Bridging the skill gap for a climate-smart agrifood future: integrated pathways for on- and off-farm workforce development

Amine AMAR

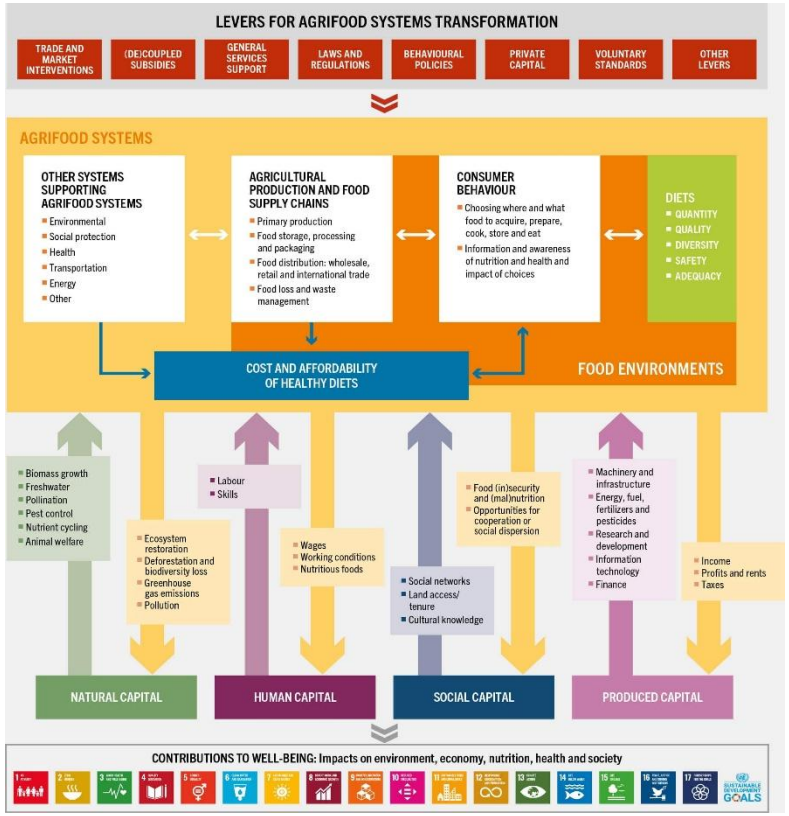
Al Akhawayn University, Ifrane, Morocco

Overview

- General context.
- Objectives & rationale.
- Data & methodology.
- Results.
- key findings & conclusion.
- Work in progress.

General context

The Agrifood system (AFS) at a crossroads



FAO's State of Food and Agriculture 2024

- **AFS**: A dynamic, interconnected socio-ecological system.
- **The dual reality:** Impacts and dependencies
  - **Dependencies:** Integrity of natural capital and the stability of ecosystem services.
  - **Impacts:** Environmental degradation, climate change, and the erosion of the natural capital.
- Compounding pressures.

General context

The Agrifood system (AFS) at a crossroads

The Transformation

- AFS are shifting towards Climate-Smart Agriculture, digitalization, and expanded off-farm activities.
- Driven by climate change, sustainability demands, and a growing population.

The Stark reality

- AFS contribute **~33%** of global greenhouse gas emissions (FAO, 2024).
- AFS employ **~1.23 billion** people, about one-third of the global workforce (FAO, 2023).

The central problem

- The transformation creates unprecedented **skill demands.**
- Current training systems are failing to equip the workforce, especially (MSMEs).

Opportunities

- Strengthen the resilience of the very MSMEs.
- Accelerate the adoption of the climate-smart practices.
- Boost incomes and fuel rural economies.

Objectives & rationale

Our core mission

To **design** and **validate** an integrated skills framework that bridges the gap between labour market needs and workforce capabilities.

