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AFRICAN SOCIETY FOR LABORATORY MEDICINE

ADVANCING THE LABORATORY PROFESSION AND NETWORKS IN AFRICA

# ANTIMICROBIAL RESISTANCE (AMR) COMMUNITY OF PRACTICE (CoP)

## Utilizing Interactive GIS platforms for Integrated Solutions in AMR, One Health, and Pandemic Preparedness: Synergies in Data Science, Bioinformatics, and GIS

**Stephen Obol Opiyo, PhD**

**Patira Data Science (Uganda and USA)**

**opiyo@patiradatascience.com**

**June 28th, 2024**

UKaid from the British people

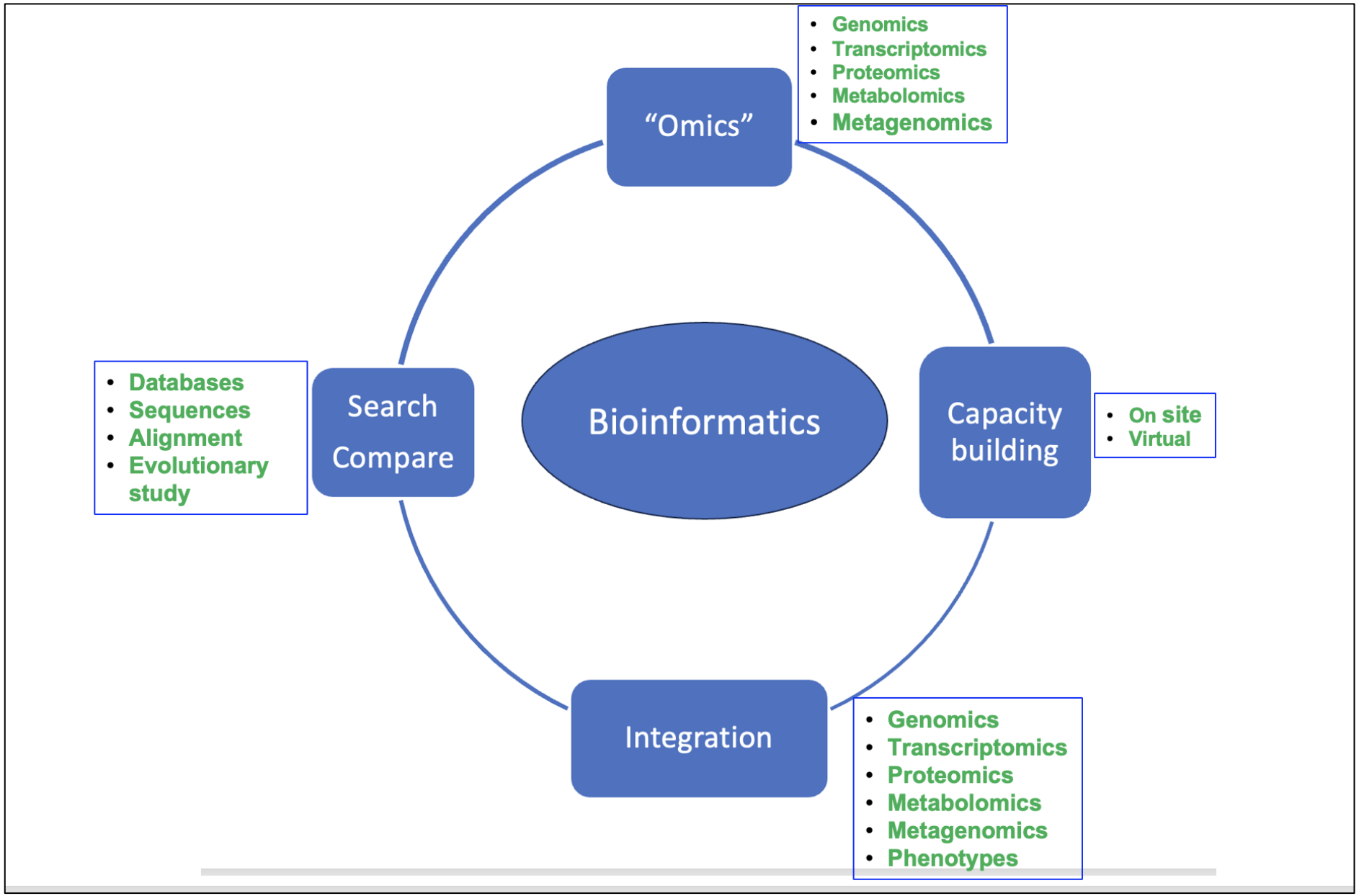
The Fleming Fund

EQuAFRICA External Quality Assessment for AMR Testing

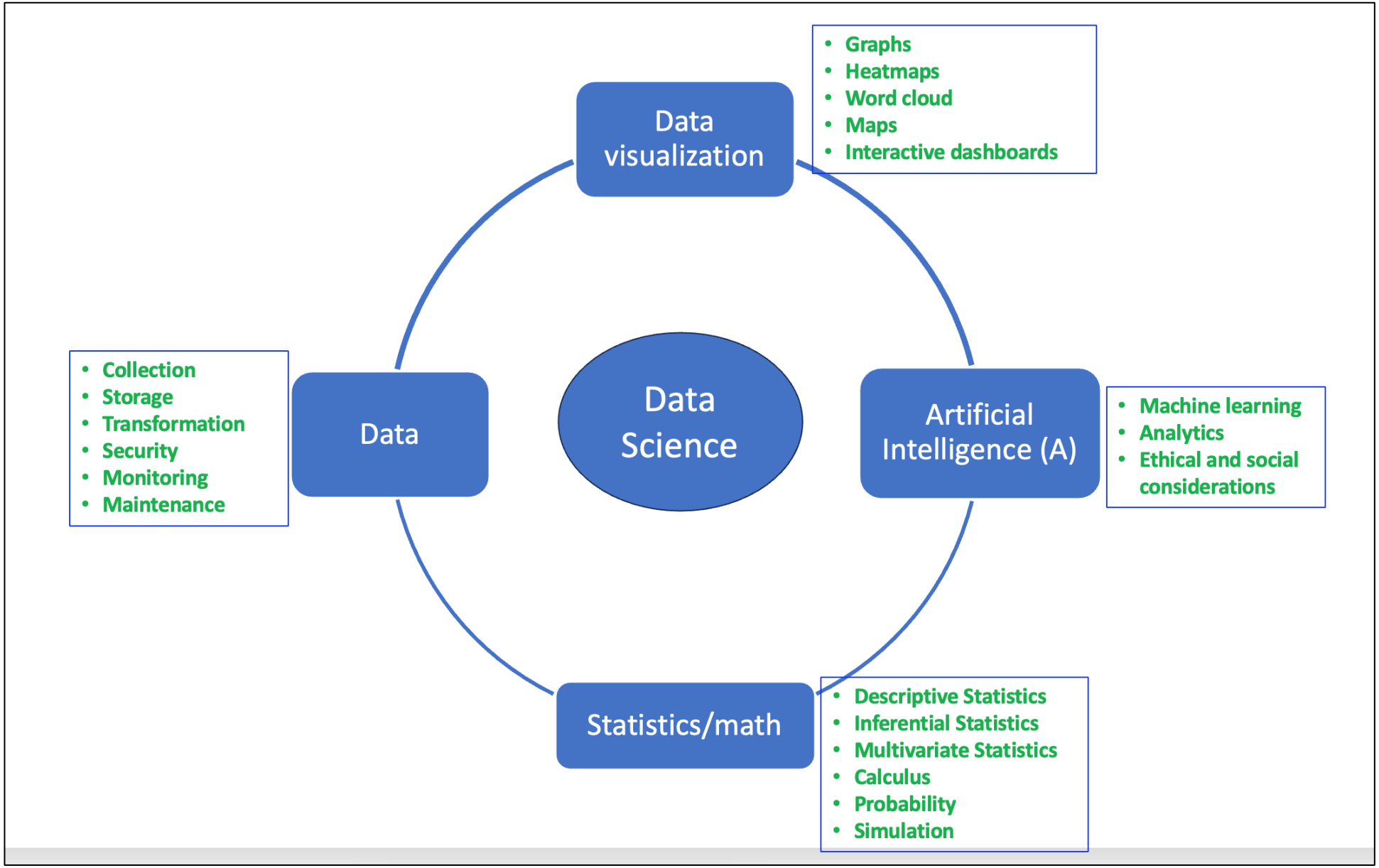
# Overview

- Introduction
  - What is Bioinformatics?
  - What is Data Science?
  - What is an interactive Geographical Information System (GIS) platform?
- Integrated solution in Antimicrobial Resistance (AMR).
- Integrated solution in One-Health.
- Integrated solution in Pandemic Preparedness.

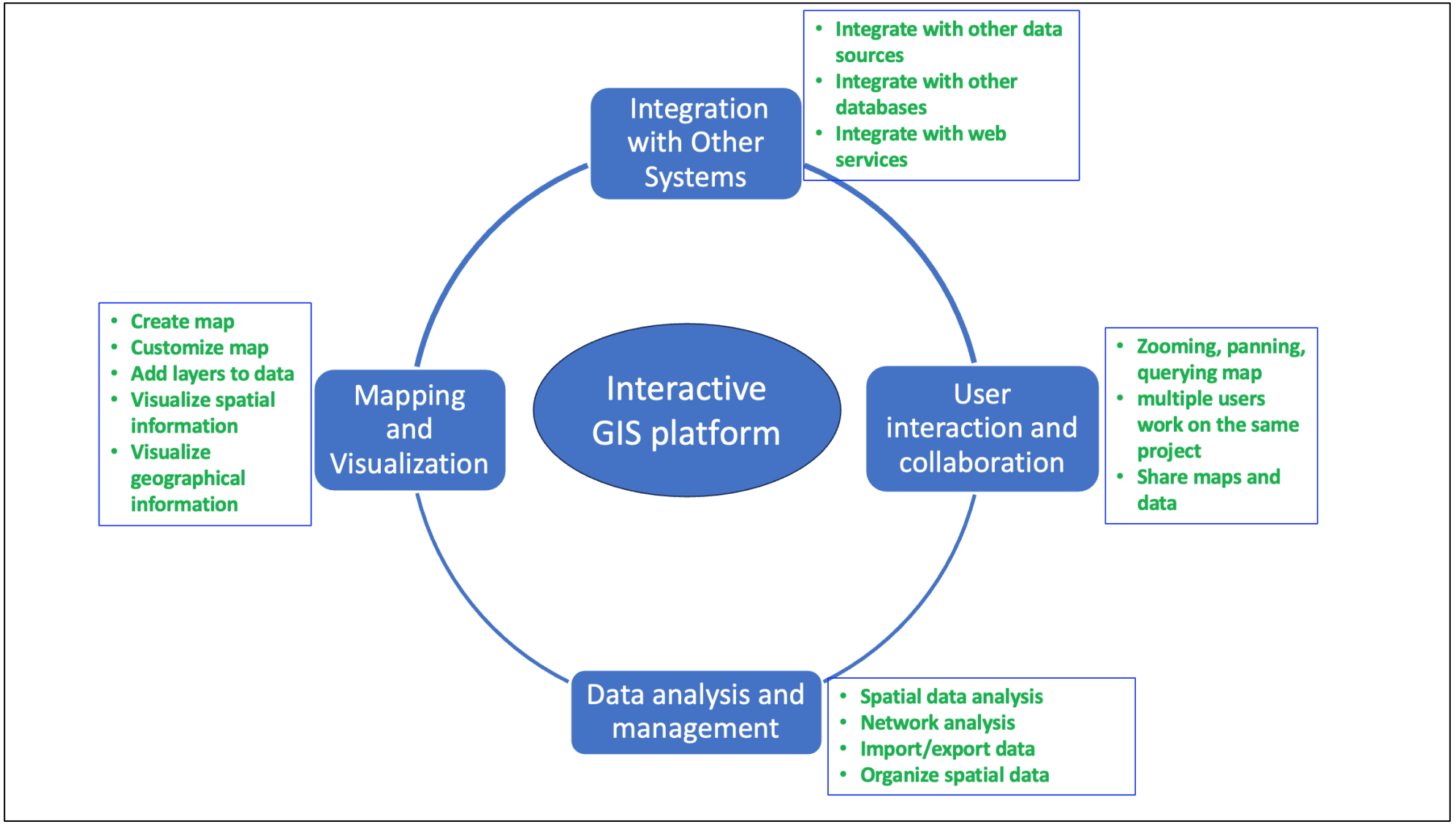
# What is Bioinformatics?



# What is Data Science?



# What is an interactive GIS platform?



# Integrated solution in AMR: Using dataset from Vivli

## Background

- Vivli (https://vivli.org) is a global clinical research data sharing platform for pharmaceutical companies (Pfizer, GSK, Johnson & Johnson, Merck, Shionogi, Paratek and Venatorx, Welcome, and others), diagnostic, biotech, etc.

