Africa-Europe Cluster of Research Excellence – CoRE-NbS:
Nature-based solutions for climate change adaptation and mitigation

Co-creation of Climate Services to Manage CC Risks to African Smallholder AgSystems

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1. INTRODUCTION

A topic at the interface of CoREs NBS and SFS

- SFS - Sustainable Food systems -- > Environmentally sound, Economically viable & Socially acceptable

- Nature-based solutions of climate change adaptation and mitigation -- > interventions Protect the climate, Protect Biodiversity , Reduce climate-induced risks through climate-smart practices enhancing climate resilience in the short- and long term

Case A: Co-developing climate information services and agro-advisory tools to enhance climate resilience for mixed crop-livestock smallholder systems (in the drylands of Senegal and Tanzania) – by JE Joseph et al. (ILRI-UGOE) - embedded in the AICCRA programme [-> Climate services hub]

Case B: Enhancing drought resilience of cocoa agroforestry systems for smallholders in Ghana, West Africa – Linking above- and below-ground traits to understand mechanisms of drought resilience - by I. Abdulai et al. (UGOE) – DFG project phase 1 (and 2 in prep.) – in collaboration with Universities of Tübingen, Ulm, TUM / Germany; and KNUST, University of Ghana, and IITA/Ghana [-> NbS hub]

2. CASE A: Co-creation of Climate Information Services and Agro-advisory Tools to Manage Climate Change Risks in the Drylands of Senegal and Tanzania

Localized rainfall onset definition

Underutilization of SCFs

Lack of Farmer-Centred Climate-informed Agro-advisory tools

Knowledge gaps in "climate information services"
(PhD research by Jacob E Joseph)

ILRI

CGIAR | AICCRA Accelerating Impacts of CGIAR Climate Research for Africa

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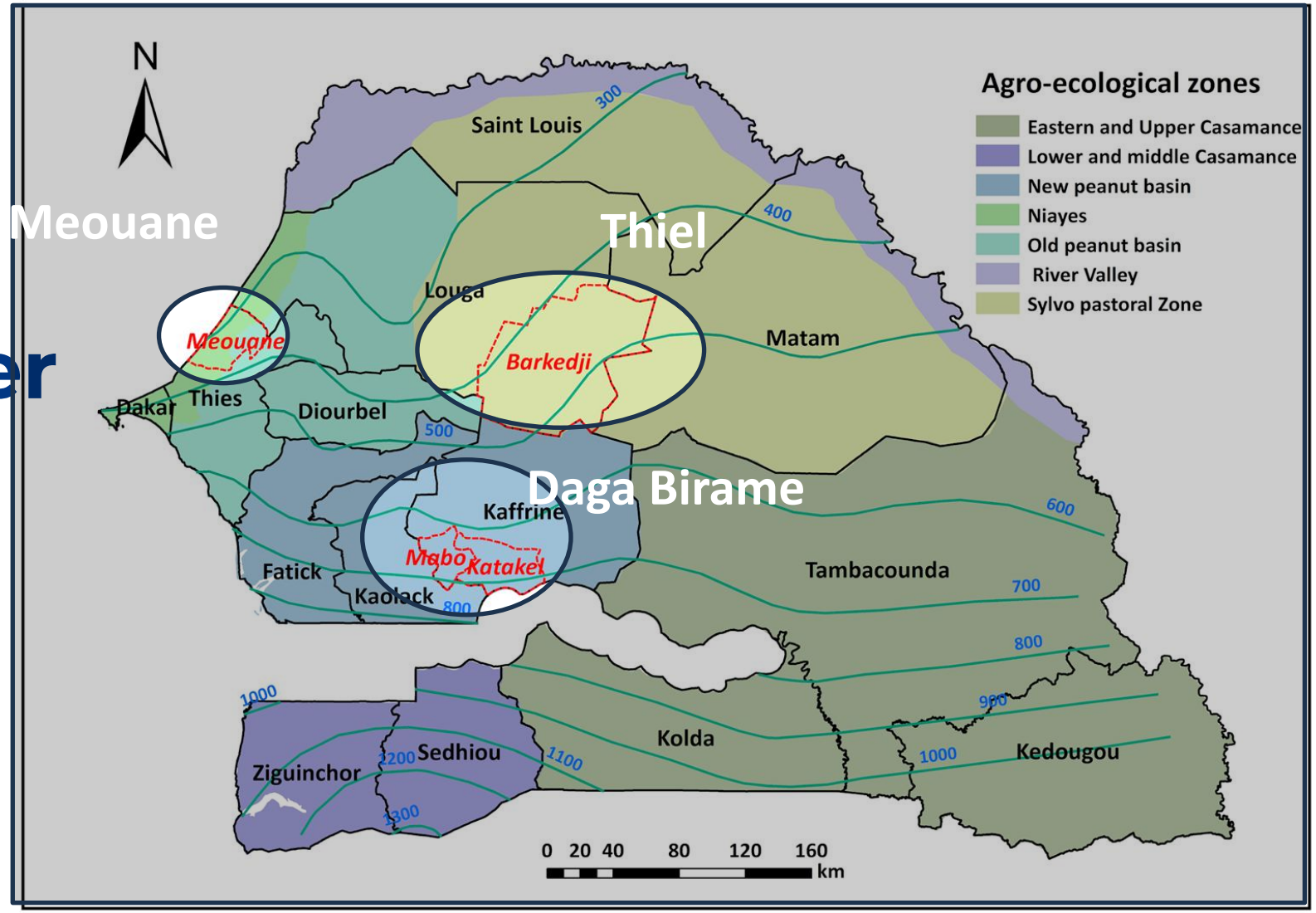
AICCRA partner Senegal,

