

ASLM

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

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Patira Data Science (Uganda and USA)

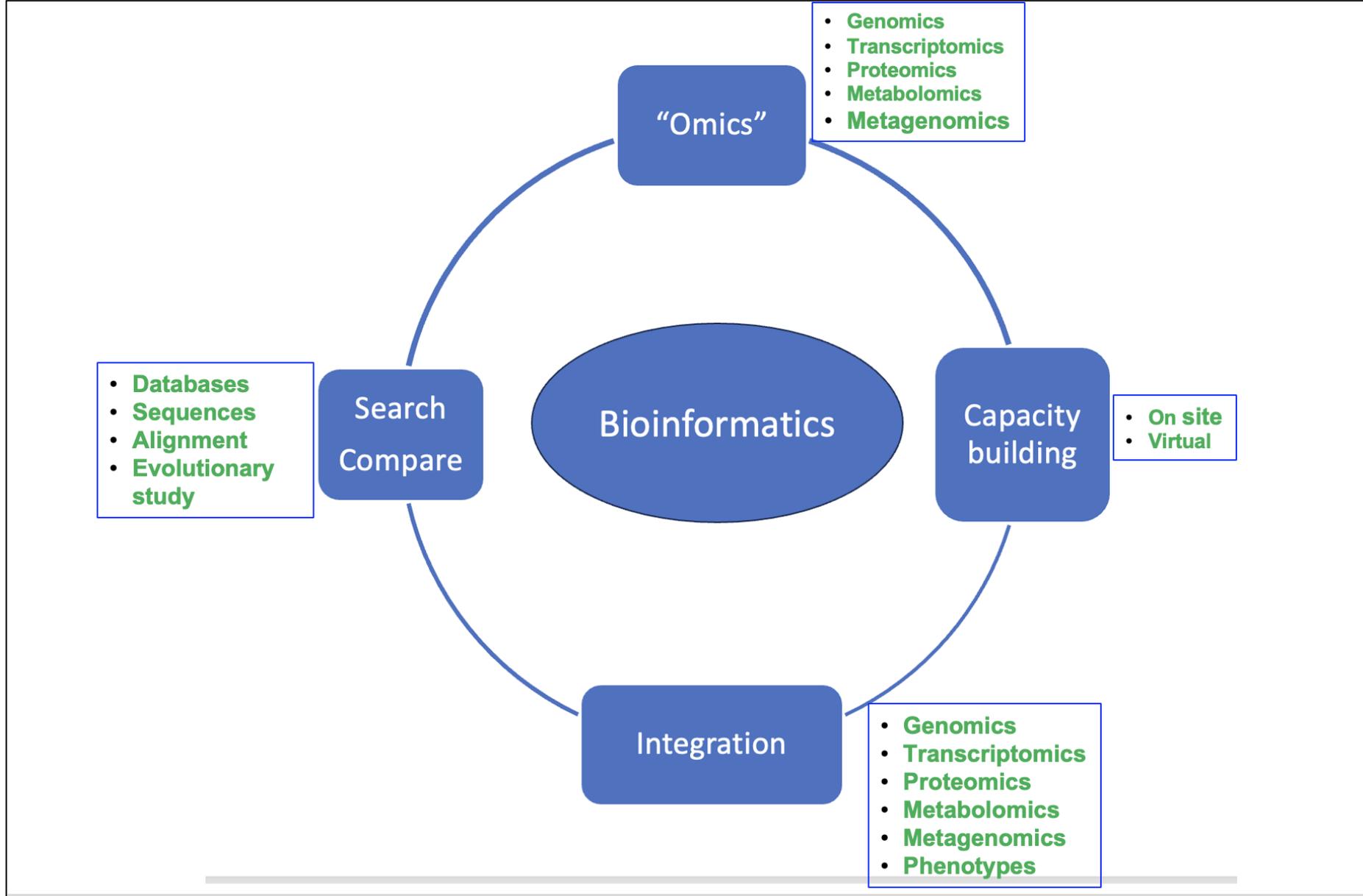
opiyo@patiradatascience.com

June 28th, 2024

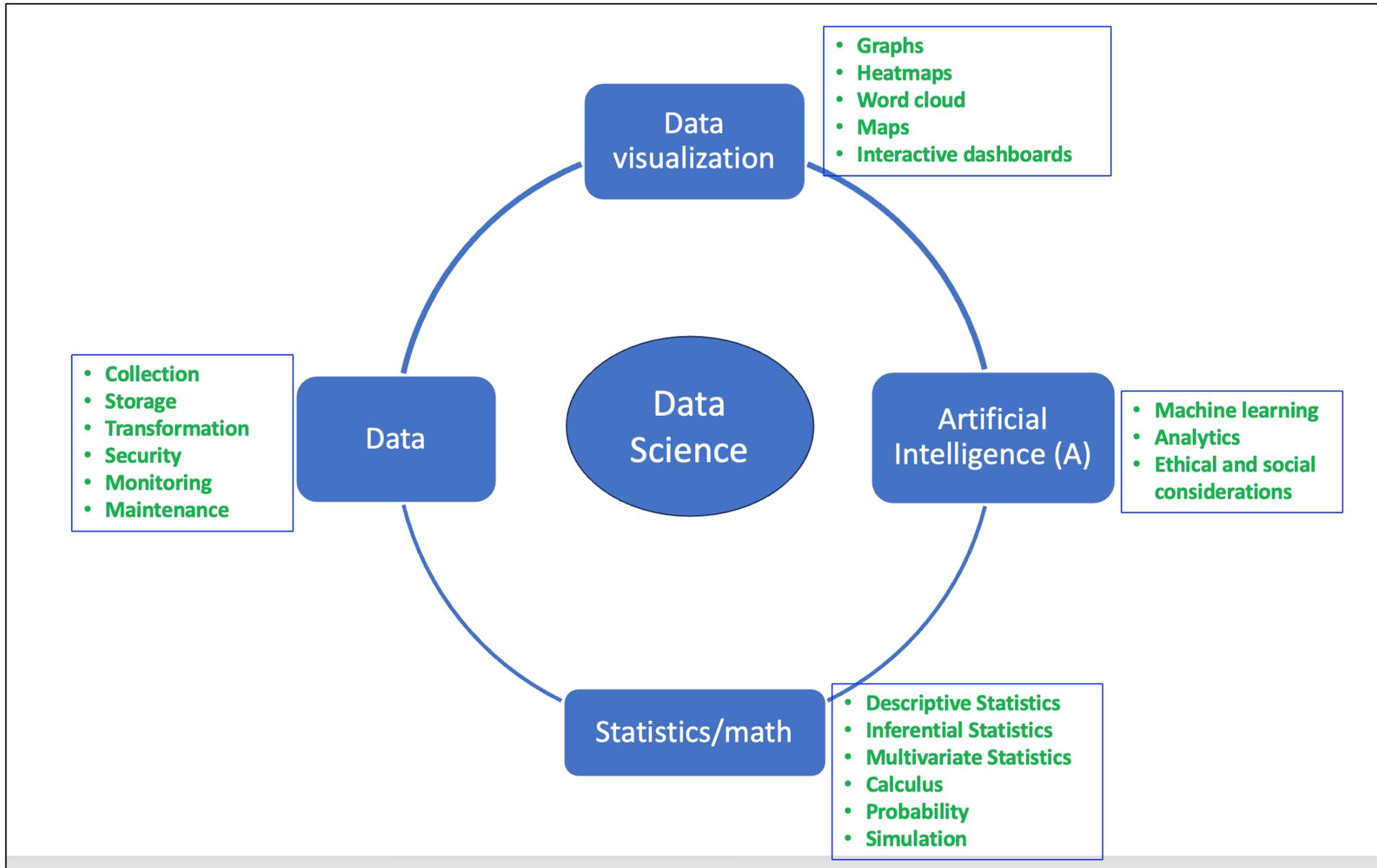


- Introduction
 - What is Bioinformatics?
 - What is Data Science?
 - What is an interactive Geographical Information System (GIS) platform?
- Integrated solution in Antimicrobial Resistance (AMR).
- Integrated solution in One-Health.
- Integrated solution in Pandemic Preparedness.