- The Vivli AMR Surveillance Open Data Re-Use Data Challenge, funded by Wellcome, was launched in April 2023.

- The goal was to promote utilization of the Vivli AMR data to more researchers and drive advances in the AMR field.

- Submitted an abstract and given access to Pfizer's data ATLAS.

# Pfizer, ATLAS (Antimicrobial Testing Leadership And Surveillance)

- ATLAS (https://www.atlas-surveillance.com)

- The ATLAS programme monitors changes in antibiotic susceptibility, bacterial resistance trends and emergence of new resistance mechanism for both marketed and in development antibiotics.

- Dataset:
  - 18 years (2004 to 2021)
  - 83 countries
  - 345 species
  - 863,509 isolates.
  - Data: Spreadsheet > 800,000 rows and 126 columns.

# Pfizer ATLAS dataset: > 800,000 rows and 126 columns

126 columns

Antibiotics

| Isolates | Family | Country | Gender | Age Group | Speciality | Source | In / Out Patient | Year | Erythromycin | Moxifloxacin | Imipenem | Levofloxacin | Ampicilin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Escherichia coli | Enterobacteriaceae | Uganda | Male | 19 to 64 Year | General Unsp | Endotrachea | No Information | 2021 | Susceptible | Intermediate | Resistant | Resistant | Resistant |
| Staphylococcus aureus | Staphylococcus spp | Uganda | Male | 0 to 2 Years | Pediatric Ge | CSF | No Information | 2021 | No Information | No Information | No Informati | No Information | No Information |
| Staphylococcus aureus | Staphylococcus spp | Uganda | Female | 19 to 64 Year | Surgery Gene | Gastric Absc | No Information | 2021 | No Information | No Information | No Informati | No Information | No Information |
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| Klebsiella variicola | Enterobacteriaceae | Uganda | Male | 65 to 84 Year | Medicine Ge | Sputum | No Information | 2021 | Susceptible | Susceptible | Resistant | Susceptible | Resistant |
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| Escherichia coli | Enterobacteriaceae | Uganda | Male | 19 to 64 Year | Other | Respiratory: | No Information | 2021 | Resistant | Intermediate | Resistant | Intermediate | Susceptible |
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| Acinetobacter nosocomialis | Non-Enterobacteriaceae | Kenya | Male | 19 to 64 Year | General Unsp | Endotrachea | No Information | 2014 | Susceptible | No Information | No Informati | Susceptible | Intermediate |
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| Escherichia coli | Enterobacteriaceae | Kenya | Female | 19 to 64 Year | Surgery Gene | Liver | No Information | 2013 | Susceptible | Susceptible | Resistant | Susceptible | Susceptible |
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| PseudomoNo Informations aeruginosa | Non-Enterobacteriaceae | Kenya | Male | 0 to 2 Years | Pediatric Ge | Wound | No Information | 2013 | Susceptible | No Information | No Informati | Susceptible | Susceptible |
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| Acinetobacter baumannii | Non-Enterobacteriaceae | Kenya | Male | 19 to 64 Year | General Unsp | Endotrachea | No Information | 2021 | Susceptible | No Information | No Informati | Resistant | Resistant |

863, 509 rows

# Challenges

- Going through the spreadsheet (863,509 x 126): 18 years (2004 to 2021), 83 countries, 345 species, and 863,509 isolates.

| Isolates | Family | Country | Gender | Age Group | Speciality | Source | In / Out Patient | Year | Erythromycin | Moxifloxacin | Imipenem | Levofloxacin | Ampicilin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Escherichia coli | Enterobacteriaceae | Uganda | Male | 19 to 64 Year | General Unsp | Endotrachea | No Information | 2021 | Susceptible | Intermediate | Resistant | Resistant | Resistant |
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| Escherichia coli | Enterobacteriaceae | Uganda | Male | 19 to 64 Year | Other | Respiratory: | No Information | 2021 | Resistant | Intermediate | Resistant | Intermediate | Susceptible |
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- Kenya has three years (2013, 2014, 2021), and Uganda (2021) on June 15, 2023.

- The African region had the lowest number of countries (13) and the fewest years of available data.

# Objectives

- **Objective 1:** Develop an interactive GIS dashboard encompassing all countries within the Vivli dataset.

- **Objective 2:** Create an interactive GIS dashboard specific to the Vivli datasets from Kenya and Uganda.

- **Objective 3:** Generate a simulated dataset specifically for Kampala, Uganda.




Opiyo SO et al. Wellcome Open Res 2024, 9:234

https://wellcomeopenresearch.org/articles/9-234

# Objective 1: ATLAS dataset presented in interactive GIS dashboard

126 columns

| Isolates | Family | Country | Gender | Age Group | Speciality | Source | In / Out Patient | Year | Erythromycin | Moxifloxacin | Imipenem | Levofloxacin | Ampicilin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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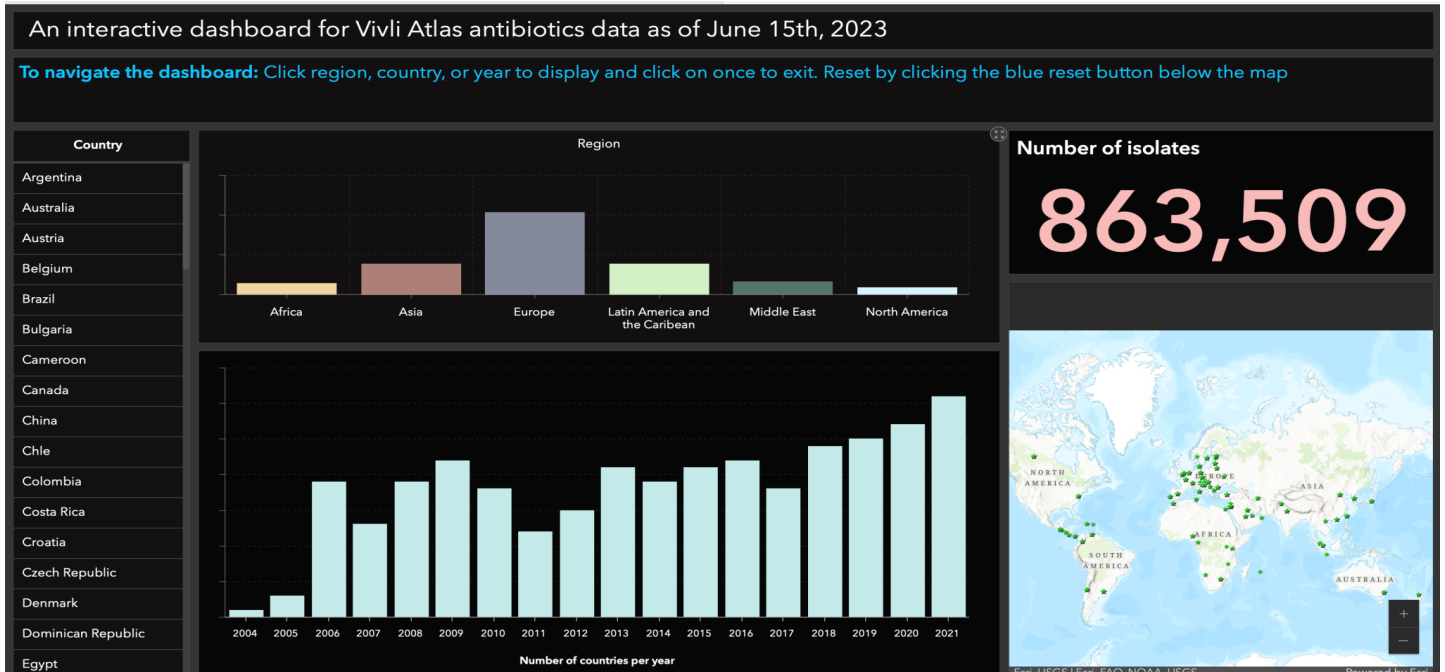
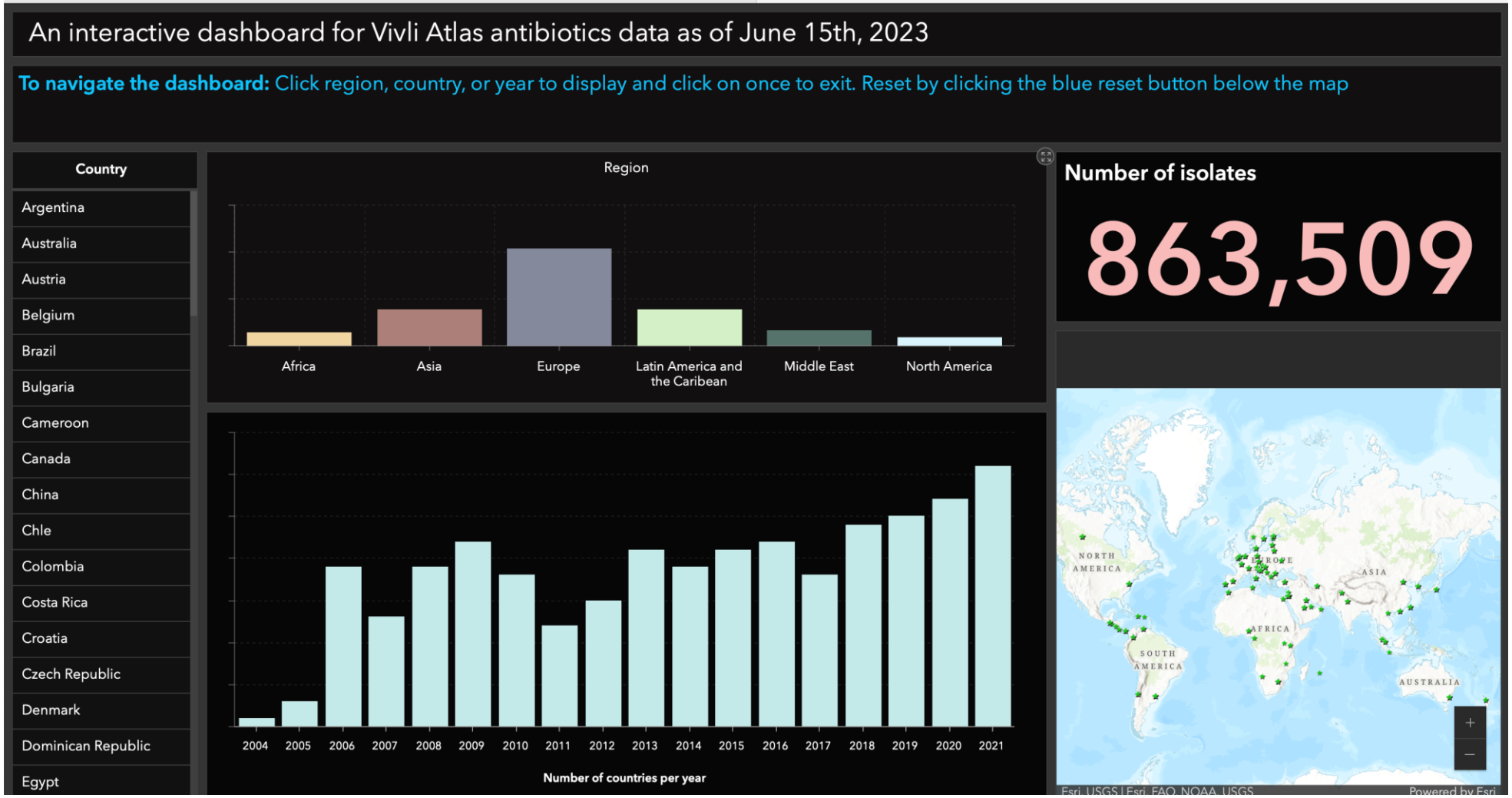
863, 509 rows



# Objective 1: Integrated solution in AMR

- Develop an interactive GIS dashboard encompassing all countries.

