THE ROLE AND IMPORTANCE OF MILLETS CULTIVATION AND BREEDING AT A GLOBAL PERSPECTIVE

Patrick Okori

RUFORUM Executive Secretary

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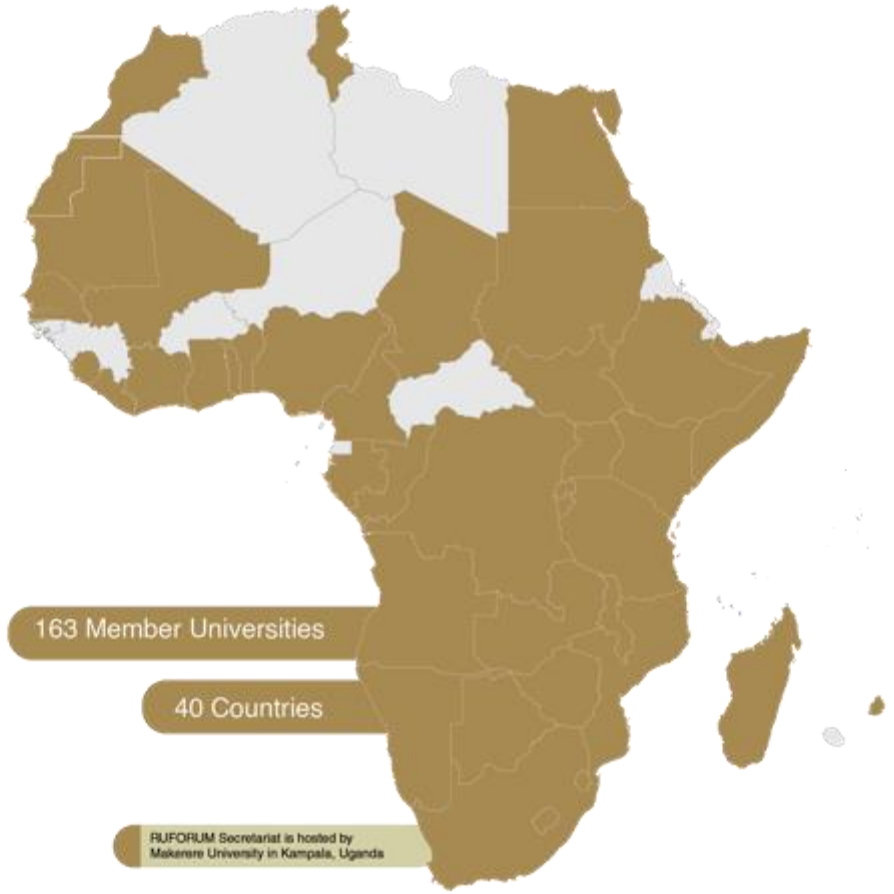
Who we are

Network of 163 Universities in 40 African Countries



Vision

Vibrant, transformative universities catalyzing sustainable, inclusive agricultural development to feed and create prosperity for Africa.

Young graduates during an experiential learning event. Photo **Credit. RUFORUM**

Why invest in Millets

Significance of #IYM2023

- Can grow on arid lands with minimal inputs & are resilient to changes in climate and weather variability.
- Contribute to increased self-sufficiency and reduce reliance on imported cereals.
- An opportunity to raise awareness and direct policy attention to the **nutritional and health benefits** of millets and their **suitability** for **cultivation** under **adverse** and changing climatic conditions.
- Promote the **sustainable production of millets**, while **highlighting** their **potential** to provide **new sustainable market opportunities** for **producers** and **consumers**

INTERNATIONAL YEAR OF MILLETS 2023

Source: www.fao.org/millets-2023

The 21st century's grand challenges

- Biodiversity loss
- Land degradation
- Ecology
- Population explosion
- Food crisis
- Health and zoonoses

Harmonious

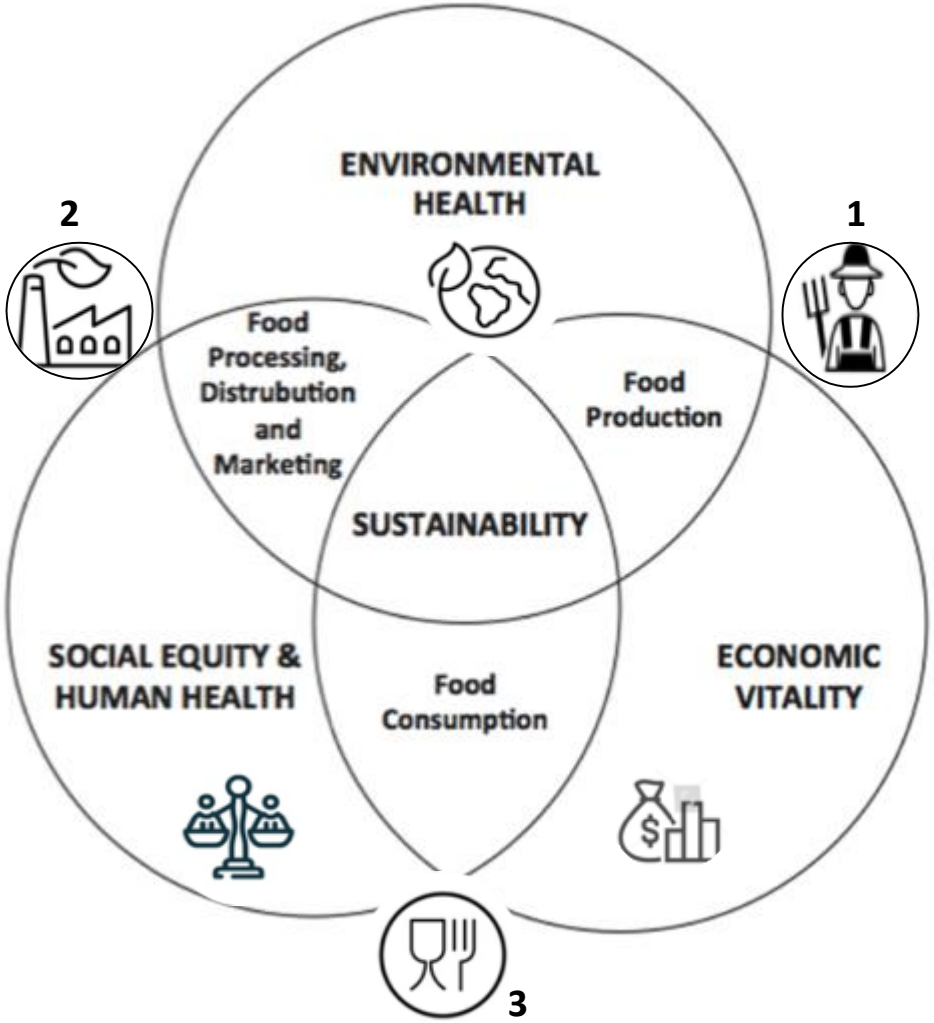
Sustainable

Equitable

Development

- Energy
- Economy/inequity
- Climate change
- Water
- Security
- Education

An equitable world is desirable: Sustainable agri-food systems are critical

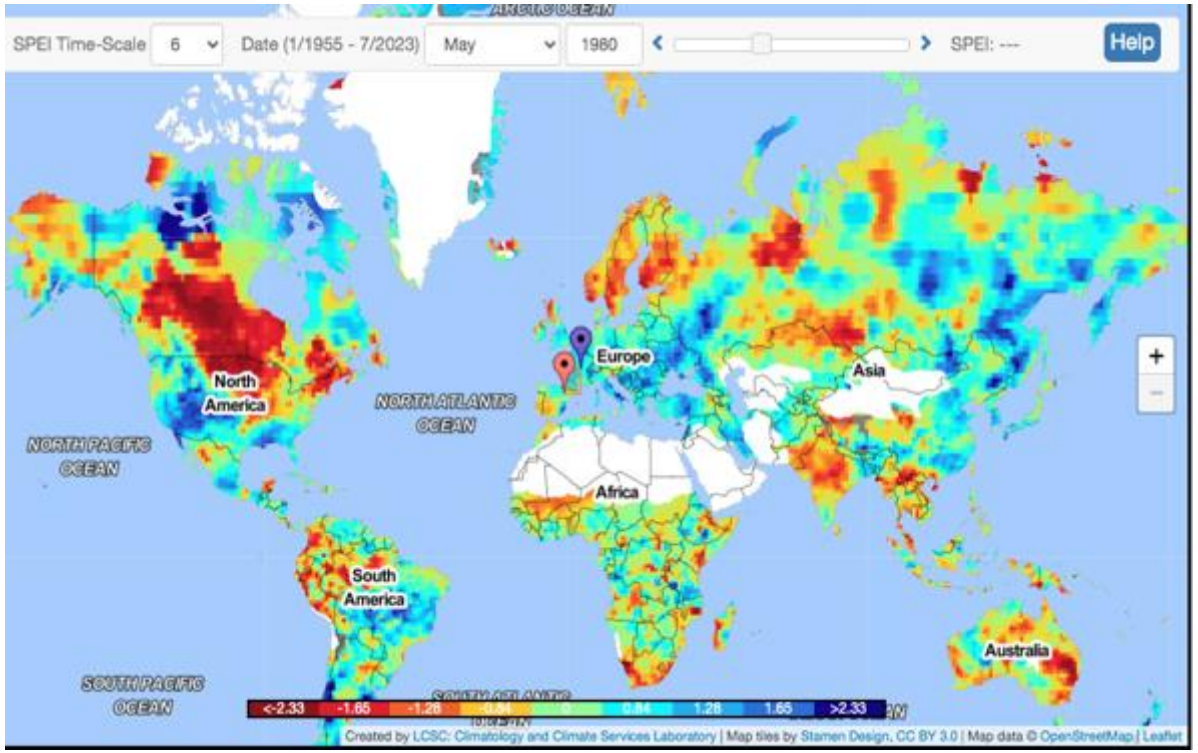


Source: Alevi Francesca (2017)