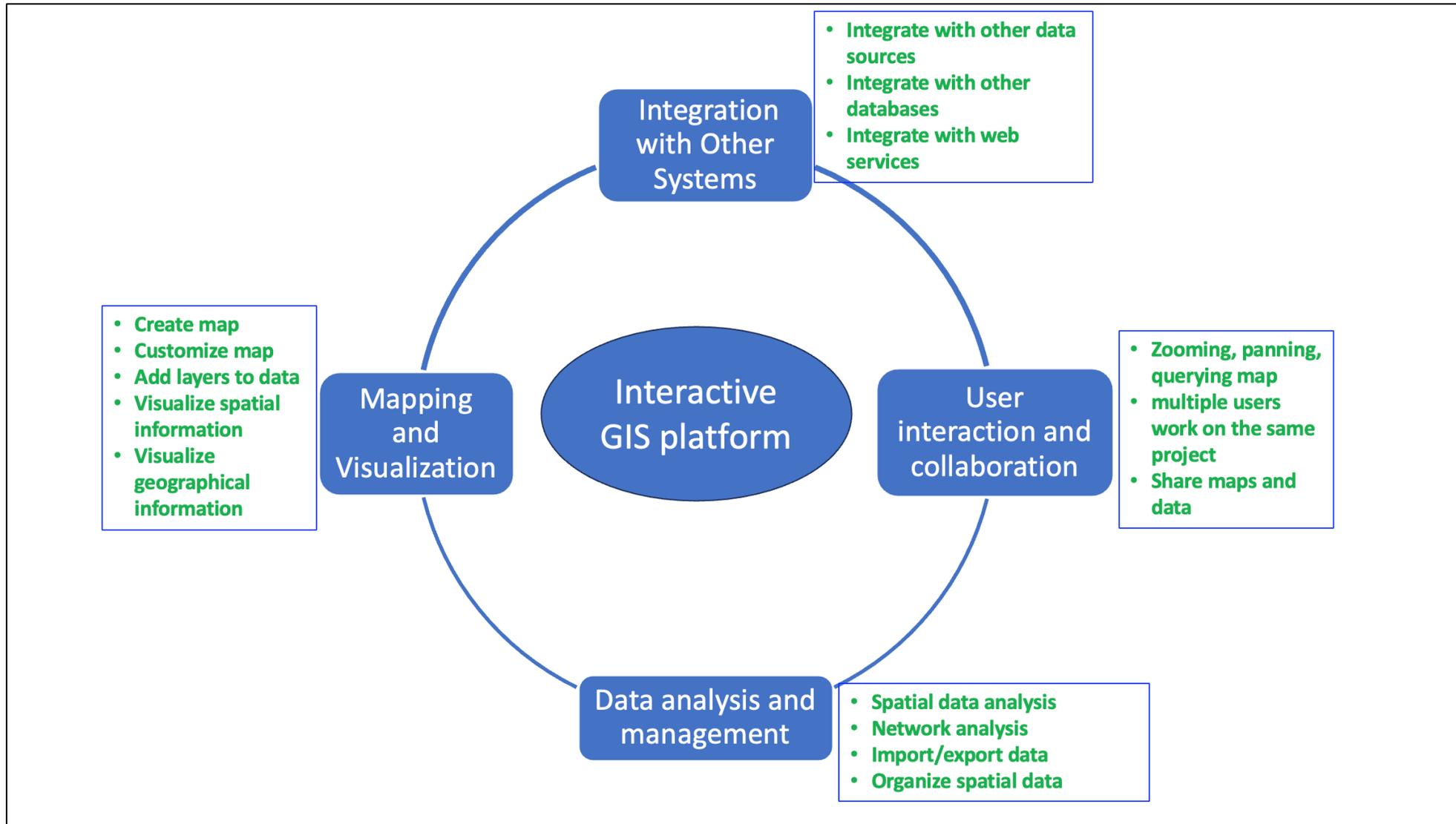
What is Bioinformatics?



What is Data Science?



What is an interactive GIS platform?



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, Wellcome, 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**.

- 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
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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
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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.

- **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

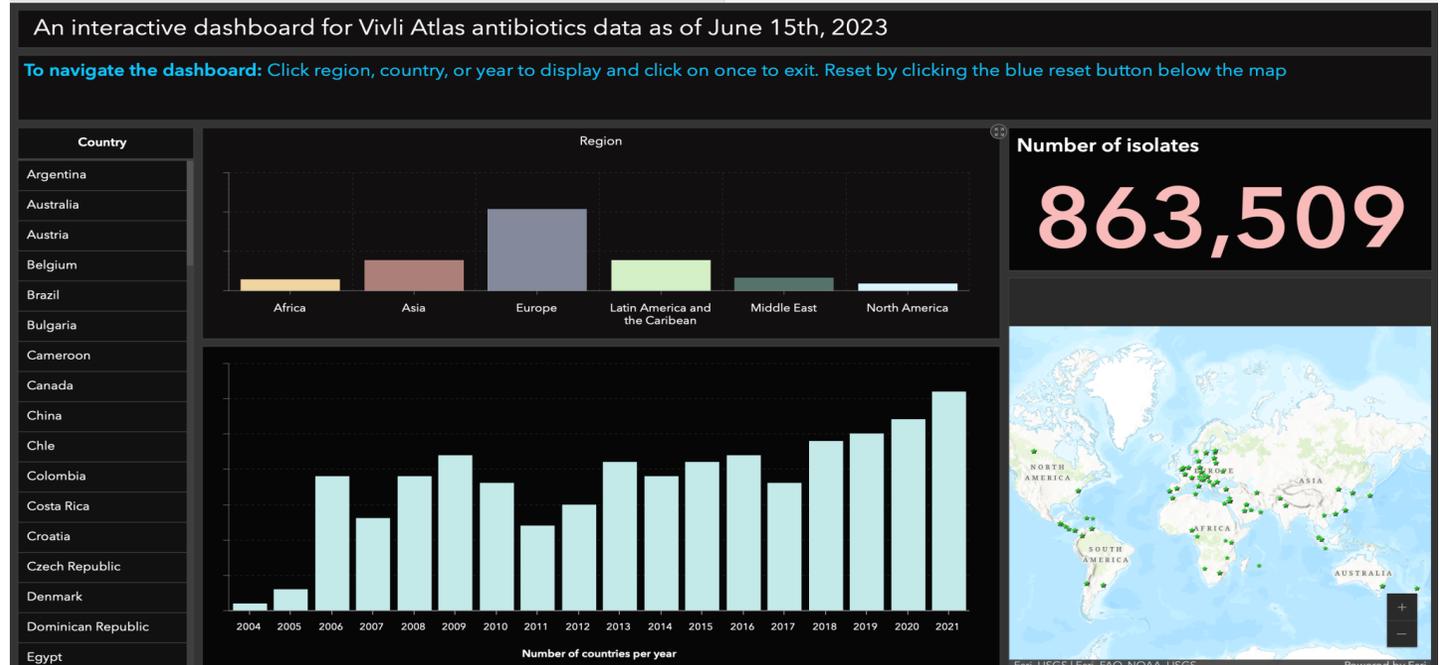
<https://wellcomeopenresearch.org/articles/9-234>

