_{S_{min}}}$$

$$T_{S_{max}} = a_1 NDVI + b_1$$

$$T_{S_{min}} = a_2 NDVI + b_2$$

Where a_1, a_2, and b_1, b_2 are empirical parameters

Crowd sourcing

- From farming communities and potential stakeholders as well as wider public.
- Dedicated mobile app
- SMS
- Social media - Twitter

http://www.inquisitr.com/2361101/burning-man-bugs-infestation-2015-festival-plagued-by-insect-swarms

Risk Modelling and Real Time Tracking

Satellite Data

NDVI

SMI

Weather Data

Temperature

Precipitation

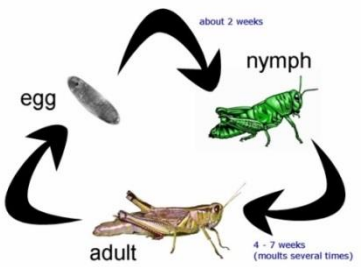
Wind

Current Online: e.g. Twitter, News websites

Telephone Hotline & SMS

Insect Activity Records

Foresight- Crops Crowd Sourcing App



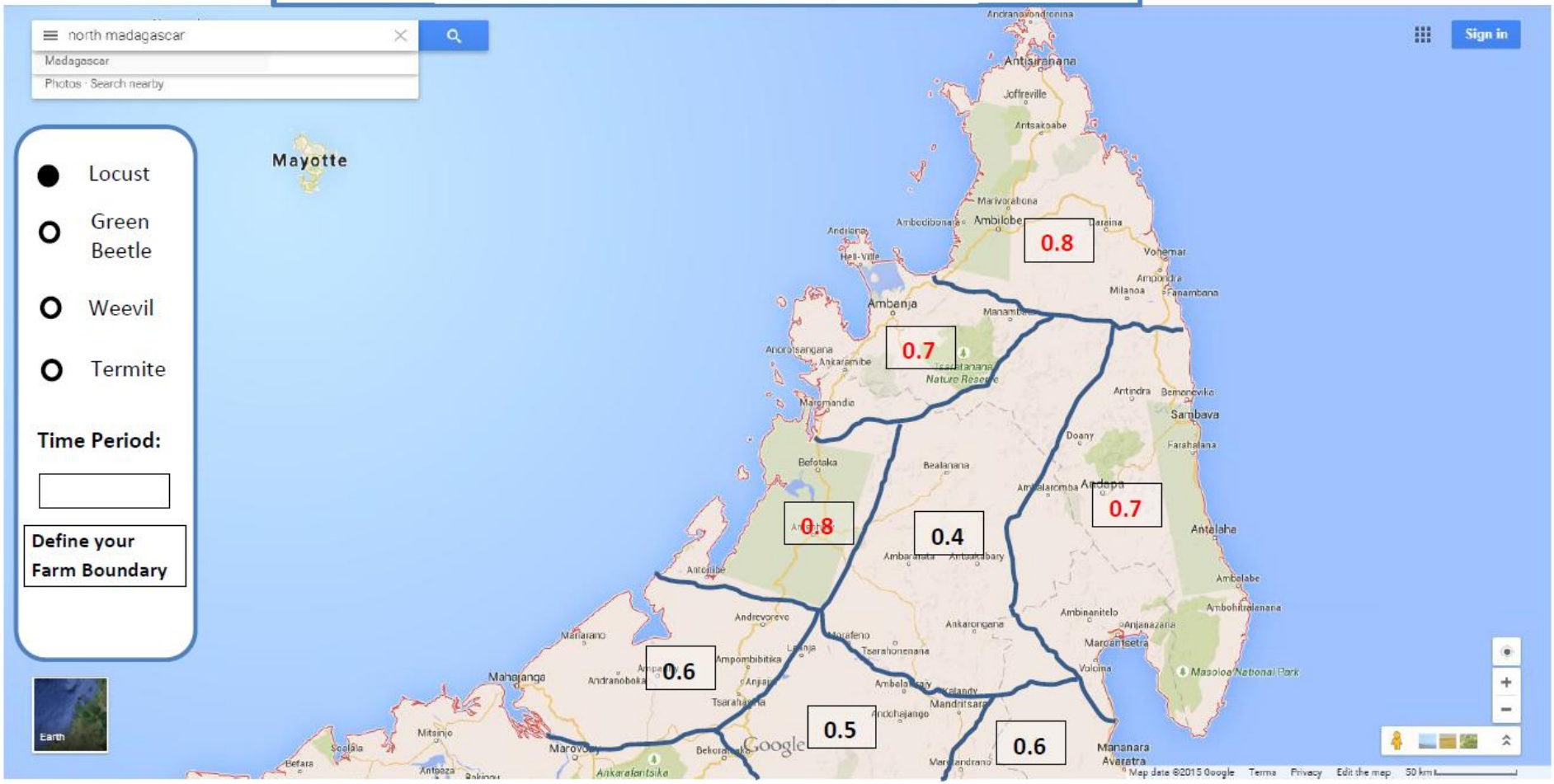
Insect lifecycle

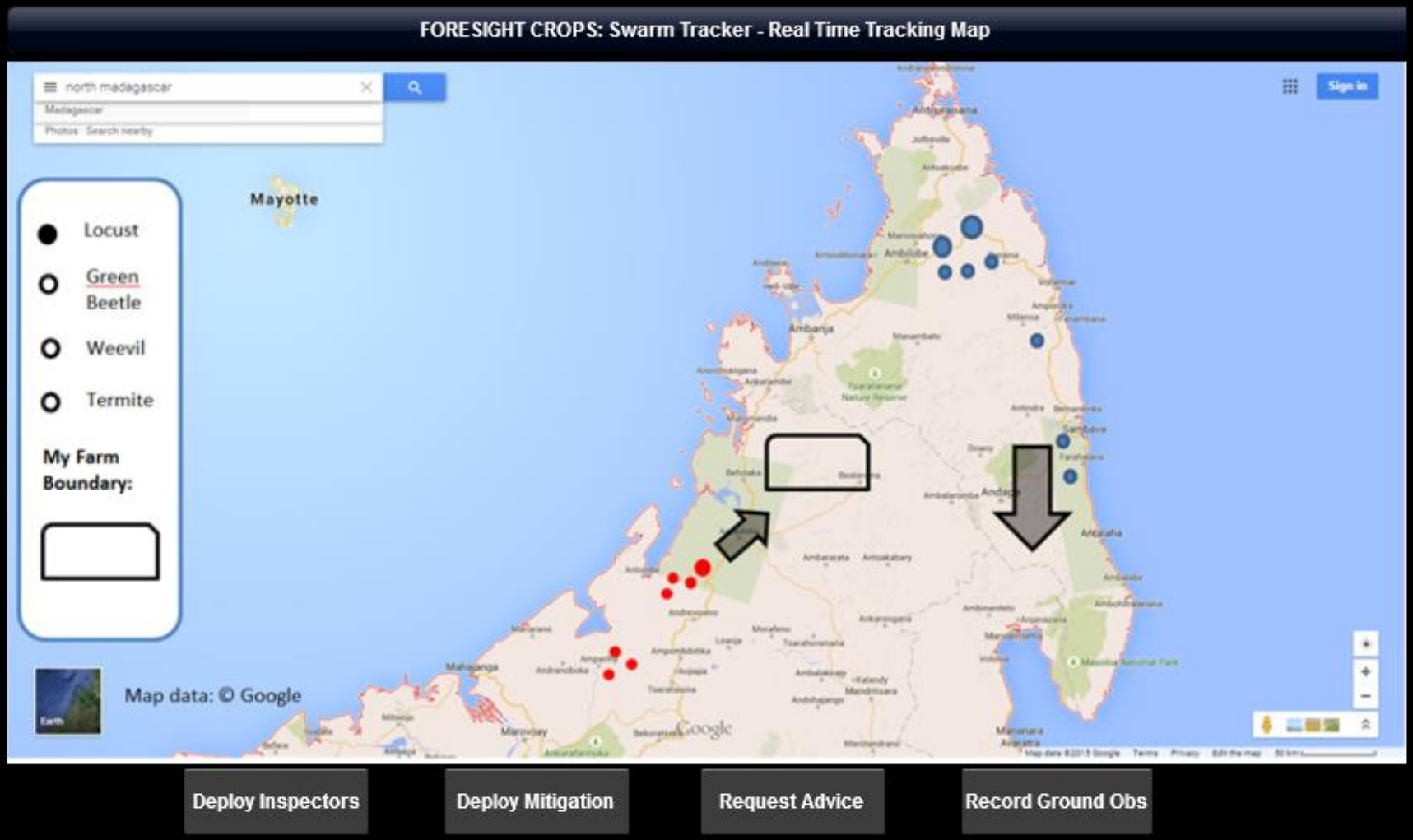
Predictive Modelling utilising Machine Learning and Statistical Analysis:

Risk/Probability Map

Swarm/Infestation Location and Direction of Encroachment

Locust Swarm Probability Map




FORESIGHT CROPS: Swarm Tracker - Real Time Tracking Map
north madagascar
Madagascar
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Mayotte
Locust
Green Beetle
Weevil
Termite
My Farm Boundary:
Map data: © Google
Deploy Inspectors
Deploy Mitigation
Request Advice
Record Ground Obs
2:30

Satellite data

Computer algorithms

Soil

Crowdsourced data

Crop science

Entomology

data

Weather

Analytics

geospatial data

Insect Swarm Risk/Probabilities

Predictions: Location & Direction

Cloud Platform (e.g. Azure or SAP Hana)

SMS and mobile app

Relevant Sectors

- Crop farming for food production.
- Crop farming to produce animal feeds.
- Plantations of cash crops such as tea, cotton, sugar cane, tobacco.
- Producing fresh flowers for export.
- Assisting small farming communities to control pest & diseases.

Value to Customers

Products and Services

- Intelligence on the risk of insect swarms (e.g. locust) and the potential impact on crops.
- Real-time monitoring of swarms. Advance warning system.
- Enable connection to relevant advice on mitigation techniques .

Activities

Risk mapping based on analysis of historical satellite and ground data.

Tracking the swarm location in real-time using the latest satellite data as well as live crowd sourced data.

Advisor service – provide contact to a crop expert. Who can advise on the type of pesticides and ideal timing for spraying.

Derived Value

- **Financial savings from reduced crop damage.**
- **Financial savings from reduced use of pesticides and less helicopter flying time.**
- **Environmental benefit of reduced pesticide use.**
- **More food available for local communities.**

Potential Customers

- Agronomist
- Farmers
  - Premium – Large farms and plantations.
  - Small farms and cooperatives.
- UN Agencies e.g. FAO
- Gov't ministries such as Ministry of Agriculture.
- Food companies such as Nestle who deal with cocoa farmer.
- Insurance companies
- Data analytics companies – e.g. SAP

Systems Integration

- Satellite data provides the ability to monitor anywhere in the world without the need to deploy staff on site.
- IoT sensors such as wireless soil and temperature sensors can incorporated into the system to provide further data, though this will increase cost.
- The Foresight Crops system can be included in a farms Integrated Pest Management System.

Future Developments

- One of the goals for the Copernicus Masters Uni Challenge was to transform bright ideas from researchers into successful commercial ventures.
- New Start-up established based at the new Space Tech Incubation facility at the University of Nottingham.
- Summer Intern as part of Space Placement in Industry (SPIN) programme run by the Satellite Applications Catapult in the UK
- Joint proposal for the UK Agri-tech Catalyst Round 6 funding call is in progress.

Thank You!