3 study regions



Ad third knowledge gap (Objectives 3.1-3-3):

- Develop and implement the Intelligent agricultural System Advisory Tool (iSAT)

  → **co-designing** → farmers and experts → crop and location-specific, climate-informed agro-advisories

- Evaluate the effectiveness of iSAT in supporting smallholder farmers' decision-making

  → **pre-season planning (strategic decisions) and in-season management (tactical decisions)**

- **Assess** the **impact/benefits of iSAT** generated advisories on farm productivity, profitability, and resource management

Hypothesis: *The co-developed climate-informed agro-advisory tools (e.g., iSAT) enhance decision-making, boost productivity and improve risk management in rainfed farming.*

Data

Agronomic and socioeconomic

- Baseline and post-season surveys to compare farmers' perceptions, yield outcomes, and advisory service effectiveness across so-called “intervention” and “control” villages.
- Surveys captured sowing dates, crop types, fertilization schedules, planting density, and pest control methods

Key Results

- **41%** Pearl millet yield increase
- **21%** Groundnut yield increase
- In cowpeas, no significant difference observed

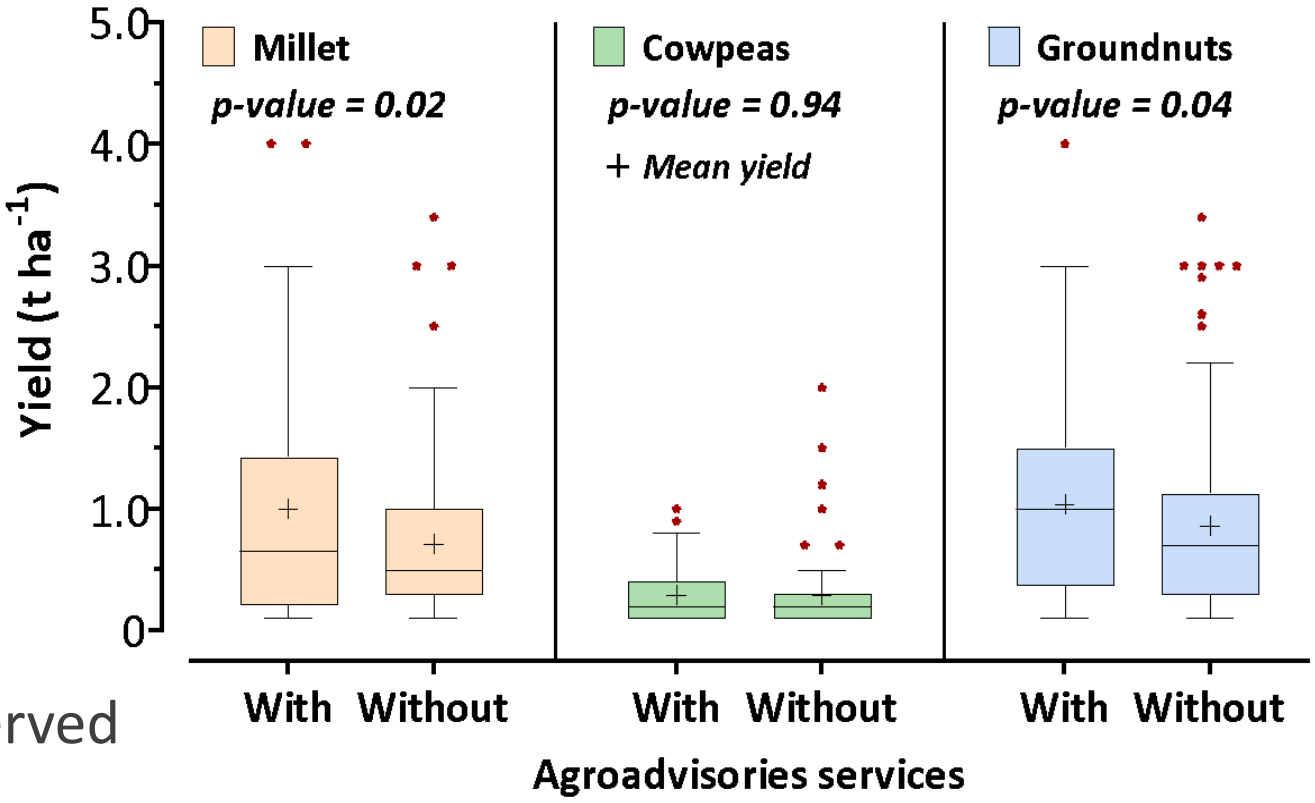
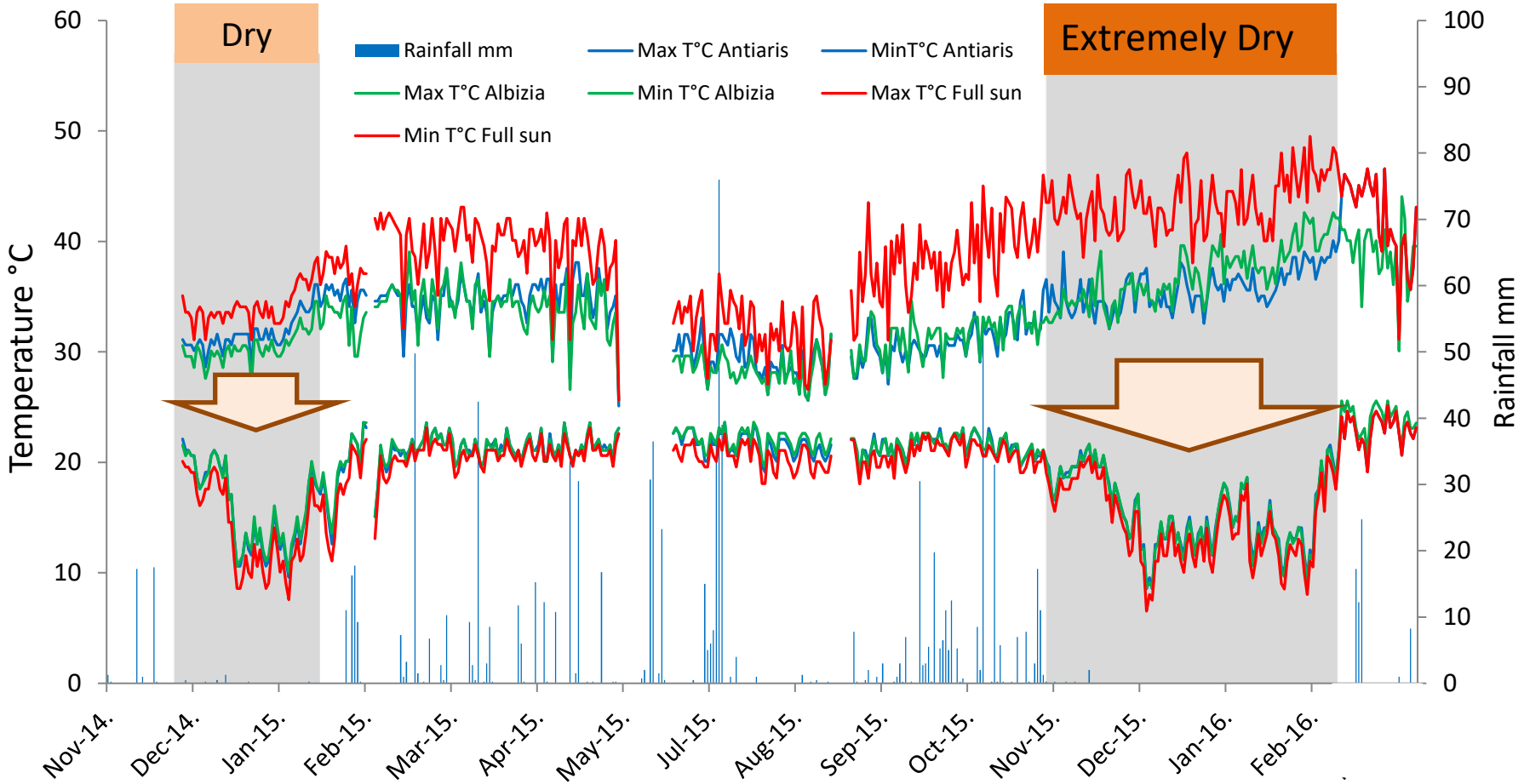


