Better lives through livestock

Biological emergencies surveillance, early warning and rapid response systems: Status and perspectives for East Africa

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Regional trainer (Central Africa) – Livestock Emergency Guidelines and Standards (LEGS)

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ILRI INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

CGIAR

Synthetic Biology Africa-Global Catastrophic Biological Risks Initiative Workshop

Kampala, 9-11 June 2022

Synbio Africa Global Catastrophic Biological Risks Initiative (SBA - GCBRI)

Centre for Tropical Livestock Genetics and Health

SYNTHETIC BIOLOGY AFRICA

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Outline

1. Background
2. Catastrophic biological emergencies & surveillance
3. Early warning and rapid response systems
4. Perspectives for East Africa

1.1- Catastrophes categories

Natural catastrophes

Biological

- Epidemic
- Insect Infestation
- Animal Stampede

Geological

- Earthquake
- Volcano
- Mass Movement (dry)

Climatological

- Extreme temperature
- Heat/cold wave
- Drought
- Fire (farm, forest, etc.

Hydrological

- Flood
- Mass movement (wet)

Meteorological

- Storm
- Cyclone
- Hurricane
- tornado

Human induced catastrophes

Nuclear | **Technological** | **Chemical**

Complex catastrophes

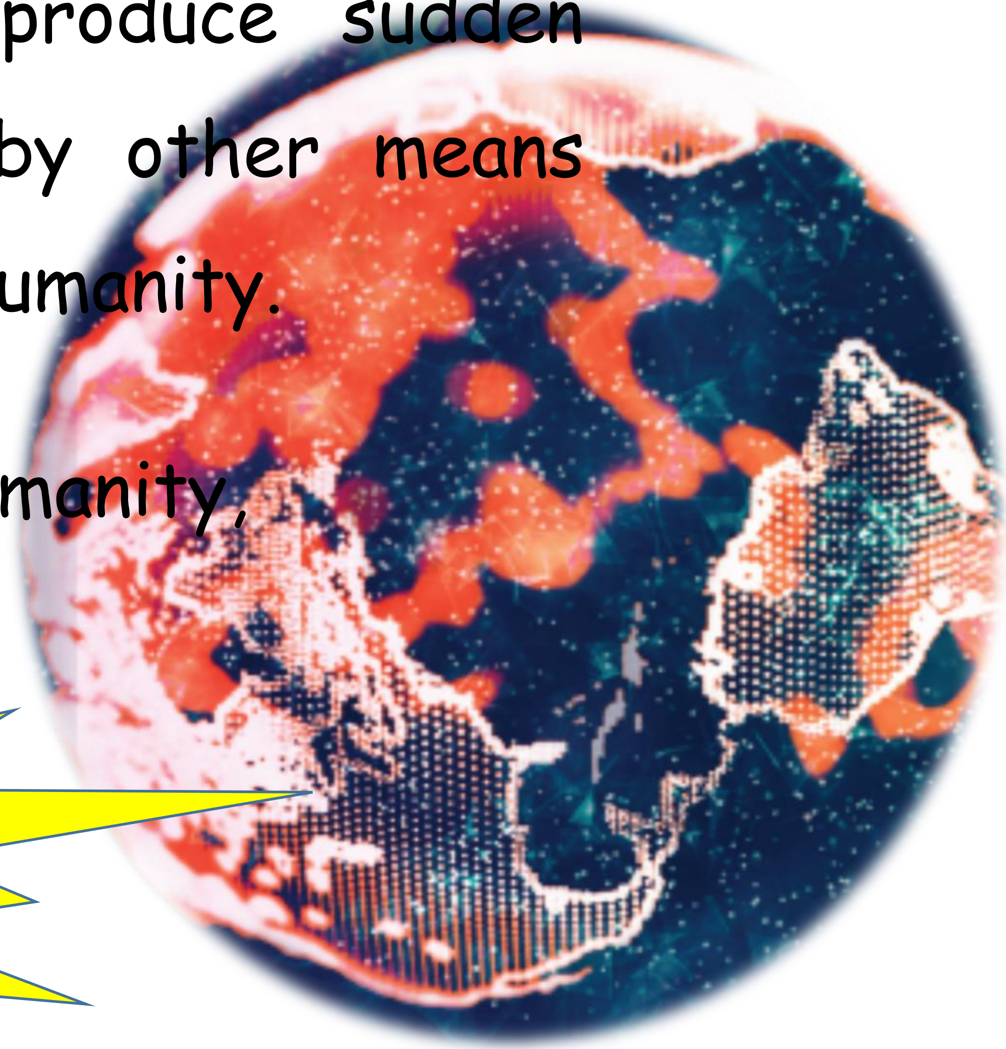
Natural Catastrophes ↔ **Humane Induced catastrophes**

Variety and types of catastrophes . Wood et al. (2013)

1.2- Global catastrophic biological risks (GCBR)

- **GCBR** - biological risk that could produce sudden disasters, mass casualty events, or by other means significantly change the trajectory of humanity.

- Natural and artificial GCBR threaten humanity, directly or indirectly,

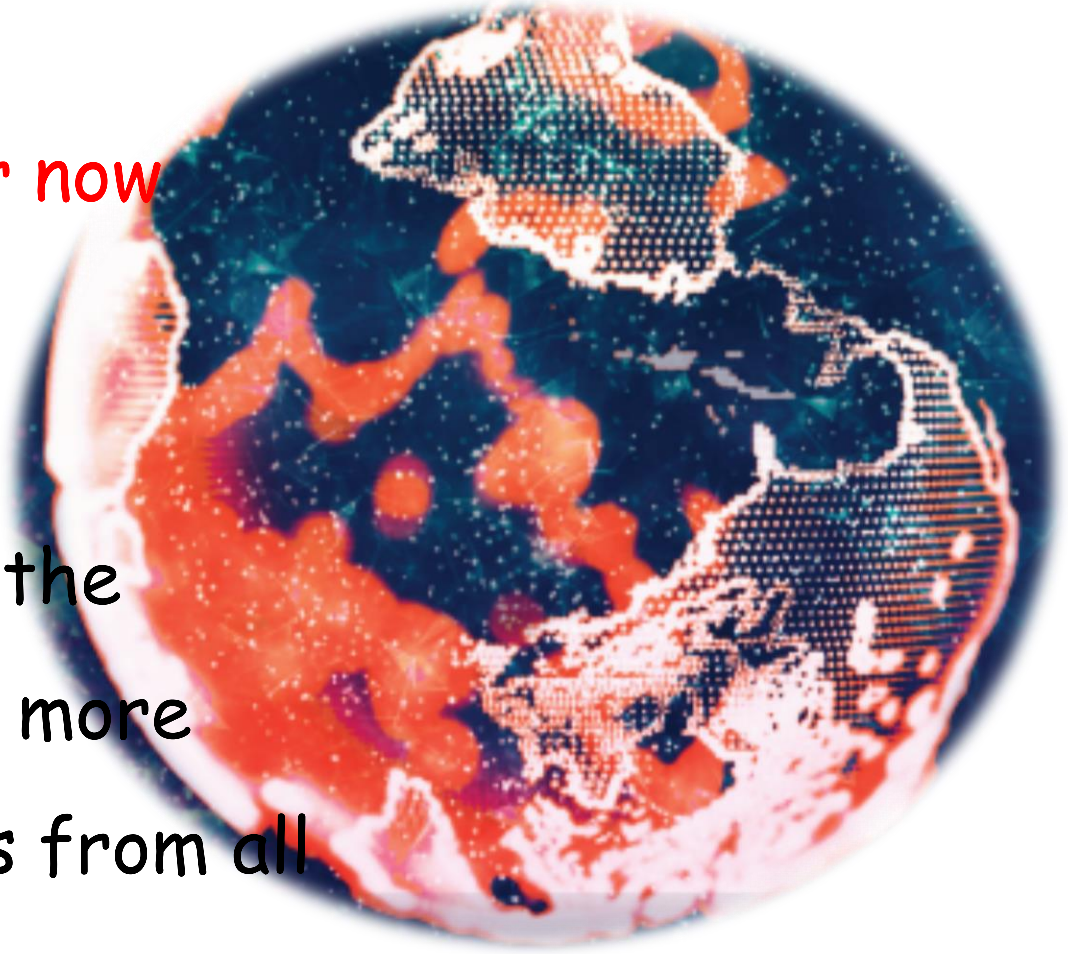


A biological risk anywhere is a risk everywhere

1.2- Global catastrophic biological risks (GCBR)

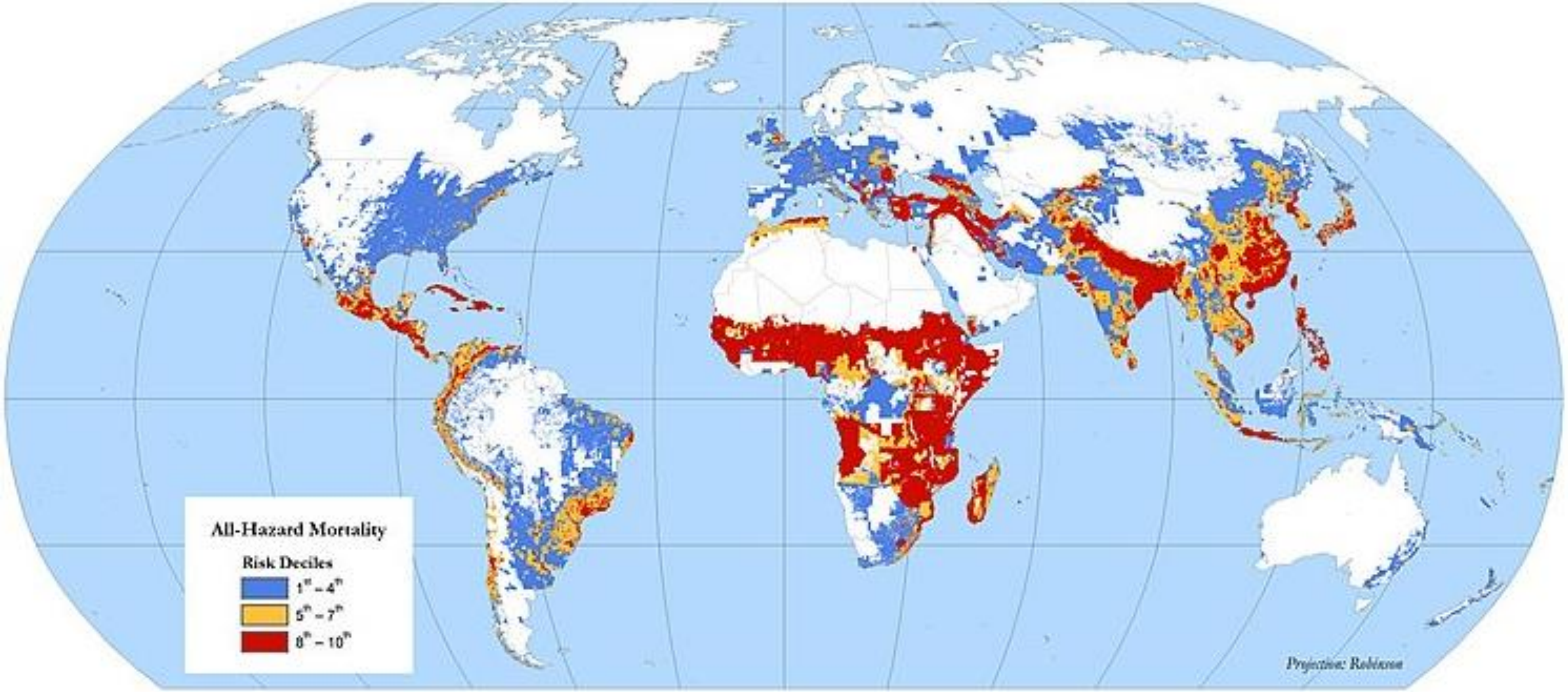
- The probability of a GCBR is hard to accurately estimate but may be higher now than ever: need closer attention.

- The global south (GS) carries most of the global burden of natural GCBR and are more exposed to emerging disease spillovers from all origins.



1.2- Global catastrophic biological risks (GCBR)

- GS should be a primary focus of efforts to **prevent** and **respond** to the **next biological catastrophes**.