Objective 1: ATLAS dataset presented in interactive GIS dashboard

126 columns

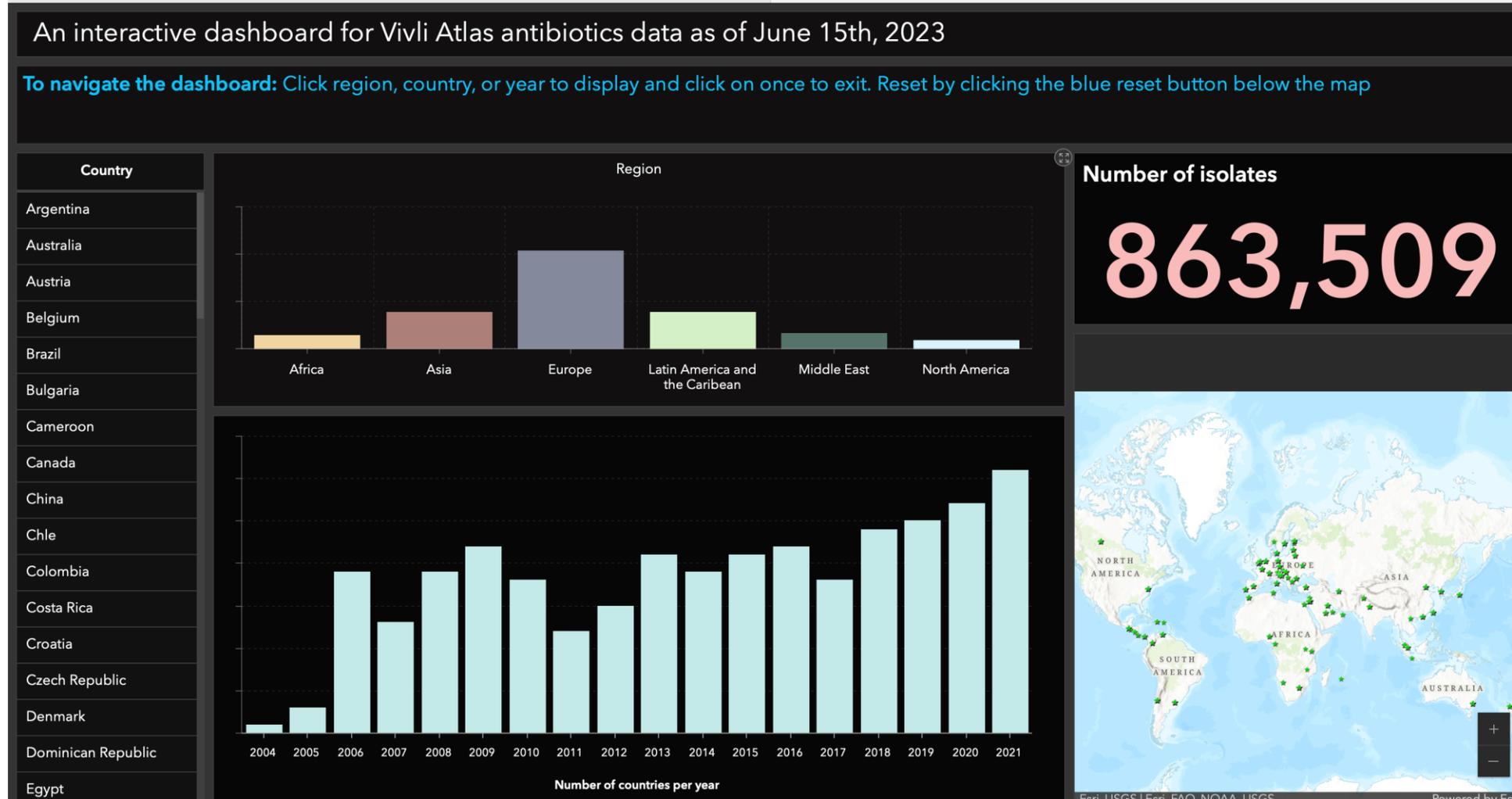
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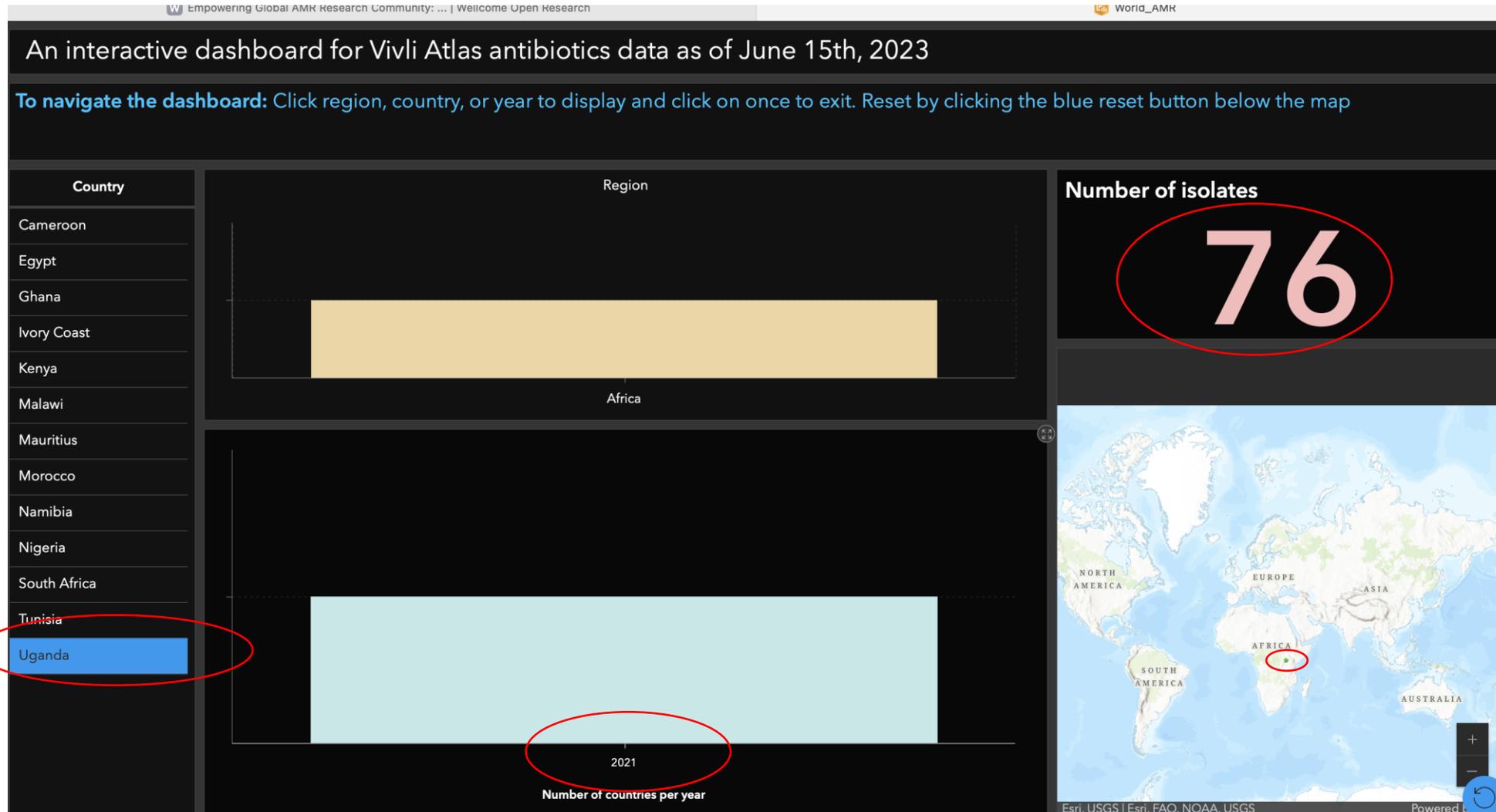


Objective 1: Integrated solution in AMR

- Develop an interactive GIS dashboard encompassing all countries.



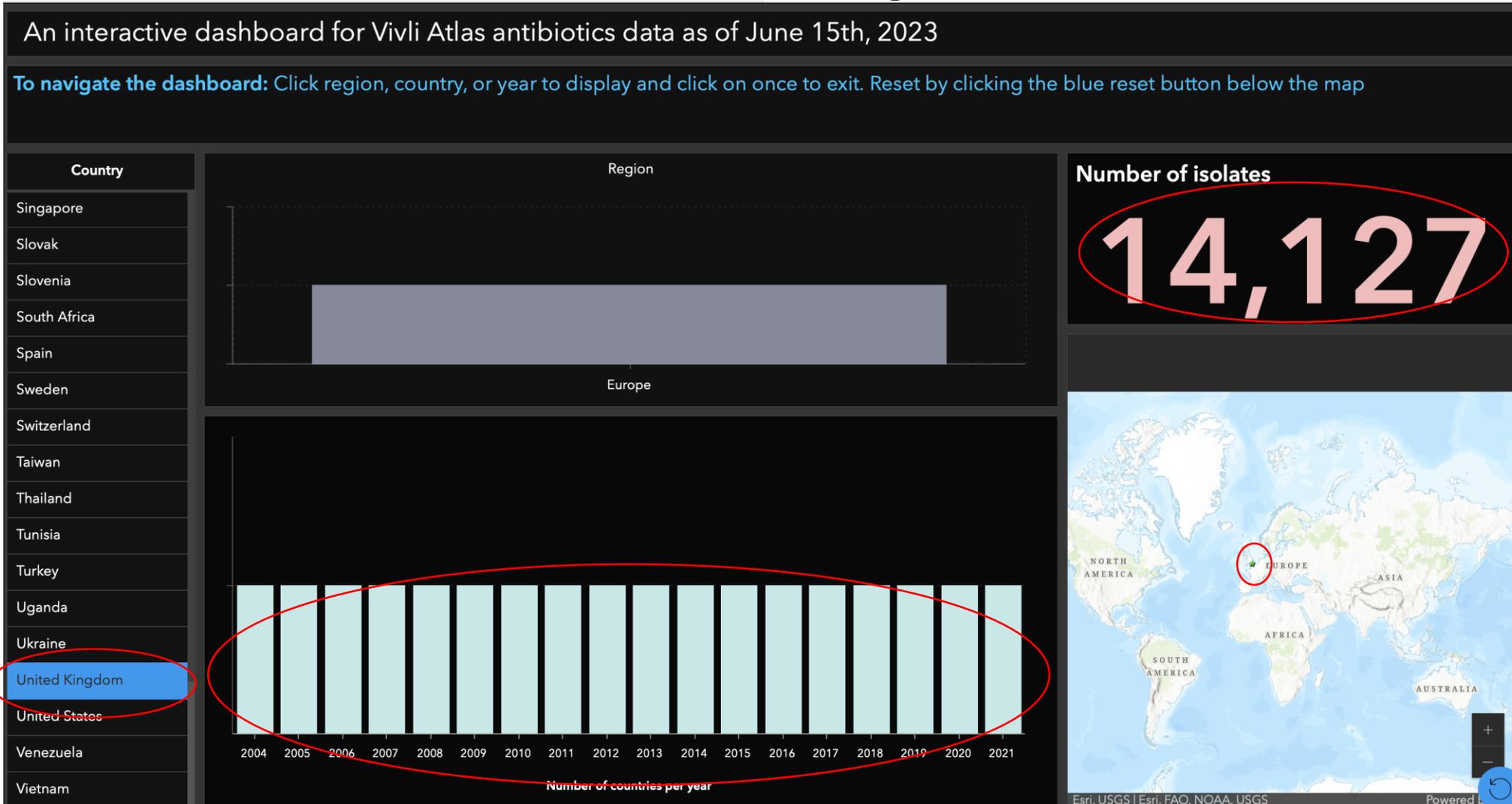
- General information about Uganda.



<https://patira.maps.arcgis.com/apps/dashboards/d89c5b039552464f8f04103f05ac889f>