Figure: Comparative distribution of crop yields for farmers ***with and without*** access to iSAT.

3. CASE B: ENHANCING DROUGHT RESILIENCE OF COCOA AGROFORESTRY SYSTEMS FOR SMALLHOLDERS IN GHANA, WEST AFRICA (I. ABDULAI/UGOE)

The challenge illustrated for cocoa agroforestry systems (cocoa-shade tree combinations) undergoing rapid climate change



Extreme heat & drought in 2015/16 dry season (Nov-Feb) at Akumadan, Ghana

CASE B: Agroforestry for drought resilience – which shade tree, where?

(-> motivated by PhD research of Issaka Abdulai in BMZ project)

Competition for resources (water)

CASE B: COMPREHENSIVE MONITORING /MEASUREMENT PROGRAMME, DFG PROJECT PHASE I (2020 -24)

(photo © I. Abdulai)

Field measurements (sap flow/transpiration, stomatal conductance soil water content, leaf phenology etc.) in cocoa agroforestry research in Ghana

DFG Deutsche Forschungsgemeinschaft
German Research Foundation

CASE B: NBS - SOLUTIONS FOR SMALLHOLDERS IN THE WEST AFRICA COCOA BELT

Different leaf functional groups of shade trees in cocoa agroforestry systems /dry season

(photo ©: I. Abdulai)

ADD-ON POTENTIAL OF BIOCHAR IN SMALLHOLDER COCOA SYSTEMS

- Cocoa biochar project: agronomic (soil water and nutrition) and C-sink potential

- Pyrolysis of crop residues (cocoa husks) : carbon and K rich biochar as fertilizer for smallholder farmers