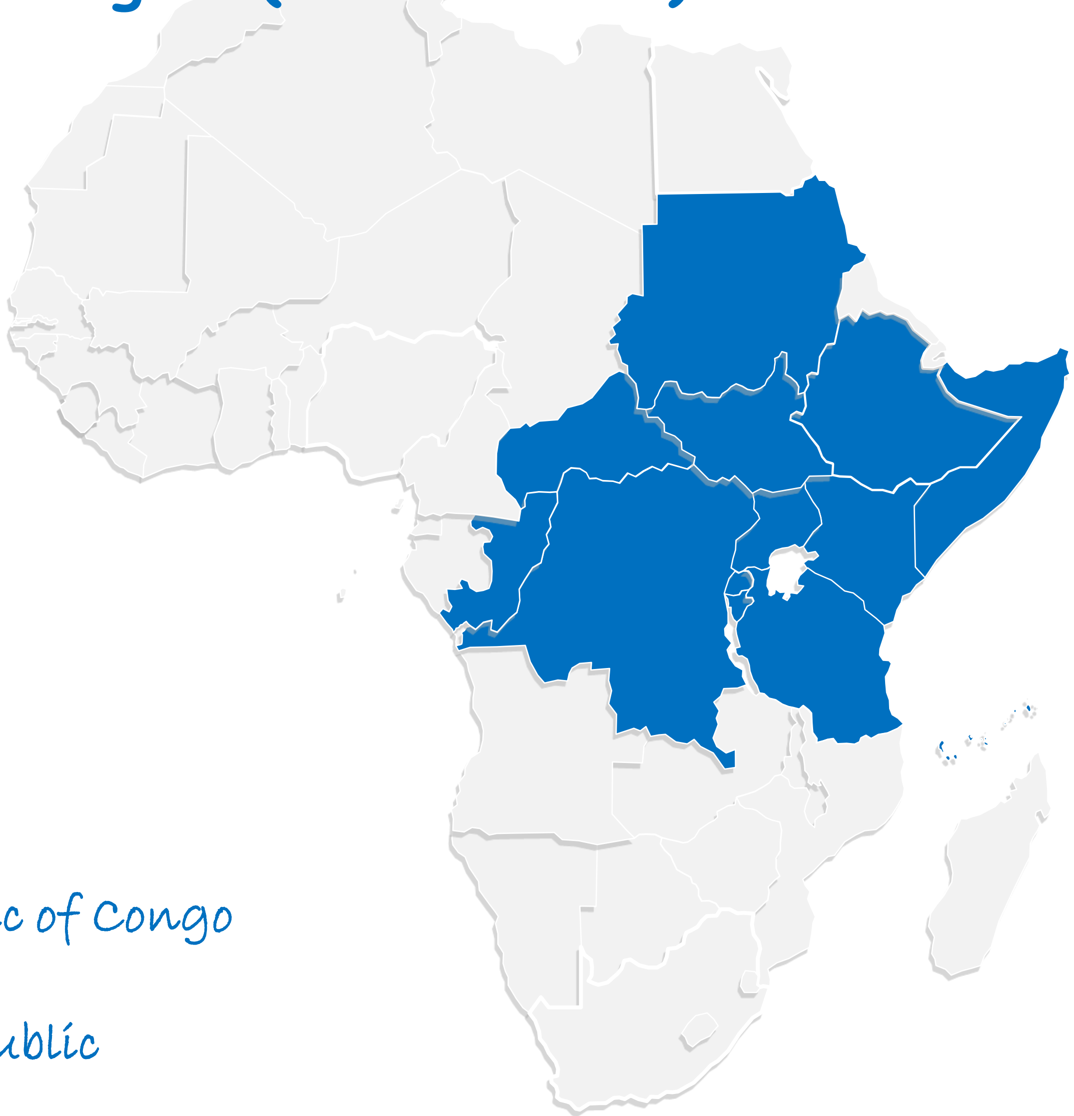
Global multihazards mortality risks and distribution (2005)

Many African countries lack the capacity to deal with these threats, or their countermeasures may be too slow.

1.2- Global catastrophic biological risks (GCBR)

SBA-GCBRI eastern region (16 countries)

1) Uganda (Centre)
2) Comoros
3) Ethiopia
4) Eritrea
5) Kenya
6) Rwanda
7) Seychelles
8) Somali
9) South Sudan
10) Tanzania
11) Burundi
12) Djibouti
13) Republic of the Congo
14) The Democratic Republic of Congo
15) Sudan
16) The Central Africa Republic



Key concerns

≥ 7.8 million
people have been pushed to the very edge of starvation

≥ 34 million
people are acutely food insecure

Fragility in the region is acute. Continued conflict in Tigray, protracted conflict in South Sudan, Sudan and Somalia threaten human and economic development gains.

COVID-19 aftershocks ripple through communities with declining income opportunities, lost livelihoods and diminished purchasing power.

≥ 9.6 million
Internally displaced people

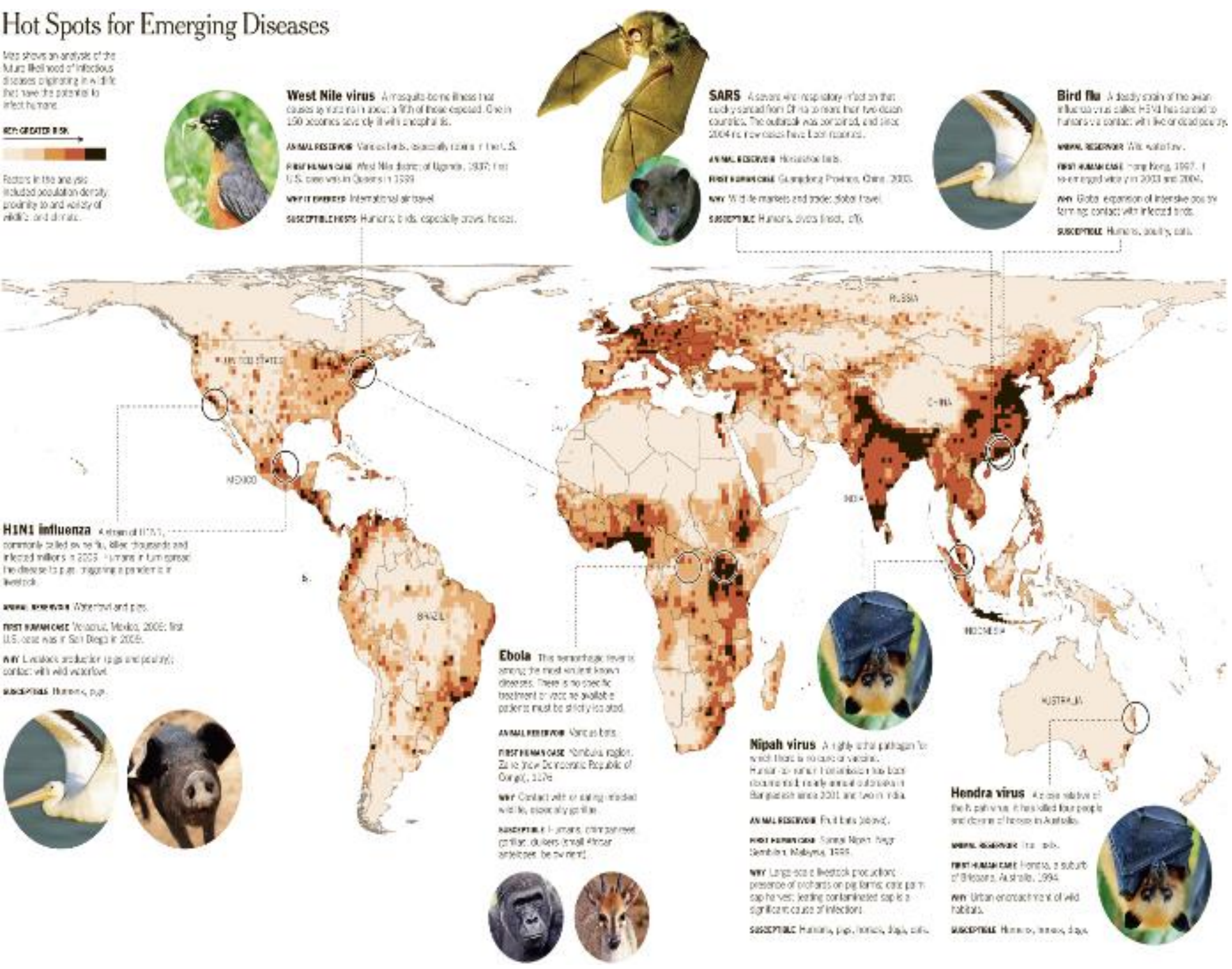
≥ 4.7 million
Refugees and asylum seekers

≥ 12.8 million
Acutely malnourished children

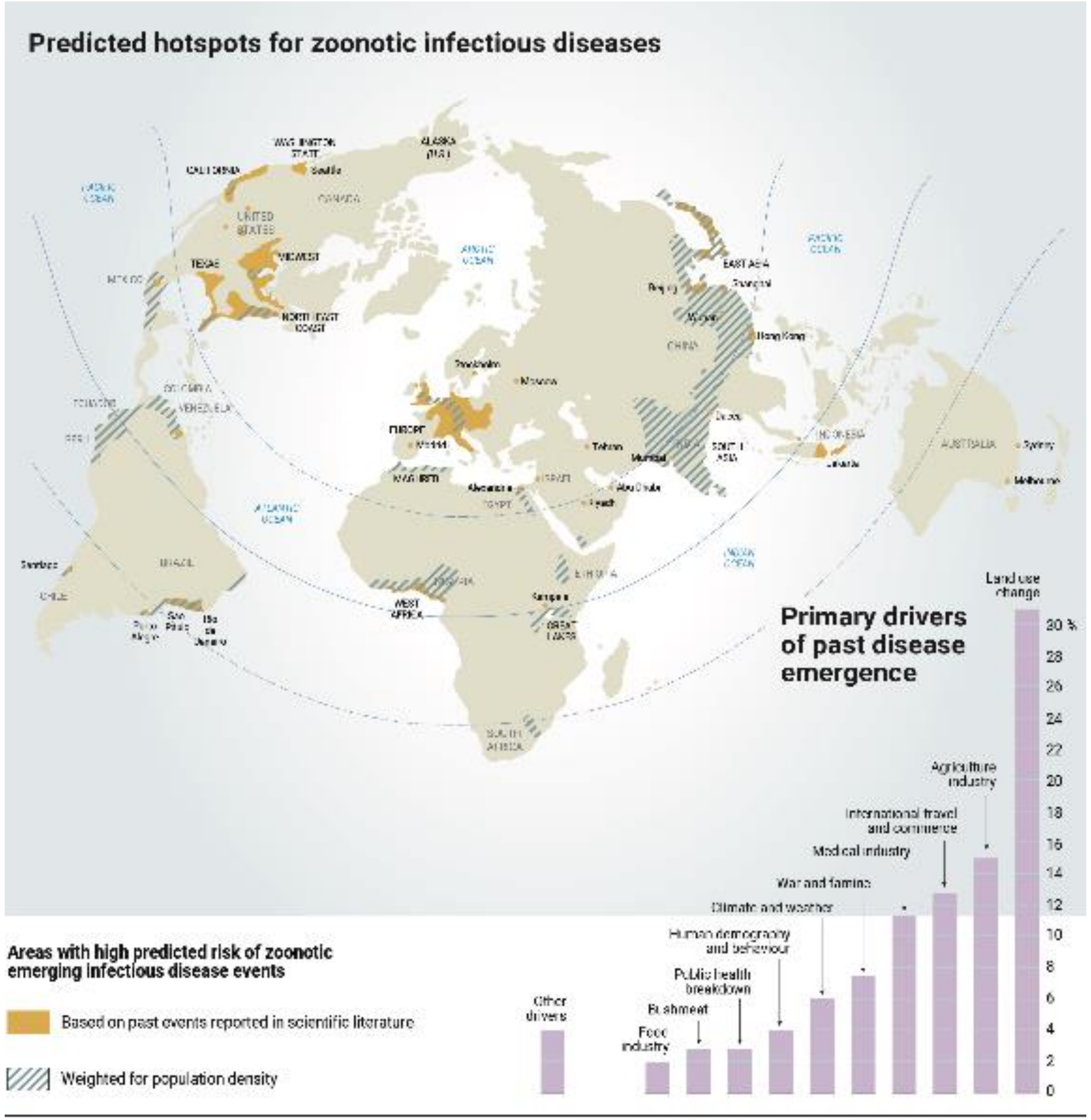
Source: UN OCHA

2- Catastrophic biological emergencies & surveillance

2.1- Origins of catastrophic biological emergencies



EcoHealth Alliance; Nature; CDC and Prevention; WHO, in NewYork Time. July 15, 2012



Source: Allen et al., 2017

2.2- Surveillance

Surveillance is the ongoing systematic identification, collection, collation, analysis and interpretation of disease occurrence and public health event data, for the purposes of taking timely, appropriate and effective action.

Surveillance is also essential for planning, implementation, monitoring and evaluation of public health practice.

2.2- Surveillance

Passive surveillance. Routine reports submitted from health and lab facilities.

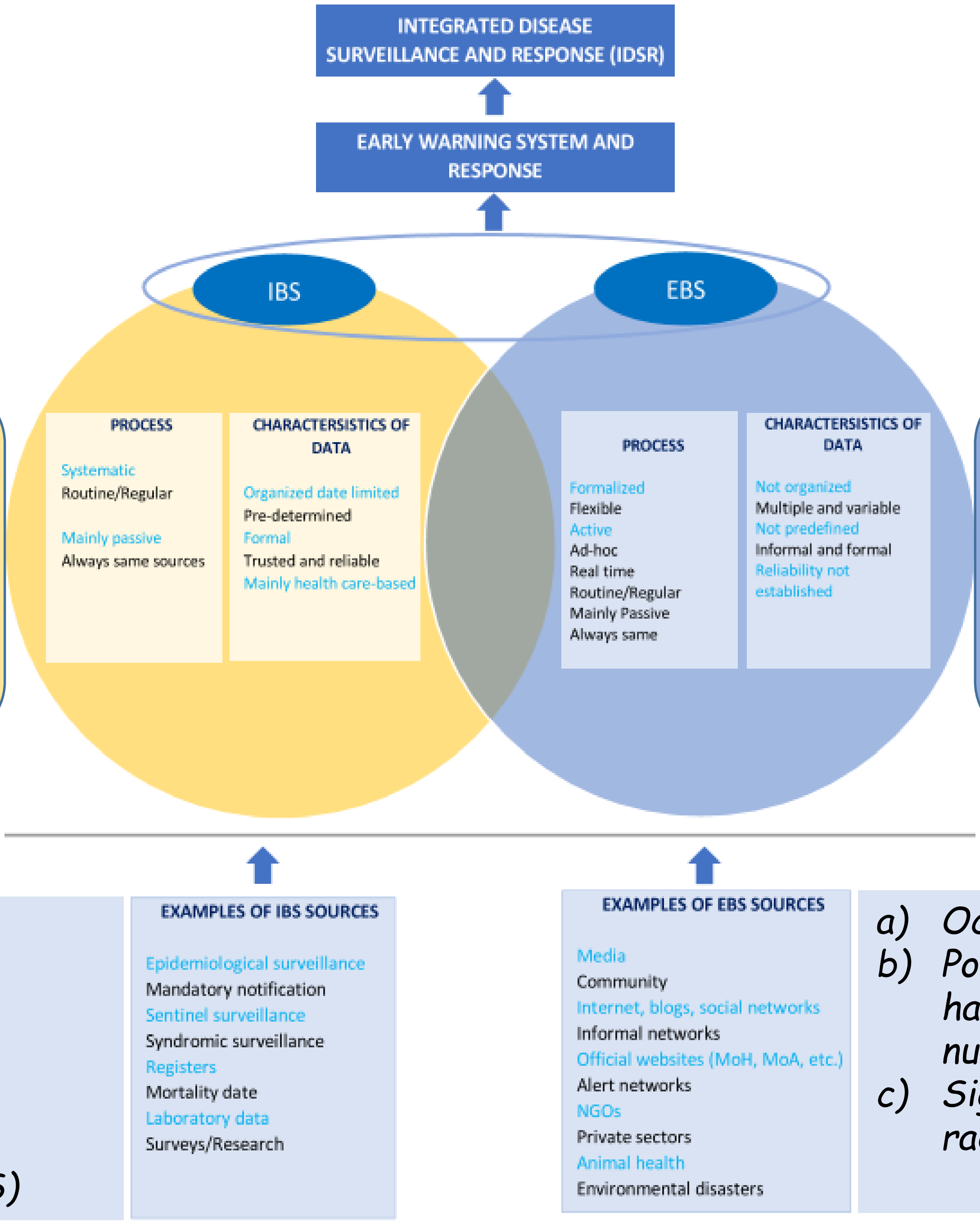
Active surveillance. Active search for cases in the community or risk related facilities: calls or moving physically to the facilities to carry out record review of data.