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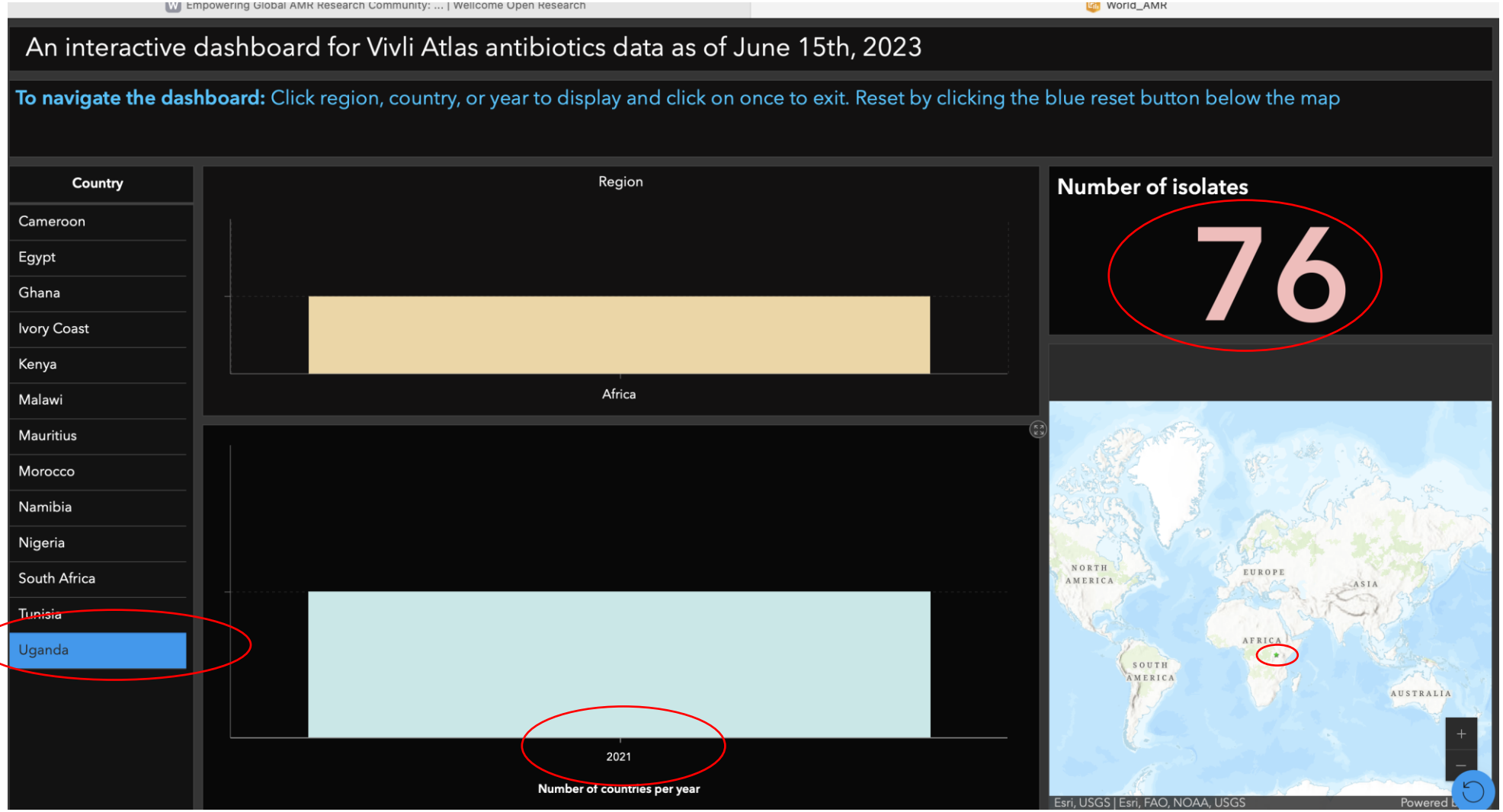
# Objective 1 continued 1

- General information about Uganda.

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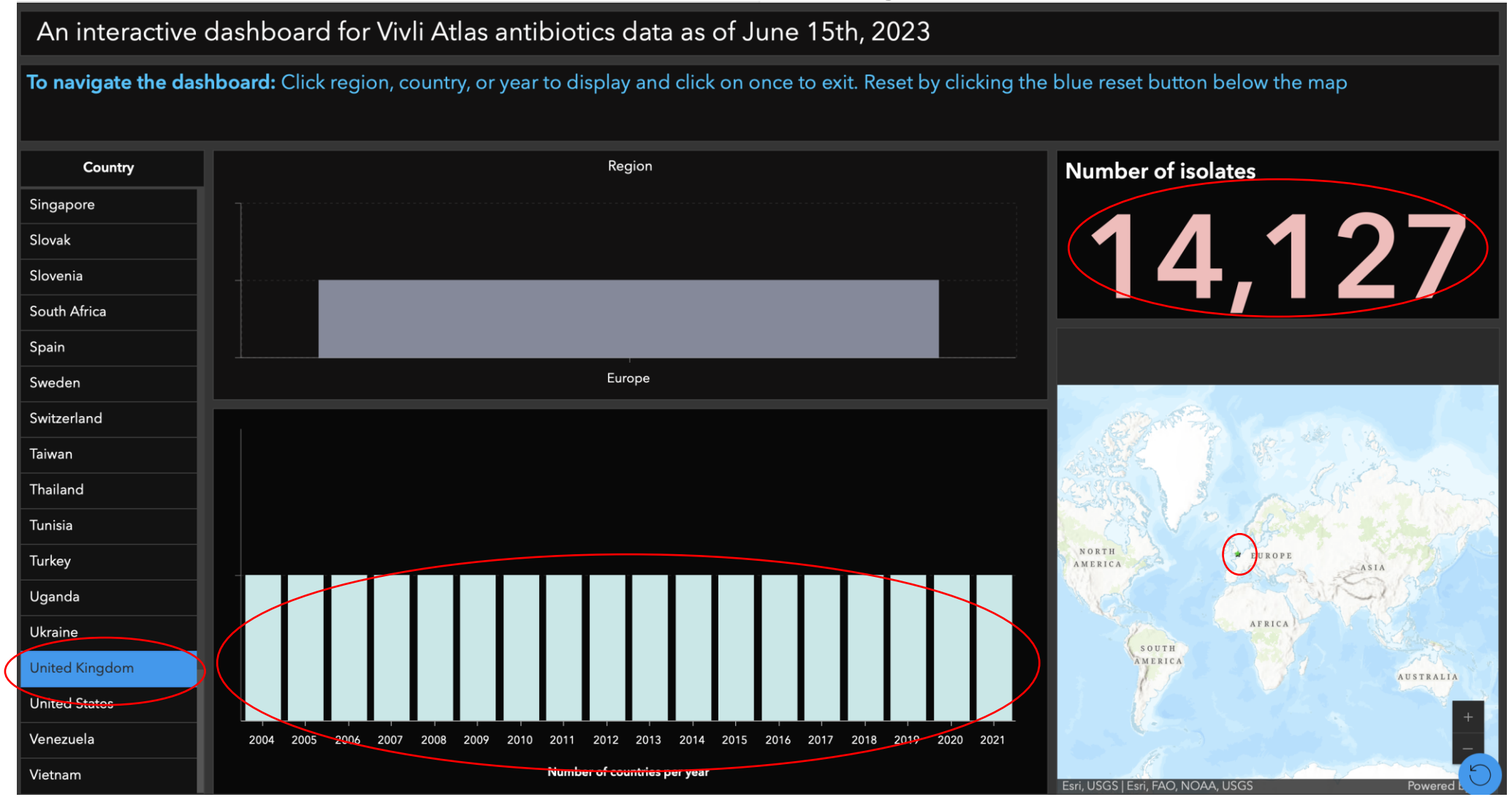
# Objective 1 continued 2

- General information about United Kingdom.

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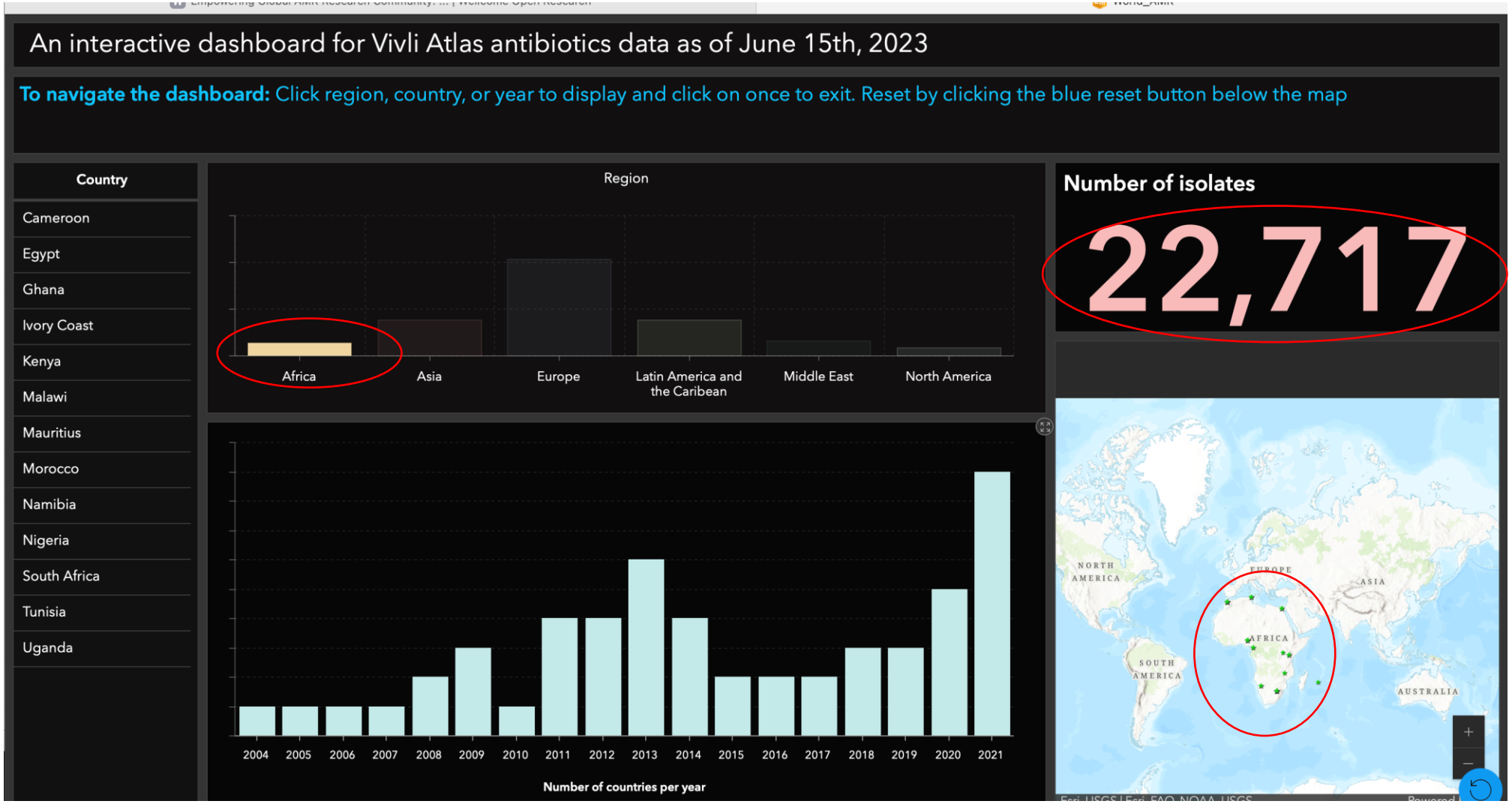
# Objective 1 continued 3

- General information about Africa region.



# Objective 2

- Create an interactive GIS dashboard specific from Kenya and Uganda.