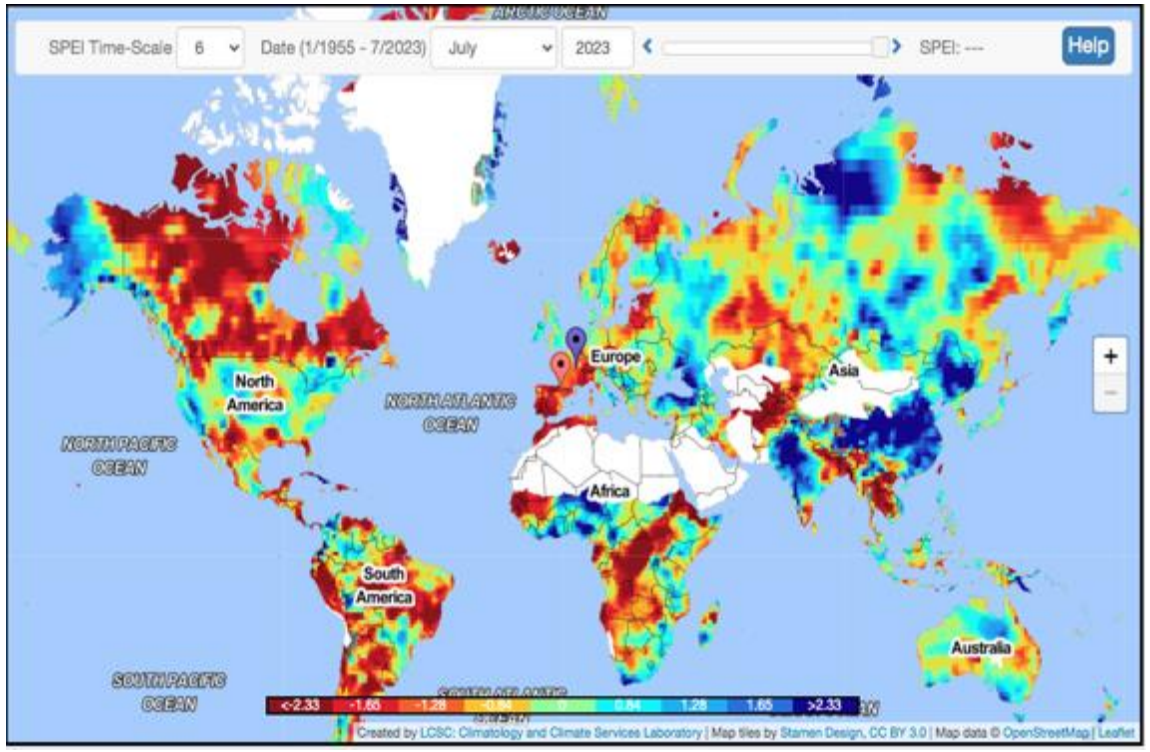
9 SDGS related to or impacting on sustainable food systems

Water scarcity impacts 40% of the world's population, with 700 million people at risk of being displacement due to drought by 2030 (Source: WHO)

Drought conditions: 1955 to 1980



Drought conditions: 1955 to 2023

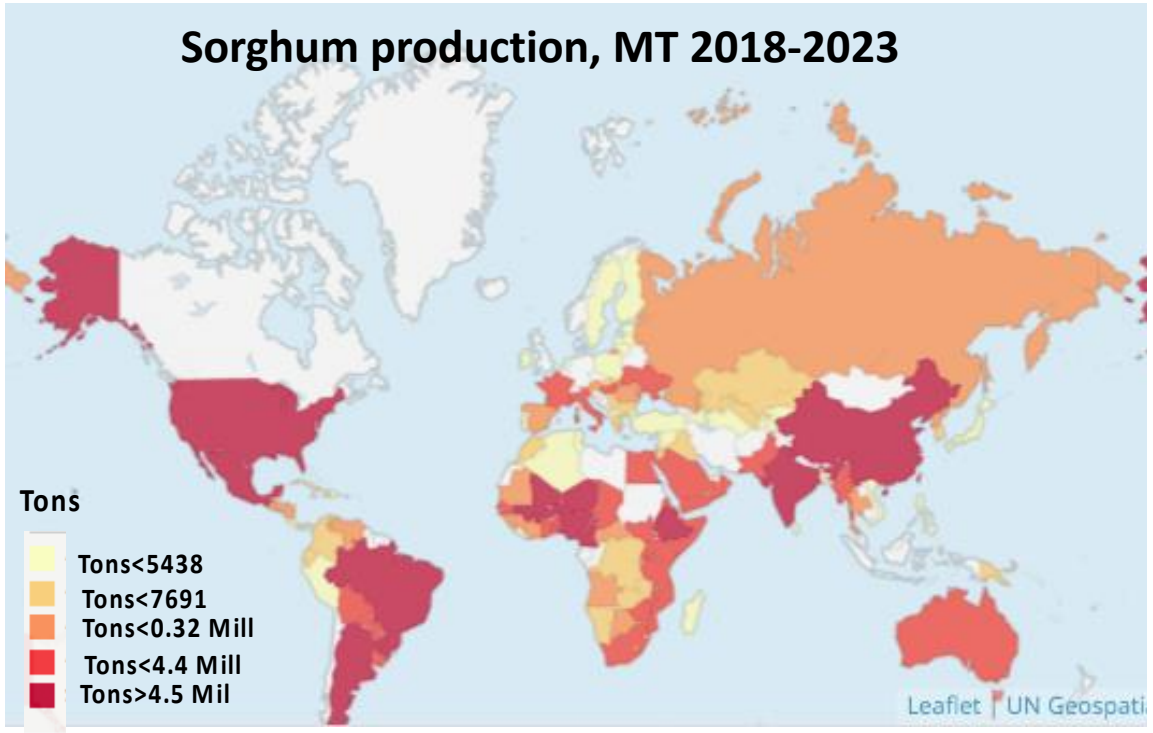


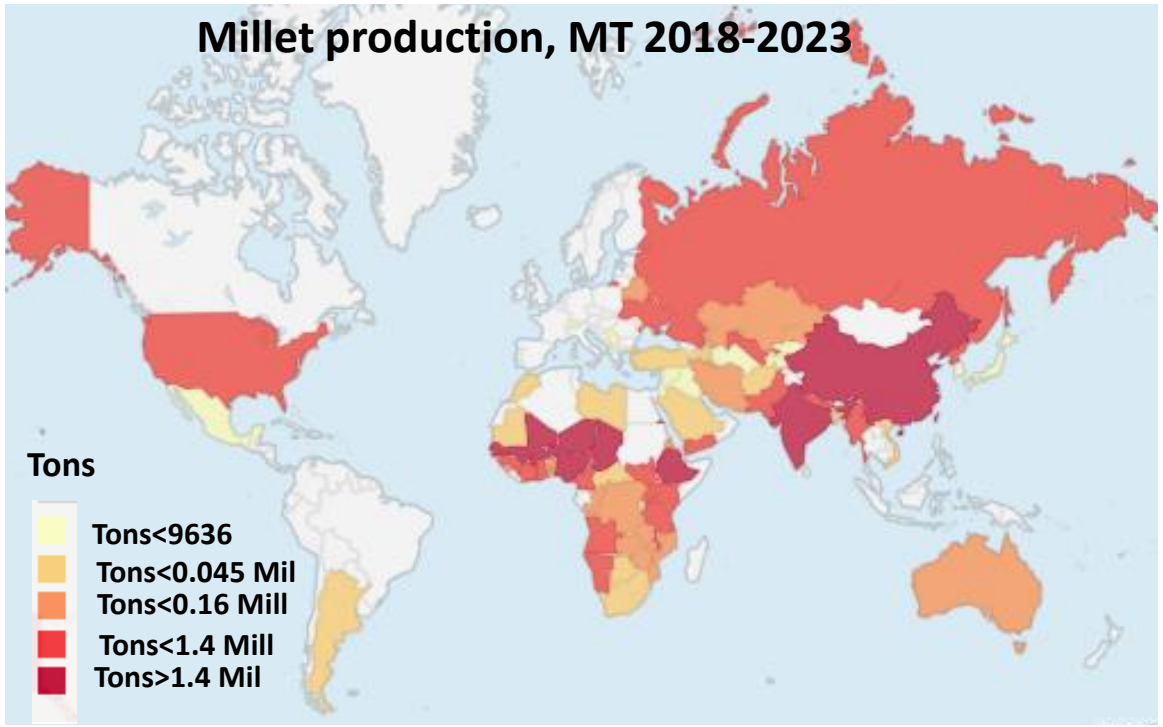
Source: Standardized Precipitation Evapotranspiration Index (SPEI) global drought monitor.