Integrated surveillance. Collecting data for multiple risk, using standardized tools.

Data collection & analysis system relies on two main channels of information or signal generation:

- Indicator-based surveillance (**IBS**):
- Event-based surveillance (**EBS**).

2.2- Surveillance



IBS:

- Systematic (regular) identification, collection, monitoring, analysis and interpretation of structured data (indicators produced by recognized and mostly formal/institutional sources).

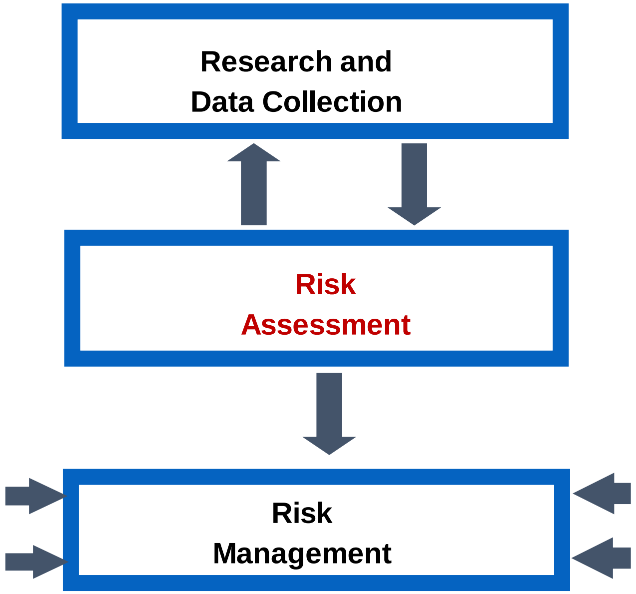
EBS:

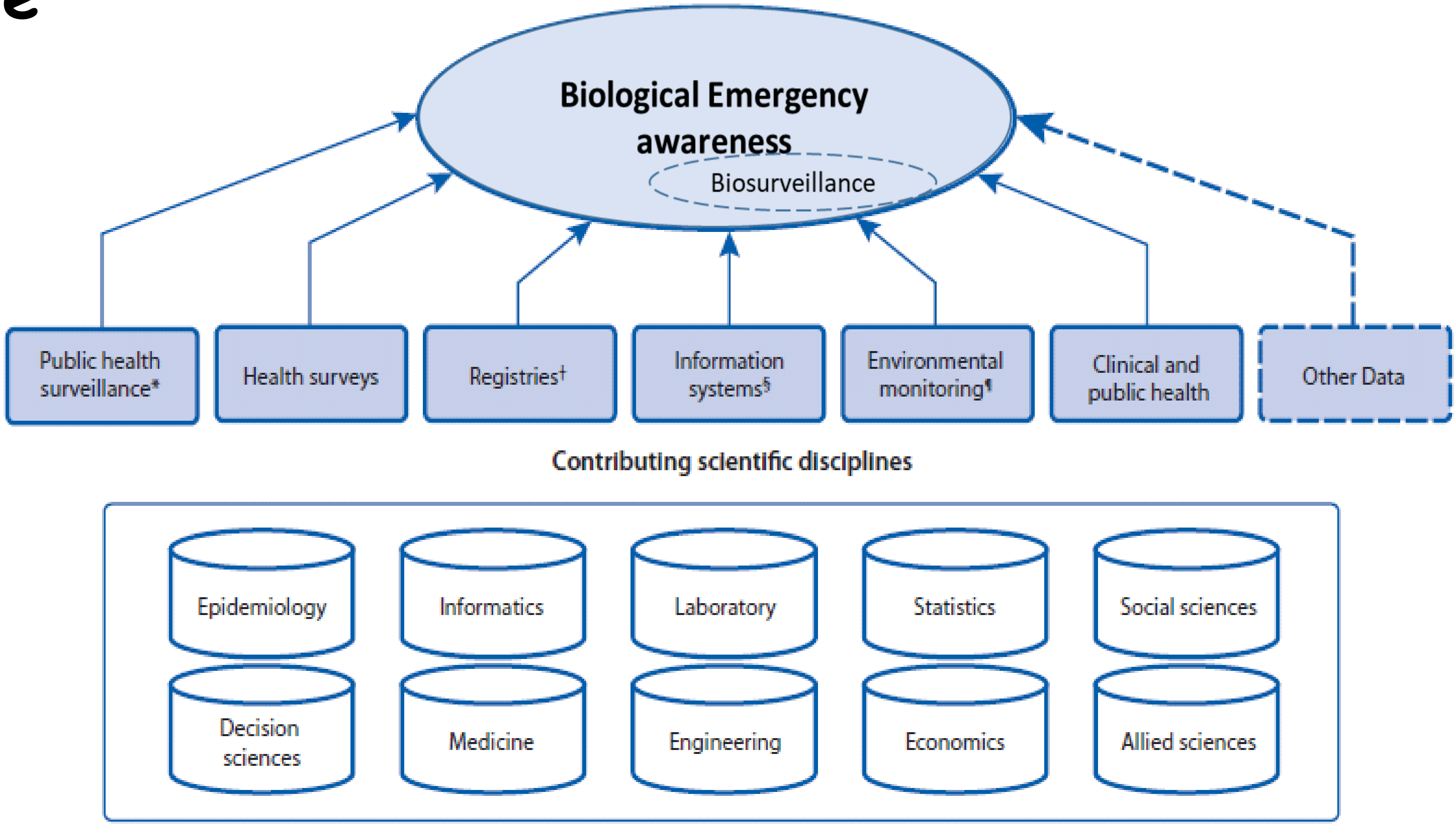
- Organized and rapid capture of information about events that are of potential risk to public health.
- Based on the screening of all available information to detect any event happening in the community.

a) Facility-based surveillance
b) Case-based surveillance
c) Sentinel surveillance
d) Syndromic surveillance
e) Laboratory-based surveillance
f) Disease-specific surveillance
g) Community-based surveillance (CBS)

a) Occurrence of a risk factor,
b) Potential exposure for human to hazards, including chemical and radio-nuclear events;
c) Sign of any biological, chemical or radiological and nuclear hazards

2.2- Surveillance





* *Systematic and continuous collection, analysis, and interpretation of data, closely integrated with the timely and coherent dissemination of the results and assessment to those who have the right to know so that action can be taken (Porta MA, Dictionary of Epidemiology, 5th Ed., Oxford University Press, 2008).*

† *Vital registration, cancer registries, and exposure registries.*

§ *Medical and laboratory records, criminal justice information, and Lexis-Nexis.*

¶ *Weather, climate change, and pollution.*

2.3- Surveillance in East Africa

East Africa steps up health emergency readiness, response

News and Press Release • **Source:** WHO • **Posted:** 6 May 2022 • **Originally published:** 6 May 2022 • **Origin:** View original

© WHO/Marta Monge

Arusha, Tanzania – Five East African countries have held their first simulation exercise since the onset of the COVID-19 pandemic to improve preparedness and bolster response to health emergencies.

Primary country:
Burundi

Other countries:
Kenya / South Sudan / Uganda / United Republic of Tanzania

Source:
World Health Organization

Format:
News and Press Release

Themes:
Disaster Management / Health

Disaster type:
Epidemic

Language:
English

https://reliefweb.int/report/burundi/east-africa-steps-health-emergency-readiness-response

WORLD VISION KENYA
ANNUAL REPORT | 2021

DISASTER MANAGEMENT

Our Disaster Management projects seek to save lives through emergency response, relief and resilience building during and after disasters.

We work with children, families and their communities in disaster preparedness to help reduce the impact of future disasters. We focus on mitigating the effects of drought, floods, conflict, violence and other emergencies such as fire and disease outbreaks.

In 2021, the main disaster management interventions were around the following areas:

- Food Aid Grants
- Peace Building Grants
- Livelihood Grants
- Emergency Response Grants

We are committed to helping communities cope effectively with, and recover from disasters such as floods, drought and disease outbreaks.

Cash Transfer

Total Cash Transfer	Beneficiaries Reached
USD 531,857	46,782

START FUND
START NETWORK

MONTHLY RISK BULLETIN
ISSUED: 27 MAY 2022

Start members and their partners should consider acting on developing risks through the Start Fund Crisis Anticipation. Click HERE for more information on Start Fund Crisis Anticipation. Click HERE for an anticipation alert note template. Click HERE for advocating anticipatory action.

UPCOMING RISKS

RISK RELEVANCE:

The risk relevance rating considers the relevance of the risk to the Start Fund Crisis Anticipation. Risks are categorised with FOREWARN input.

- HIGH RELEVANCE
- MEDIUM RELEVANCE
- LOW RELEVANCE

INFORM GLOBAL RISK INDEX:

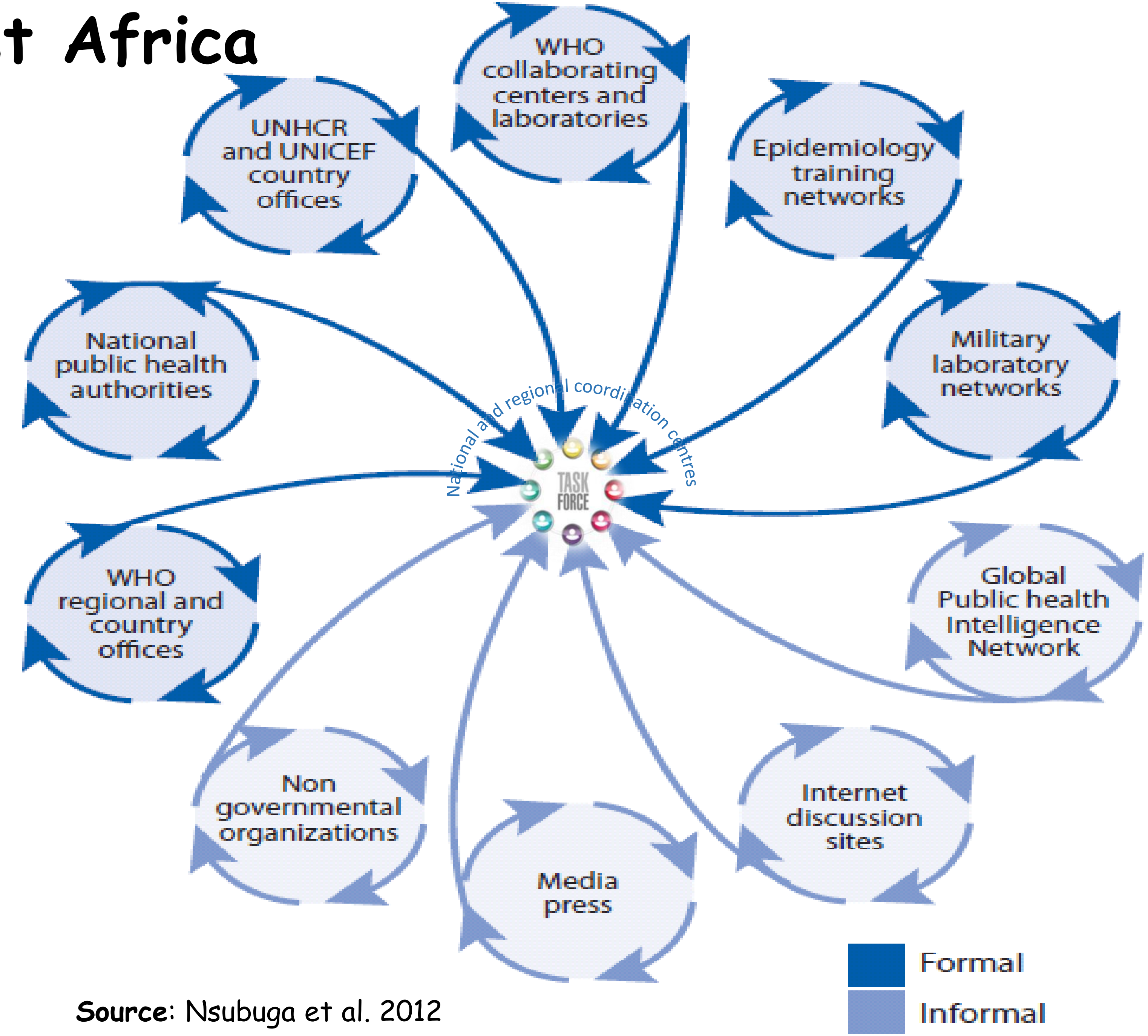
The INFORM risk index identifies countries at risk from humanitarian crises and disasters that could overwhelm national response capacity. It is made up of three dimensions – hazards and exposure, vulnerability and lack of coping capacity.