| | | | | | | | | | Antibiotics | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pathogen | Family | Country | Gender | Age Group | Speciality | Source | In / Out Patient | Year | Erythromycin | Moxifloxacin | Imipenem | Levofloxacin | Ampicilin |
| Escherichia coli | Enterobacteriaceae | Uganda | Male | 19 to 64 Year | General Unsp | Endotrachea | No Information | 2021 | Susceptible | Intermediate | Resistant | Resistant | Resistant |
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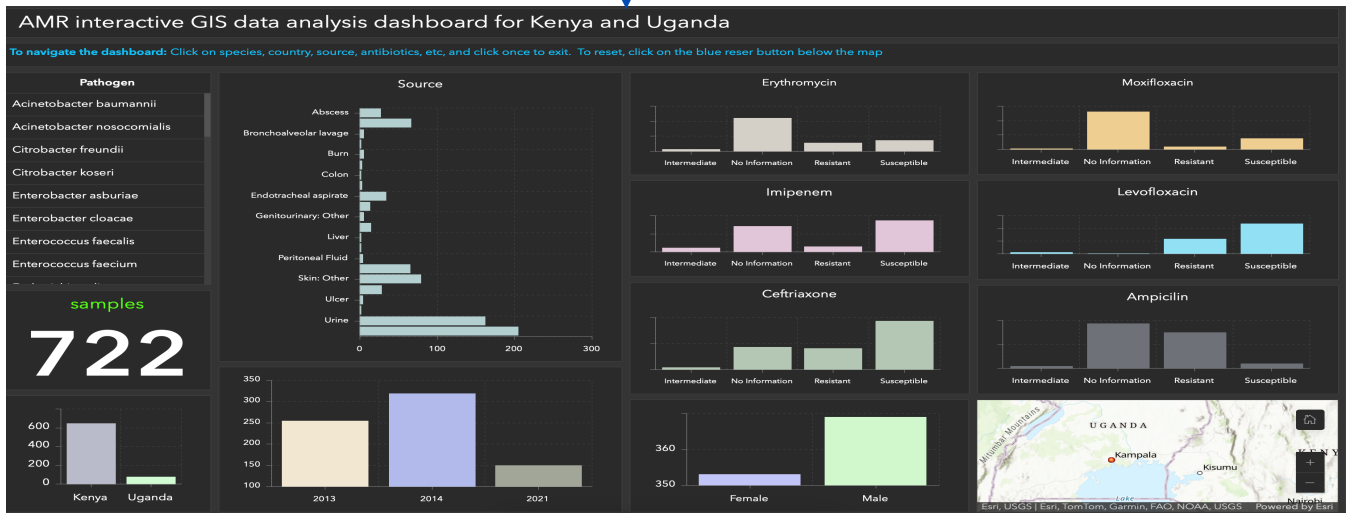
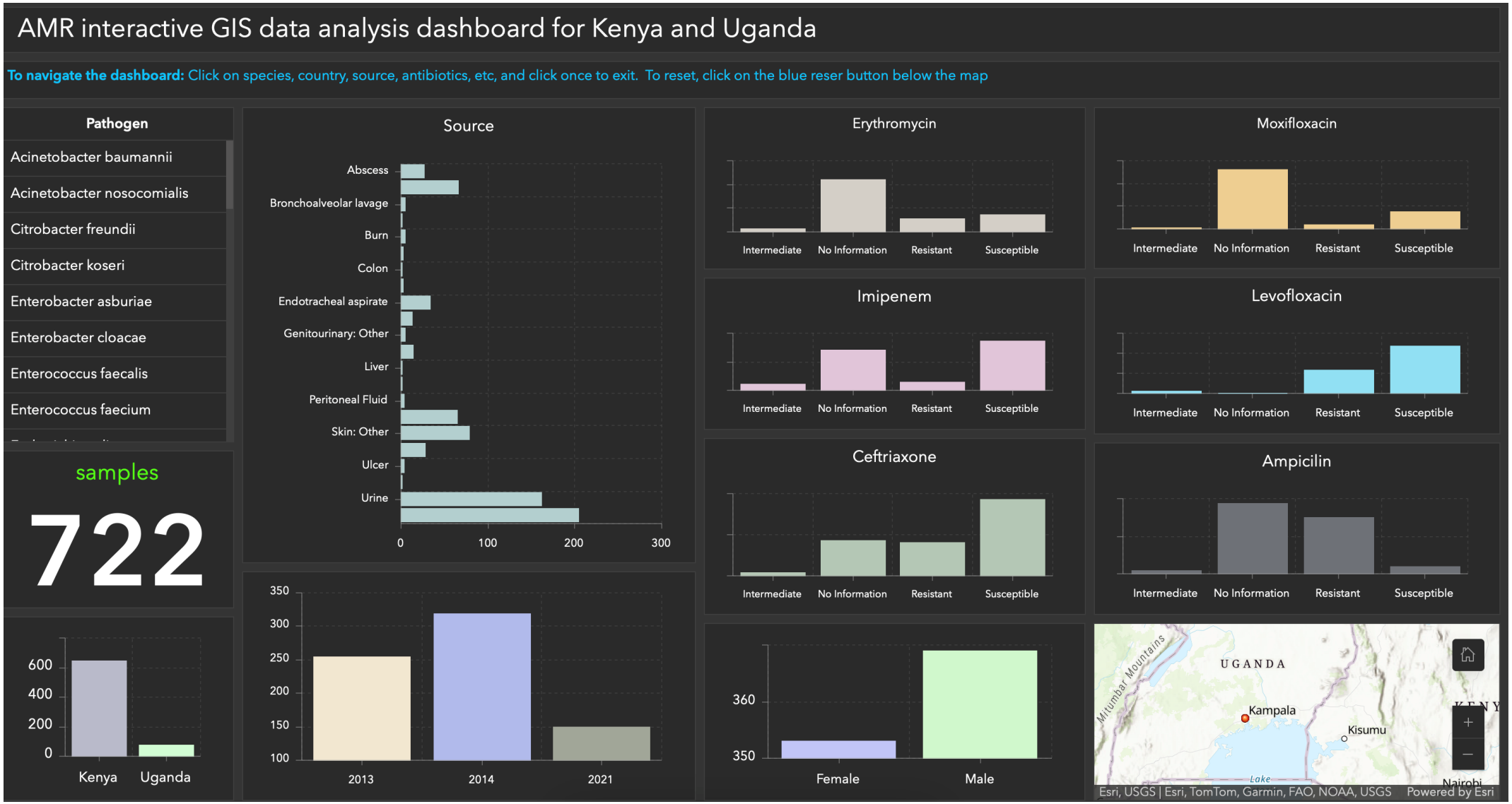


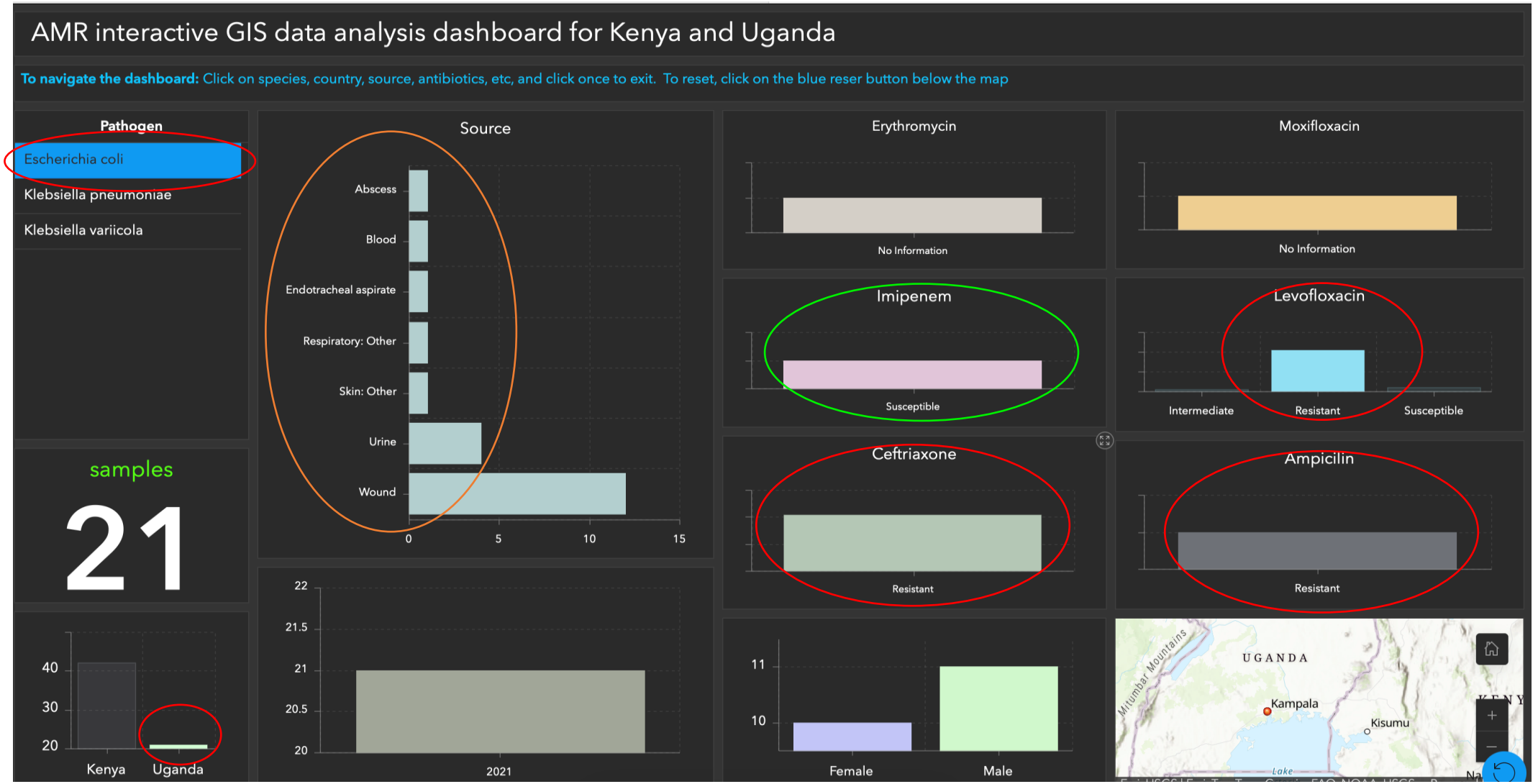
# Objective 2 continued 1

- Create an interactive GIS dashboard specific from Kenya and Uganda.



# Objective 2 continued 2

- Interactive GIS dashboard, Uganda (*E.coli*)

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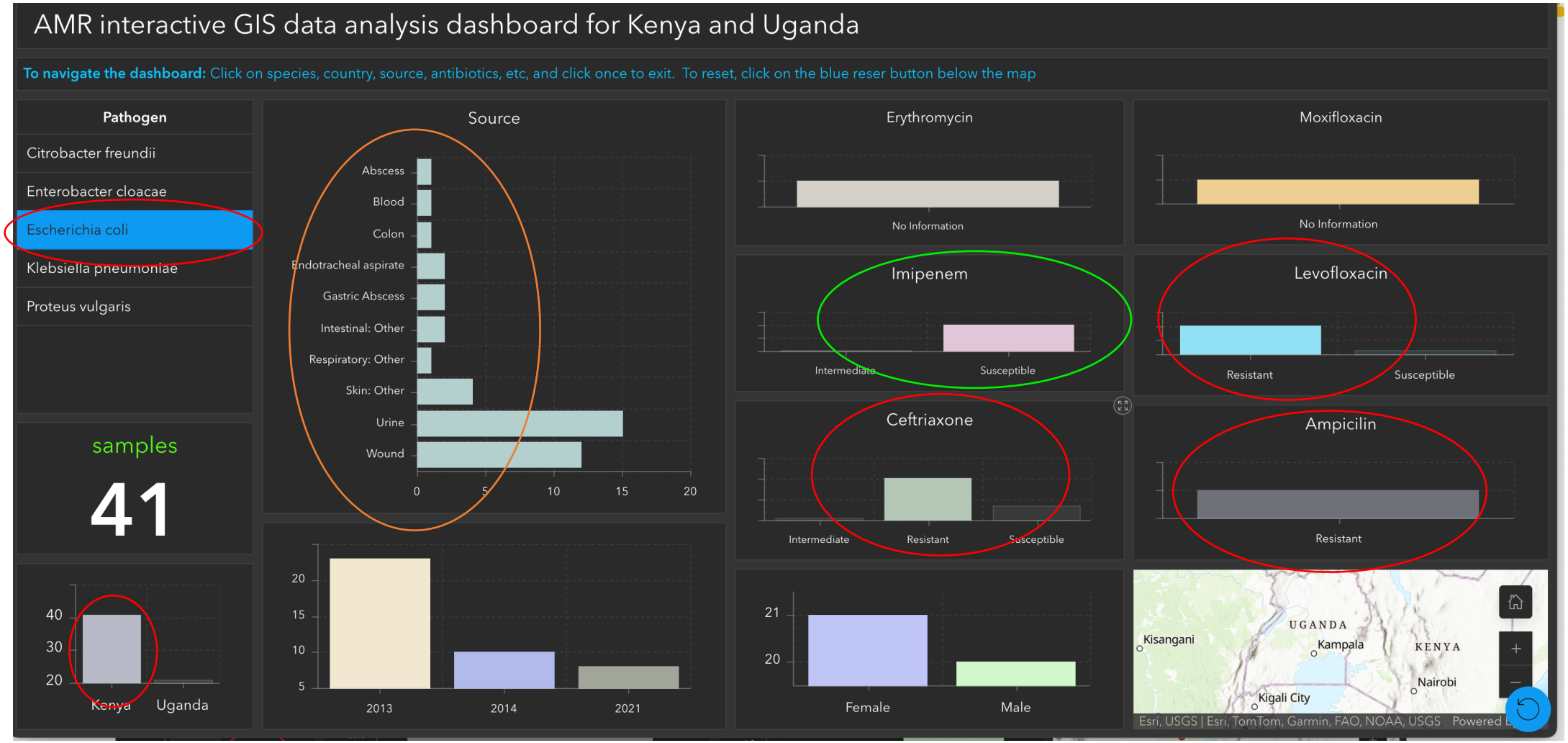
# Objective 2 continued 3

- Interactive GIS dashboard, Kenya (*E.coli*)