Millets are resilient crops adapted for increasing drought threat: What are they and where are they produced

Small grain cereals comprising
pearl, proso, foxtail, barnyard, little, kodo, browntop, finger and guinea millets, as well as black and white fonio, sorghum, teff and Job's tears, and many other diverse and local species.







Source: FAO STAT, 2023

Nutritional benefits of millets

Millet Crop	Botanical name	Nutritional benefits
Finger	*Eleusine coracana*	Rich in Cu, Mg, P, Se, Fe & thiamin,
Pearl	*Pennisetum glaucum*	Rich in Cu, Fe, Mg P, Se, Zn, thiamin & vit B6
Sorghum	*Sorghum bilocor*	Rich in, pantothenic acid, Cu, Mg, P, Fe, Zn, Niacin, thiamin & vitamin B6
Teff	*Eragrostis tef*	Rich in Cu, Fe, Mg, P, thiamin, vitamin B6, riboflavin, niacin, pantothenic acid
Prosso	*Panicum miliaceum*	Rich in thiamin, Cu, P, Mg, Zn, Fe, Se, riboflavin, niacin, pantothenic acid & vit B6
Foxtail	*Setaria italica*	Rich in high in Cu, Mg, Se, thiamin, P, & Zn
Kodo	*Paspalum scrobiculatum*	Rich in high in Cu, Mg, Se, Zn, thiamin, riboflavin
Little Millet	*Panicum sumatrense*	Rich in Cu, Mg, Se, P, Zn, & thiamin,
White Fono	*Digitaria exilis*	Rich in Cu, Folate, Mg, P, & Zn
Jobs Tears	*Coix lacryma-jobi*	Rich in Cu, Mg, P, Fe, Zn & thiamin

Photo credit:
ICRISAT

Millets vs major staples: Rice and maize

	Carbohydrates, proteins, and lipid metabolism
Body health	**Body immunity, suppress inflammation**
	Healthy cardio vascular systems, suppressed anemia (RBC production)

Cereals	Iron (Fe) (mg/100 g)	Zinc (Zn) (mg/100 g)	Calcium (Ca) (mg/100 g)
Pearl Millet	**10.72 ± 0.15b**	11.40 ± 0.14b	11.35 ± 0.14a
Brown rice	0.00 ± 0E−7a	12.15 ± 0.21a	16.60 ± 0.16b
Maize	0.00 ± 0E−7a	11.80 ± 0.14ab	21.24 ± 0.14c
P-value	0.000*	0.047*	.000*

Source: Food Sci Nutr 2020 8:2692–2698

Millets: Multiple uses

Food and industrial use

Sorghum Bread

Sorghum Cake

Beer

Ethanol

Livestock feed

Sorghum silage

Pasture

pellets

Millets: Production challenges- Biological

Stem borer

Sorghum midge

Sorghum shoot fly

Fall armyworm (FAW)

Striga

Drought stress

Kernel smut

Head blast

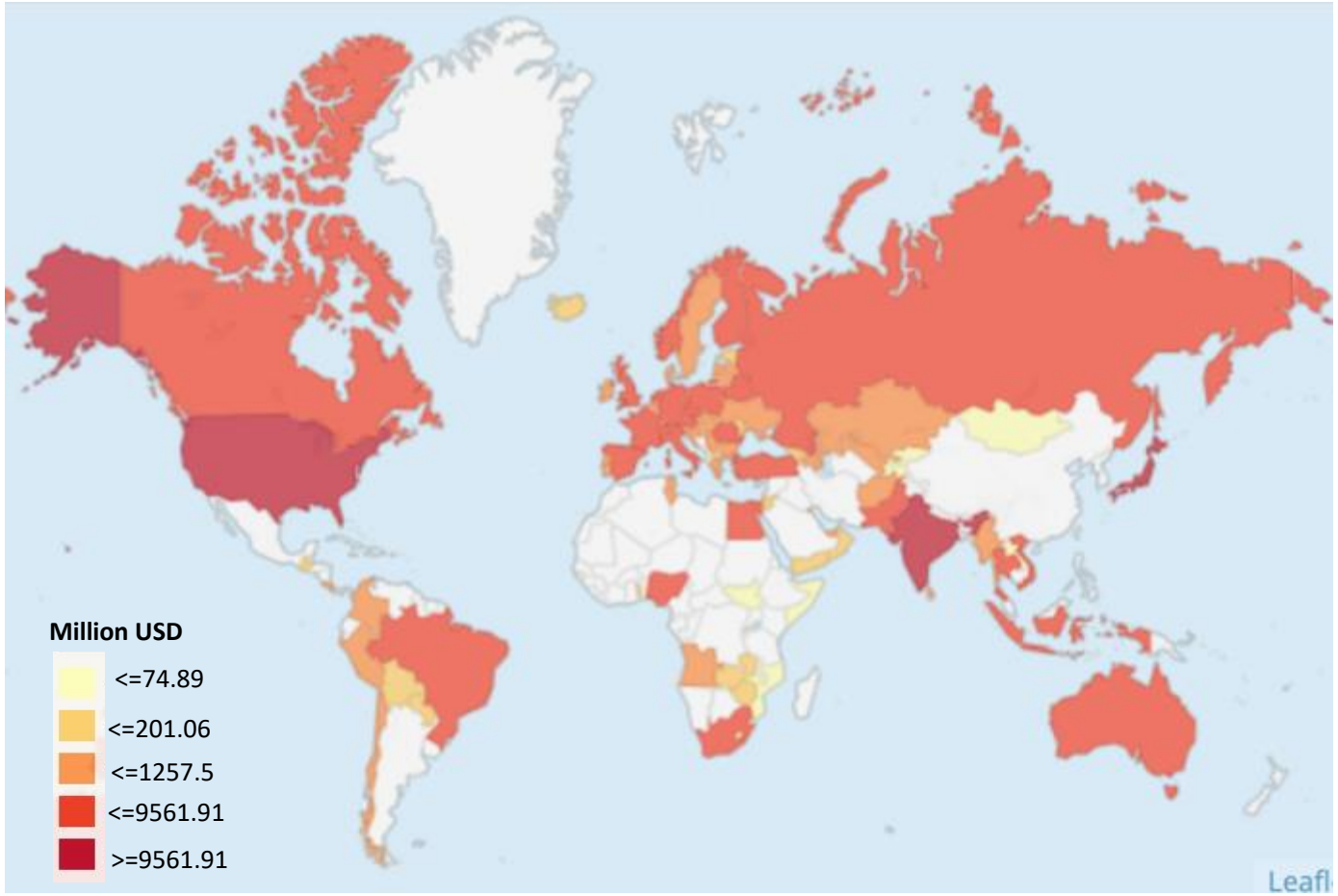
Source: MaRCCI Uganda, ICRISAT, Lubadde et al., 2019