HIGH RELEVANCE

RISK & COUNTRY/	RISK INFORMATION	SOURCE/KEY
ELECTION VIOLENCE KENYA INFORM RISK CLASS: HIGH	[illegible]	ACLED CRISIS GROUP IFRC

2.3- Surveillance in East Africa

Catastrophic biological surveillance frameworks in East Africa



Source: Nsubuga et al. 2012

International Livestock Research Institute (ILRI)

ILRI offices and staff worldwide

- Main Campuses in **Kenya** & **Ethiopia**,
- Offices in 17 other countries

- Cutting-edge research infrastructures, a range of highly specialized laboratories, a gene bank and a large farm.

Research Programmes

- Livestock Genetics and Centre for Tropical Livestock Genetics and Health (CTLGH)
- Animal and human health
- BecA-ILRI hub
- Feed and forage development
- Sustainable livestock systems
- Policies, institutions and livelihoods
- Impact at scale

ILRI
INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE
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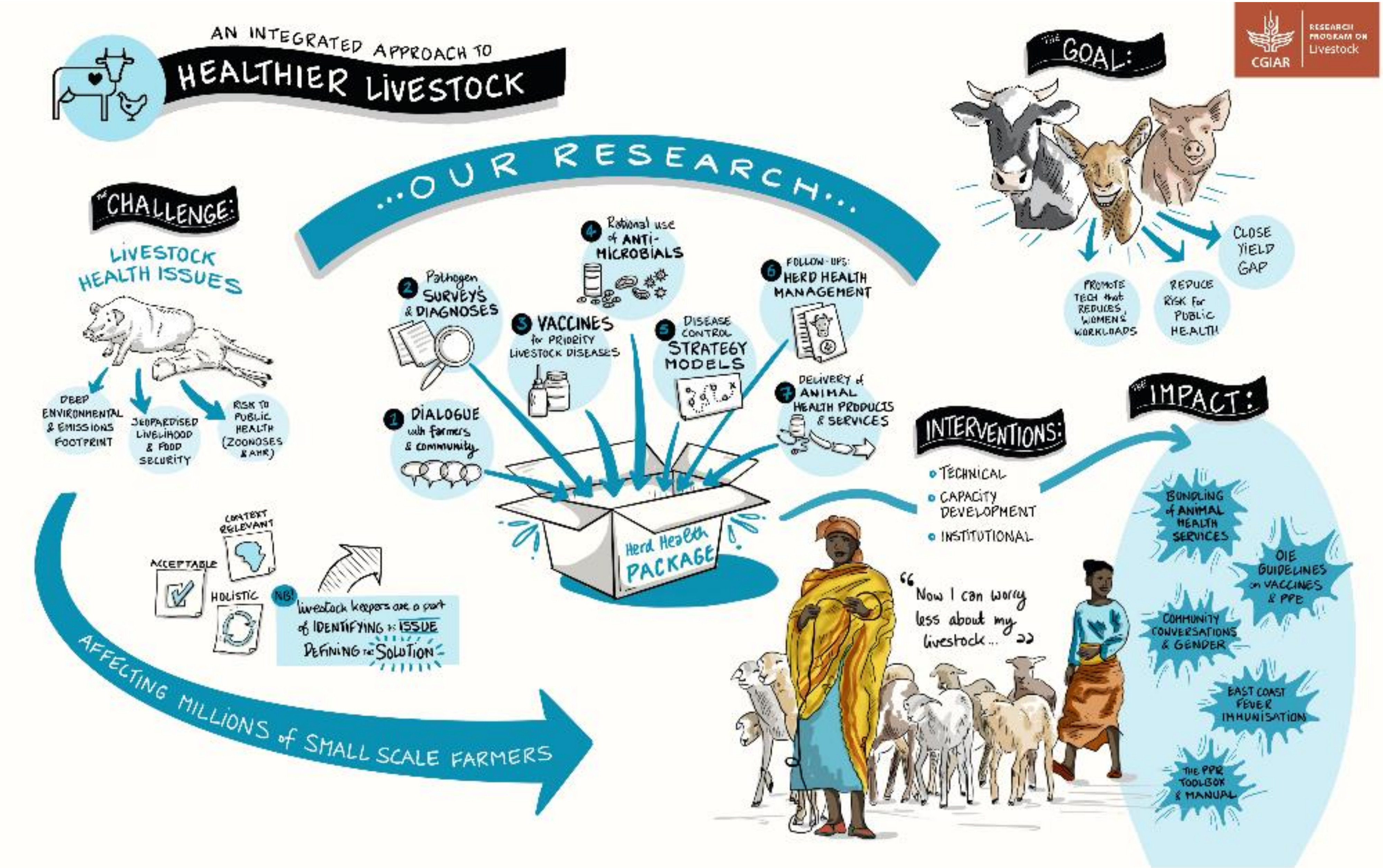
Biological surveillance at the International Livestock Research Institute



ILRI CGIAR

BUiLD Boosting Uganda's Investment in Livestock Development

Rift Valley fever

Kristina Roesel

Develop a socio-economic framework to assess the impact of RVF interventions

Ex-ante analyses of control options; KAP questionnaire surveys; Gender assessments – exposure and constraints on uptake of interventions

Improve RVF surveillance and outbreak response

Outbreak investigations, Genotyping – RVF and other viruses; Serology (establish Gn/Gc distribution); Entomological studies; Risk mapping, sentinel studies

Inform the National Action Plan / Policy

Contingency plans/decision support tools (risk maps); Community trainings

Cross-cutting :

South-south learning & regional networking/coordination (Kenya-Uganda)

Alignment with international recommendations (e.g. OIE PPR GEP and PVS)

Capacity development

Antimicrobial resistance (AMR)

BUiLD Boosting Uganda's Investment in Livestock Development

Arshnee Moodley

The Fleming Fund

TRIGGERS

Vétérinaires Sans Frontières Germany

BfR Bundesinstitut für Risikobewertung

CGIAR ANTIMICROBIAL RESISTANCE Hub

ILRI

CGIAR

Understand antimicrobials (AM) use in broiler production in Uganda

Grey literature review, policy review; AMUSE tool survey

Prevalence study (E. coli, Enterococci, Salmonella); risk factor analysis; MALDI-TOF MS

Understand transmission pathways of bacteria in poultry farms

Quantification AMR in poultry farms, farm workers, environment (E. coli, Enterococci, Salmonella); WGS; residue testing at retail

Assess capacity development gaps in the implementation of the AMR National Action Plan

Support review of National AMR Action Plan; Strengthen surveillance system; Awareness creation of farmers and human-centred behaviour change campaigns

One Health Research, Education and Outreach Centre in Africa (OHRECA)

Bernard Bett

Neglected Zoonotic Diseases (NZDs)

- Collection of robust empirical economic & epidemiological data on the impact of One Health approaches for zoonotic disease control
- Support needs based research on endemic zoonoses

Food Safety

- Improve food safety in informal markets in Africa
- Support behaviour change interventions on food safety

- Quantifying the 'Business Case' for One Health
- Capacity strengthening
- Integrated surveillance systems

- Supports studies to identify drivers of EIDs and generate EID hotspot maps
- Enhance surveillance and response to EID events

Emerging Infectious Diseases (EIDs)

- Conduct Amuse, KAP, and AMR situation analyses to guide new research
- Support refinement of AMR action plans in selected countries

Antimicrobial Resistance (AMR)

OHRECA
One Health Centre in Africa

ILRI

CGIAR

The LiveGene Program


Steve Kemp ***Okeyo Mwai***

Translating Genetic Research to Adoption & Social Value

Targeting → Gene Discovery → Delivering Genetic Gains

ILRI strategic objectives → Provide evidence to decision makers → Promote science-based strategies → Co-create capacity

Preparing the regulatory, safety & public awareness environment


Kenyan and regional regulators and stakeholders meet in ILRI with their global counterparts to discuss the Mzima Cow project

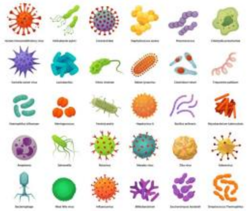
- Ground-breaking Science
- The Challenge of Adoption
- Defining the Testing Routemap

"Systems Change at the Speed of Trust":

Establishing trust is key to regulatory progress and the eventual adoption and understanding of genome edited livestock

ILRI CGIAR

2.4 Genomic data production for biological surveillance: ILRI



Biorepository*

Low throughput

Medium throughput

High

Sequencers (Illumina MiSeq and NextSeq, ONT MinION, etc.)

Various sequencing Platforms/services

- **DNA seq. :** functional annotations
- **RNA seq. :** Gene expression data
- **Proteins seq. :** protein structures
- **Metabolites:** small molecule structures

HPC storage infrastructure

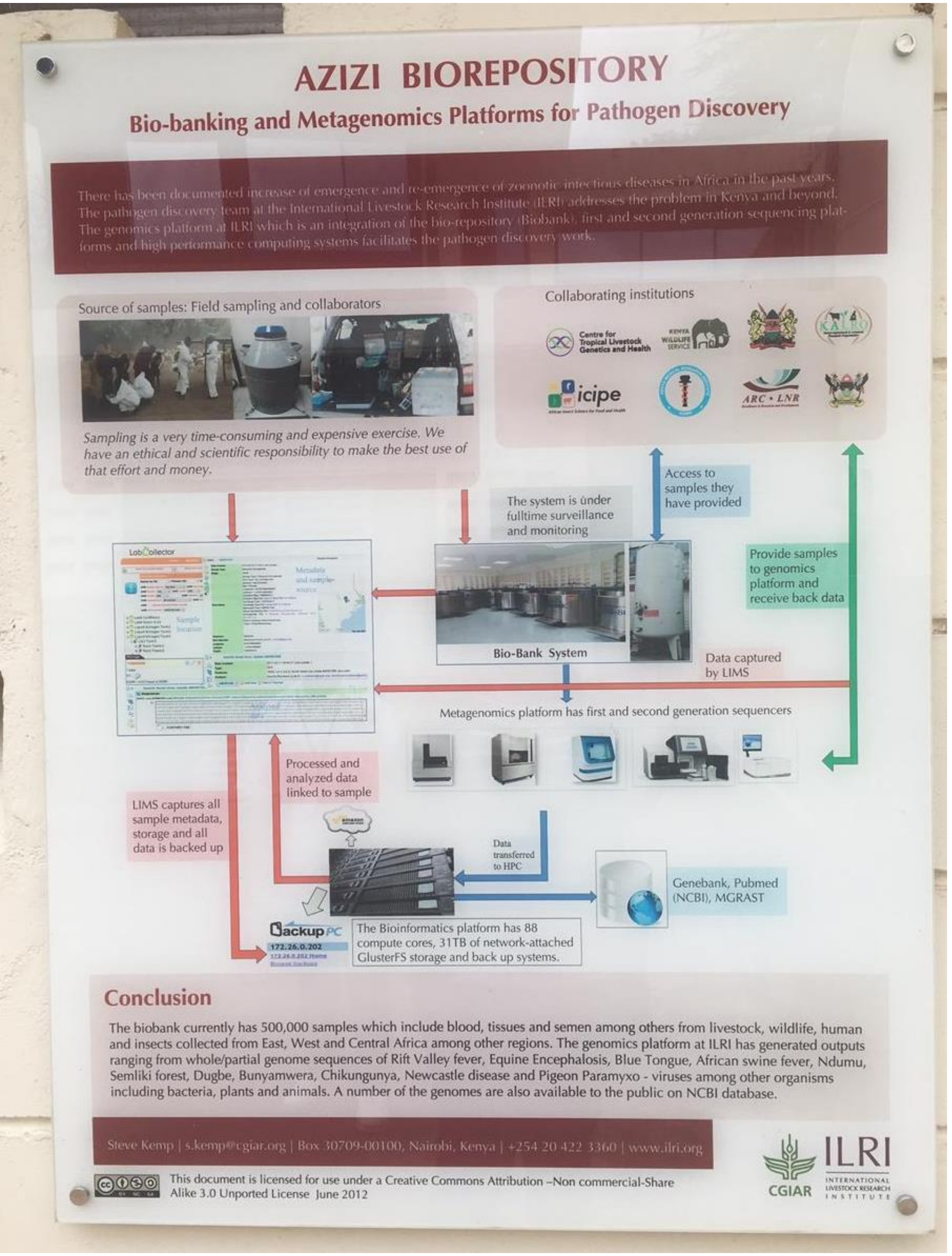
- Physical redundancy (through a RAID array)
- Logical redundancy (through the GlusterFS storage supervision software that implements logical replicas)

Security

- INSDC databases (ENA, GenBank, DDBJ) for most sequences
- GISAID for SARS-CoV-2 sequences