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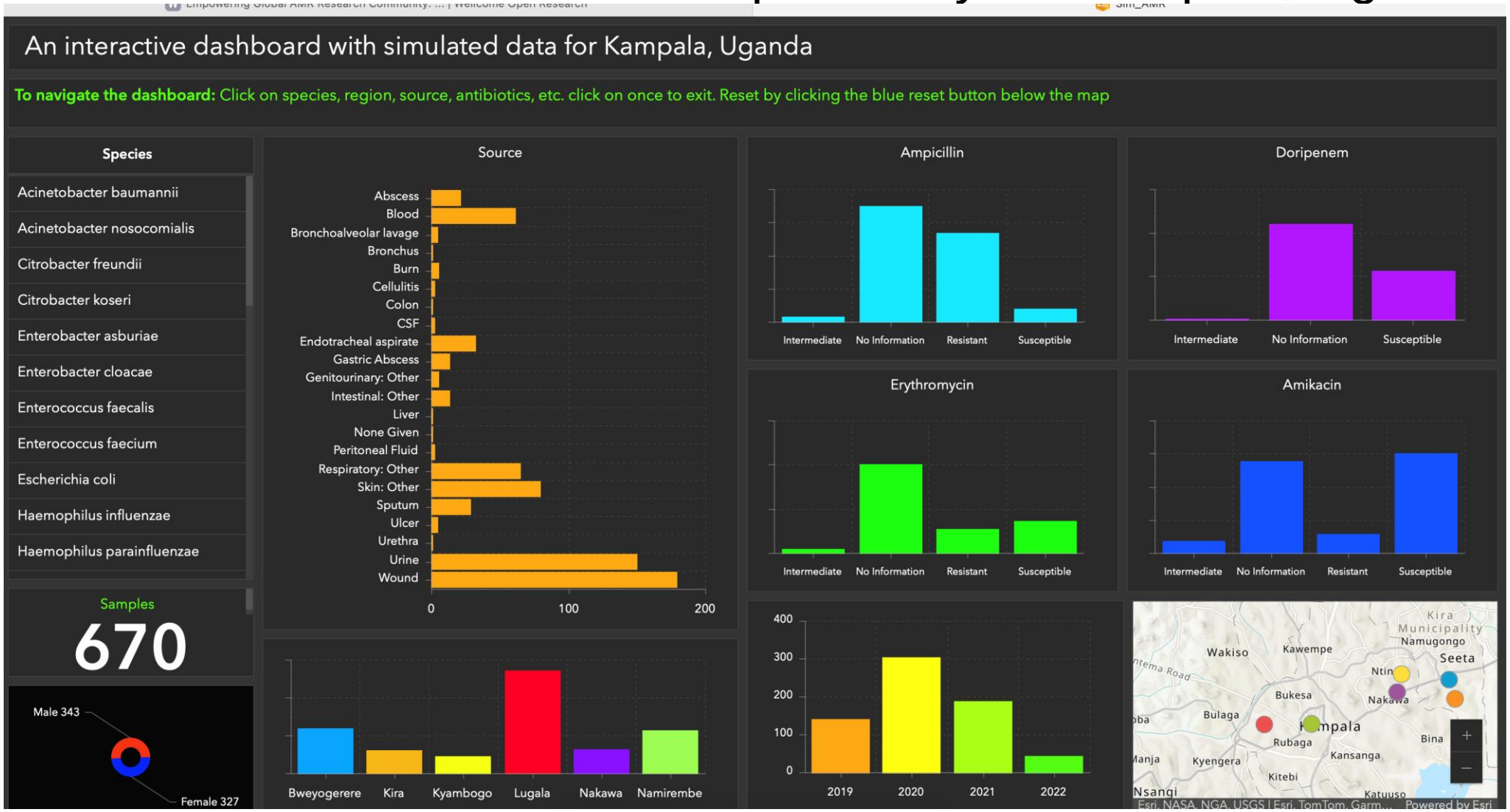
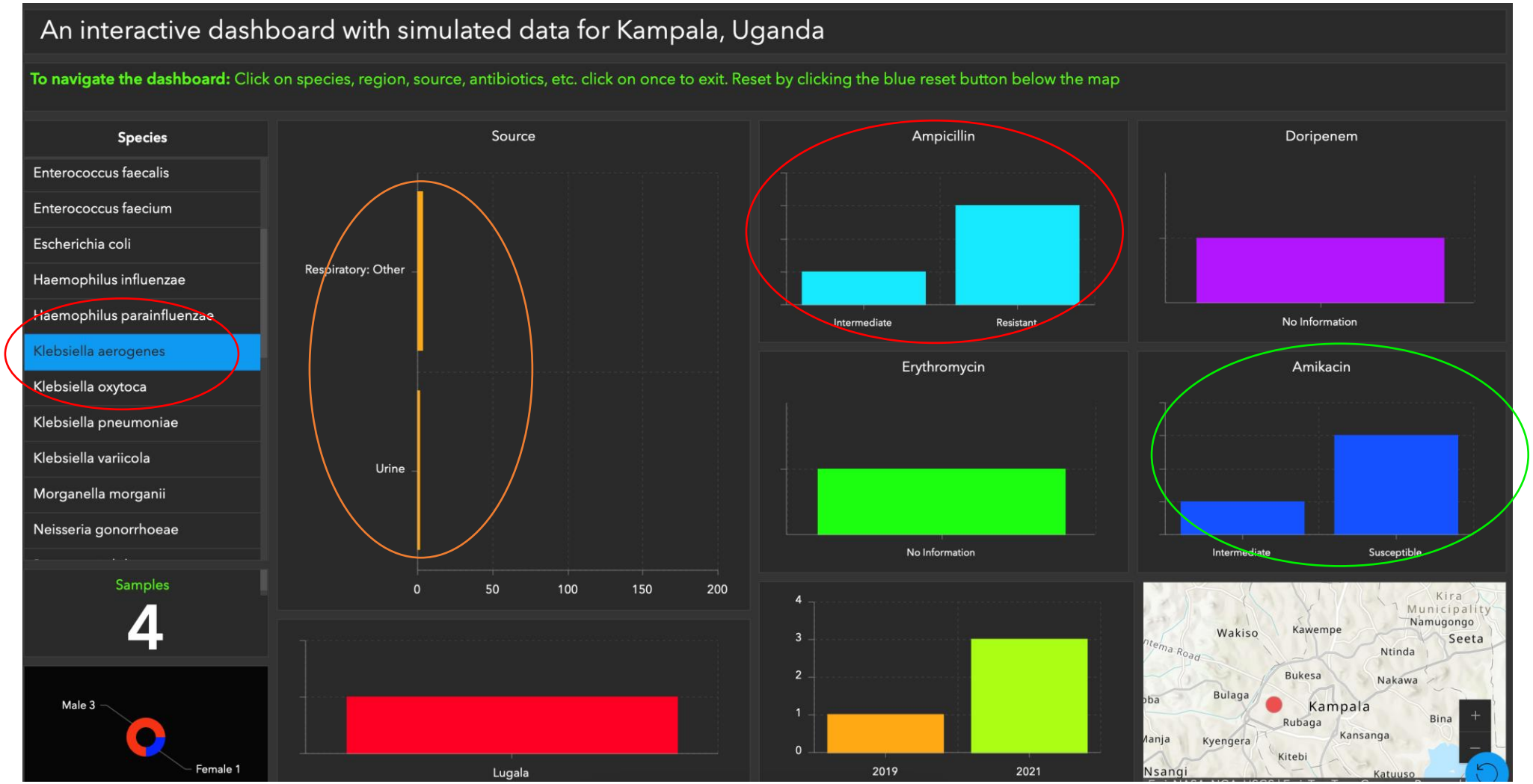
# Objective 3

- Generate a simulated dataset specifically for Kampala, Uganda.



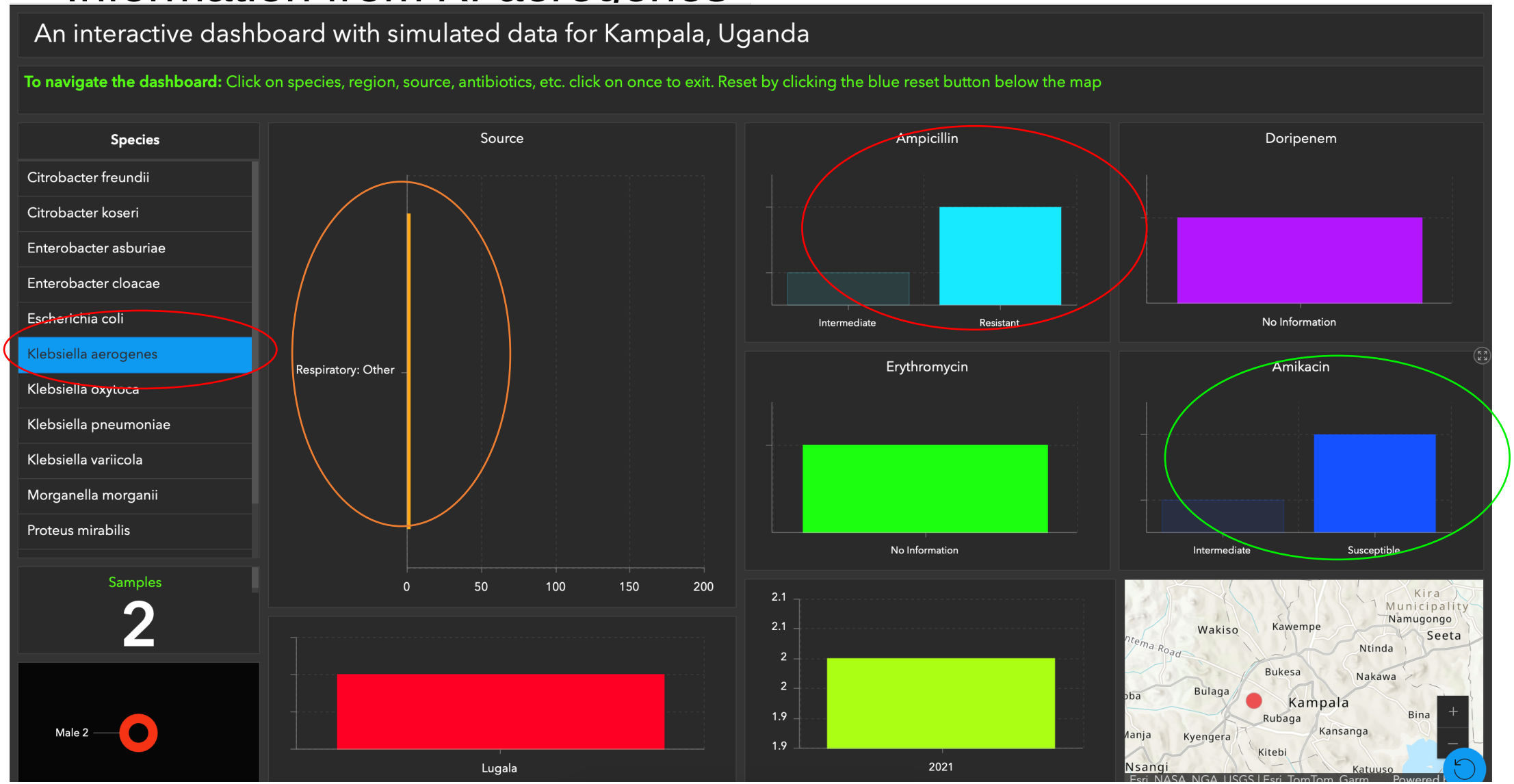
# Objective 3 continued 1

- Information from *Klebsiella aerogenes*.



# Objective 3 continued 2

- Information from *K. aerogenes*



# Impact of interactive AMR GIS dashboards

- Comprehensive and Versatile Tools
  - ➢ Designed for AMR data exploration and analysis.
  - ➢ Suitable for researchers, policymakers, and healthcare professionals.
- Wide Range of Functionalities
  - ➢ Provide access to healthcare, public health, demographics, and economics datasets.
  - ➢ Centralized hub for easy access and analysis of aggregated and organized datasets.

# Impact continue 1

- Data Exploration and Analysis
  - ➢ Allow users to perform complex queries and conduct in-depth analyses.
  - ➢ Enables exploration of patterns, trends, and correlations across multiple regions/districts.
- Cross-Country Comparisons
  - ➢ Facilitate the identification of similarities and differences between countries.
  - ➢ Support the examination of the impact of policies and interventions in specific countries.