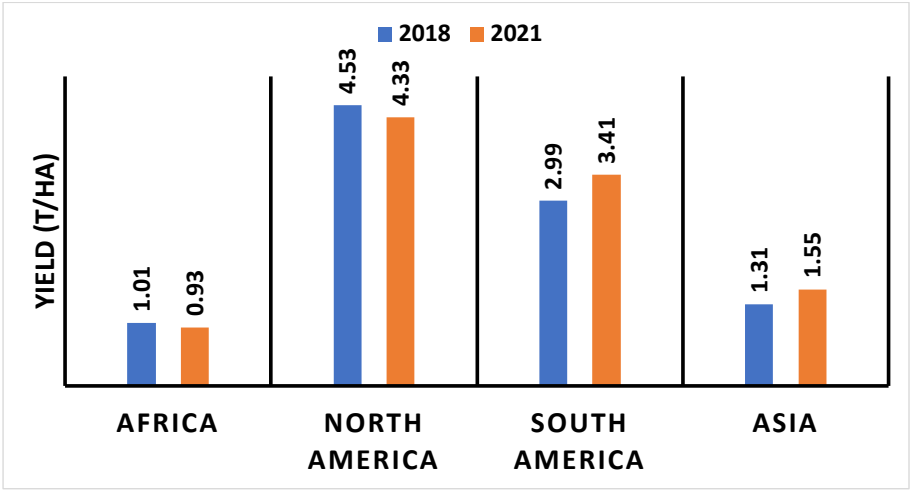
Major challenges to millets production

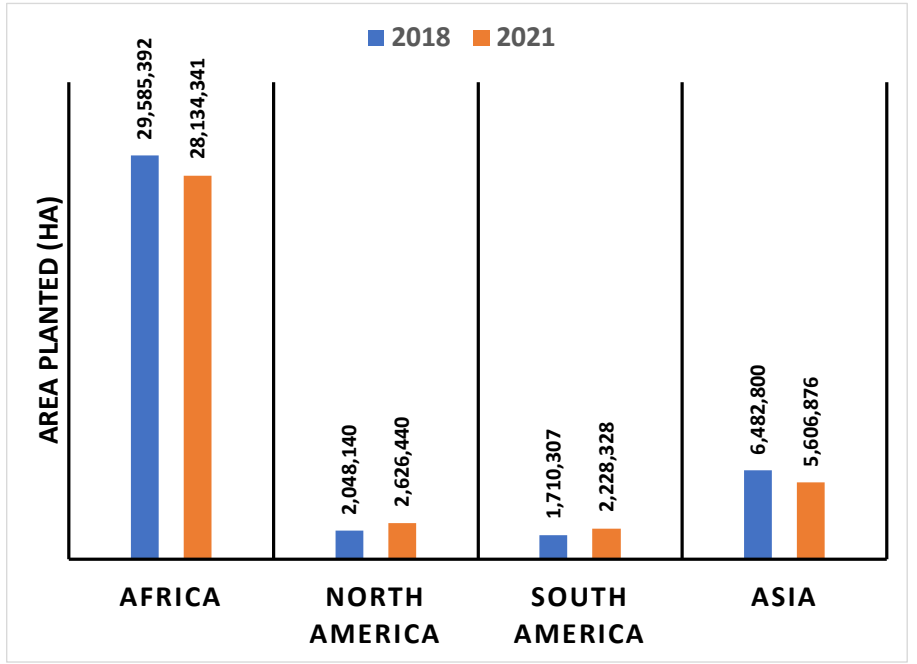
- Declining production area
- Emergent and endemic pests and diseases
- Limited access to improved seed especially millet (pearl and finger)
- Limited investments in food processing
- Low investment in R&D
- Weak product value chains for local to export markets

Millets: The investments impact production

Expenditure in the agriculture sector (US$) 2001 - 2021



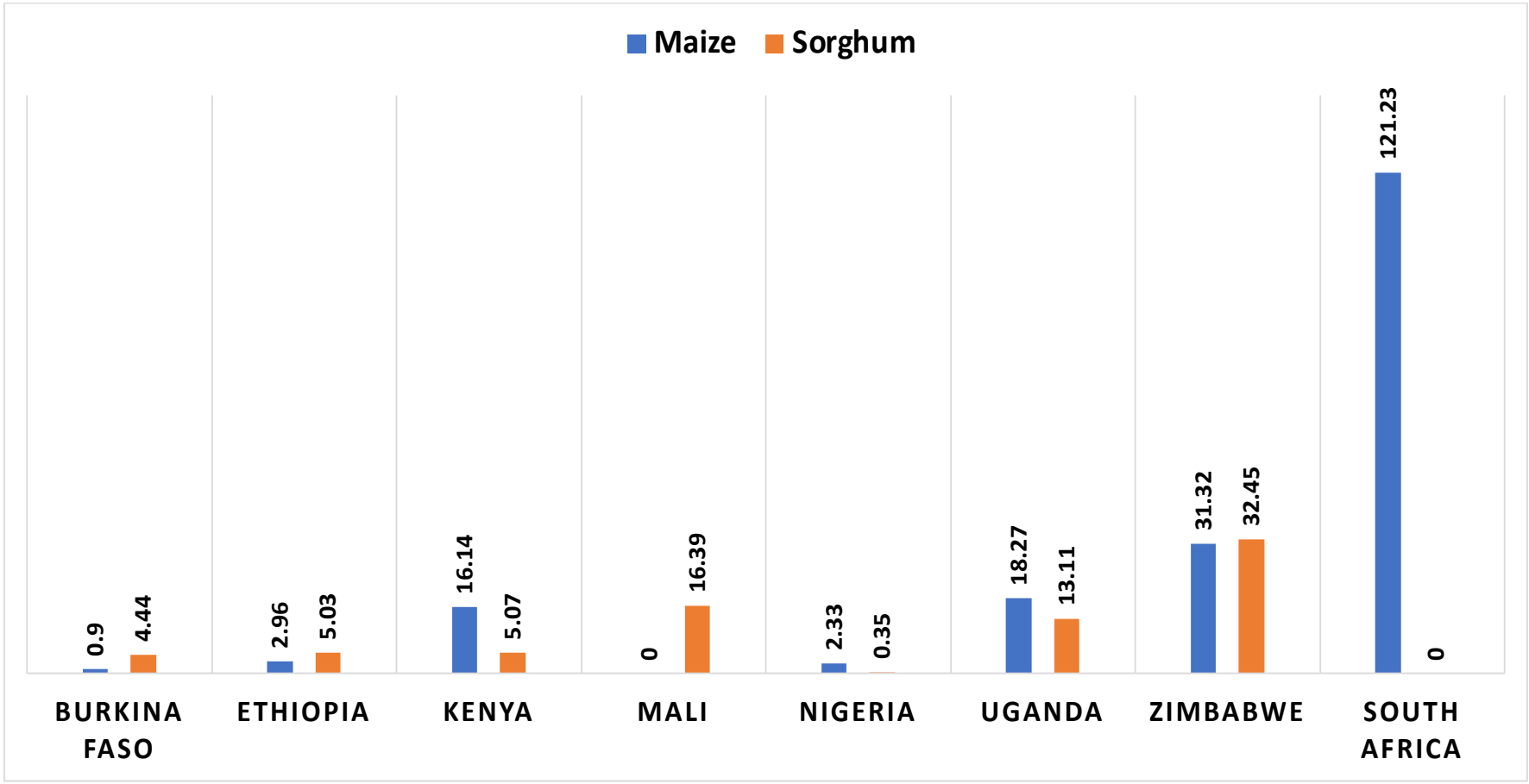




Source: FAOSAT 2023

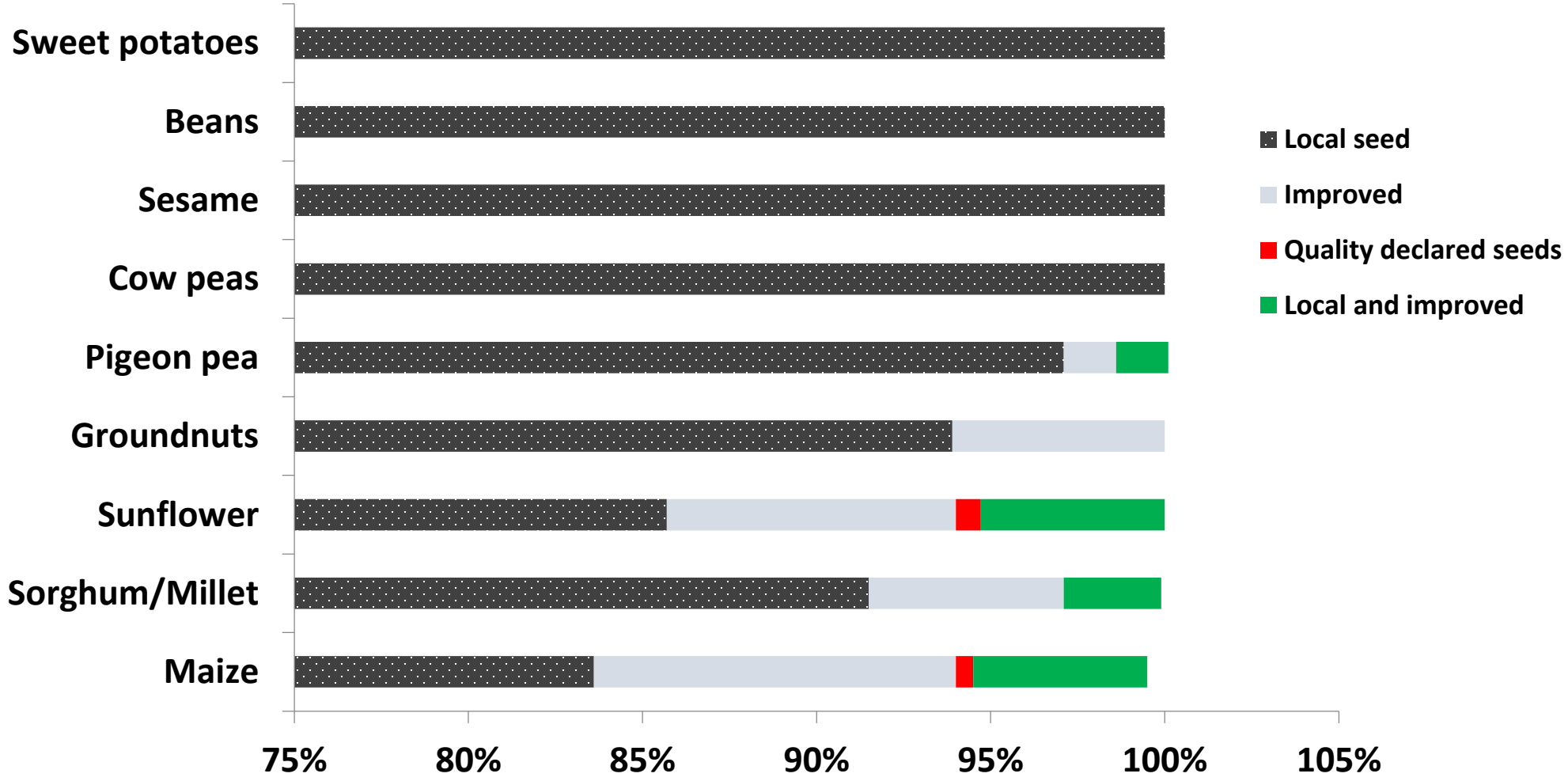
Millets relatively underinvested compared to other cereals