4. SYNTHESIS AND OUTLOOK : THE CHALLENGE ILLUSTRATED FOR SMALLHOLDER CROP-LIVESTOCK FARMERS IN AFRICAN DRYLANDS

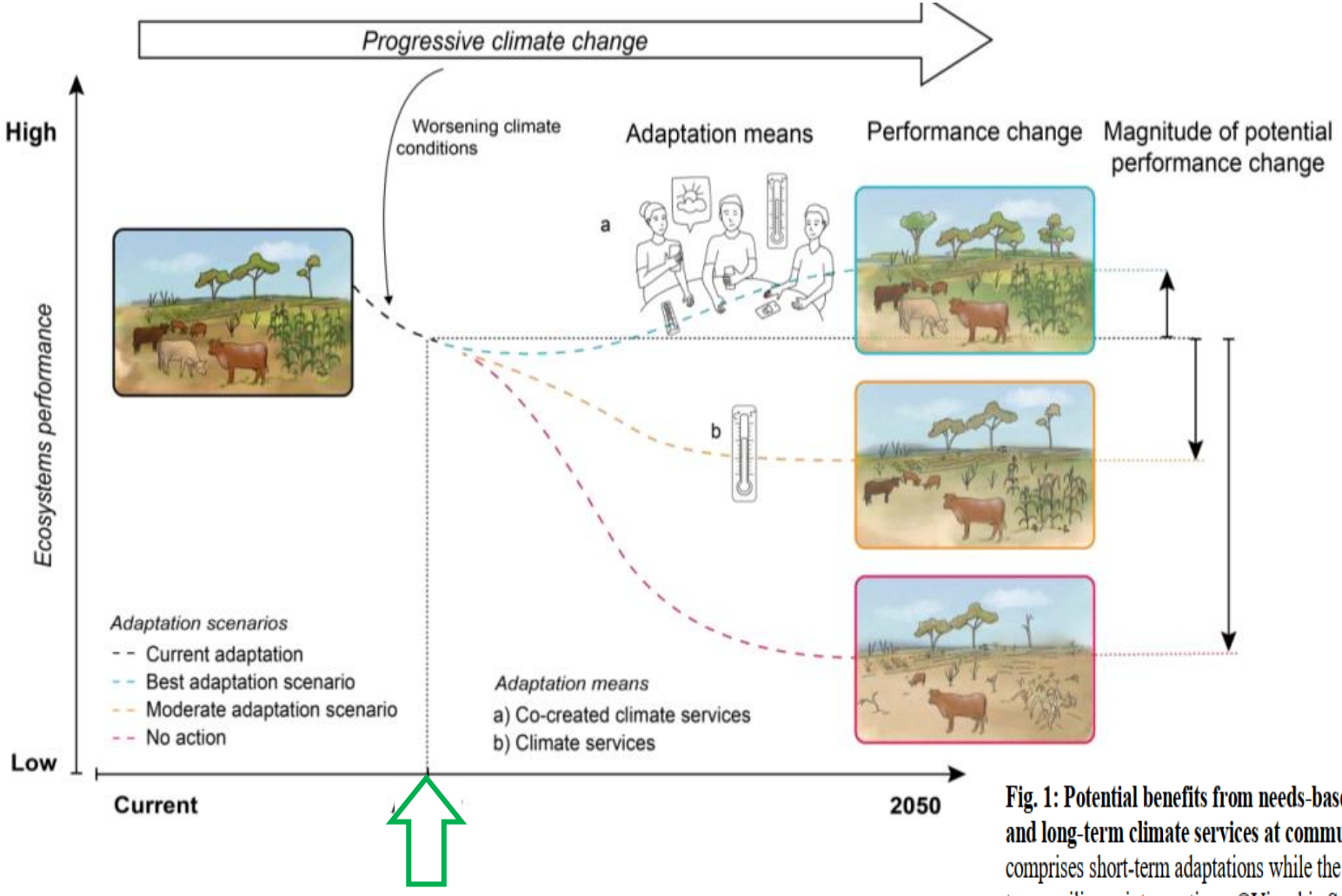


Fig. 1: Potential benefits from needs-based adaptations derived from AfriDry's approach of co-creating and linking short- and long-term climate services at community level versus no action. In our example, the moderate adaptation scenario only comprises short-term adaptations while the best scenario comprises optimised climate services combined with risk reducing long-term resilience interventions. ©Visual in Science LAB