Uploaded on various platforms

ILRI Biorepository to support pathogen discovery



➔ 09 tanks ➔ 80000 samples per tanks ➔ Total capacity: 720 000 samples

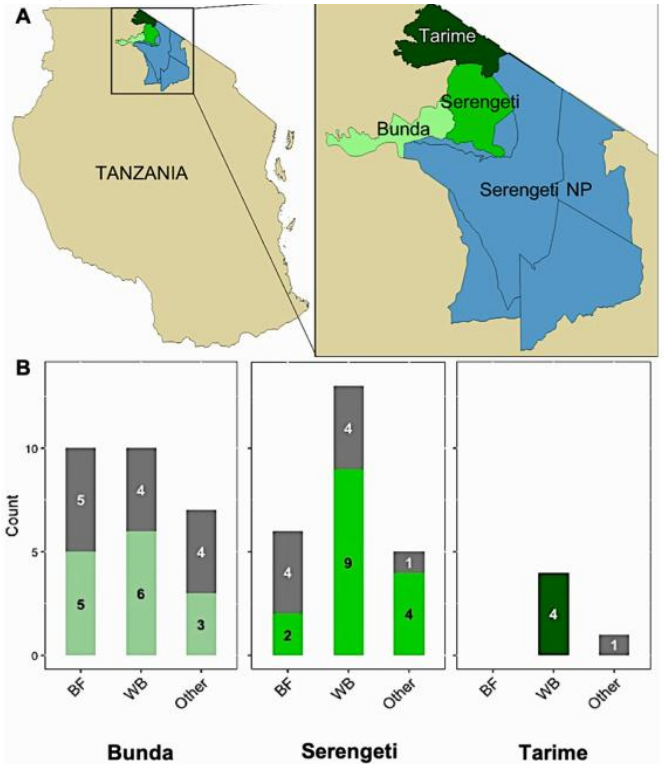
www.nature.com/scientificreports

SCIENTIFIC REPORTS
natureresearch

OPEN

Microbial Diversity in Bushmeat Samples Recovered from the Serengeti Ecosystem in Tanzania

Robab Katani[1,2], Megan A. Schilling[2,3], Beatus Lyimo[4], Triza Tonui[5], Isabella M. Cattadori[2,6], Ernest Eblate[4,7], Andimile Martin[4], Anna B. Estes[2,4], Teresia Buza[2], Dennis Rentsch[8], Karen W. Davenport[9], Blake T. Hovde[9], Samson Lyimo[4], Lydia Munuo[4], Francesca Stomeo[5,10], Christian Tiambo[5], Jessica Radzio-Basu[1,2], Fausta Mosha[11], Peter J. Hudson[1,2], Joram J. Buza[4] & Vivek Kapur[1,2,3,4*]



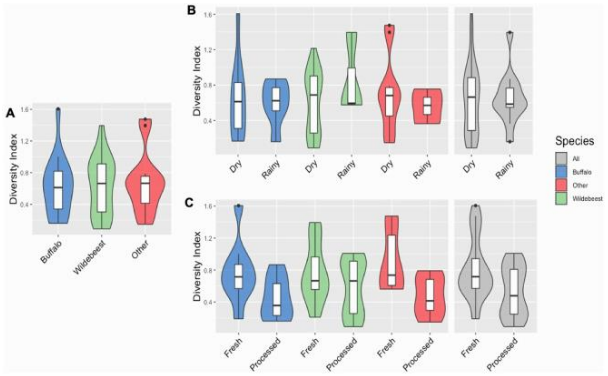


Figure. Samples from wildlife species collected from the Western Serengeti.

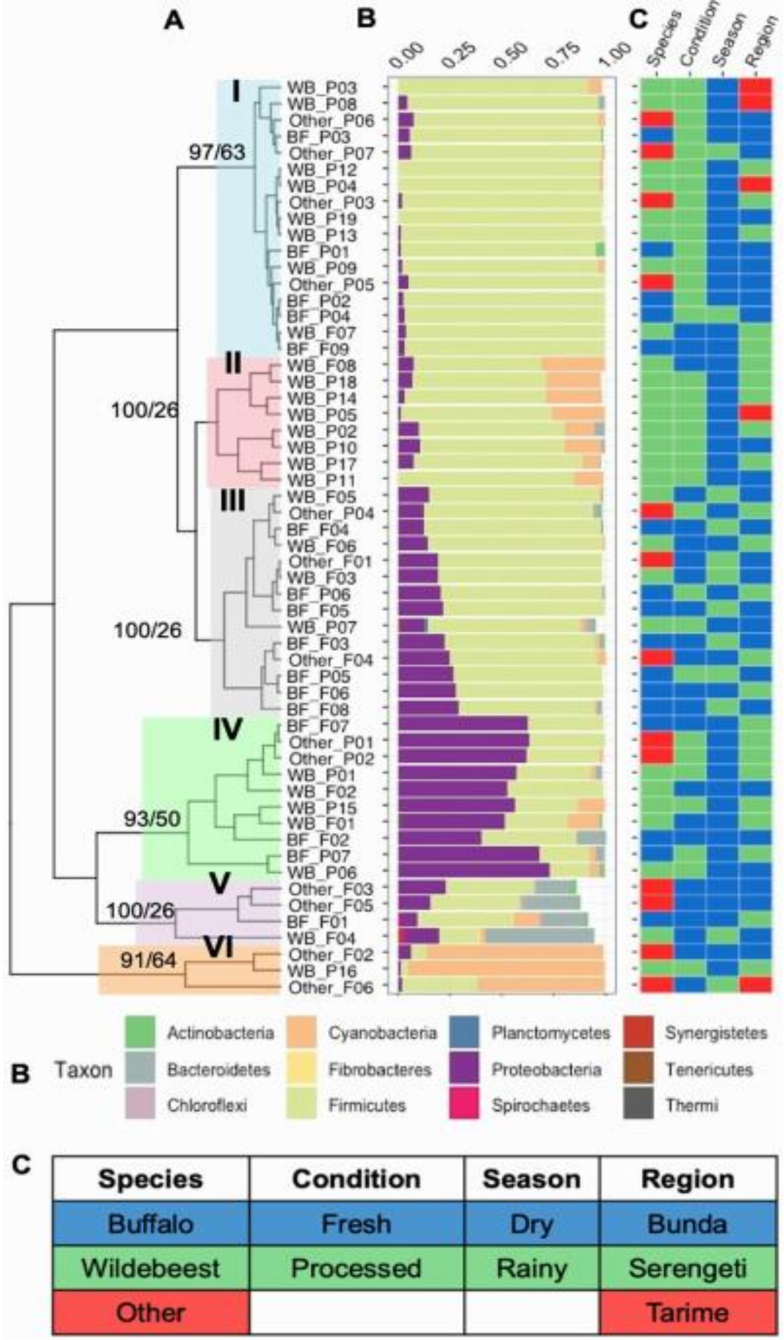


Figure. Hierarchical clustering of samples based on the relative abundance of phyla.

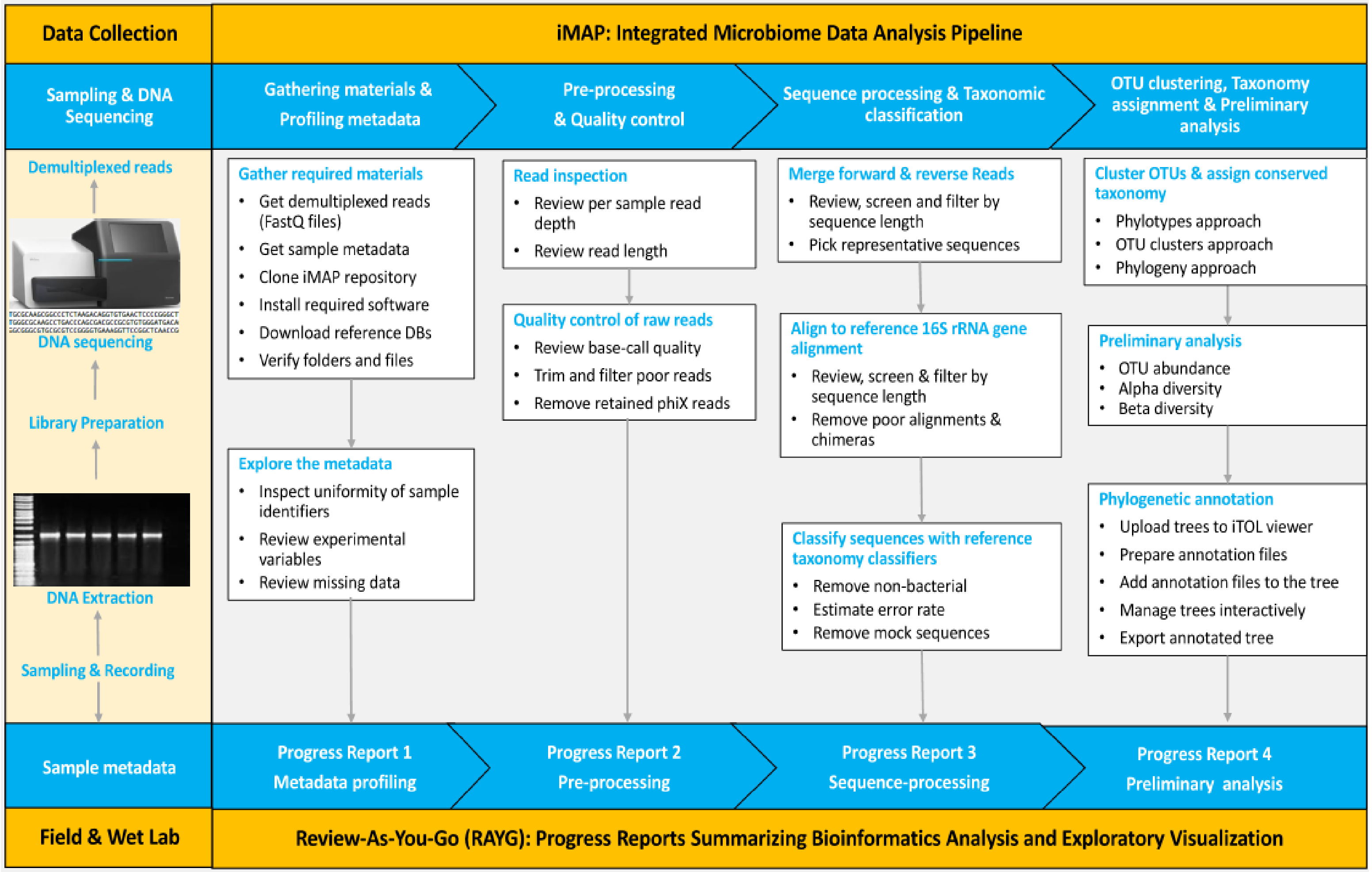
Buza *et al. BMC Bioinformatics* (2019) 20:374
https://doi.org/10.1186/s12859-019-2965-4

BMC Bioinformatics

SOFTWARE Open Access

iMAP: an integrated bioinformatics and visualization pipeline for microbiome data analysis

Teresia M. Buza[1,2*], Triza Tonui[3], Francesca Stomeo[3,9], Christian Tiambo[3], Robab Katani[1,4], Megan Schilling[1,5], Beatus Lyimo[6], Paul Gwakisa[7], Isabella M. Cattadori[1,8], Joram Buza[6] and Vivek Kapur[1,4,5,6]



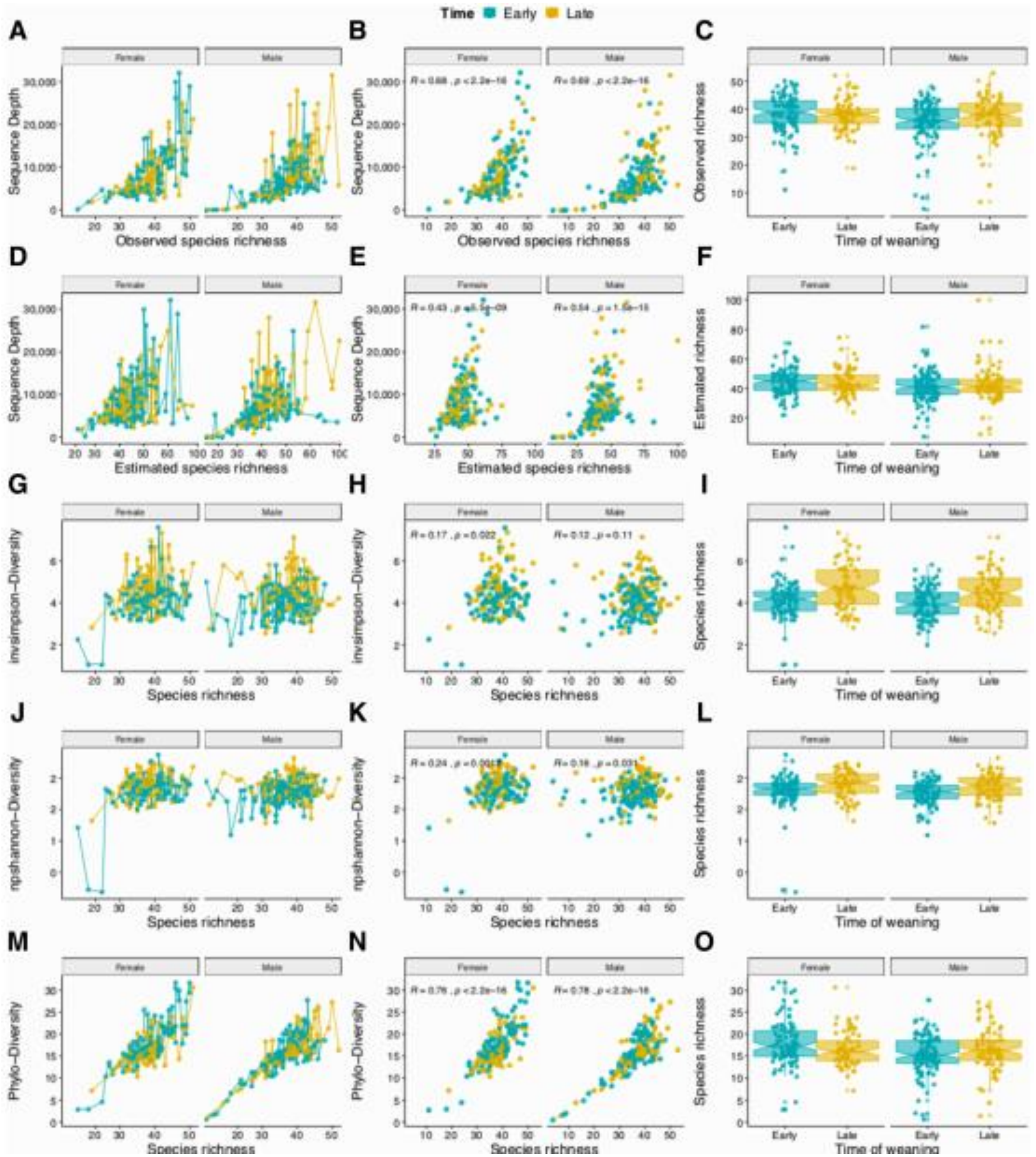


Fig. Species richness and diversity.
The figure clearly reveals the differences observed in species abundances when comparing the main experimental variables including sex (orange) and time post weaning (green)