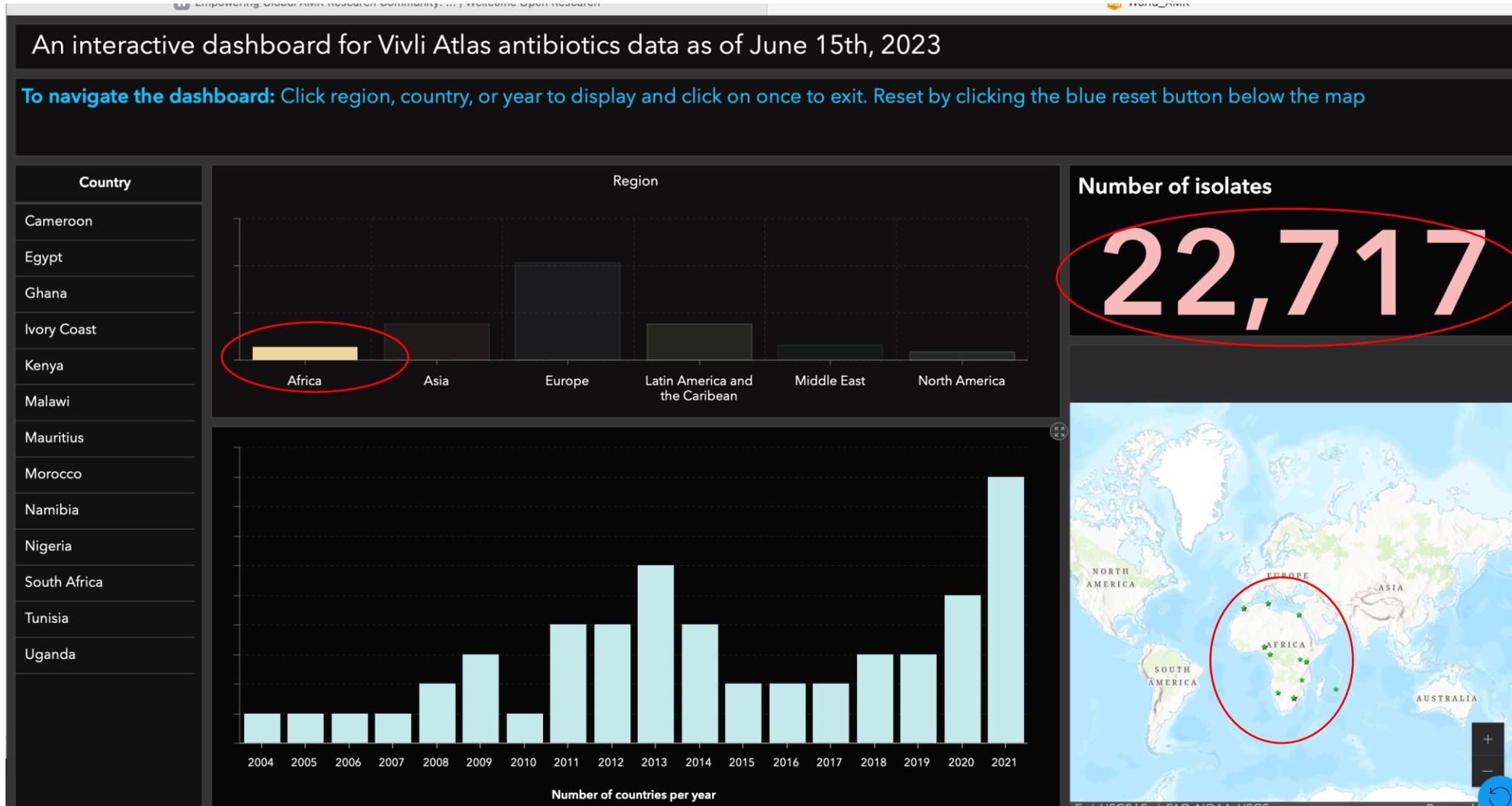
Objective 1 continued 2

- General information about United Kingdom.



<https://patira.maps.arcgis.com/apps/dashboards/d89c5b039552464f8f04103f05ac889f>

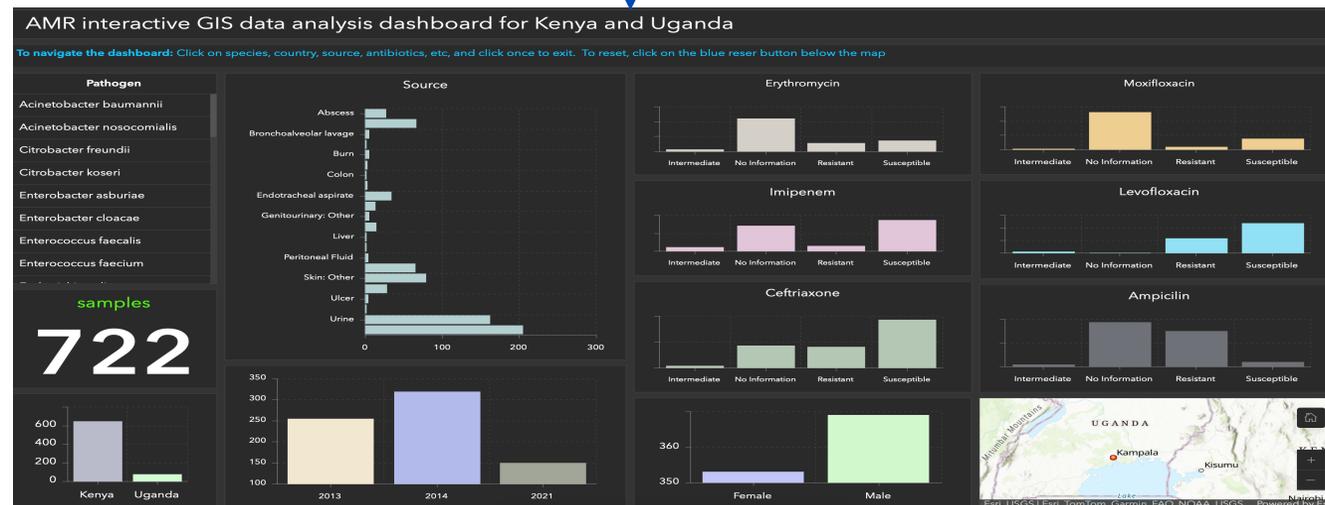
- General information about Africa region.