4. SYNTHESIS AND OUTLOOK

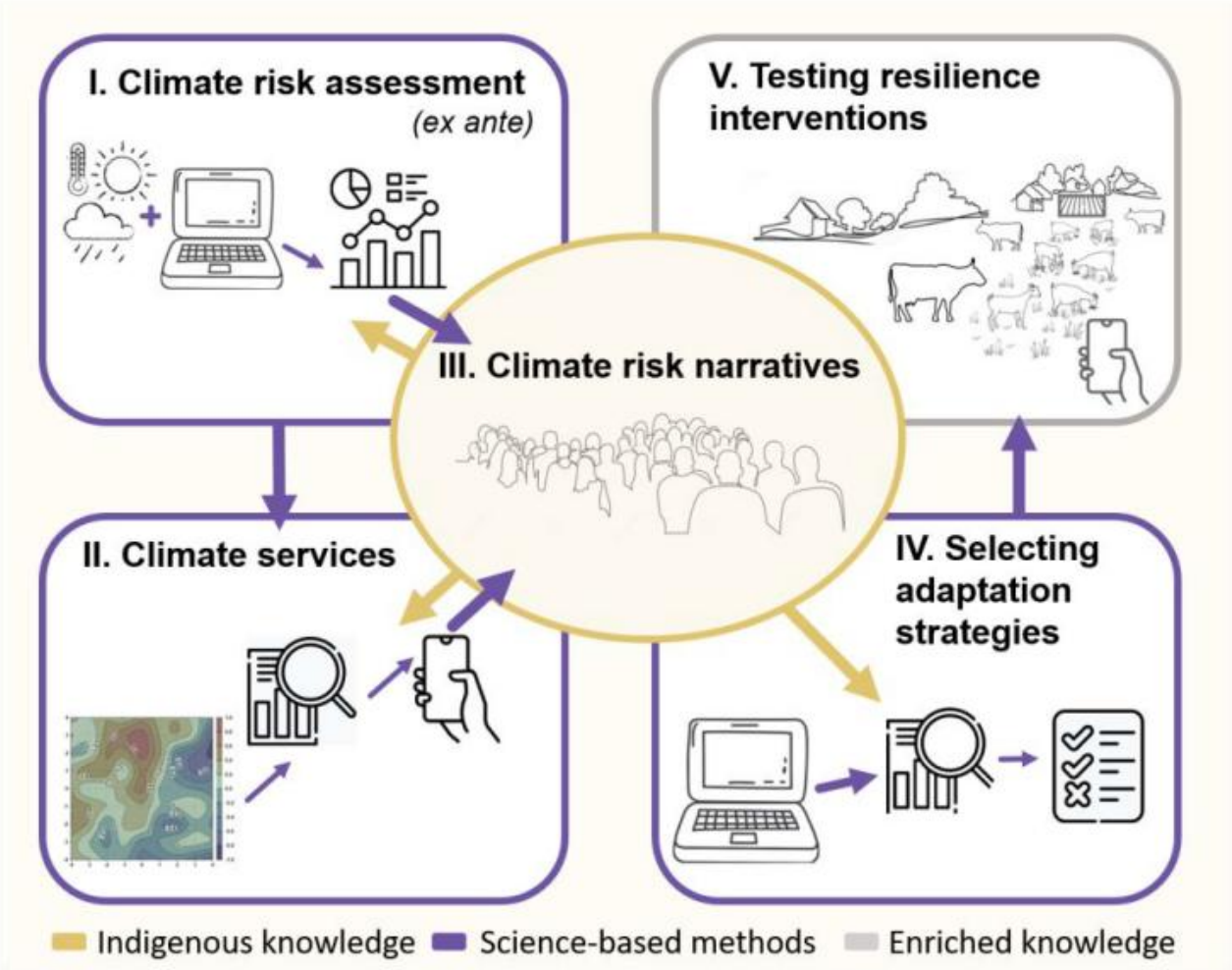


Fig.: Methdodology

linking science in the form of I. Climate risk assessment through impact modelling, with II. Climate services that integrate local and indigenous knowledge through collaborative activities. These feed into III. Climate risk narratives that lead to IV. Selection of adaptation strategies, and, V. Testing of resilience interventions and associated outputs.

Thanks for your attention!

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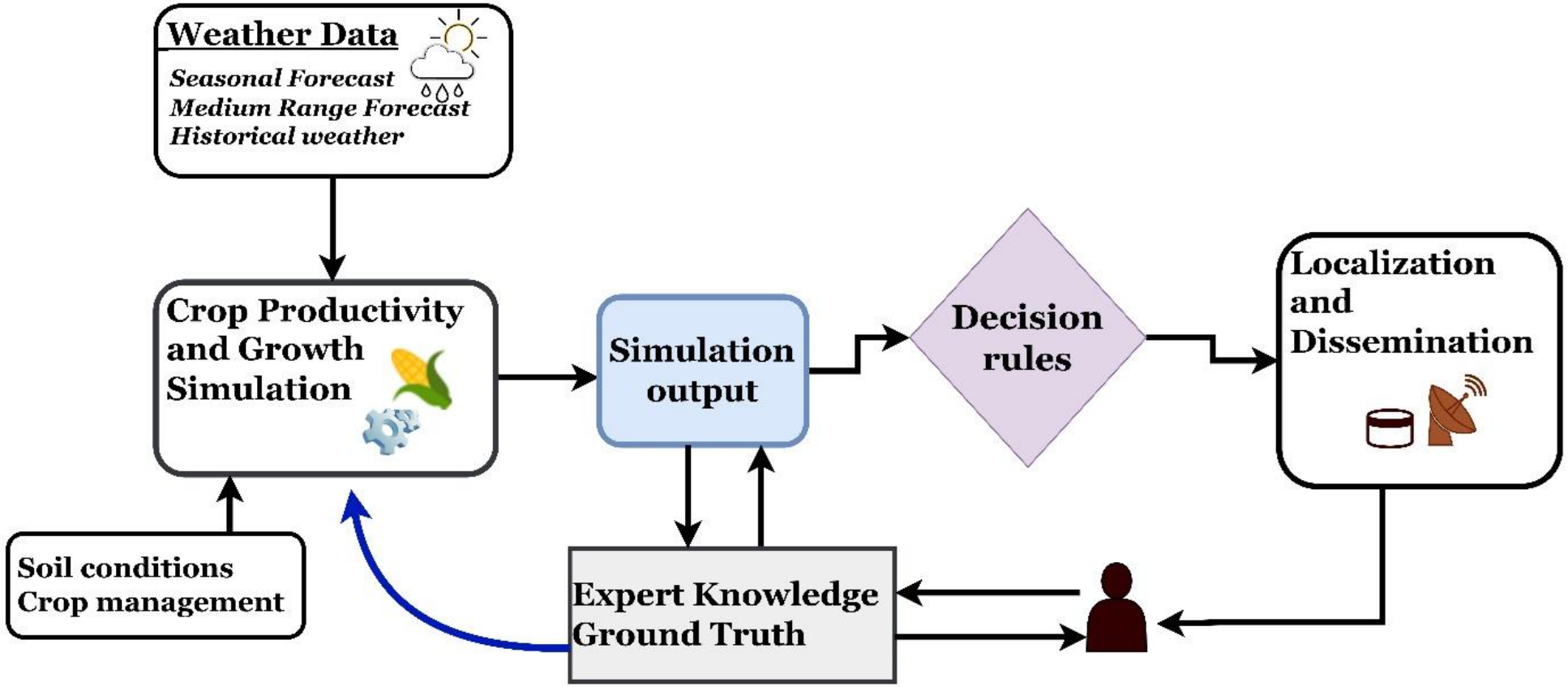
5. PUBLICATIONS (A SELECTION)