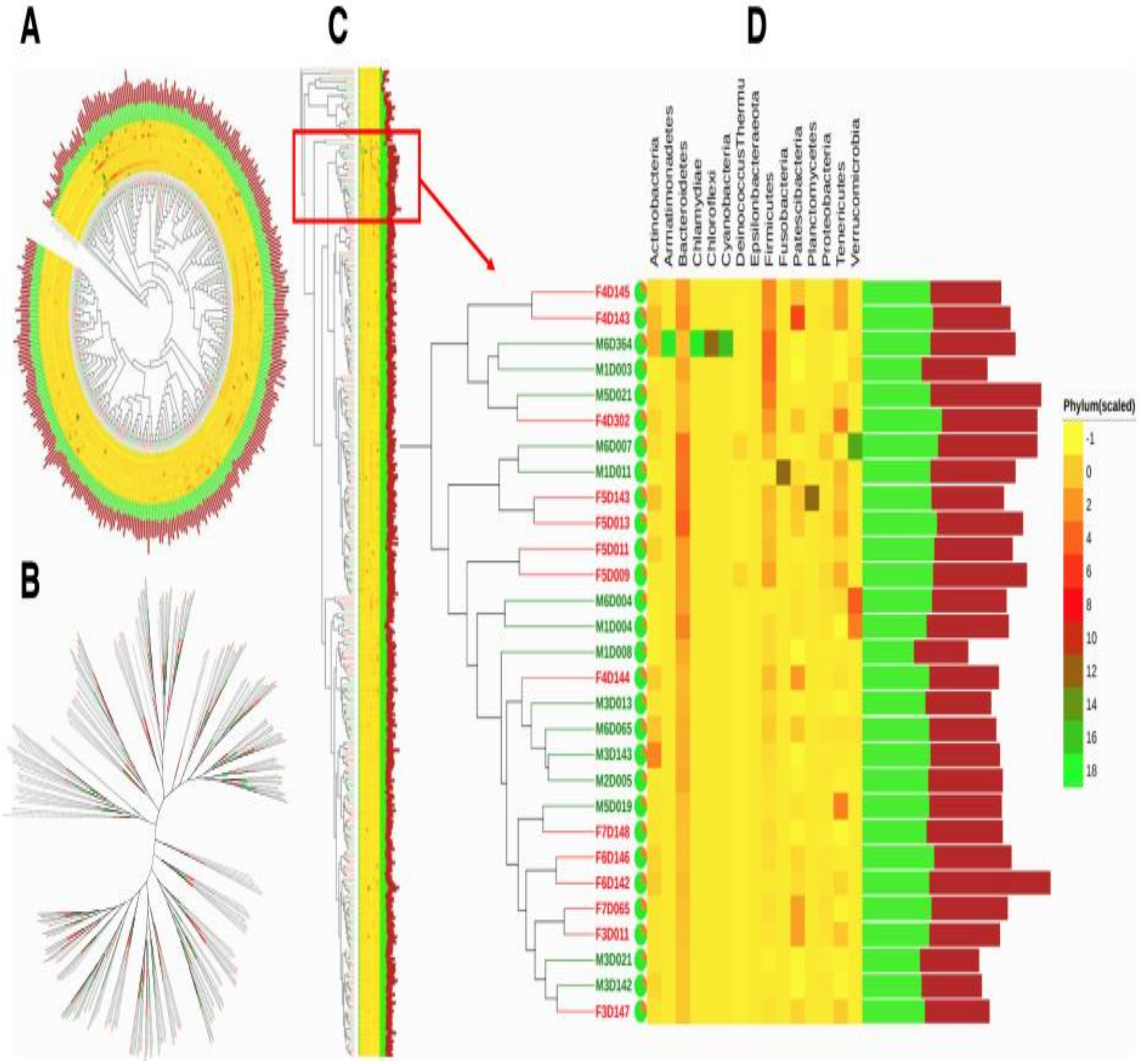


Fig. Phylogenetic relationship and annotation of samples grouped by sex variable. The circular phylograms (a), unrooted cladogram (b), and the rectangular phylograms (c) display the relationships of the 360 samples used in the case study.

2.5 Potential for genomic surveillance of catastrophic biological risks in East Africa

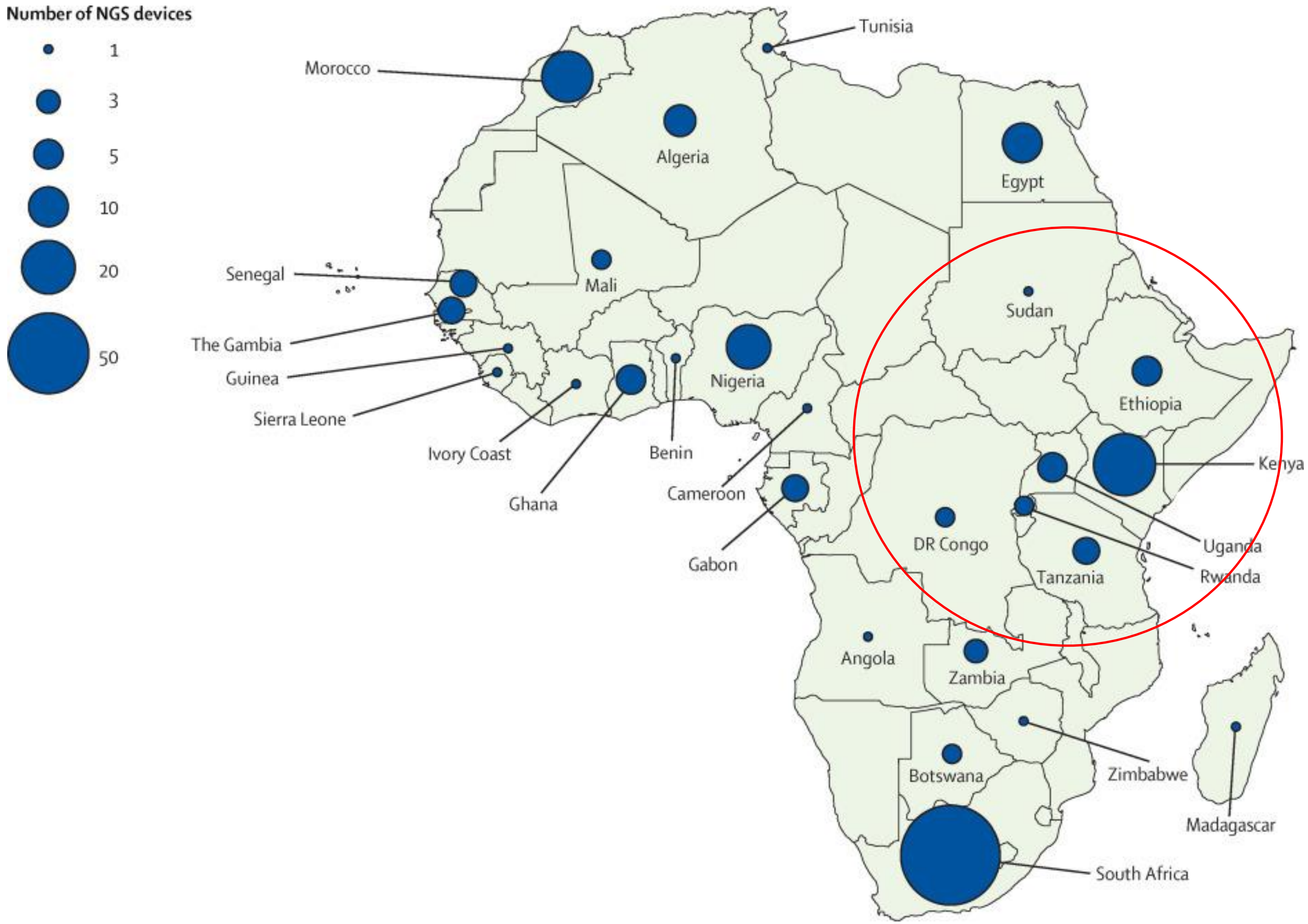
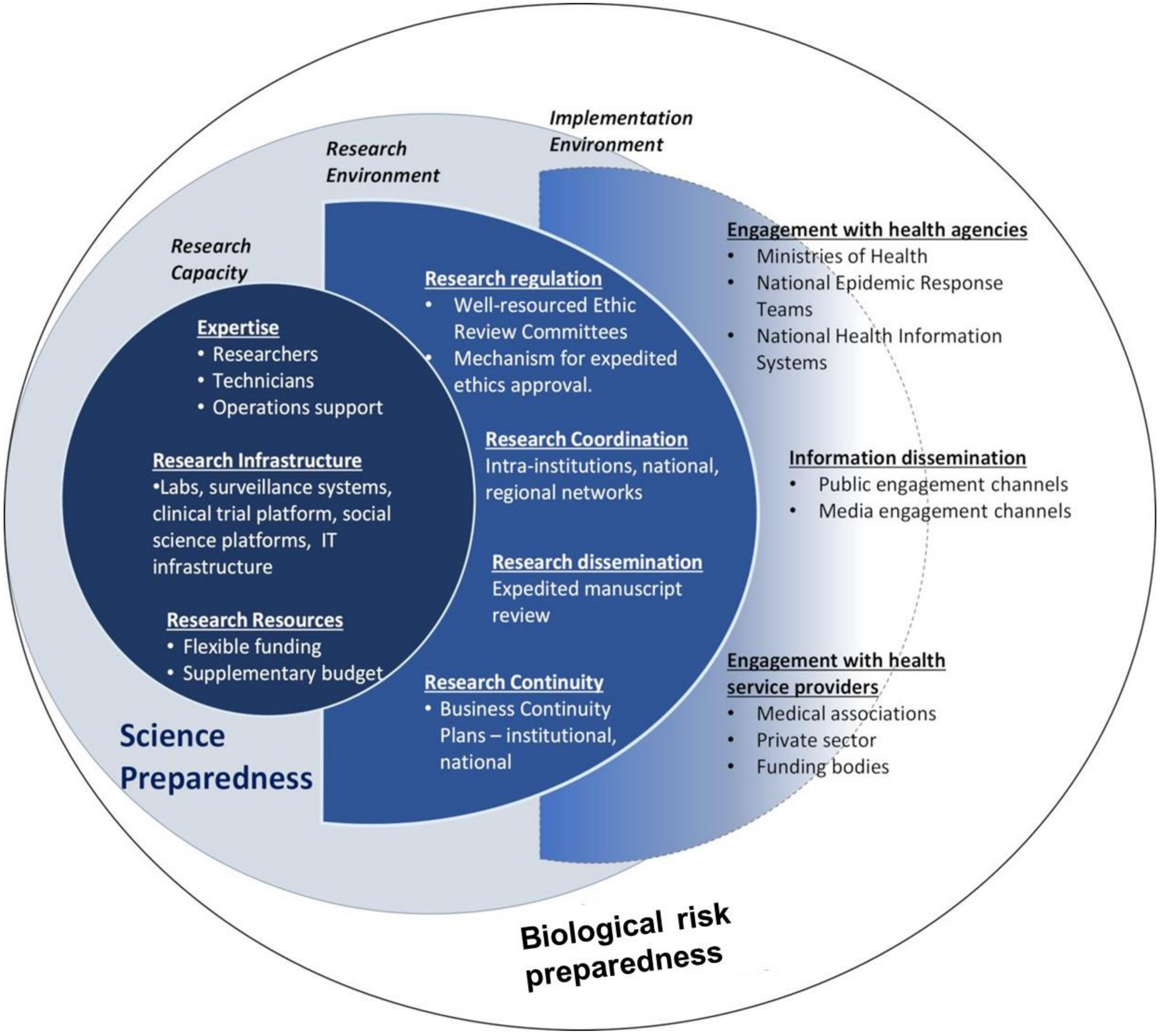


Fig. Next-generation sequencing capacity in Africa

As prerequisites for preparedness



3- Early warning & rapid response systems

3.1 Early warning and rapid response systems (EWRS) are intended to:

- Identify and analyse risk trends,
- alert to catastrophe risk,
- inform decision-making and,
- initiate timely responses to prevent worst consequences.

EWRS:

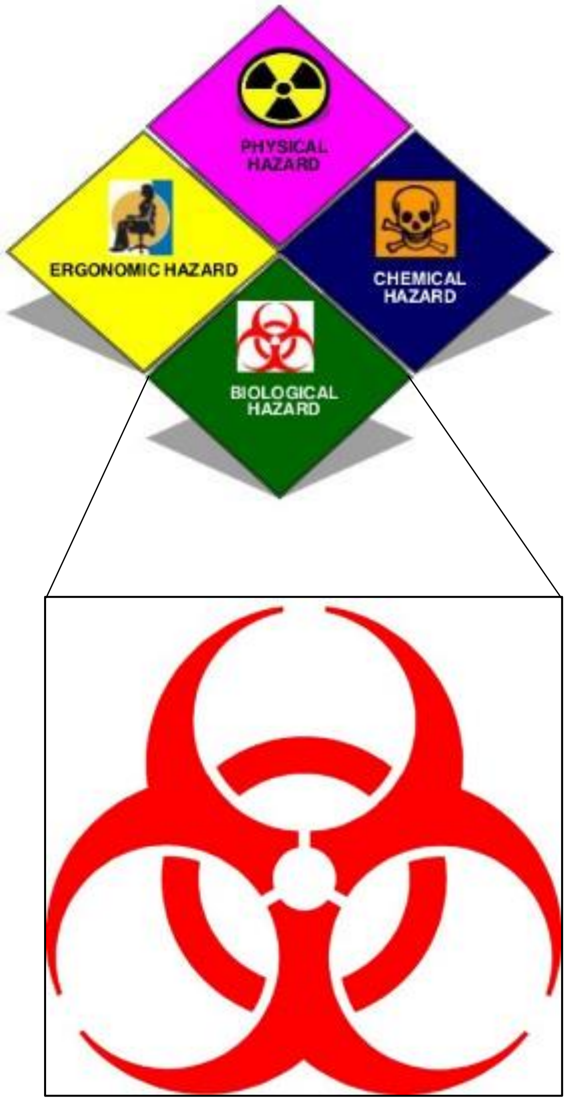
- Data collection and verification and,
- **Risk analysis** identifying emergency trends and dynamics at various levels.