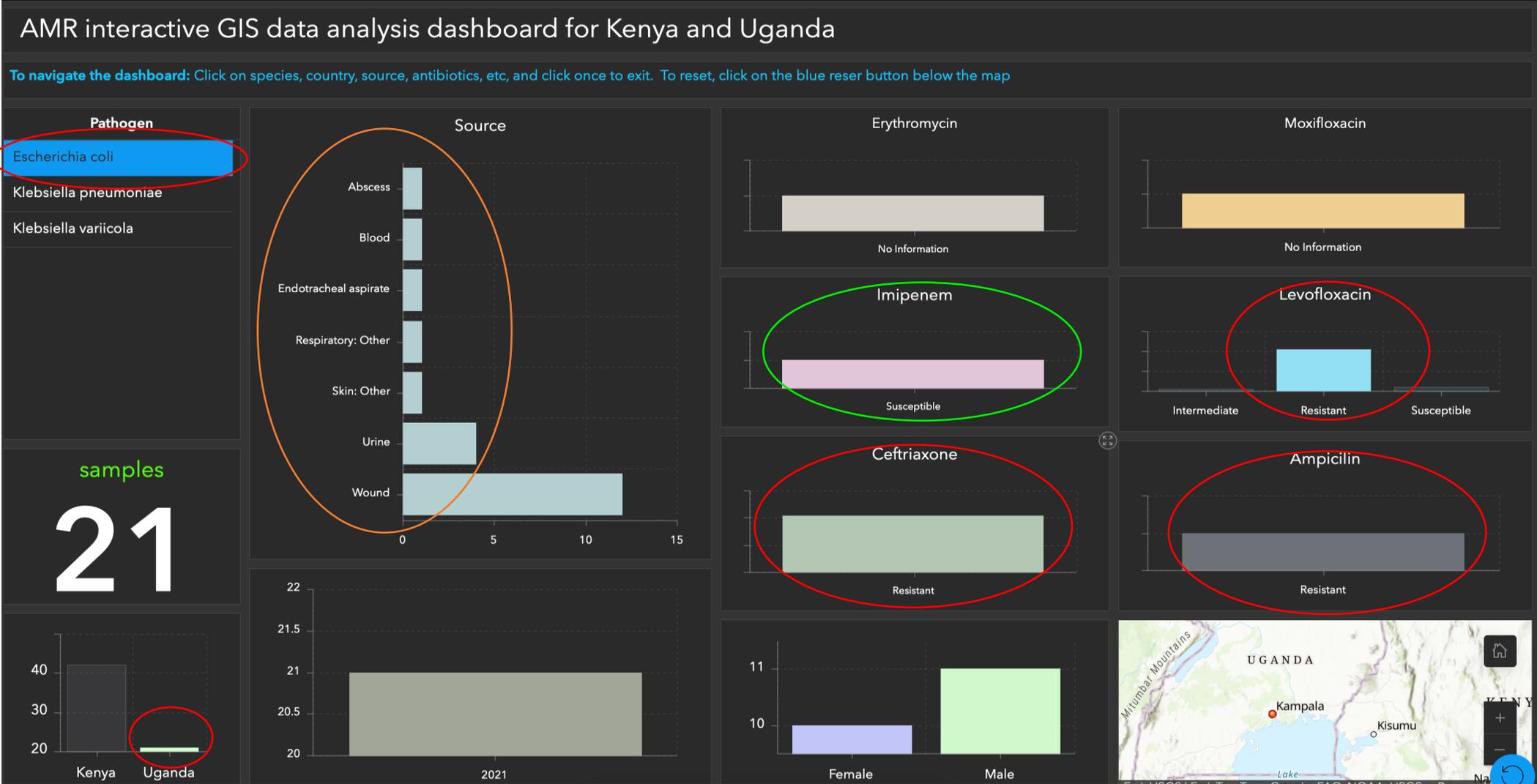
Objective 2

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

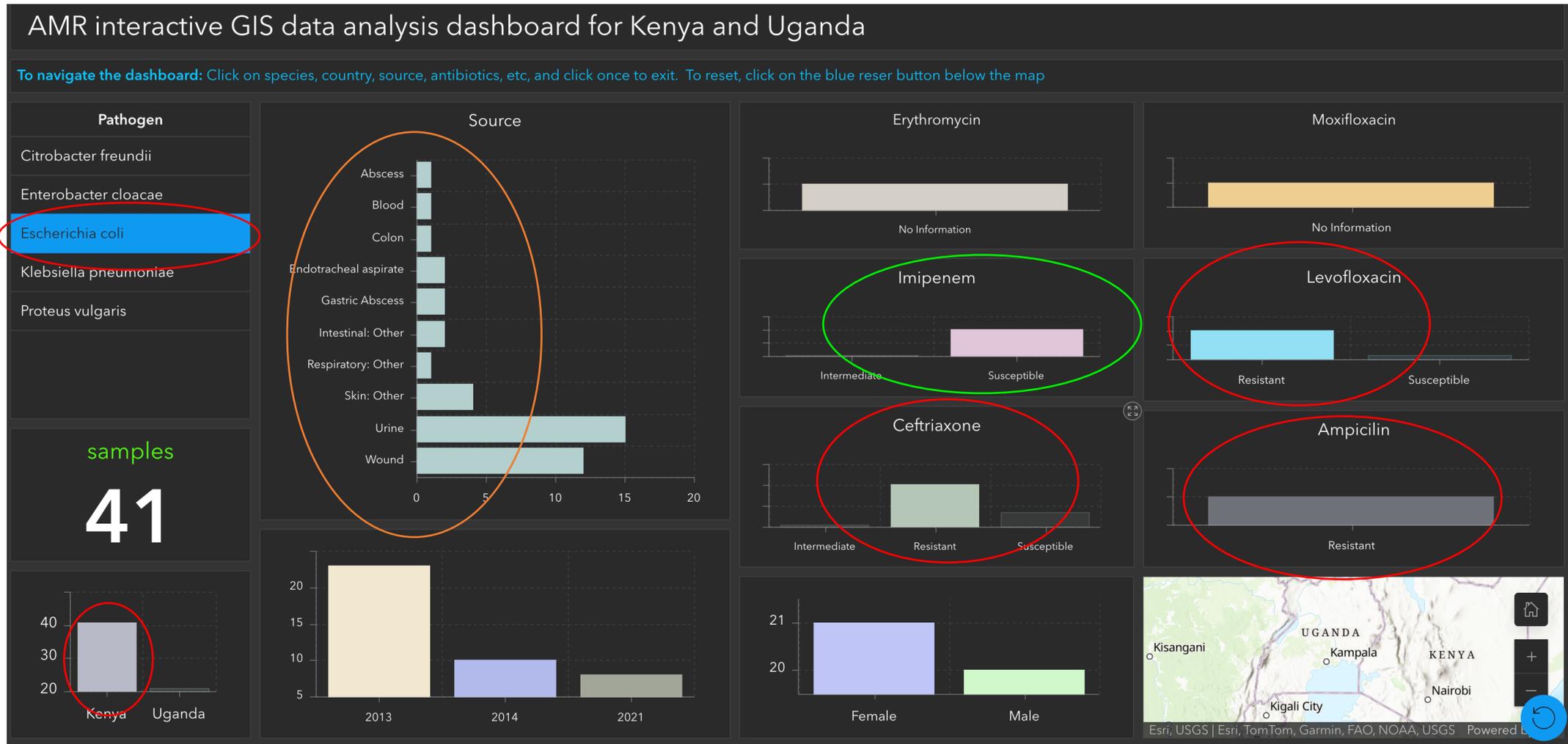
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- Interactive GIS dashboard, Uganda (*E.coli*)

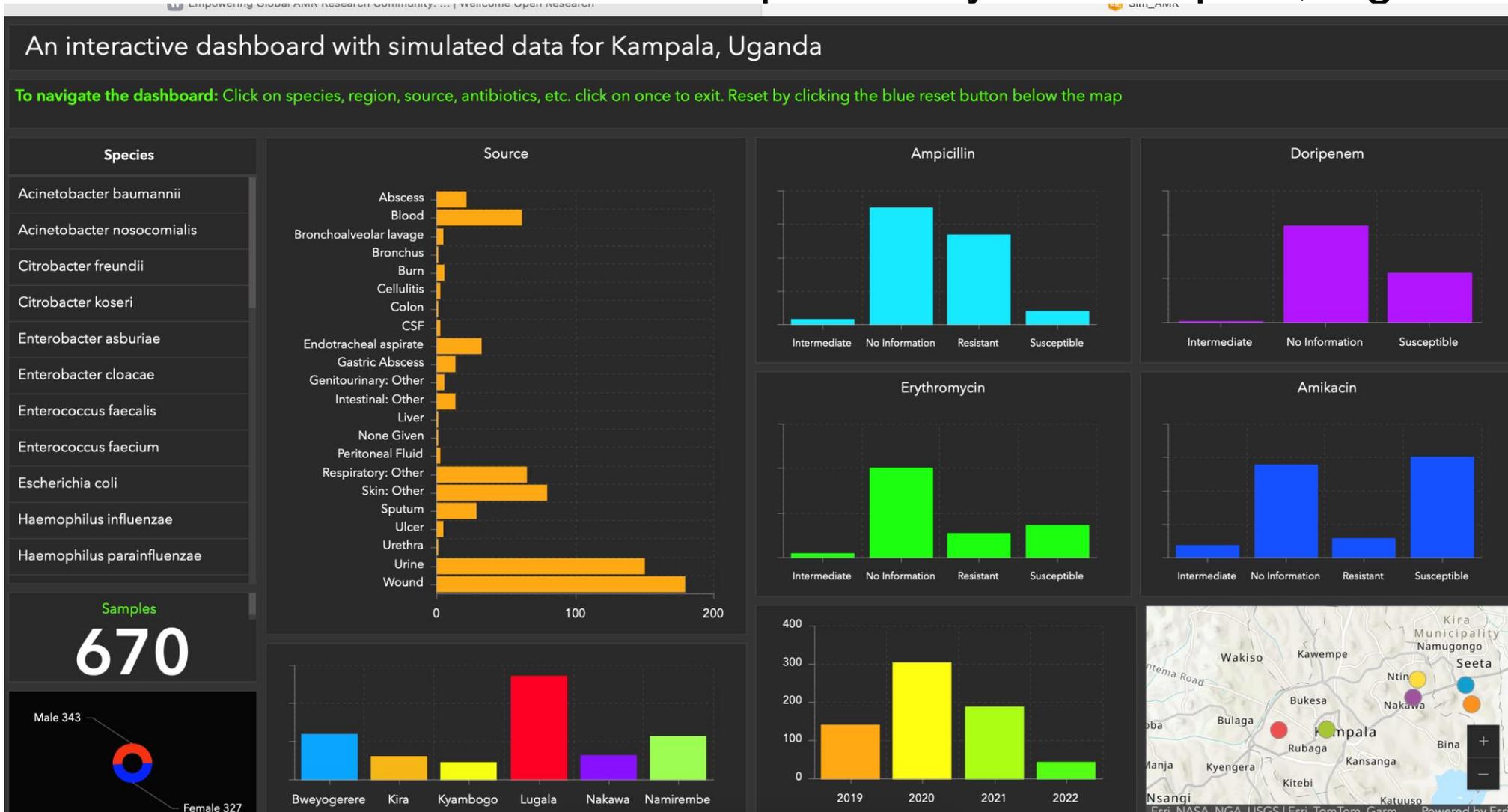


- Interactive GIS dashboard, Kenya (*E.coli*)



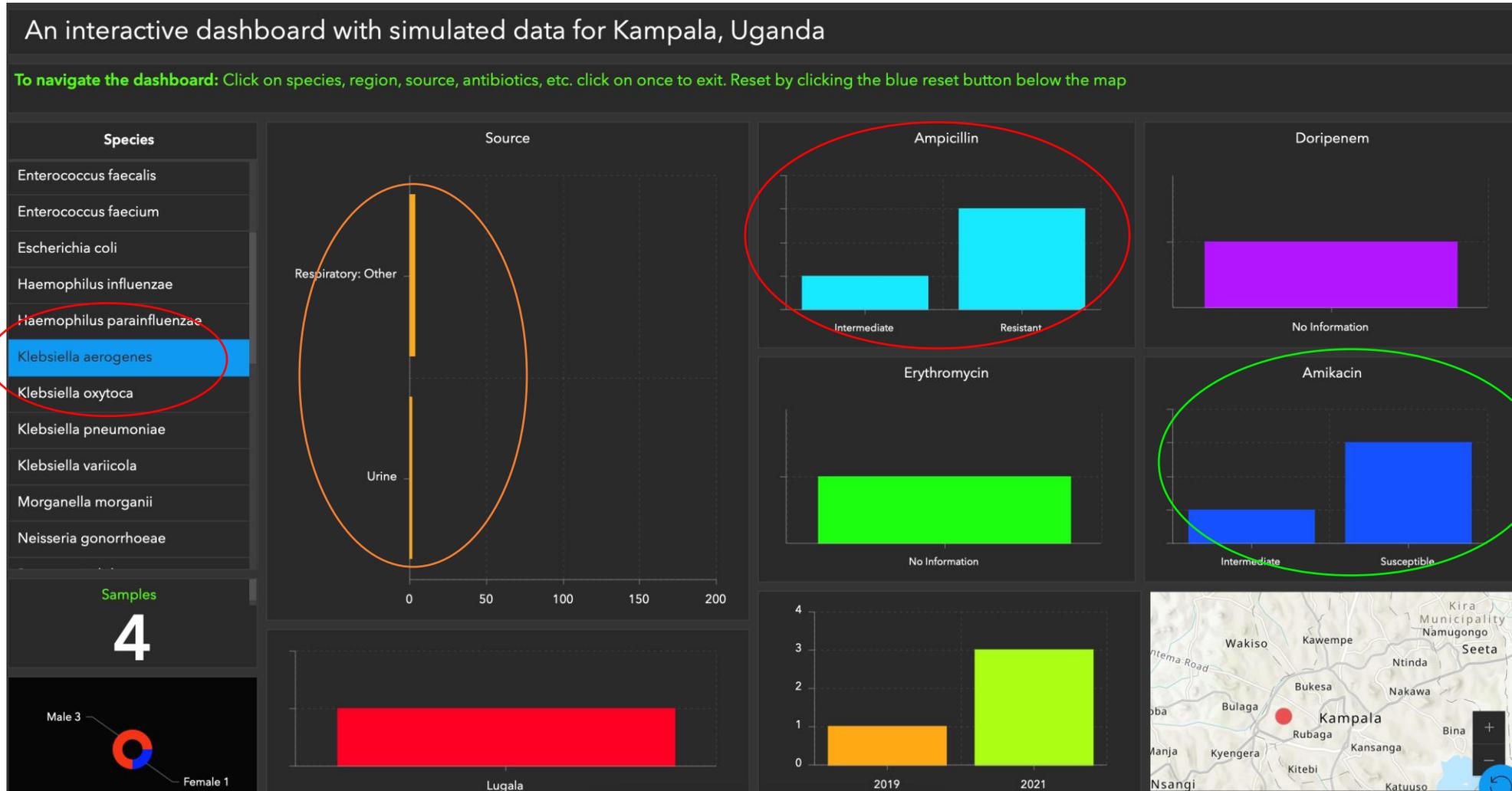
Objective 3

- Generate a simulated dataset specifically for Kampala, Uganda.