- **Abdulai, I.,** Hoffmann, M., Kahiluoto, H., .., Rötter, R.P., 2025a. Root traits of shade trees in cocoa agroforestry systems are associated with functional leaf phenology. https://doi.org/10.21203/RS.3.RS-5972723/V1
- **Abdulai, I.,** Hoffmann, M., Kahiluoto, H., Dipploid, A., M., Ahmed, M.A., Asare, R., Asante, W.A., Rotter, R.P., 2025b. functional groups of leaf phenology are key to build climate-resilience in cocoa agroforestry systems. Agric. Ecosyst. Environ. 379. https://doi.org/10.1016/j.agee.2024.109363
- **Abdulai, I.,** Hoffmann, M.P., Jassogne, L.,..., Rötter, R.P., 2020. Variations in yield gaps of smallholder cocoa systems and the main determining factors along a climate gradient in Ghana. Agric. Syst. 181, 102812. https://doi.org/10.1016/j.agsy.2020.102812
- **Abdulai, I.,** Jassogne, L., Graefe, S., ..., Vaast, P., 2018. Characterization of cocoa production, income diversification and shade tree management along a climate gradient in Ghana. PLoS One 13, e0195777. https://doi.org/10.1371/journal.pone.0195777
- **Abdulai, I.,** Vaast, P., Hoffmann, M.P., ..., Graefe, S., 2017. Cocoa agroforestry is less resilient to sub-optimal and extreme climate than cocoa in full sun. Glob. Chang. Biol. 24, 273–286. https://doi.org/10.1111/gcb.13885
- **Joseph, J. E.,** Akinseye, F. M., Worou, O. N., Faye, A., Konte, O., Whitbread, A. M., & Rötter, R. P. (2023). Assessment of the relations between crop yield variability and the onset and intensity of the West African Monsoon. Agricultural and Forest Meteorology, 333, 109431. https://doi.org/10.1016/j.agrformet.2023.109431
- **Joseph, J.E**., K.P.C Rao, E. Swai, A.M. Whitbread, R.P. Rötter (2025). How beneficial are seasonal climate forecasts for climate risk management? An appraisal for crop production in Tanzania. Climate Risk Management 47, 100686. https://doi.org/10.1016/j.crm.2024.100686

The Approach



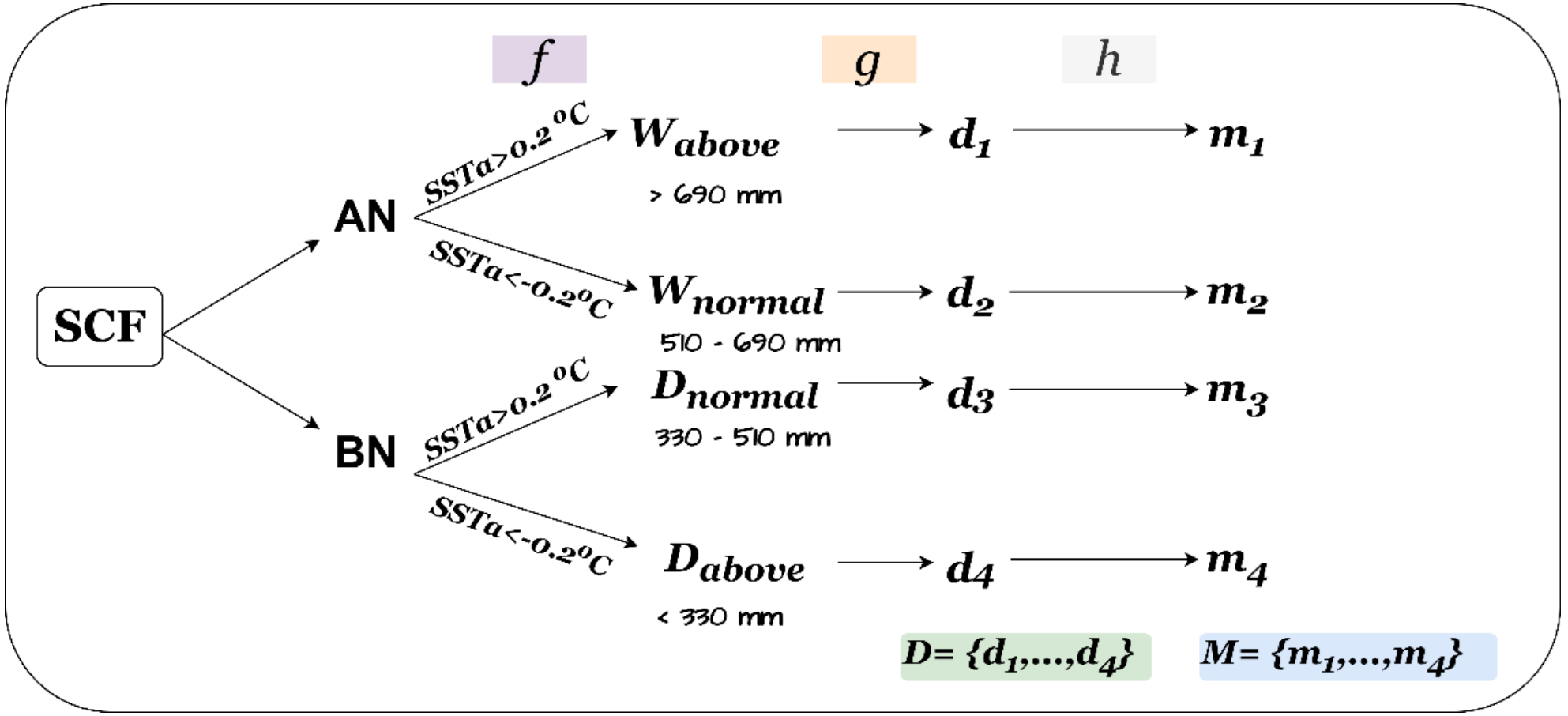
[The iSAT Framework]