Based on this analysis, recommendations can be made for timely and appropriate preventive action, or early response options, to targeted stakeholders.

3.2 Bio-risk assessment and management

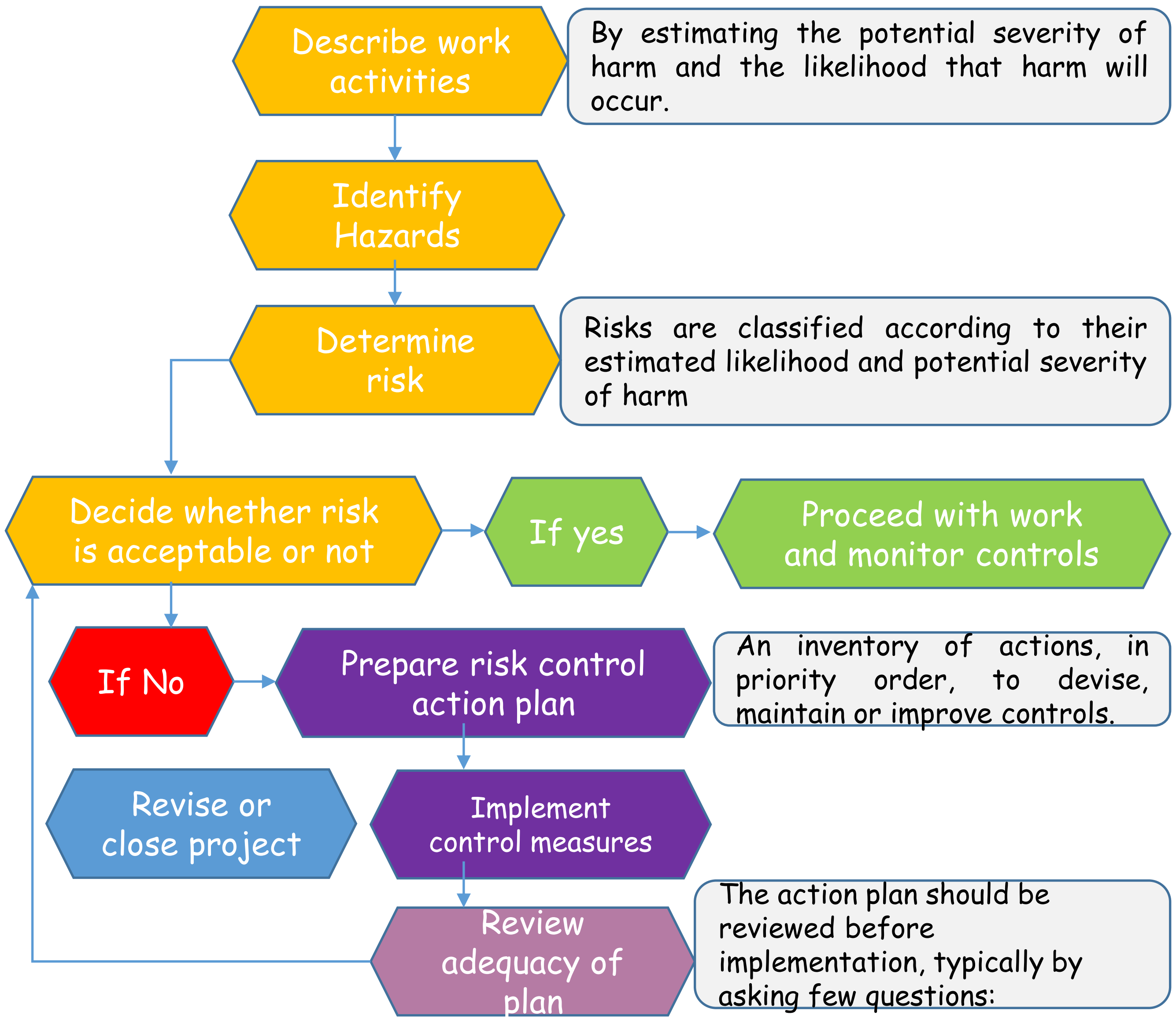
Risk = Severity x Likelihood

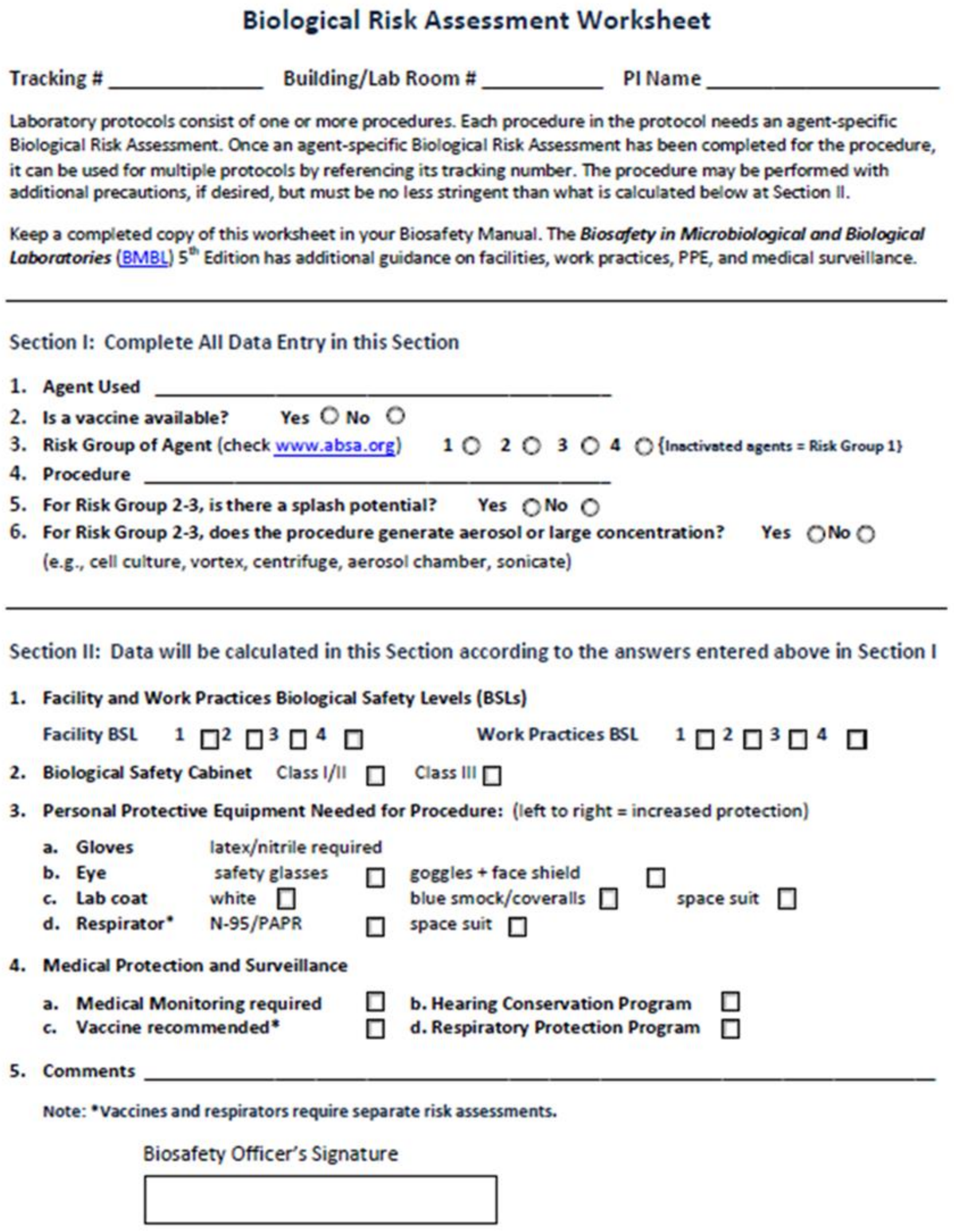
Combination of the probability of occurrence of harm and the severity of that harm where the source of harm is a biological agent or toxin.



Source:
- unintentional exposure,
- accidental release or loss,
- theft, misuse,
- diversion,
- unauthorized access or
- intentional unauthorized release

Practical risk assessment





Biological Risk Assessment Worksheet

Tracking # ____________ Building/Lab Room # __________ PI Name ______________

Laboratory protocols consist of one or more procedures. Each procedure in the protocol needs an agent-specific Biological Risk Assessment. Once an agent-specific Biological Risk Assessment has been completed for the procedure, it can be used for multiple protocols by referencing its tracking number. The procedure may be performed with additional precautions, if desired, but must be no less stringent than what is calculated below at Section II.

Keep a completed copy of this worksheet in your Biosafety Manual. The *Biosafety in Microbiological and Biological Laboratories* (BMBL) 5th Edition has additional guidance on facilities, work practices, PPE, and medical surveillance.

Section I: Complete All Data Entry in this Section

1. **Agent Used** ______________________________
2. **Is a vaccine available?** Yes ○ No ○
3. **Risk Group of Agent** (check www.absa.org) 1 ○ 2 ○ 3 ○ 4 ○ (Inactivated agents = Risk Group 1)
4. **Procedure** ______________________________
5. **For Risk Group 2-3, is there a splash potential?** Yes ○ No ○
6. **For Risk Group 2-3, does the procedure generate aerosol or large concentration?** Yes ○ No ○
   (e.g., cell culture, vortex, centrifuge, aerosol chamber, sonicate)

Section II: Data will be calculated in this Section according to the answers entered above in Section I

1. **Facility and Work Practices Biological Safety Levels (BSLs)**
   Facility BSL 1 ☐ 2 ☐ 3 ☐ 4 ☐ Work Practices BSL 1 ☐ 2 ☐ 3 ☐ 4 ☐
2. **Biological Safety Cabinet** Class I/II ☐ Class III ☐
3. **Personal Protective Equipment Needed for Procedure:** (left to right = increased protection)
   a. Gloves latex/nitrile required
   b. Eye safety glasses ☐ goggles + face shield ☐
   c. Lab coat white ☐ blue smock/coveralls ☐ space suit ☐
   d. Respirator* N-95/PAPR ☐ space suit ☐
4. **Medical Protection and Surveillance**
   a. Medical Monitoring required ☐ b. Hearing Conservation Program ☐
   c. Vaccine recommended* ☐ d. Respiratory Protection Program ☐
5. **Comments** ______________________________

Note: *Vaccines and respirators require separate risk assessments.

Biosafety Officer's Signature

Biorisk Assessment Sheet

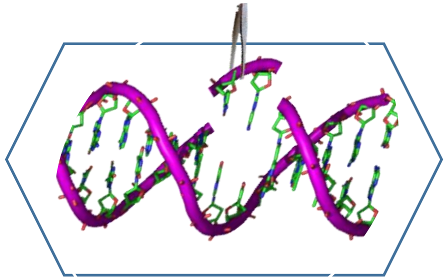
Practical risk assessment

Pathogen risk assessments

▪ One for every pathogen used	✓ Conducted before it is brought in ✓ Determines Risk Group ✓ Required by law based on main host/target (CBSG)
▪ Covers all aspects of use	✓ Storage, ✓ containment, ✓ handling PPE ✓ SOPs for entire lifecycle
▪ Pathogen Safety Data Sheet (PSDS) created	✓ Pathogenicity, ✓ route of infection, ✓ infectious dose, ✓ survival in the environment

Practical risk assessment

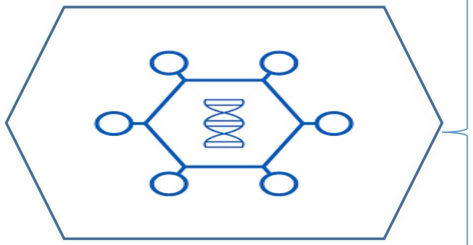
Genetically modified/edited organisms (GMO/GEO) present an interesting challenge for Pathogen Risk Assessments.