Objective 3 continued 1

- Information from *Klebsiella aerogenes*.

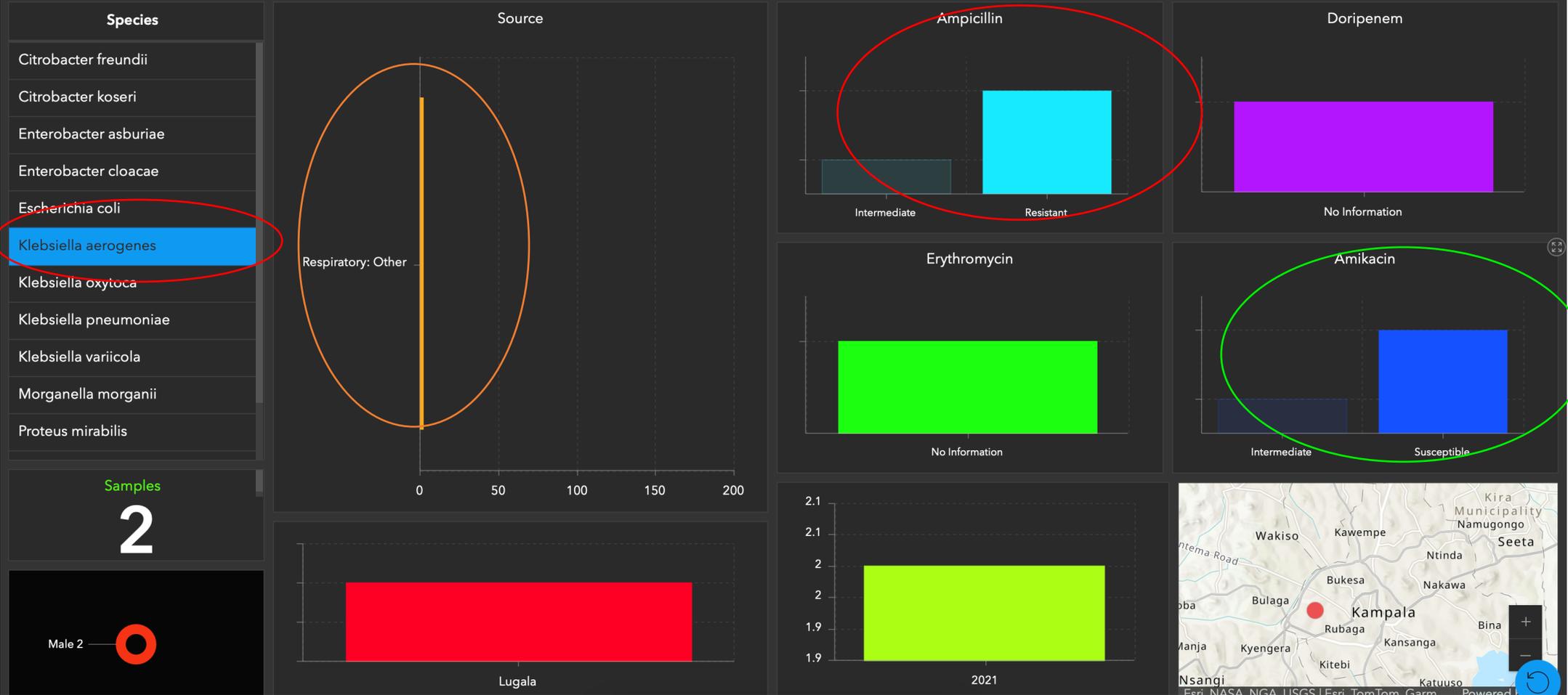




- Information from *K. aerogenes*

An interactive dashboard with simulated data for Kampala, Uganda

To navigate the dashboard: Click on species, region, source, antibiotics, etc. click on once to exit. Reset by clicking the blue reset button below the map



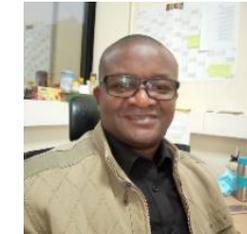
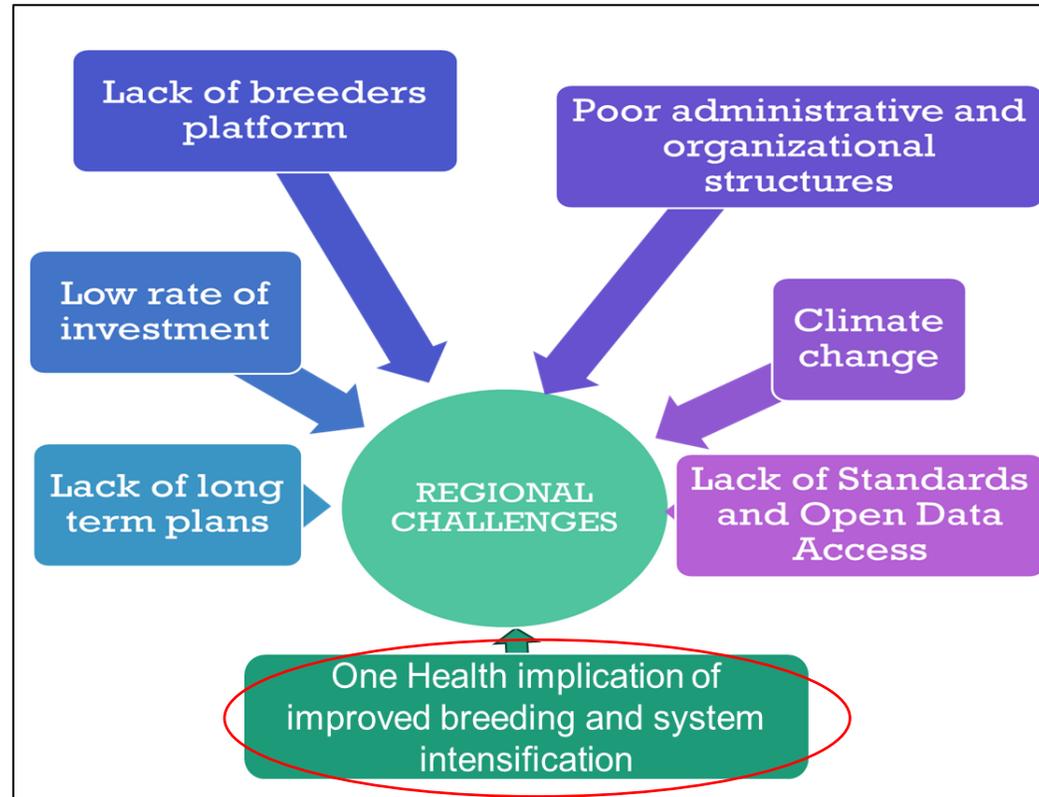
- Comprehensive and Versatile Tools
 - Designed for AMR data exploration and analysis.
 - Suitable for researchers, policymakers, and healthcare professionals.
- Wide Range of Functionalities
 - Provide access to healthcare, public health, demographics, and economics datasets.
 - Centralized hub for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

- **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.

- 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.

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.

- 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**)

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).