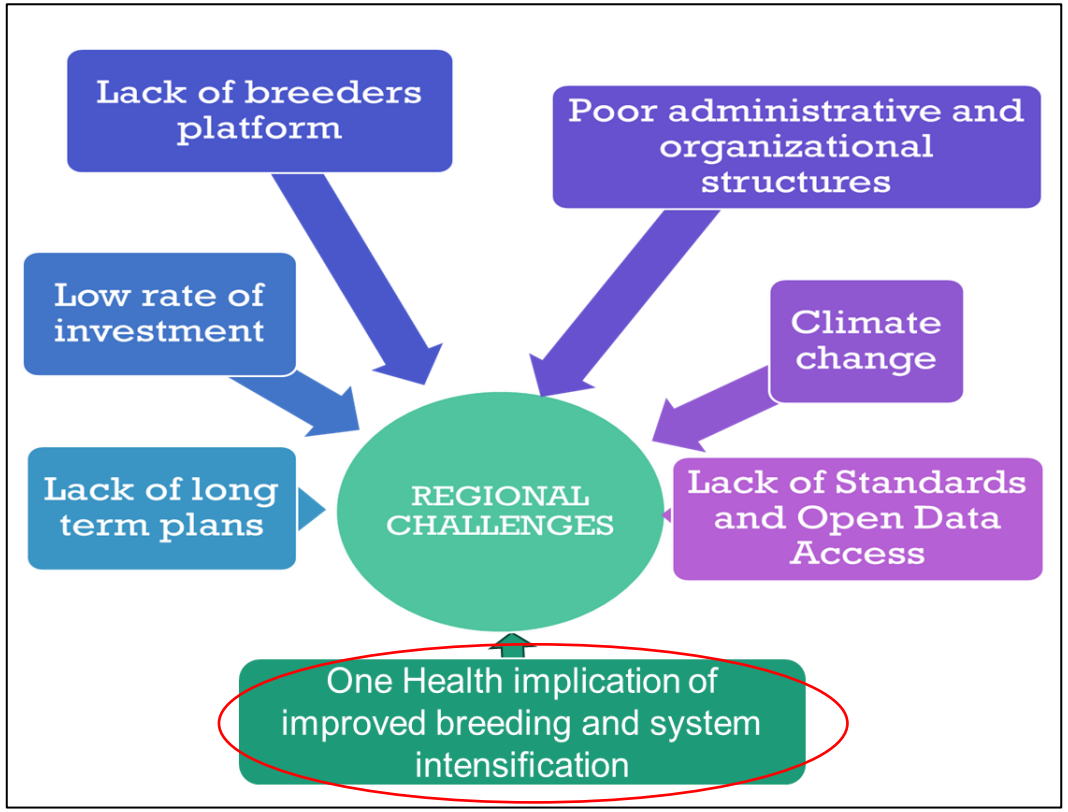
# Impact continue 2

- Decision-Making Support
  - ➢ Policymakers can use insights to inform decision-making processes.
  - ➢ Help evaluate the effectiveness of strategies and identify areas needing improvement.
  - ➢ Aid in developing evidence-based practices, policies, and interventions.
- Empowerment through Data
  - ➢ Empower users to derive valuable insights from AMR datasets across multiple countries.
  - ➢ Support evidence-based decision-making and improvement of AMR research worldwide.

# Integrated solution in One-Health

## Background

- Key Challenges in Animal Breeding Across African Regions.




Dr. Christian Tiambo (ILRI), Green Gold AgroVenture

Ms. Peace Aber (MAGMA)

- Challenges in animal breeding and One Health implication in Africa.

# African Union Animal Resource Seed Centres of Excellence (AU-ARSCoEs)

- West Africa (CIRDES in Bobo Dioulasso, Burkina Faso).
- Southern Africa (Department of Agricultural Research in Gaborone, Botswana).
- Eastern Africa (National Animal Genetic Resource Centre and Data Bank in Entebbe, Uganda).
- Central Africa (University of Dschang, Cameroon)
- North Africa (Banque Nationale de Genes in Tunis, Tunisia)

# One-Health: Animal seeds continued 1

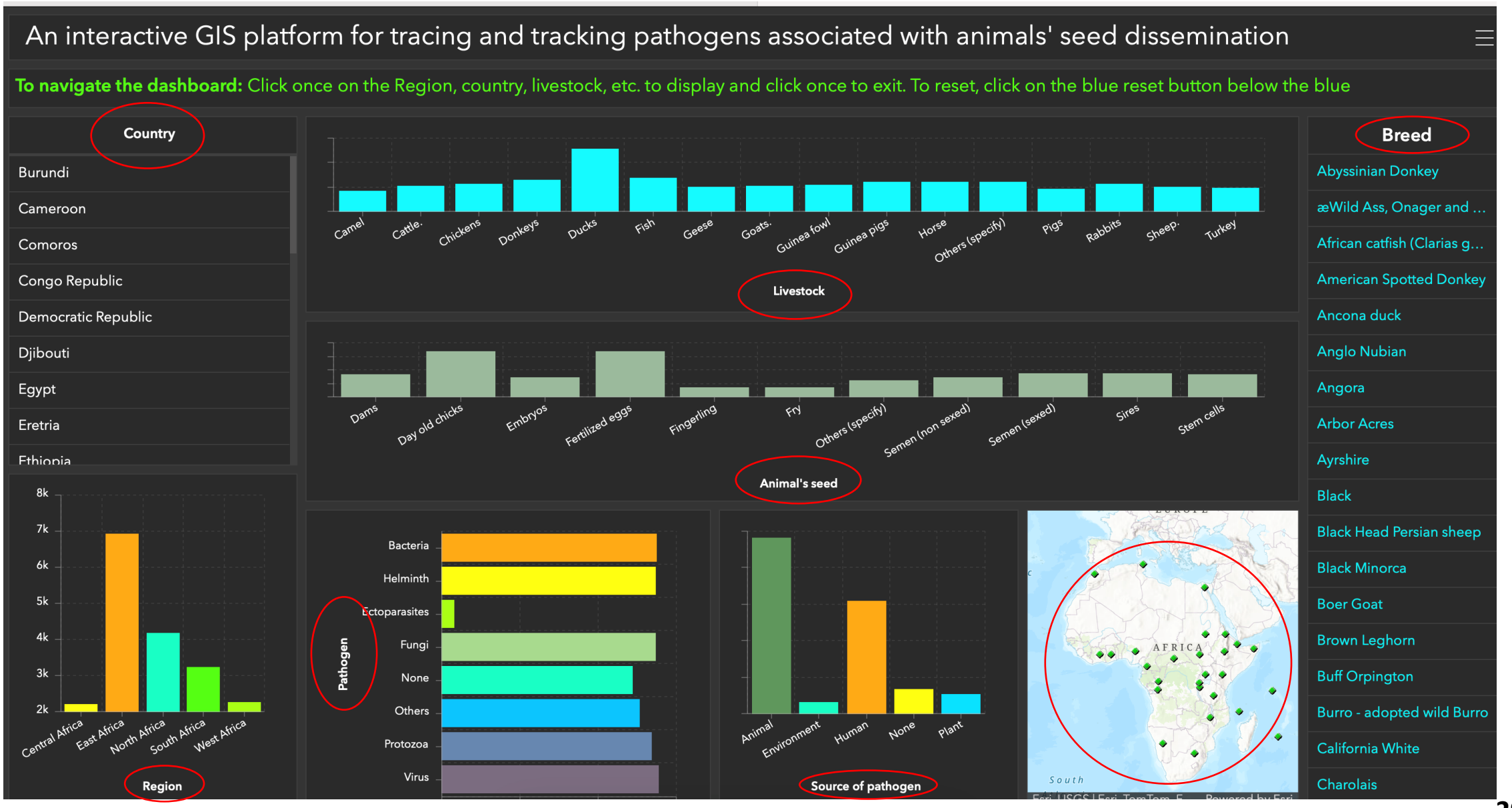
**Innovation to track and trace dissemination of animal seeds and associated pathogen surveillance in Africa**

- **Simulated data**
  - African countries

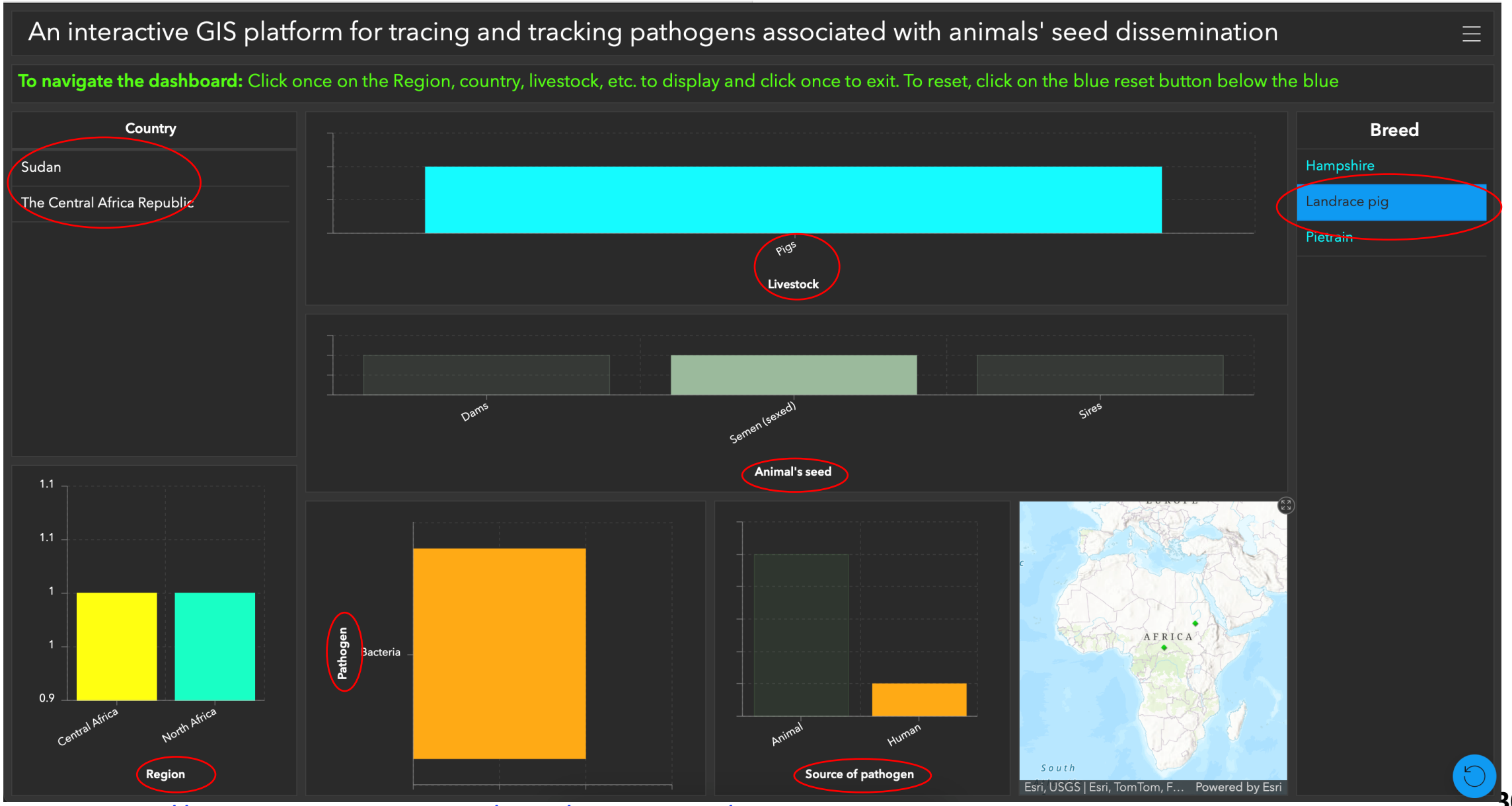
- **Animal breeding**
  - Livestock (Cattle, donkeys, pigs, chicken, ducks, fish, etc.).
  - Breed (Jersey, African catfish, local pigs, etc.).
  - Animal seeds (Dams, day old chicks, embryos, semen, etc.).

- **One-Health**
  - Pathogens (Bacteria, fungi, virus, etc.).
  - Source of pathogens (environment, human, plant, and animal).