Specific objectives

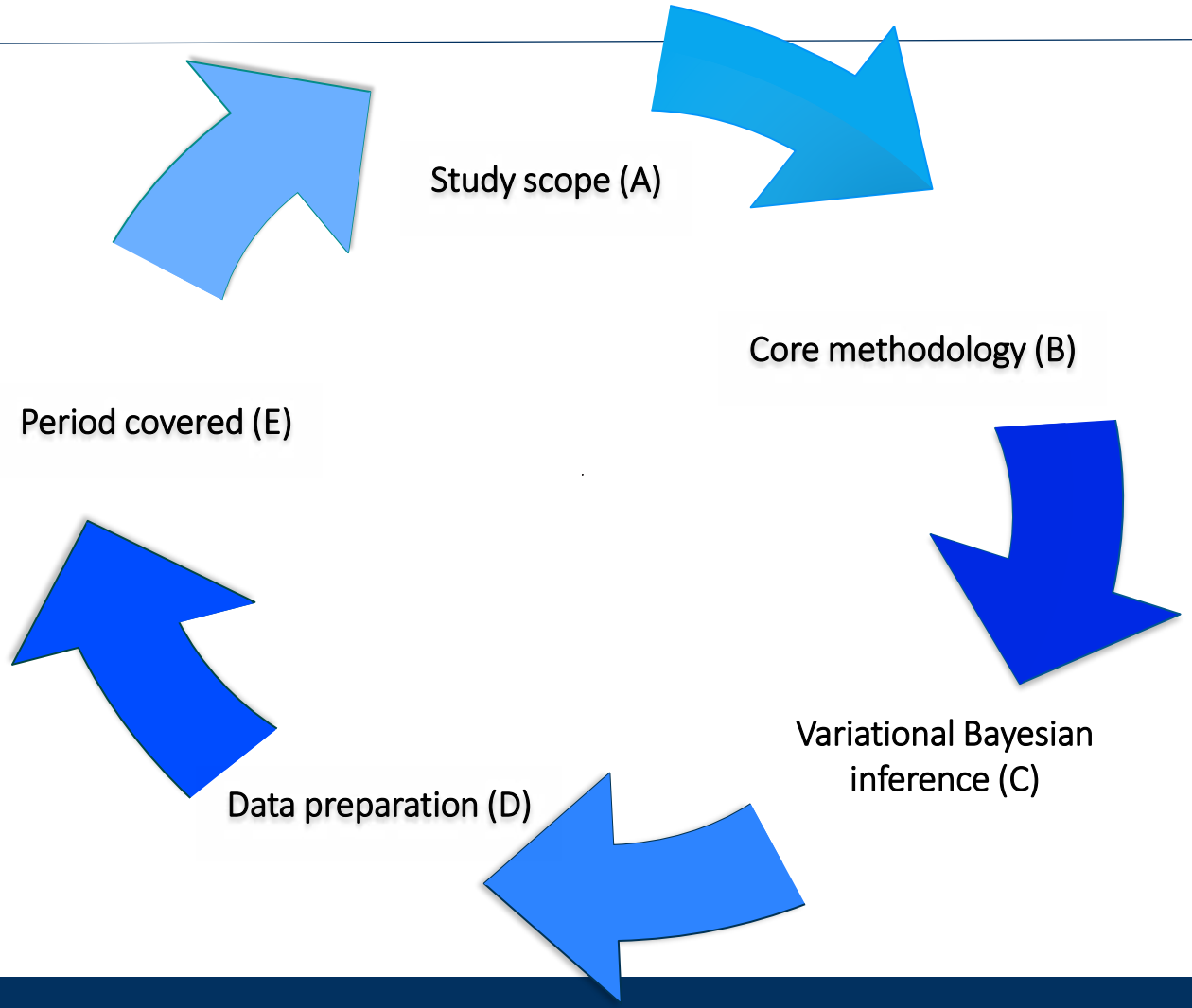
Map emerging skill demands driven by CSA and digitalization.
Assess critical skill gaps in on- and off-farm labour forces.
Identify high-impact interventions using robust causal inference methods.

Guiding research questions

What **new skills** are essential?
Where are the most pressing skill **deficiencies**?
Which interventions are most **effective**?

Data & methodology

A Robust causal approach (1/4)