Sorghum and maize varieties released over the recent three years per 1 million ha



Source: National variety catalogues and TASAI

Less than 10% of farmers, use improved seeds or quality declared seeds



Source: ICRISAT-Africa RISING Team

Millets research for development to remedy key challenges

Research strategy for Millets breeding

Breeding
- New market required productive, nutritious resilient varieties

Crop physiology
- Site optimization (TFP), trait utilization, Phenotypic tools & ideotype modeling

Gene bank/conservation
- Resource conservation and utilization for the present and future posterity

Genomics and pre-breeding and bioinformatics
- Trait discovery and deployment for contemporary development needs
- Pre-breeding, data science

Cell and molecular biology and trait engineering
- Advances that enhance crop improvement, management and nutrition

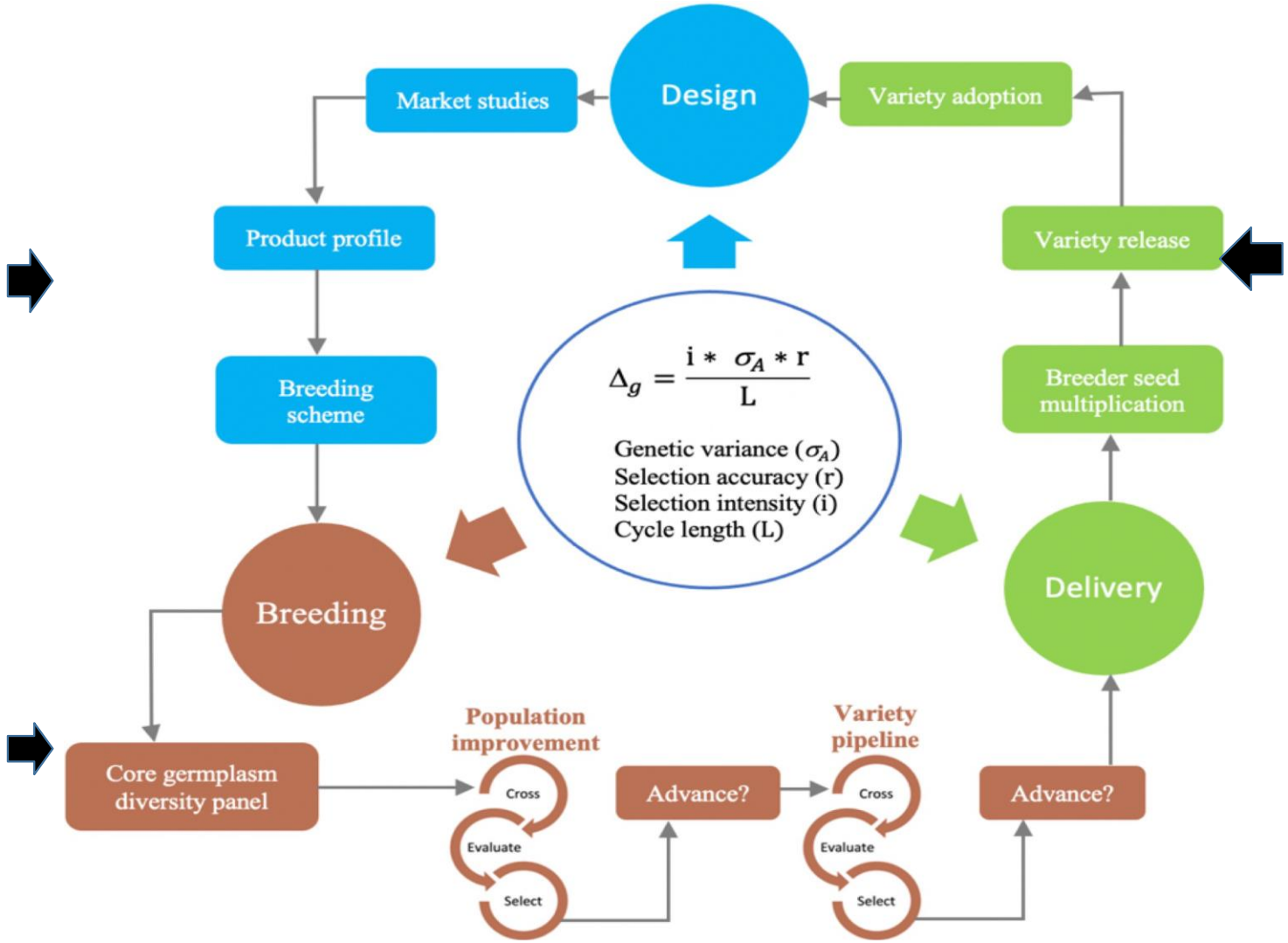
Crop protection
- Biotic stress resilient varieties and IPDM

Seed Systems
- Effective and efficient seed delivery systems for millets

Source: UNFood Summit 2021; Action Tracts

Millets breeding: Achieving genetic gains will drive investments

- Market intelligence
- Economic benefits
- Social inclusion



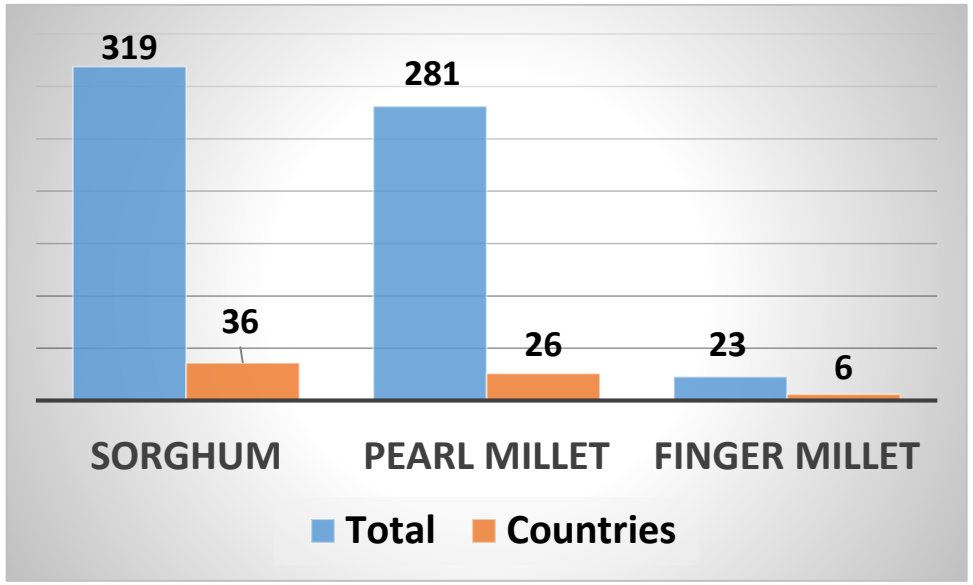
- Desired products
- Efficient seed delivery

Genetic gain in breeding pipeline

Deployment of markers to fasten breeding

Adapted and from EiB and following BPAT. Its currently used by One-CGIAR, NARS and IARCs

Millets breeding: Combined releases-global



Source: ICRISAT, Nairobi

Millets breeding: Achieving genetics gains driving investments- Sorghum

38 Releases during past 10 years across East and southern Africa

27 Open pollinated varieties & **12** Hybrids

2019 IESV 24029 SH

NACO 1; Pilira 3

KARI Mtama 2 (IS 8193)

2018-Pilira 4 (IESV 23010 DL)