# Interactive GIS platform for animals' seed dissemination



# Tracking semen (sexed) from a pig

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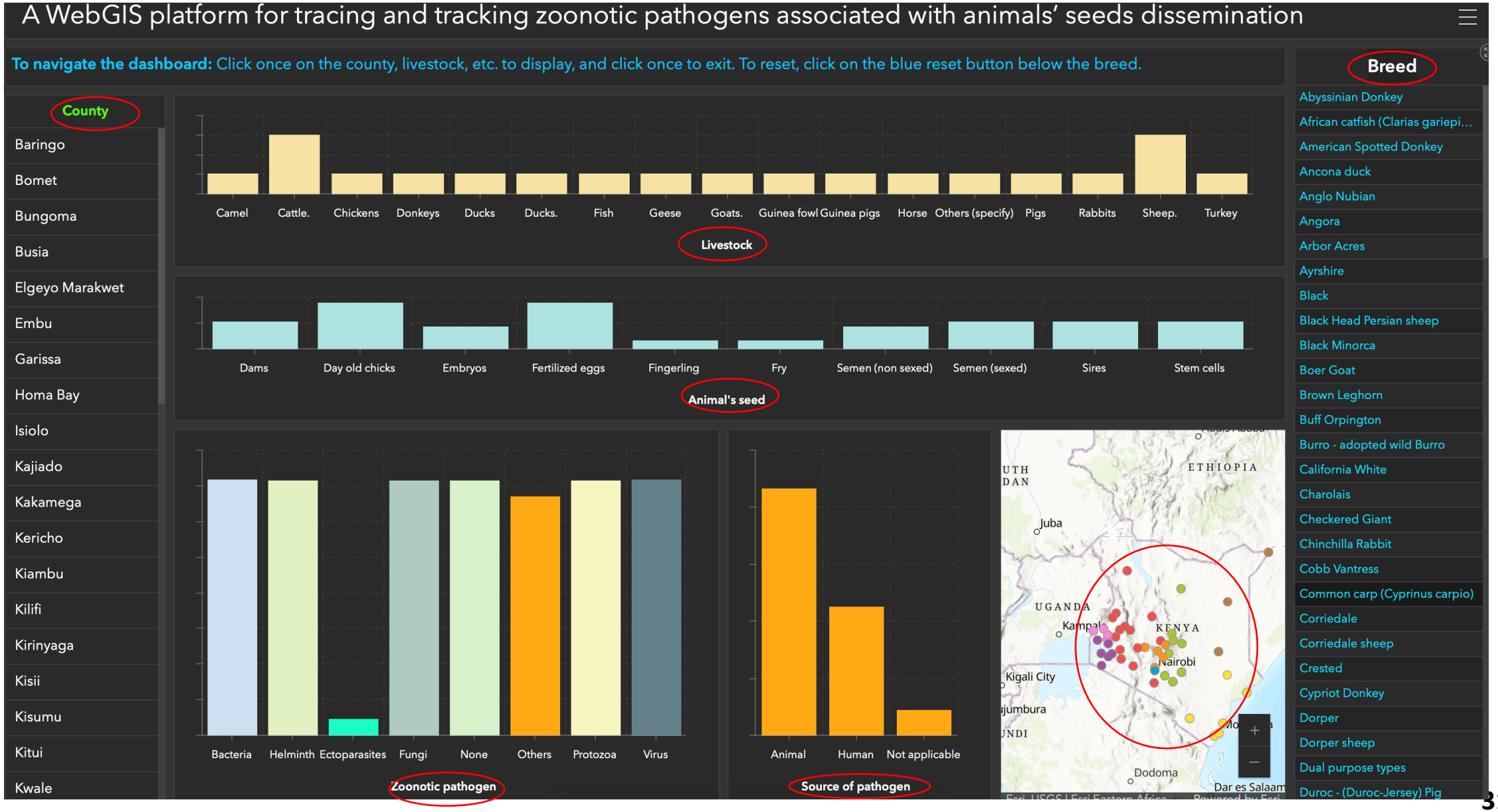
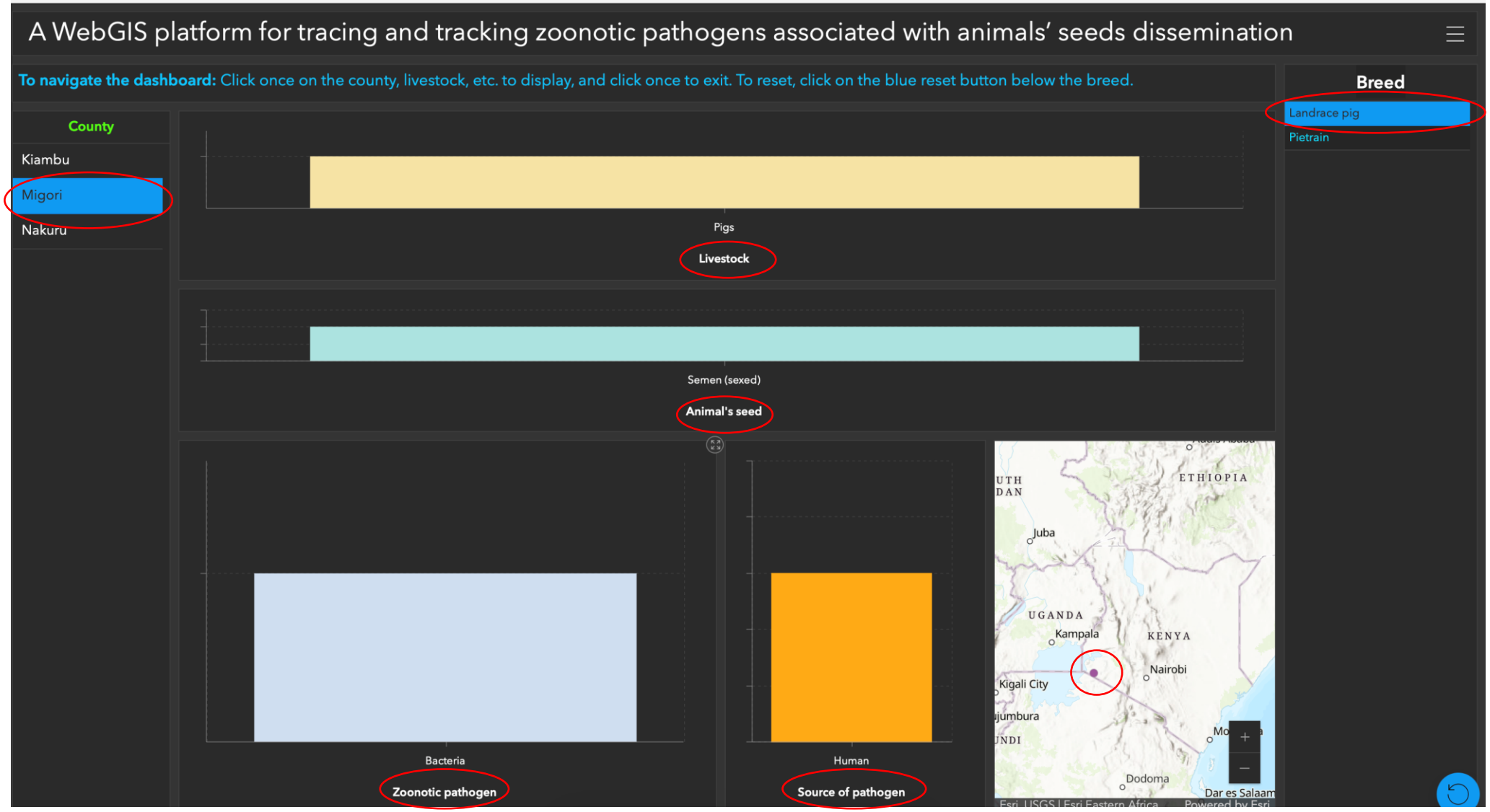
# Tracking data from Kenya (county)



# Tracking semen to a county in Kenya

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# Summary of Integrated solution in One-Health

- Demonstrated how dissemination of animal genetic material and associated pathogens could be tracked and traced.

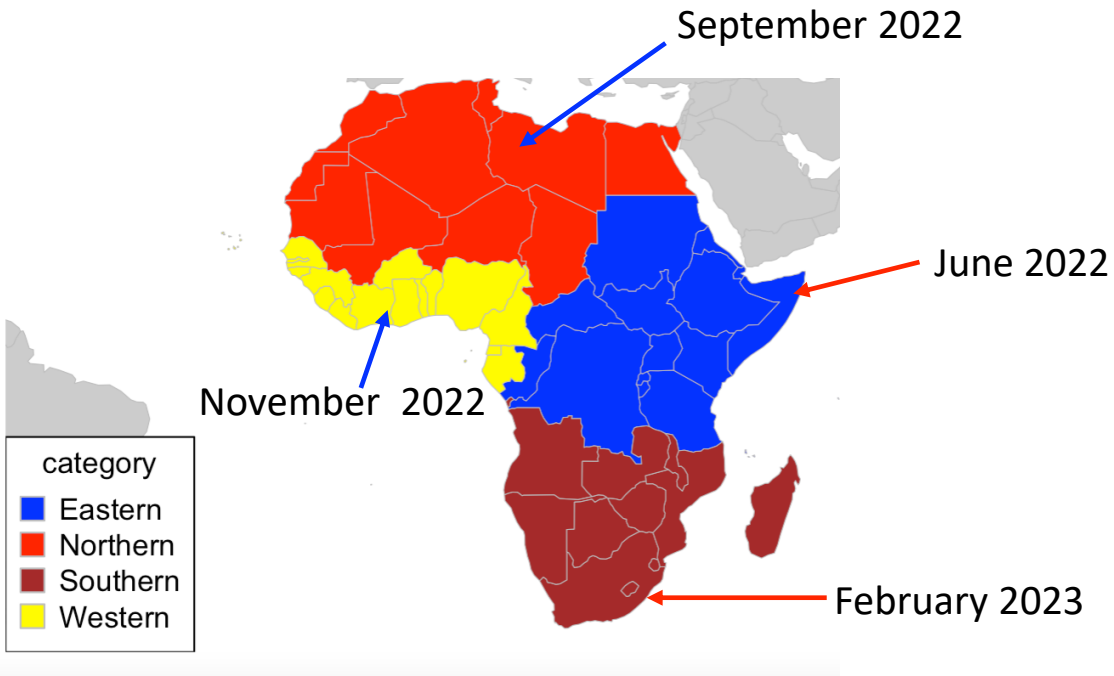
- GIS platform for Africa regions, countries.

- GIS platform at a country level, Kenya (county level).

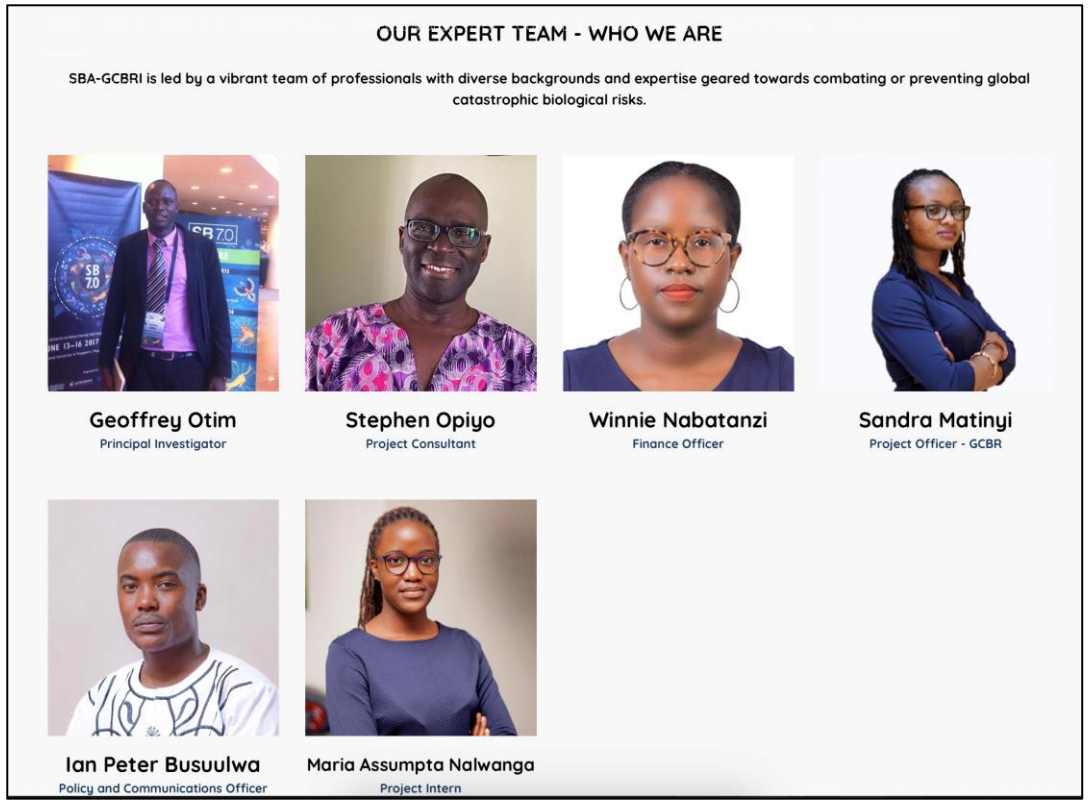
# Integrated solution in Pandemic Preparedness

## Background

- 2022 **SynBio Africa** received funds for Global Catastrophic Biological Risks (GCBRs) initiative.




**Workshops**




http://gcbri.synbioafrica.com

- Workshops identified information required to develop a rapid warning system for pandemic preparedness

# A Rapid Warning System for Pandemic Preparedness

- **Key Concepts:** Development of a Rapid Warning System for detecting, preventing, and responding to biological risks.

- **Proposed Activities:** Use a One-health approach to develop a rapid warning system to detect, prevent, and respond to biological risks.

- **GIS platform**: Use interactive **GIS** platform to **track** activities.