4. SYNTHESIS AND OUTLOOK:
A POTENTIAL JOINT CORE (NBS & SFS) RESEARCH & CAPACITY DEVELOPMENT PROGRAM

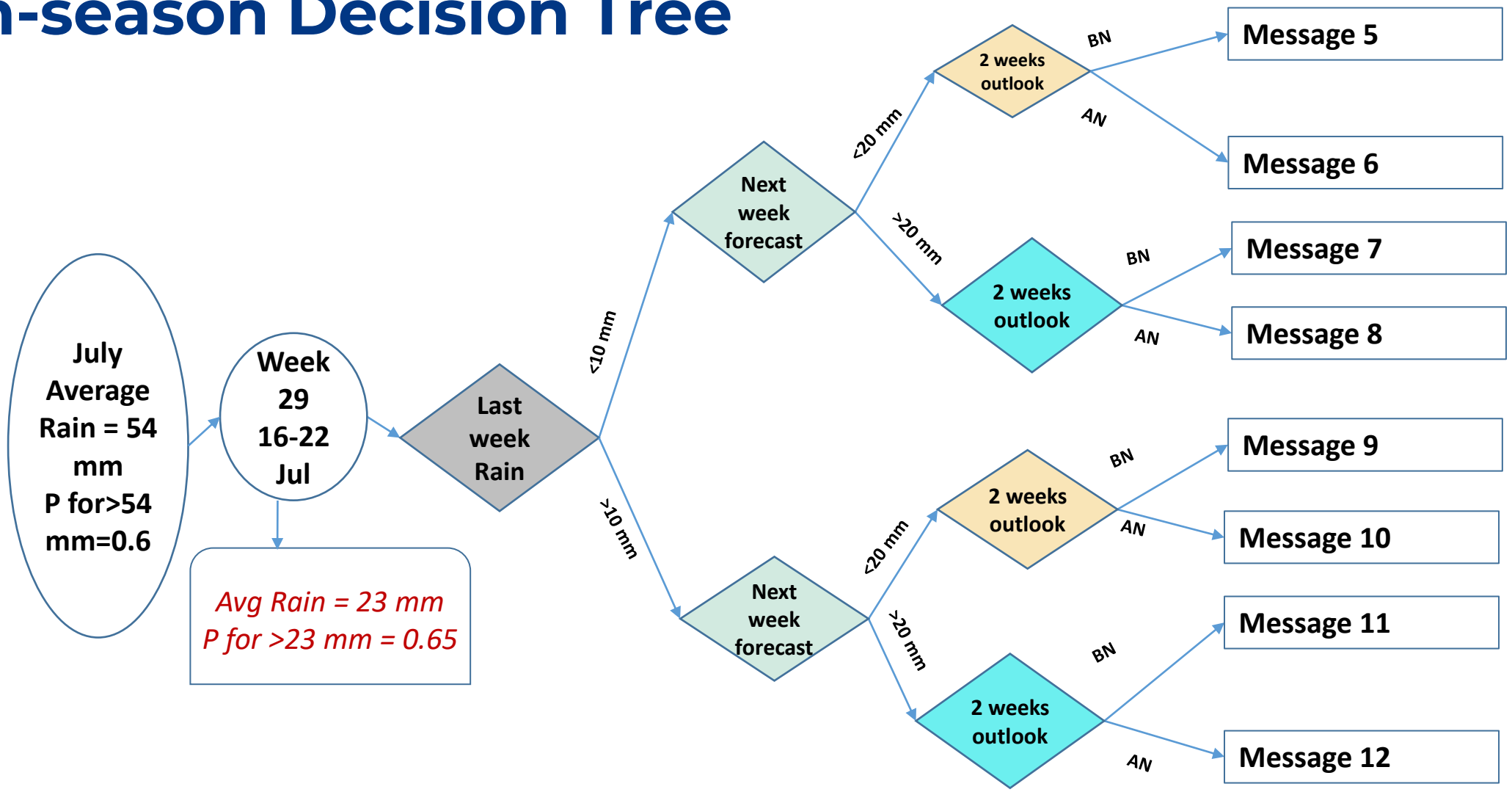
- 1. **Establish community co-learning platforms** connected to multi-stakeholder networks including scientists for building the knowledge co-production scheme to assess adaptation needs and co-create a framework **to analyse resilience along agro-ecological gradients in African drylands;**
- 2. Participatively **identify and evaluate short-term climate risk management practices** (i.e., for the upcoming growing season) by utilizing improved and extended databases and tools for risk identification, prediction and avoidance;
- 3. **Co-create narratives and long-term resilience interventions** and implement them by utilizing improved / extended databases and tools as well as scenario analyses with a **time horizon up to the 2050s;**
- 4. Build on, improve, extend, combine, and **integrate existing databases and tools for the co-development of climate information and services including short- and long-term risk management strategies** and resilience interventions that effectively respond to local needs;
- 5. **Provide the required capacity building** through synthesizing, upscaling and communicating co-produced scenario pathways for agro-pastoral management adapted to the upcoming climate threats for the drylands of Africa.