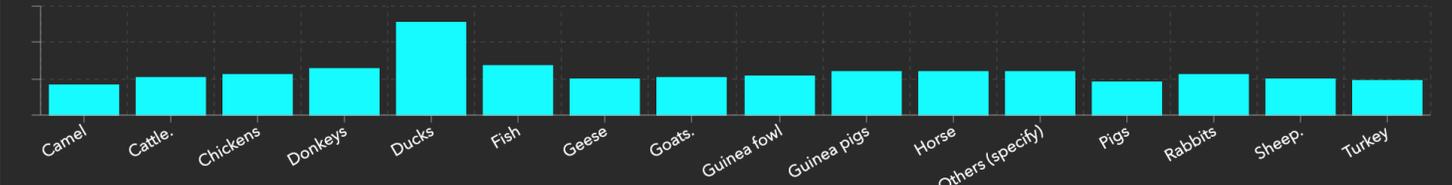
Interactive GIS platform for animals' seed dissemination

An interactive GIS platform for tracing and tracking pathogens associated with animals' seed dissemination

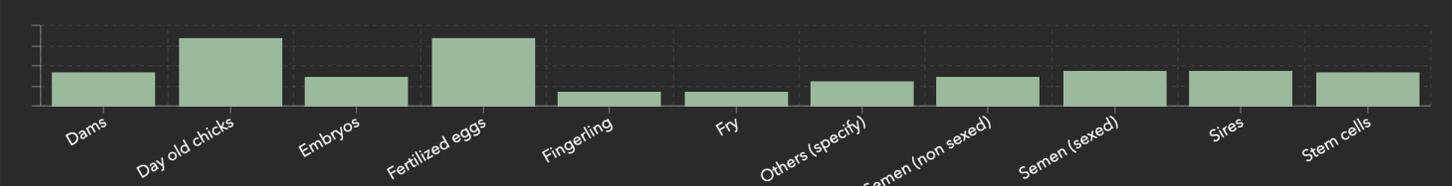
To navigate the dashboard: Click once on the Region, country, livestock, etc. to display and click once to exit. To reset, click on the blue reset button below the blue

Country

- Burundi
- Cameroon
- Comoros
- Congo Republic
- Democratic Republic
- Djibouti
- Egypt
- Eretria
- Ethiopia



Livestock



Animal's seed

Pathogen

Bacteria	~7.5k
Helminth	~6.5k
Ectoparasites	~0.5k
Fungi	~4.5k
None	~3.5k
Others	~3.0k
Protozoa	~2.5k
Virus	~2.0k

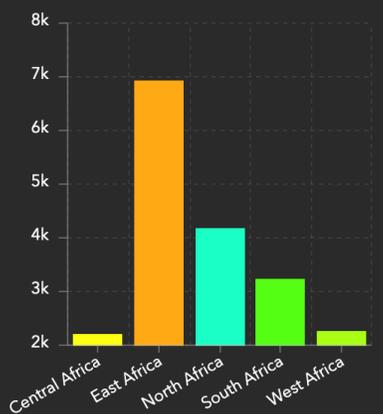
Source of pathogen

Animal	~7.5k
Environment	~1.0k
Human	~5.0k
None	~2.0k
Plant	~1.5k

Breed

- Abyssinian Donkey
- æWild Ass, Onager and ...
- African catfish (Clarias g...
- American Spotted Donkey
- Ancona duck
- Anglo Nubian
- Angora
- Arbor Acres
- Ayrshire
- Black
- Black Head Persian sheep
- Black Minorca
- Boer Goat
- Brown Leghorn
- Buff Orpington
- Burro - adopted wild Burro
- California White
- Charolais

Region



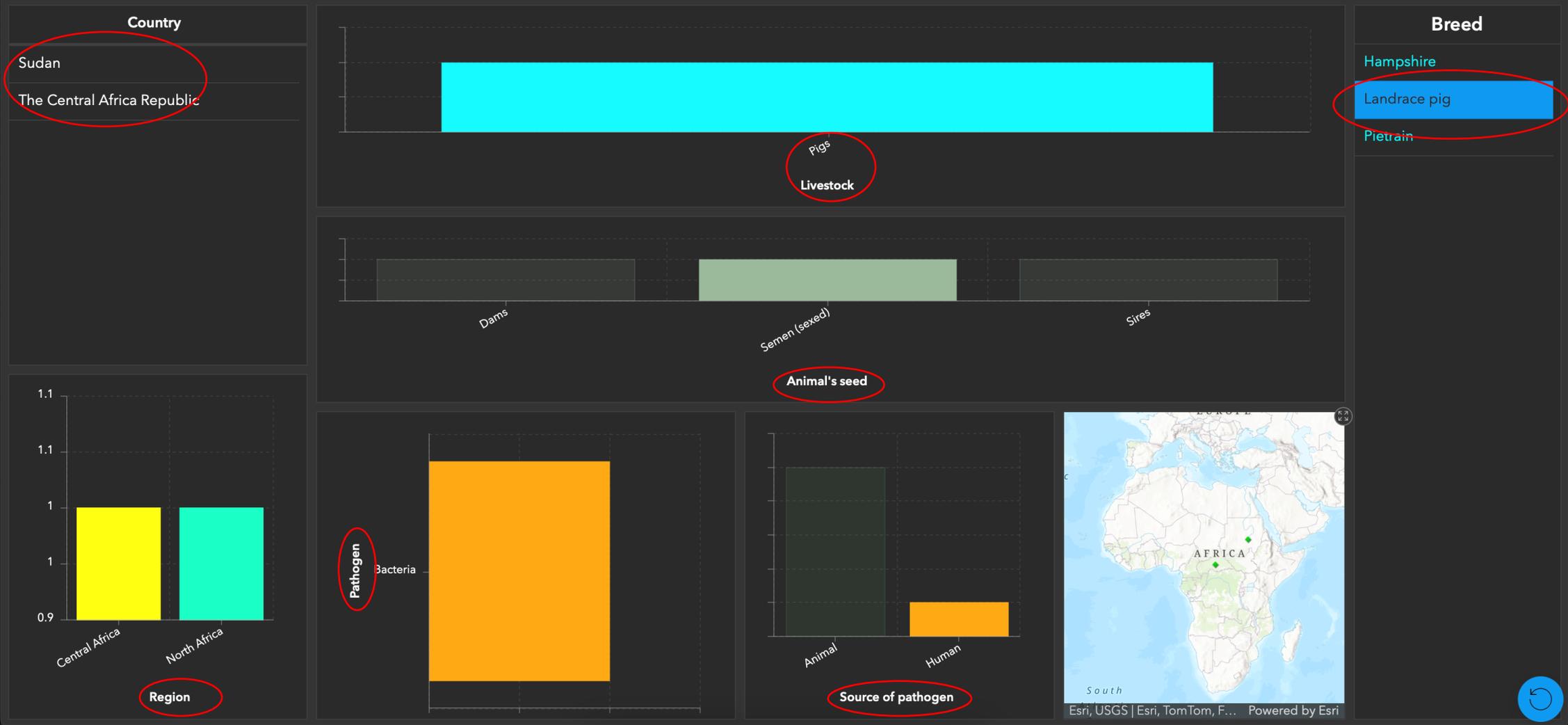


Tracking semen (sexed) from a pig



An interactive GIS platform for tracing and tracking pathogens associated with animals' seed dissemination

To navigate the dashboard: Click once on the Region, country, livestock, etc. to display and click once to exit. To reset, click on the blue reset button below the blue



Tracking data from Kenya (county)



A WebGIS platform for tracing and tracking zoonotic pathogens associated with animals' seeds dissemination

To navigate the dashboard: Click once on the county, livestock, etc. to display, and click once to exit. To reset, click on the blue reset button below the breed.

County

- Baringo
- Bomet
- Bungoma
- Busia
- Elgeyo Marakwet
- Embu
- Garissa
- Homa Bay
- Isiolo
- Kajiado
- Kakamega
- Kericho
- Kiambu
- Kilifi
- Kirinyaga
- Kisii
- Kisumu
- Kitui
- Kwale

Livestock

Animal's seed

Zoonotic pathogen

Source of pathogen

Breed

- Abyssinian Donkey
- African catfish (Clarias gariepi...
- American Spotted Donkey
- Ancona duck
- Anglo Nubian
- Angora
- Arbor Acres
- Ayrshire
- Black
- Black Head Persian sheep
- Black Minorca
- Boer Goat
- Brown Leghorn
- Buff Orpington
- Burro - adopted wild Burro
- California White
- Charolais
- Checkered Giant
- Chinchilla Rabbit
- Cobb Vantress
- Common carp (Cyprinus carpio)
- Corriedale
- Corriedale sheep
- Crested
- Cypriot Donkey
- Dorper
- Dorper sheep
- Dual purpose types
- Duroc - (Duroc-Jersey) Pig

Tracking semen to a county in Kenya



A WebGIS platform for tracing and tracking zoonotic pathogens associated with animals' seeds dissemination

To navigate the dashboard: Click once on the county, livestock, etc. to display, and click once to exit. To reset, click on the blue reset button below the breed.

County

- Kiambu
- Migori**
- Nakuru

Breed

- Landrace pig**
- Pietrain

Livestock

Pigs

Animal's seed

Semen (sexed)

Zoonotic pathogen

Bacteria

Source of pathogen

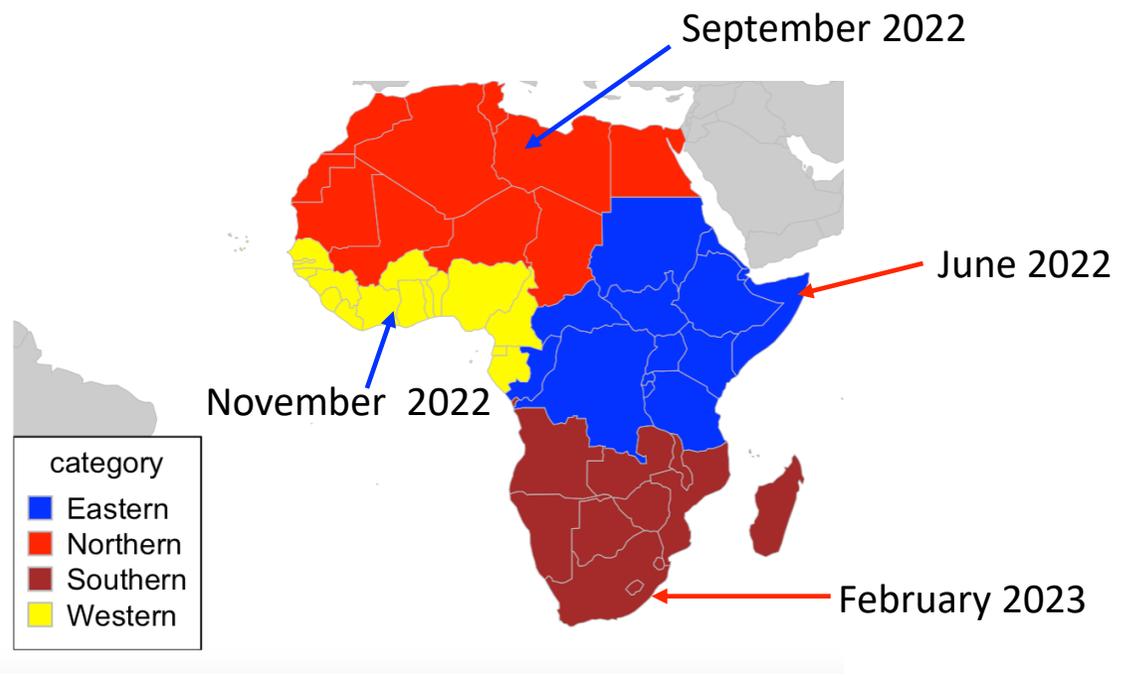
Human

<https://patira.maps.arcgis.com/apps/dashboards/e965867a92a745a38cee4099809d1b0a>

- 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**).