# Requirements to develop biological risks warning system

| Source of data | Source of biological risks | Technology | Human resource | Capacity development | Stakeholders/ collaborators |
|---|---|---|---|---|---|
| Metrics (Number reported cases, patients' symptoms) | Community | Tools for testing biological risks | Skilled technicians required for sample collection, analysis, and interpretation | New courses | Government |
| One-health (humans, animals, environments, plants) | Laboratory | Biological reagents and electronics components, and tools for sample storage | Public health officials to work with the community | Certification in various fields | Non-government |
| Genomics | Wildlife | Computers, databases, data storage, and data analysis | Wildlife officials to work with the wildlife pathogens | Workshops | Private sectors |
| Climate | Engineered | Next generation sequencing equipment | Veterinary doctors to work with domestic animal pathogens | Conferences | Public sectors |
| Human behavior and social-economic data | Others | Mobile application technology | Medical doctors work with human pathogens | Refresher courses | Educational Institutions |
| Literature, mainstream media, social media | | Transport technology | Phytopathologists work with plant pathogens | Training of trainers | Ministries |
| Regional (Africa CDC) | | Surveillance | Data scientists, and bioinformaticians to analyze and interpret genomics data | Fellowships | Regional partners |
| International (WHO) | | Artificial Intelligence | Government officials to work on legal framework and policy | Others | International |
| | | | Trainers to train people in different areas | | Donors |

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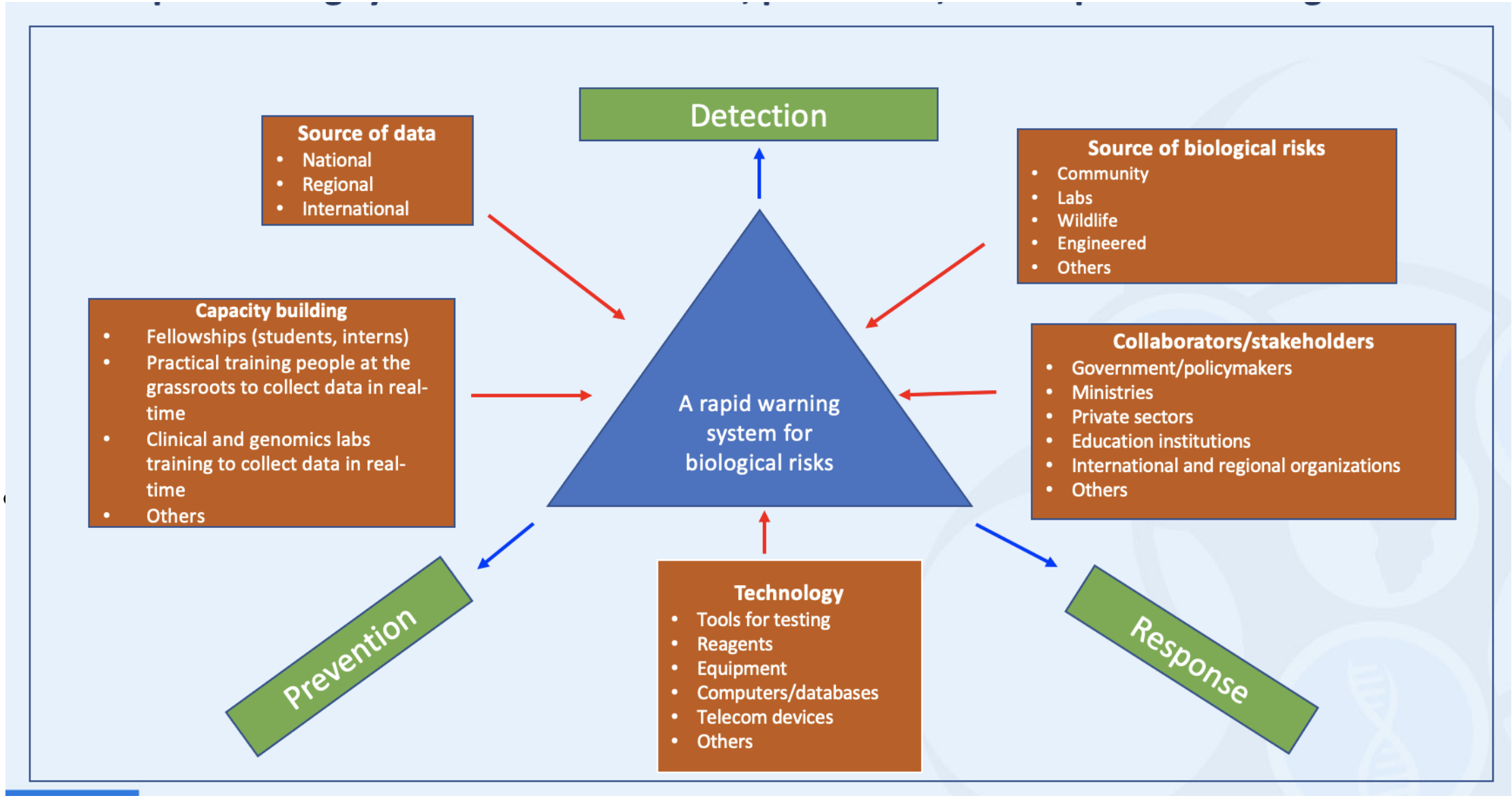
# A rapid warning system to detect, prevent, and response to biological risks

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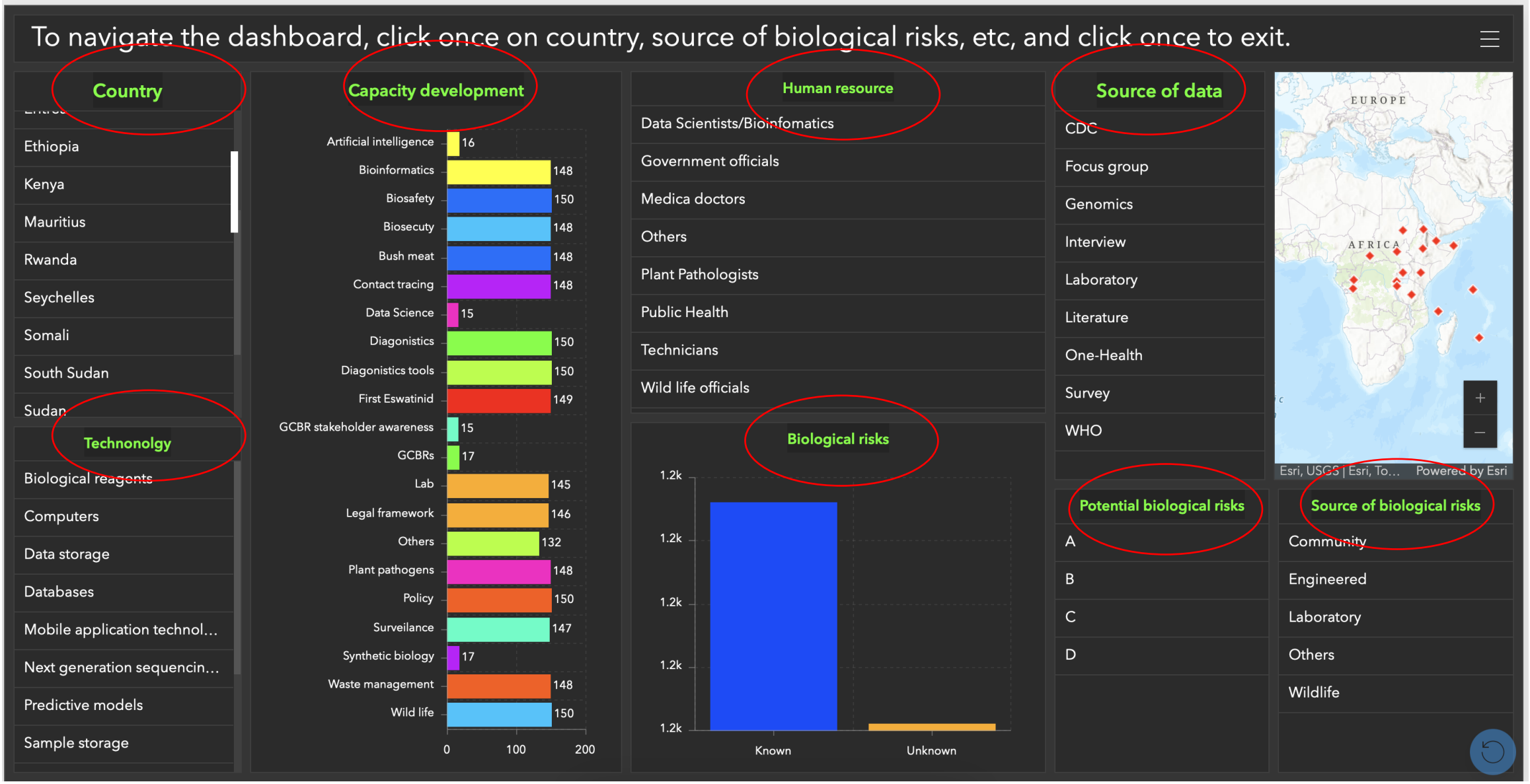
# Interactive GIS platform for a rapid warning system for biological risks

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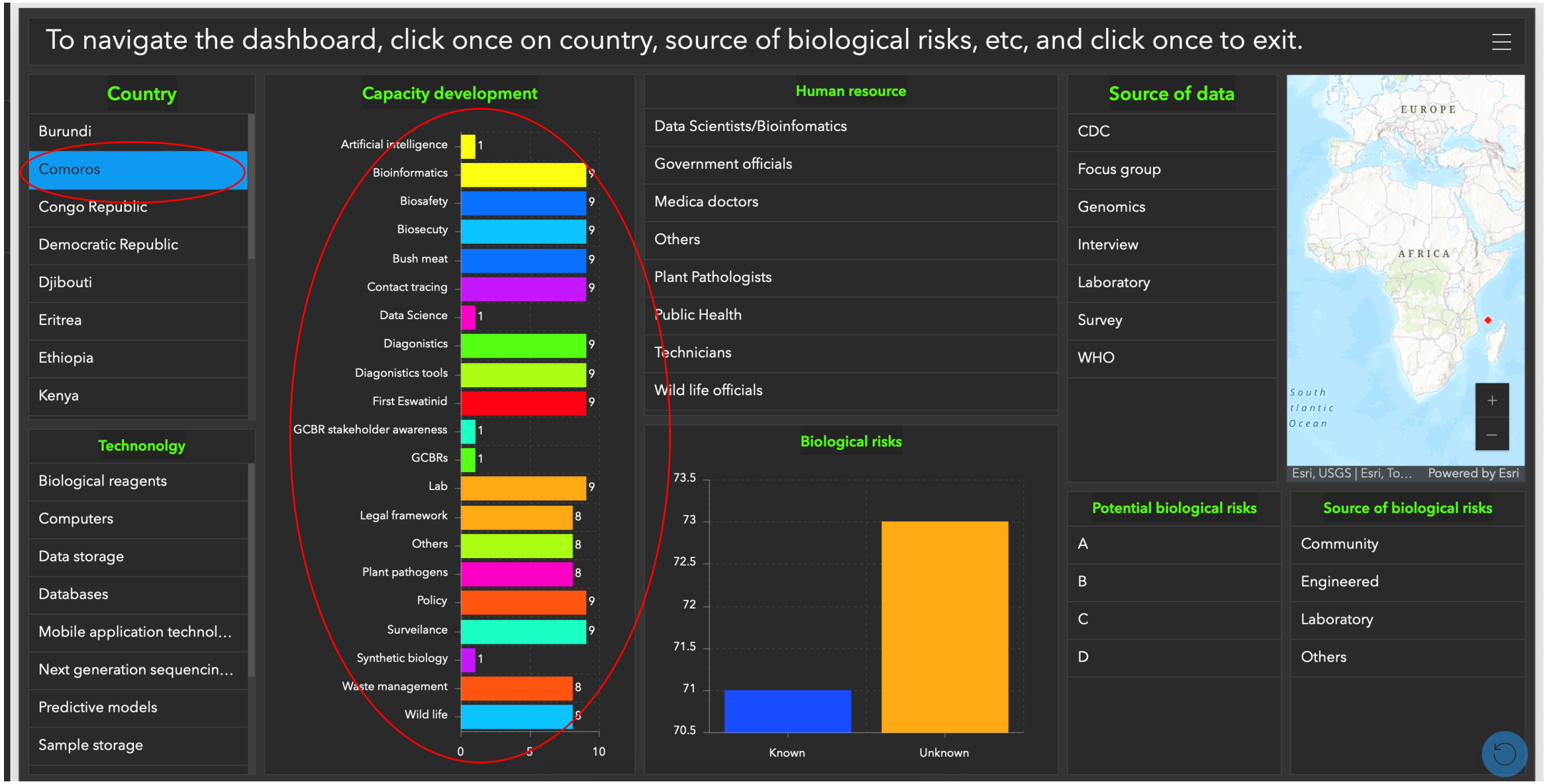
# A model of a rapid warning system for biological risks

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# Demonstration AMR data from South Africa

South Africa

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- Audience
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- Wellcome



Collaborators




Co-authors

ASLM

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# THANK YOU

Patira MCI Synthetic Biology Africa SBA Pfizer Wellcome Green Gold Vivli Center for Global Clinical Research Data Open Philanthropy ILRI International Livestock Research Institute CGIAR Centre for Tropical Livestock Genetics and Health