EXPECTED OUTPUT ➔ Going beyond the state-of-the-art by developing climate services driven by local (indigenous) knowledge & needs (of smallholder cocoa, crop-livestock farmers, pastoralists…)

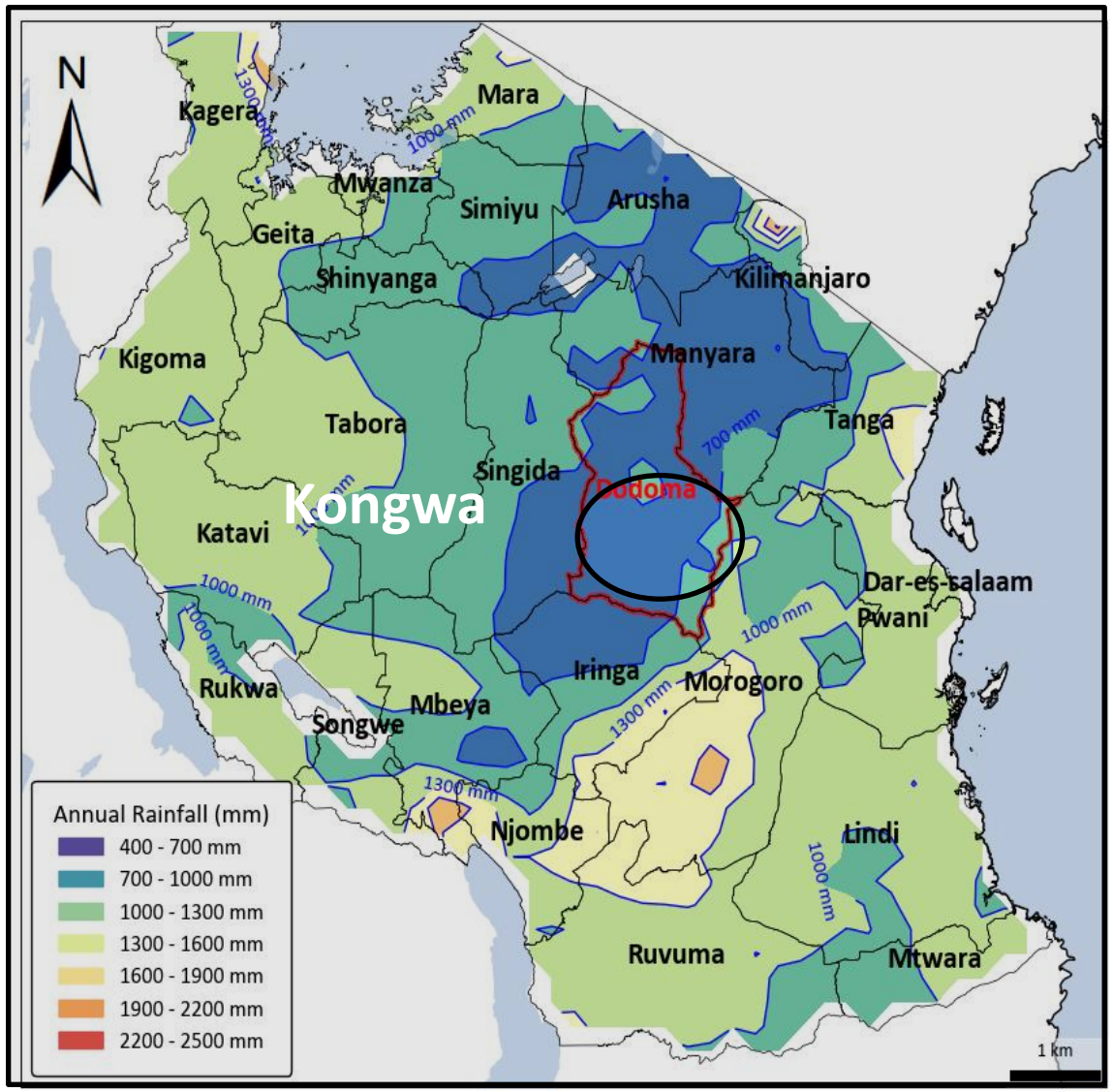
Pre-season Decision Tree



In-season Decision Tree



Tanzania


N
Kagera
Mara
Mwanza
Simiyu
Arusha
Geita
Shinyanga
Kilimanjaro
Kigoma
Manyara
Tabora
Tanga
Singida
Dodoma
Kongwa
Katavi
Dar-es-salaam
Pwani
Iringa
Morogoro
Rukwa
Mbeya
Songwe
Njombe
Lindi
Ruvuma
Mtwara
1000 mm
1300 mm
700 mm
1 km
Annual Rainfall (mm)
400 - 700 mm
700 - 1000 mm
1000 - 1300 mm
1300 - 1600 mm
1600 - 1900 mm
1900 - 2200 mm
2200 - 2500 mm

Synthesis and Discussion

- Location-specific validation of gridded precipitation products (GPPs)
  - → improve rainfall predictions and yield estimates
  - → enhance the accuracy of climate risk assessments
- Forecast accuracy and interpretability are crucial for usability and impact
- Farmer-centric agro-advisory tools like iSAT can
  - → significantly enhance climate-informed decision-making,
  - → boosting productivity and reducing input costs.
- **The private sector**, like Jokalante in Senegal, plays a key role in scaling CIS for climate-resilient agriculture.

The food system and its drivers

Growing and demographically changing population

Resource scarcity and competition

Global environmental change (incl. land degradation & climate change)

Increase in purchasing power (income) and preferences(dietary change)

GHG emissions and CC Mitigation /Adaptation options

AIM

Threaten

Influence

Food Security

All people, at **all times**, have **physical and economic access** to **sufficient, safe and nutritious food** that meets their dietary needs and food preferences for an active and healthy life