Background

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



Workshops

OUR EXPERT TEAM - WHO WE ARE

SBA-GCBRI is led by a vibrant team of professionals with diverse backgrounds and expertise geared towards combating or preventing global catastrophic biological risks.

 Geoffrey Otim Principal Investigator	 Stephen Opiyo Project Consultant	 Winnie Nabatanzi Finance Officer	 Sandra Matinyi Project Officer - GCBR
 Ian Peter Busuulwa Policy and Communications Officer	 Maria Assumpta Nalwanga Project Intern		

<http://gcbri.synbioafrica.com>

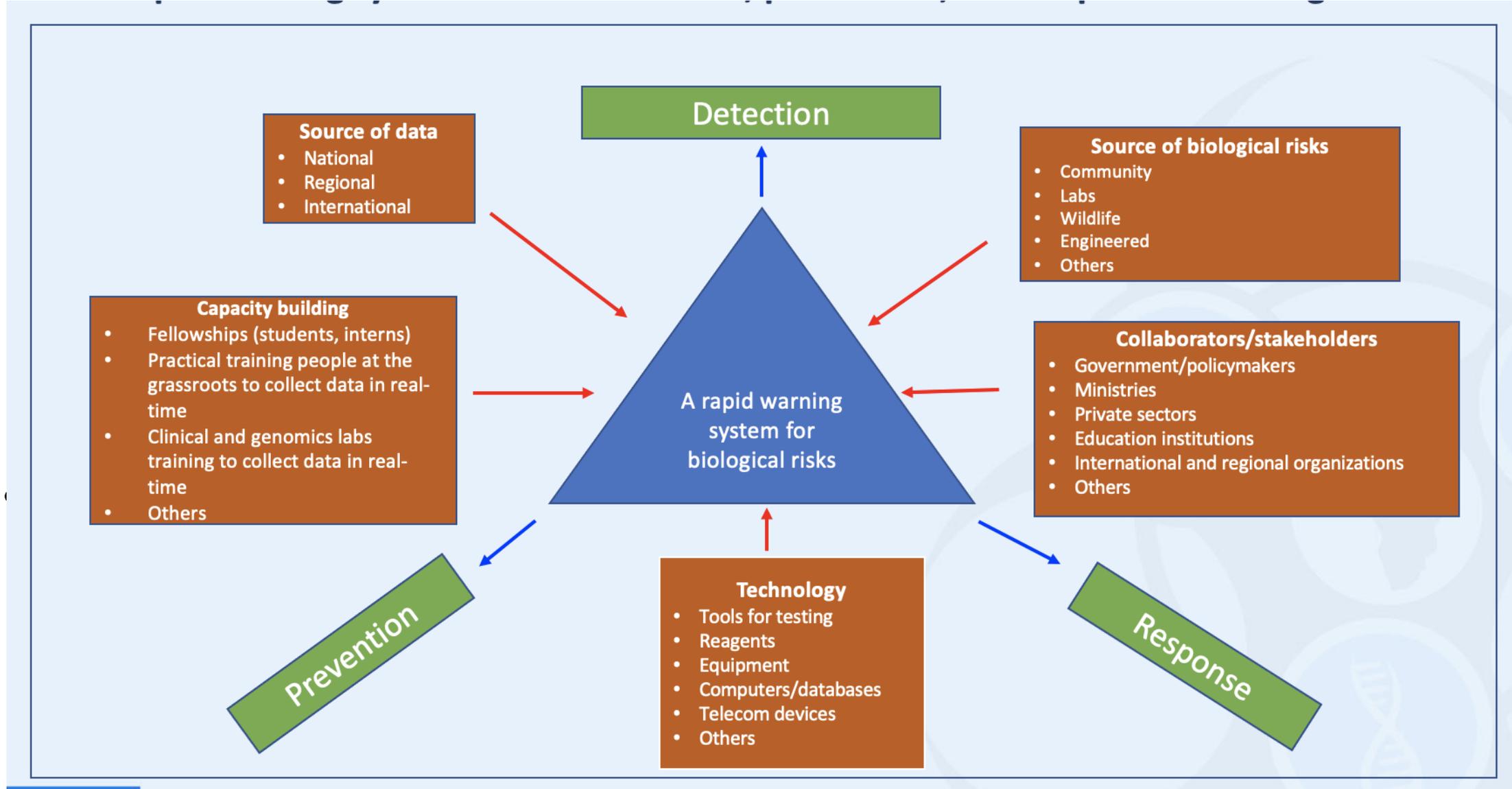
- Workshops identified information required to develop a rapid warning system for pandemic preparedness

- **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



To navigate the dashboard, click once on country, source of biological risks, etc, and click once to exit.

Country

- Ethiopia
- Kenya
- Mauritius
- Rwanda
- Seychelles
- Somali
- South Sudan
- Sudan
- Biological reagents
- Computers
- Data storage
- Databases
- Mobile application technol...
- Next generation sequencin...
- Predictive models
- Sample storage

Capacity development

Category	Value
Artificial intelligence	16
Bioinformatics	148
Biosafety	150
Biosecurity	148
Bush meat	148
Contact tracing	148
Data Science	15
Diagonistics	150
Diagonistics tools	150
First Eswatinid	149
GCBR stakeholder awareness	15
GCBRs	17
Lab	145
Legal framework	146
Others	132
Plant pathogens	148
Policy	150
Surveillance	147
Synthetic biology	17
Waste management	148
Wild life	150

Human resource

- Data Scientists/Bioinformatics
- Government officials
- Medica doctors
- Others
- Plant Pathologists
- Public Health
- Technicians
- Wild life officials

Source of data

- CDC
- Focus group
- Genomics
- Interview
- Laboratory
- Literature
- One-Health
- Survey
- WHO

Biological risks

Category	Value
Known	~1.2k
Unknown	~0.1k

Esri, USGS | Esri, To... Powered by Esri

Potential biological risks

- A
- B
- C
- D

Source of biological risks

- Community
- Engineered
- Laboratory
- Others
- Wildlife

A model of a rapid warning system for biological risks



To navigate the dashboard, click once on country, source of biological risks, etc, and click once to exit.

The dashboard is divided into several sections:

- Country:** A list of countries including Burundi, Comoros (highlighted with a red circle), Congo Republic, Democratic Republic, Djibouti, Eritrea, Ethiopia, and Kenya.
- Technology:** A list of technologies including Biological reagents, Computers, Data storage, Databases, Mobile application technol..., Next generation sequencin..., Predictive models, and Sample storage.
- Capacity development:** A horizontal bar chart showing scores for various categories. A red circle highlights this section. The data is as follows:

Category	Score
Artificial intelligence	1
Bioinformatics	9
Biosafety	9
Biosecurity	9
Bush meat	9
Contact tracing	9
Data Science	1
Diagonistics	9
Diagonistics tools	9
First Eswatinid	9
GCBR stakeholder awareness	1
GCBRs	1
Lab	9
Legal framework	8
Others	8
Plant pathogens	8
Policy	9
Surveillance	9
Synthetic biology	1
Waste management	8
Wild life	8
- Human resource:** A list of roles including Data Scientists/Bioinformatics, Government officials, Medica doctors, Others, Plant Pathologists, Public Health, Technicians, and Wild life officials.
- Source of data:** A list of data sources including CDC, Focus group, Genomics, Interview, Laboratory, Survey, and WHO.
- Biological risks:** A vertical bar chart comparing 'Known' (score ~71) and 'Unknown' (score ~73) risks.
- Potential biological risks:** A list of risk types including A, B, C, and D.
- Source of biological risks:** A list of risk sources including Community, Engineered, Laboratory, and Others.
- Map:** A map of Africa with a red diamond marker on the island of Comoros. Labels for 'EUROPE' and 'AFRICA' are visible. The map is powered by Esri.

South Africa

<https://patira.maps.arcgis.com/apps/dashboards/fc77ef3185fc467d96d7033ac4bb3001>

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- ASLM
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- Wellcome



Collaborators



Co-authors

ASLM

AFRICAN SOCIETY FOR LABORATORY MEDICINE

ADVANCING THE LABORATORY PROFESSION AND NETWORKS IN AFRICA

ANTIMICROBIAL RESISTANCE (AMR) COMMUNITY OF PRACTICE (CoP)



THANK YOU