GMO/GEO

- Risk can increase or decrease
  - ✓ Depends on transformation and gene(s) affected
  - ✓ Original organism and source of genes considered first
- Reassessment of risk required with alteration of:
  - ✓ Pathogenicity/virulence
  - ✓ Pharmacological activity (resistance)
  - ✓ Genes related to hazardous properties (Production of toxins, oncogenes,
- Ability to replicate
  - ✓ Attenuation
  - ✓ Change in host range
- Containment level of organisms
  - ✓ Gene recipient and gene donor
- Potential pathogenic factors of genetic info
- Possible novel hazards
- Survivability outside containment zone

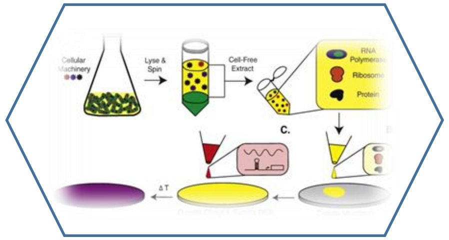
Practical risk assessment



Viral Vectors

- Engineered viruses
  - ✓ Can create GMOs
  - ✓ Transient or permanent gene modification
- Considerations similar to GMO
- “Safety features” included in design
  - ✓ Reduced risk
  - ✓ Replication deficiency
- Additional risk from retroviral vectors
  - ✓ Modify host DNA permanently
  - ✓ Potential for oncogenesis (mutation causing cancer)

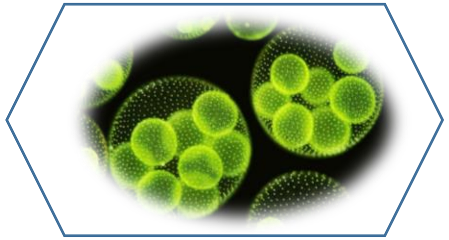
Practical risk assessment



Synthetic Biology

- Genes/sequences created synthetically
  - ✓ Not found in nature
  - ✓ More novel approach
- Risk difficult to assess
  - ✓ Effects not always predictable
  - ✓ Careful assessment and testing required
- Interaction with existing genes/gene products
  - ✓ Unexpected risks

Practical risk assessment



Toxins

Not infectious material or toxic chemical

- ✓ Separate risk assessment required
- ✓ Common regulated toxins listed in HPTA
  - *Schedule 1 and Part I of Schedule 5*

Considerations

- ✓ Toxicity (lethal dose and/or effective dose)
- ✓ Risk and routes of exposure
- ✓ Concentration and amount used
- ✓ Rate of action
  - Neurotoxins effective in minutes/hours
  - Cytotoxins effective in hours/days
- ✓ Availability of treatment

Classification of biological risk by groups

- **Group 1: (no or very low individual and community risk):** A microorganism that is unlikely to cause disease

- **Group 2: (moderate individual risk, low community risk):** A pathogen that can cause disease but is unlikely to be a serious hazard to individuals, community, livestock or environment.

- **Risk Group 3: (high individual risk, low community risk):** A pathogen usually causes serious human/animal disease but does not ordinarily contaminate others.

- **Risk Group 4: (high individual and community risk):** A pathogen usually causes serious human/animal disease and can be transmitted to others directly or indirectly.

Classification of biological risk by groups

	Slightly harmful	Harmful	Extremely harmful
Highly unlikely	Trivial risk*	Tolerable risk#	Moderate risk$
Unlikely	Tolerable risk	Moderate risk	Substantial risk†
Likely	Moderate risk	Substantial risk	Intolerable risk¥

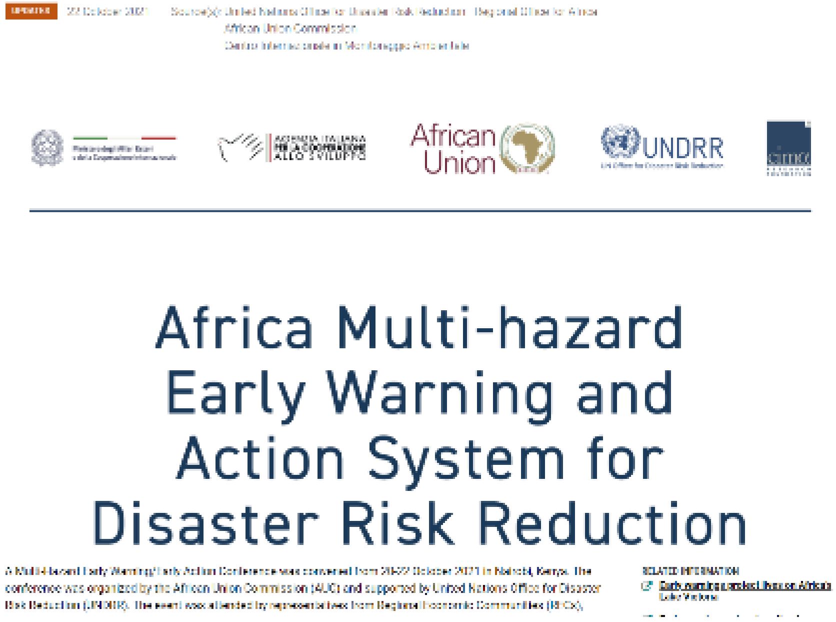
** No action required, and no documentary records need to be kept.*
 # No additional controls required, but monitoring required to ensure that the controls are maintained.
$ Efforts needed to reduce the risk within a defined time period. If moderate risk is associated with extremely harmful consequences, further assessment necessary to establish the likelihood of harm the need for improved control measures
† No activity authorized until the risk has been reduced. Where the risk involves work in progress, urgent action should be taken.
¥ No activity authorized to started or continued until the risk has been reduced. If it is not possible to reduce risk, work has to remain prohibited.

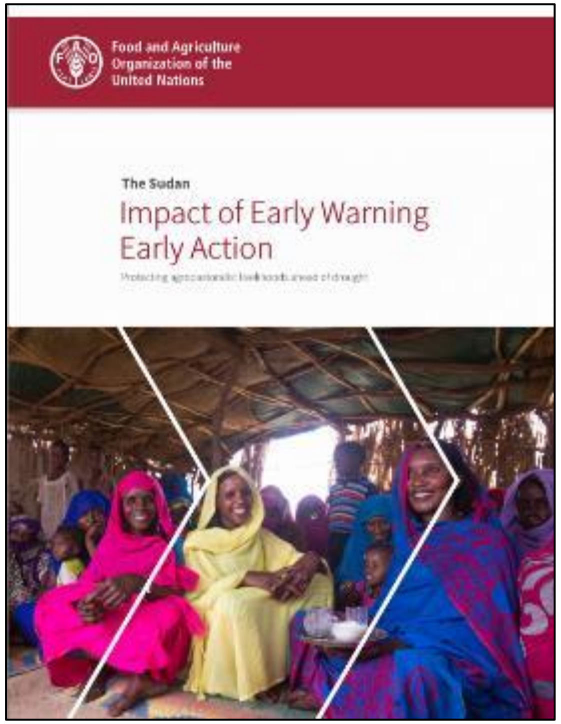
Early warning and rapid response systems in East Africa: the capabilities

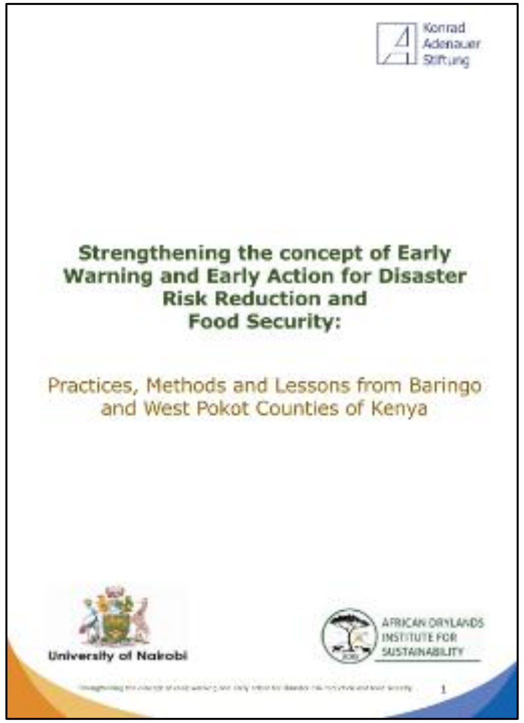
AU sets up Nairobi situation room to help Africa mitigate disasters

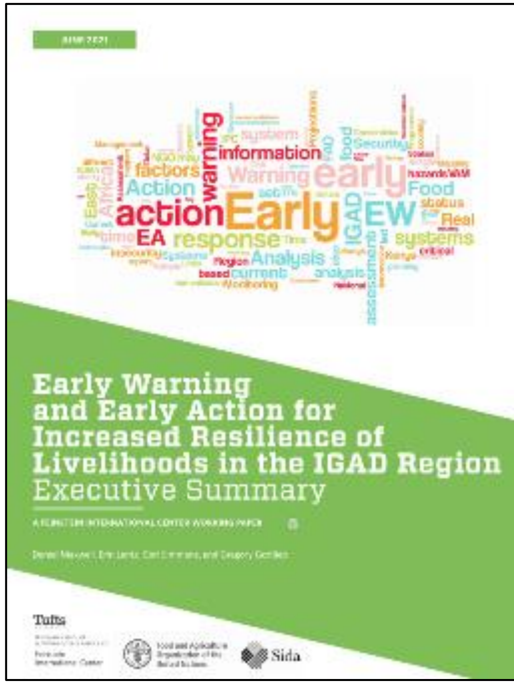
https://www.voanews.com/a/au-sets-up-nairobi-situation-room-to-help-africa-mitigate-disasters/6315749.html

Early warning and Rapid response systems in East Africa: the capabilities

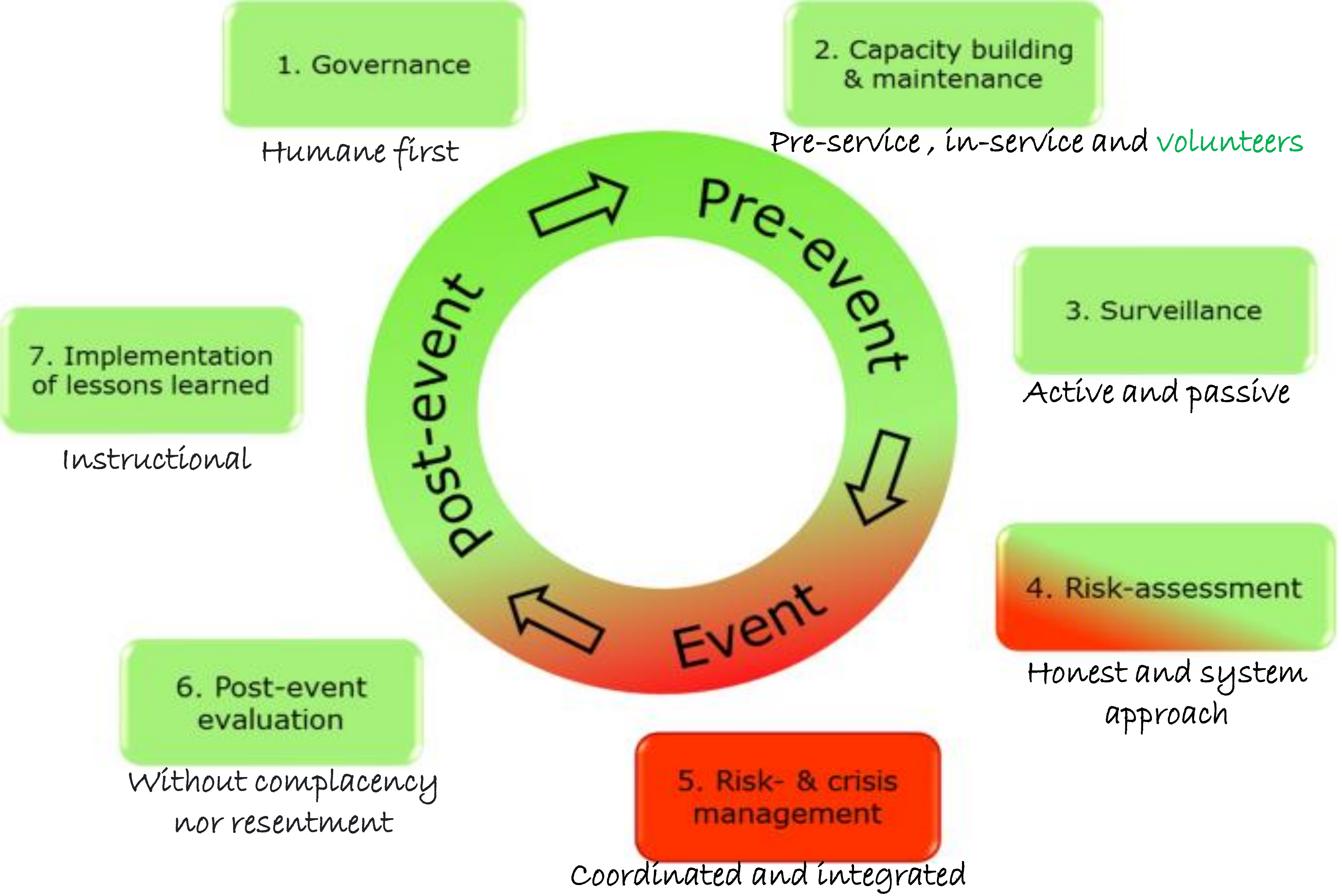








4. Perspectives for East Africa



Propositions for actions forwards for SBA-GCBRI

1. **Plan from known and likely catastrophic biological risks and actions**
   - Improve contingency planning, from interventions back to information needs
   - Identify early actions for catastrophic biological risks
   - Coordinate the multiple demands on timeliness
   - Share information across borders
   - Involve at-risk communities, and learn from existing success

Propositions for actions forwards for SBA-GCBRI

2. Information/data and analysis

- Focus Information/data needs on contingency planning
- Improve biorisk Analysis / modeling
- Broaden the information base and improve information sharing and availability
- Build real-time monitoring into information or alert systems
- Prioritize capacity building

Propositions for actions forwards for SBA-GCBRI

3. Cross-cutting recommendations

- Clarify the role of governments and NGOs
- National and regional regulatory frameworks
- Face ethical issues head on
- Learn from mistakes and learn from covid-19
- Depoliticize information, analysis, and action
- Build in accountability and involve at-risk communities

Propositions for actions forward for SBA-GCBRI

Some needs for capacity building

- Training & demos for community preparedness and recovery
- Catastrophic biological risk operations coordination
- CBR public information sharing & warning
- Fatality management and Mass care (Medical surge, countermeasure dispensing & administration, materiel management and distribution)
- Nonpharmaceutical interventions and harnessing traditional knowledge
- Public and vet. health laboratory testing, Biological surveillance and epidemiological investigation
- Volunteer management .

Thank you

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