NACO SH 1, Kensorg

Pilira 5

Source: ICRISAT, Nairobi

Millets breeding: Achieving genetics gains driving investments: Finger millet

Recent releases in East and Southern Africa

NAROMIL 1: Yield: 3-4.1 t/ha; Ca=660 mg/100g; Protein 9.8mg/100

NAROMIL 2: Yield 3.9-4.0 t/ha, Protein= 12.2 mg/100g; Diastatic value 45

NAROMIL 5: Yield 2.6-3.5; Protein =12.2%; Diastatic Unit 50.3

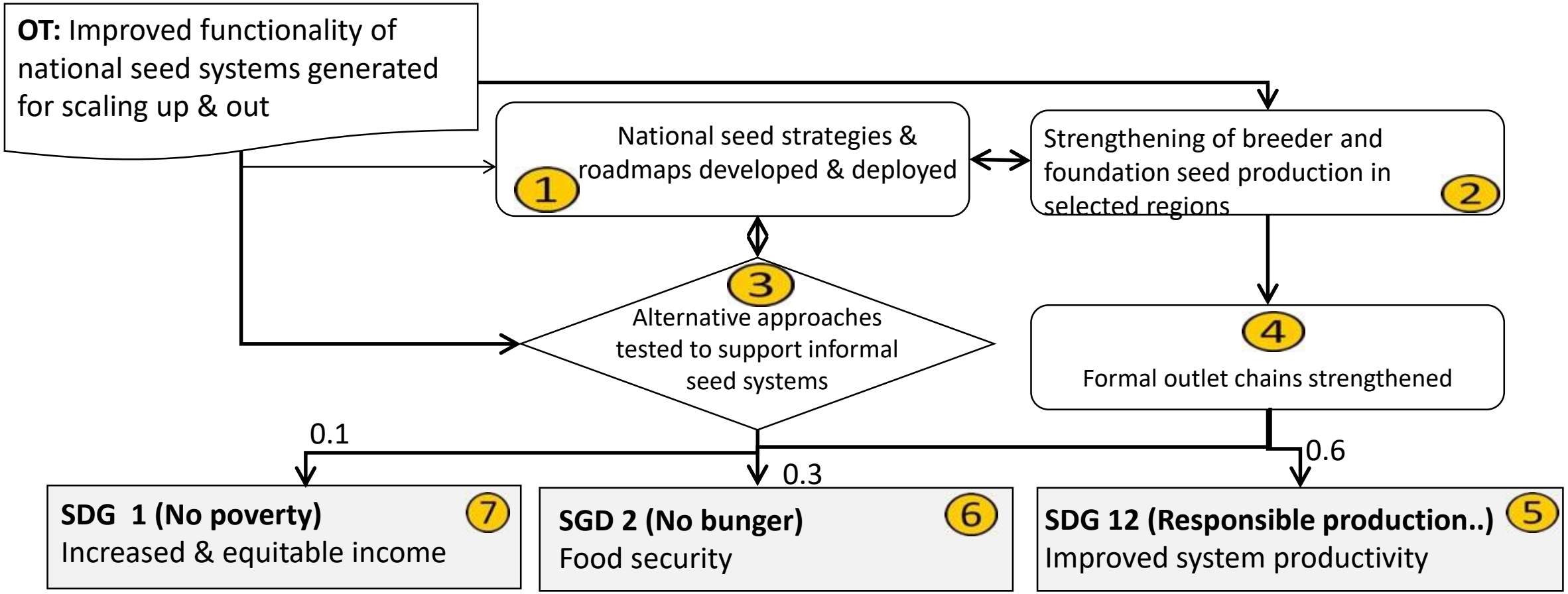
KNE 741: High protein content, very early maturing targeted for cool dry areas

Snapping variety released for ease of harvesting

Source: ICRISAT, Nairobi

Product life cycle management: Last mile delivery

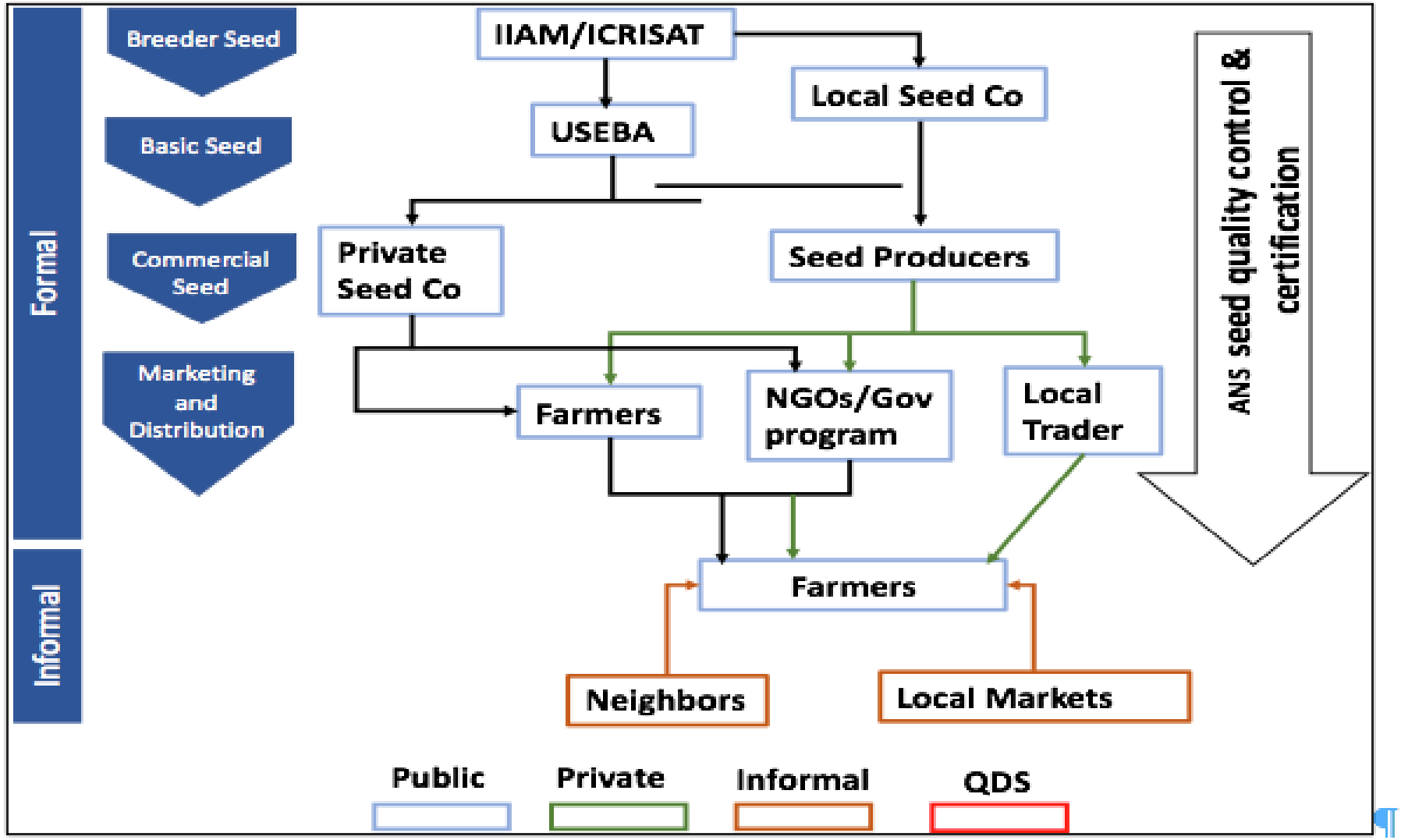
Strategic framework for seed and knowledge delivery



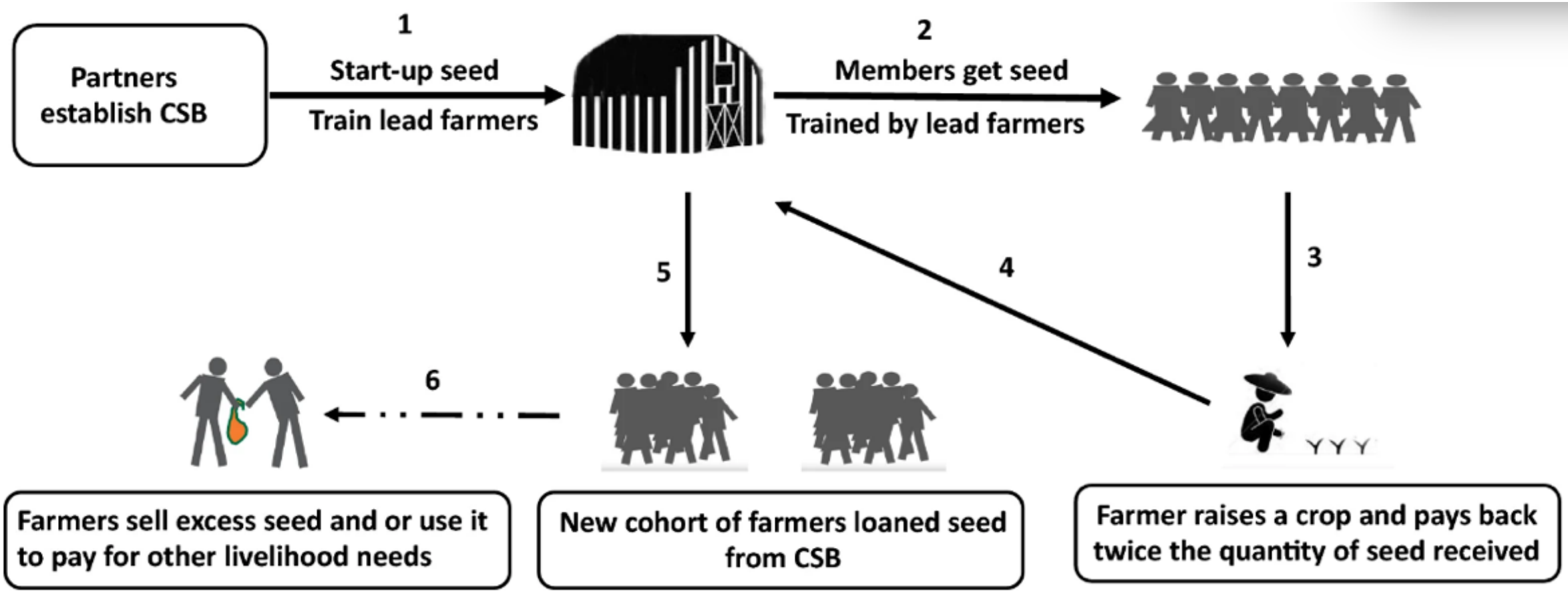
X indicators:

1) Number of seed strategies & roadmaps
2) Number of NARES contacts
3) Number of breeders & sales outlets
4) Volume of seed type eg. (Breeder) produced
5) Quantity of seed sales
6) Sales figures (disaggregated)
7) Yield and production volumes
8) Proportion of farmers using improved seed
9) Household food availability and incomes statistics

Strengthening formal seed systems: Early generation seed production a major hinderance

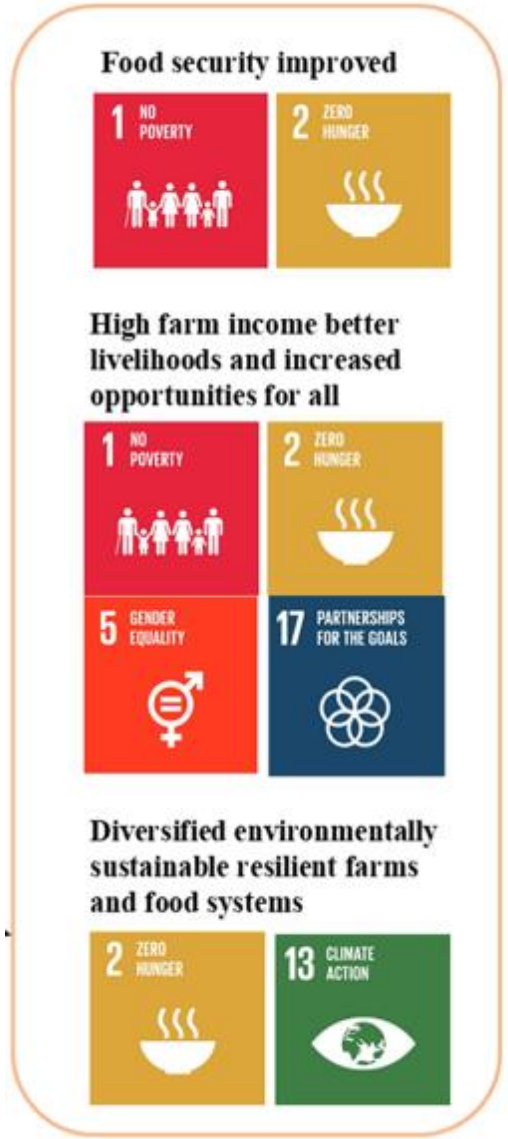


Alternative seed systems for greater inclusion especially for under invested crops- Millets



Source: Okori et al., 2022. https://doi.org/10.1186/s40066-022-00375-4

Intensifying Millets derived impacts



1. Must close the R4D gap: Under-investment triggering sluggish total factor productivity growth- SSA, SA

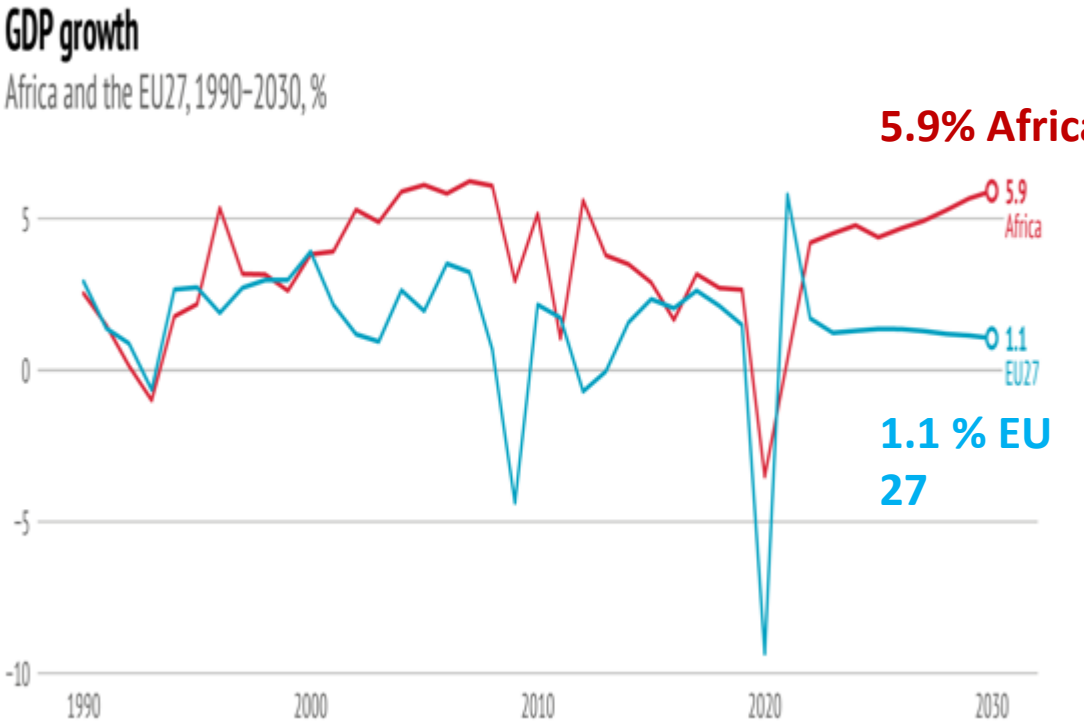
	TFP Growth	Technology Efficiency	Technology Progress	Scaling Efficiency
North Africa	**1.080**	0.980	**1.083**	**0.999**
Central Africa	**1.067**	1.007	**1.056**	**1.000**
West Africa	1.058	0.989	**1.089**	**1.008**
East Africa	**1.045**	0.980	**1.136**	**0.968**
Southern Africa	1.043	0.972	**1.100**	**0.998**

Source: Sustainability (2022), 14: 6411

Key observations

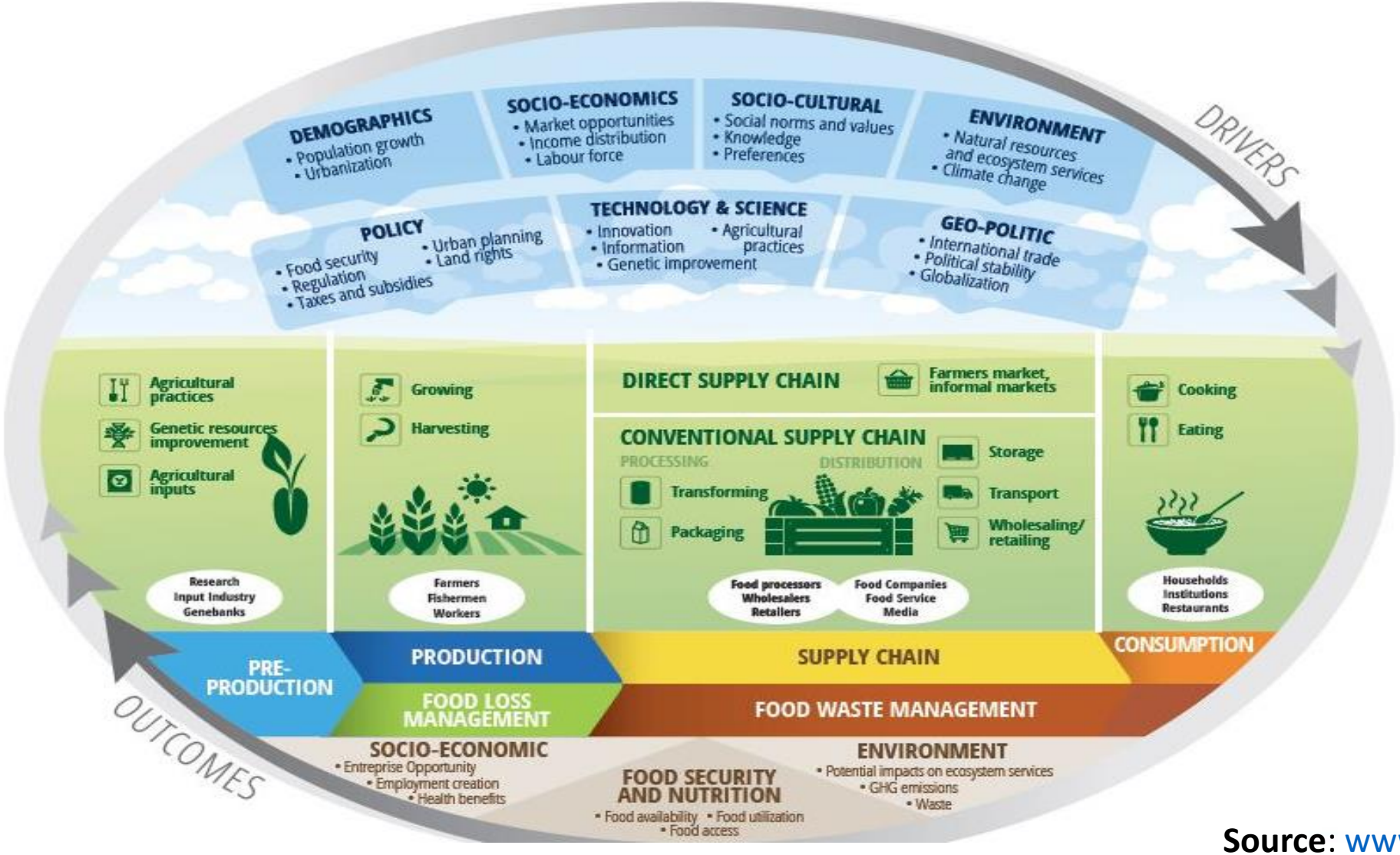
- Regions making progress, have significant agriculture expenditure by government
- Productivity growth is highest in North Africa (**8%**), lowest in East Africa (**4.5%**) and Southern Africa (**4.3%**).
- Growth is driven by introduction of ***new technologies***.
- East Africa has highest rate of technology introduction
- Scaling-out of technologies is stagnant- ***many producers are still left out.***

Agriculture to be a 1 trillion dollar industry by 2030 and should be a focus investment sector



Source: Imagining Africa in 2030. EU Institute for Security Studies, 2021.

2. An integrated systems R4D is necessary



The net effects of the drivers and outcomes of agrifood systems transformation must meet the planets boundary limits for carbon emission and other requirements

Source: www.cigar.org

3. Knowledge must drive policy and investments: Whole ecosystem actions are more effective

University/Research Networks

Structural Reforms

- **Reconfigure refocus-** delivery and management to engage in agrifood political economy
- **Great fit to more users;** one world one health: a common future
- Innovative financing **including private equity for STI**

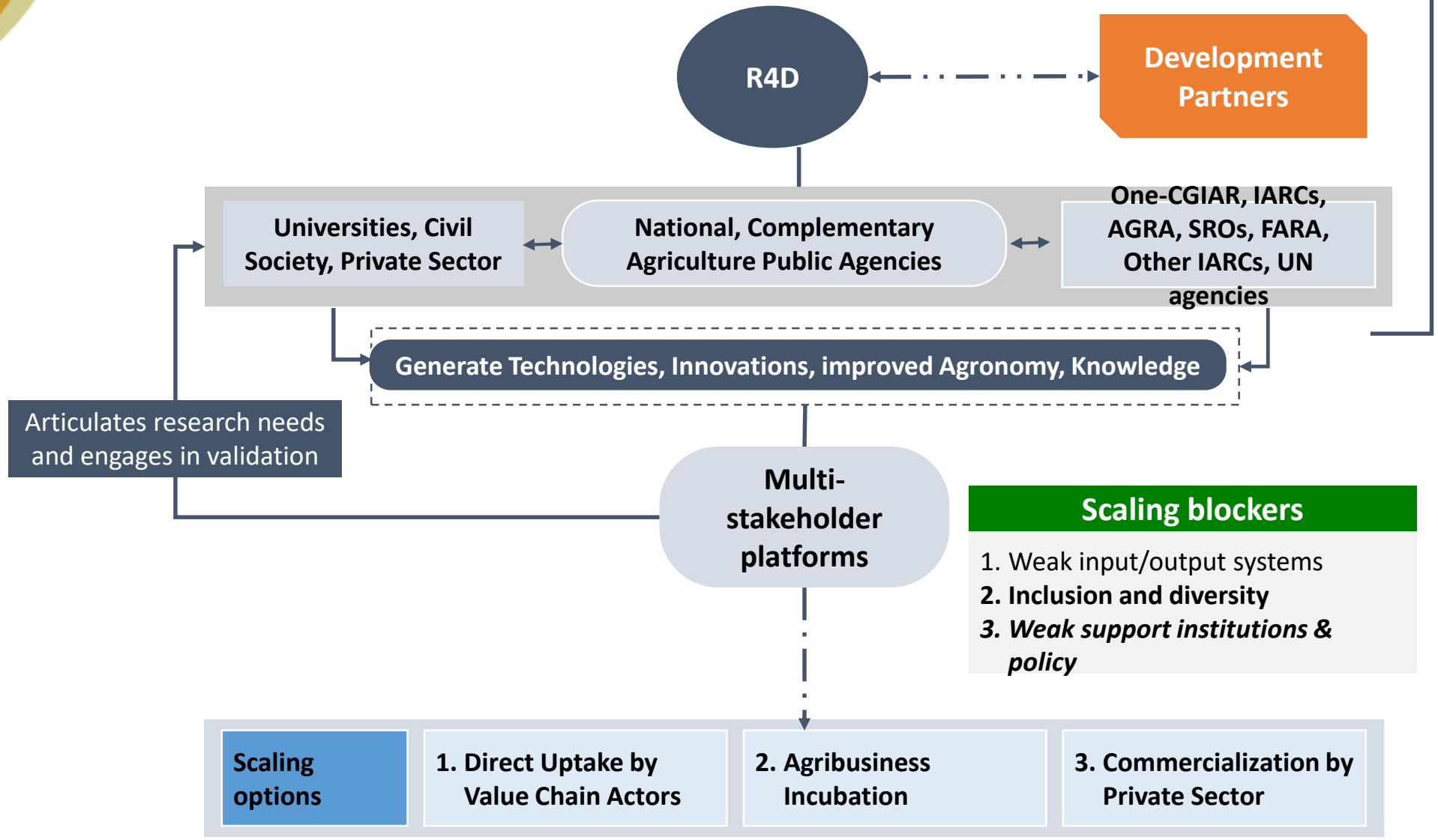
Institutional Dimension

- **Strategic partnerships (N/S, S/S)**
- **Comprehensive Human Capital programming** Reduce ratio of scientist to development impact
- **Leverage and centers of leadership**- Breeding, Food security, Intensification, climate Science **etc**

Functional Dimension

- **A shift to PPPs for**, research to delivery
- **Intensification of research and engagement** with impact actors
- **Policy and development practice**. Sustainability, strategy and financing

4. Leverage leaders in STI in collaboratives



Ecosystem Blockers

1. **Capacities (R4D)**
2. Funding- Complementarity vs competition
3. **Access to innovations, Technologies and knowledge**

Scaling blockers

1. Weak input/output systems
2. **Inclusion and diversity**
3. ***Weak support institutions & policy***

5. Recognize diversity: “No one size fits all”

Divergent pathways for impact

Full

Technology adoption

Poor

Innovators

Engage input and output markets; financial services

Broker technology
N/S; SS, PPP, fast track release, promote + Companion value chains

Broker technology
Fast tract release + build informal systems for technology transfer

Adopters

Education
Agronomy- Soil Fert + water, weeds, multiple cropping +
Processing,
Nutrition + small livestock

Time

Takeaway messages:

Need to strengthen food production to consumption fundamentals through STIs

- Yield enhancing resilient technologies (New varieties, breeds)
- Value added and post-harvest reduction for diversified urbanising populations
- Renewable production systems – Agroecology perspectives to secure posterity
- Effective and efficient knowledge generation

Human capital development to support agrifood system growth

- Balance the HR pyramid for STI and entrepreneurship
- Leverage and convergence in STI and Human capital development

Policies, institutions and markets

- Foresight and strategy investment planning
- Measurement, accountability and learning to inform investments and redesign of adaptation measures

Acknowledgments

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RUFORUM
Capacity Building in Agriculture

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