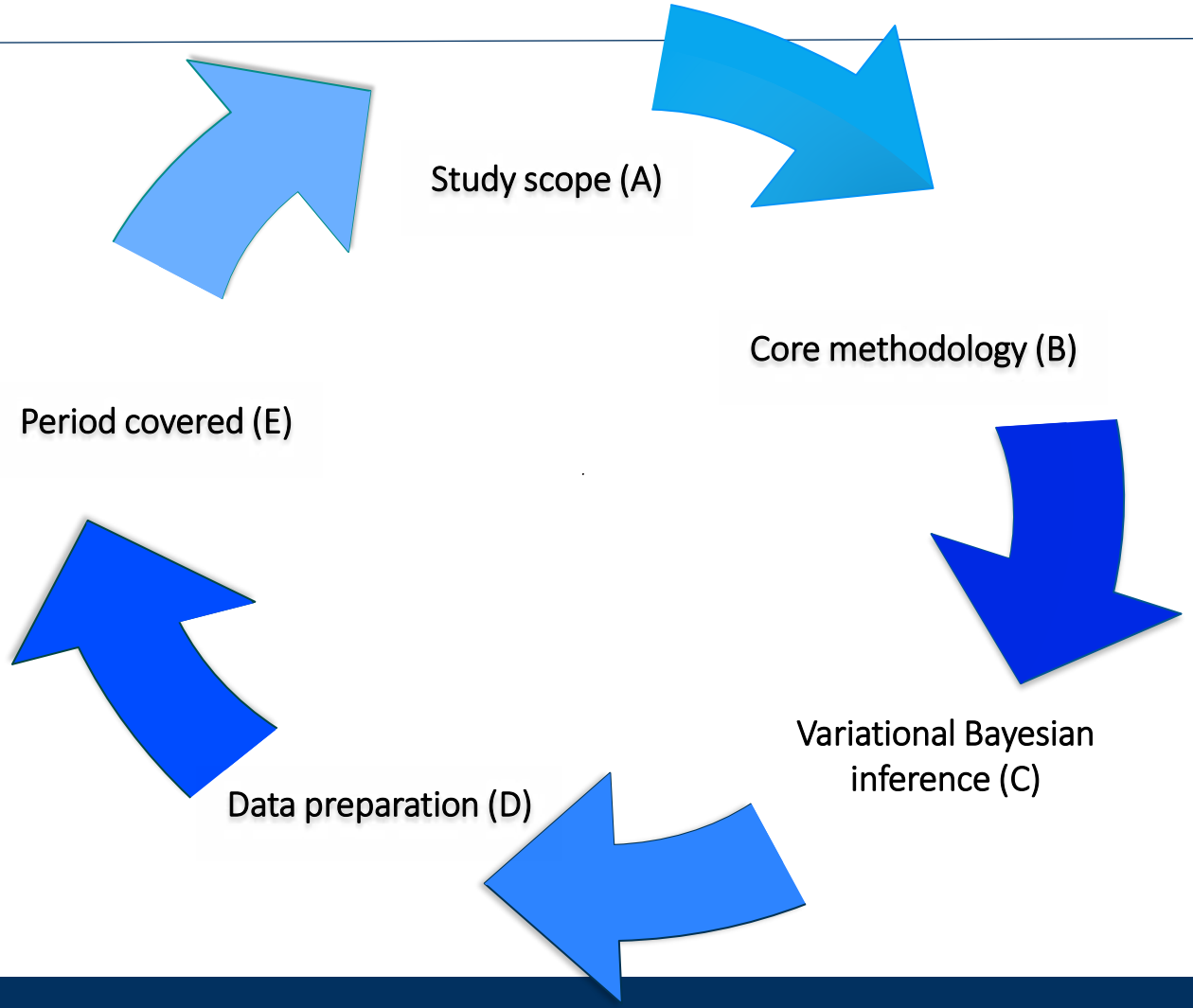


- **Study Scope (A)**

- Propose an integrated skills framework.
- Map future skill demands, assesses current gaps and propose a skills delivery ecosystem.
- Estimate the causal impact of workforce interventions.
- Evaluate the impact of the proposed framework.

Data & methodology

A Robust causal approach (2/4)



- **Core methodology (B) and Variational Bayesian inference (C)**

- DML uses ML to control for high dimensional variables, providing unbiased estimates of the causal effect of training interventions on resilience.

- Enhance with VB and go beyond a single estimate to provide a full posterior distribution.

- Quantify uncertainty and allow for probabilistic statements.

Data & methodology

A Robust causal approach (3/4)

Variable Name	Source	Description
age	IFPRI	Age of household head or primary respondent (years)
gender	IFPRI	Gender of household head or respondent (male/female)
education	IFPRI	Highest level of education attained by household head
household_size	IFPRI	Number of household members
income	IFPRI	Total household income (local currency)
farm_size	IFPRI	Total land area under cultivation (hectares)
crop_production	IFPRI/FAO	Quantity of crops produced (kg or tons per crop)
livestock_units	IFPRI/FAO	Number of livestock units (standardized)
input_use	IFPRI	Use of fertilizers, pesticides, irrigation (kg/ha or liters/ha)
digital_access	IFPRI	Access to digital tools (smartphone, internet, mobile apps)
off_farm_employment	IFPRI	Participation in non-agricultural employment (yes/no)
enterprise_size	IFPRI	Number of employees in the MSME
revenue	IFPRI	Annual revenue of MSME (local currency)
market_access	IFPRI/FAO	Access to local, regional, or international markets
training_participation	IFPRI	Participation in structured training programs (yes/no)
skill_score	IFPRI	Composite score of workforce skills (digital, climate-smart practices, financial management)
intervention	Study Data	Indicator for receiving the workforce intervention
regional_climate	FAO	Agro-ecological zone or climate classification
fertilizer_use	FAO	Quantity of fertilizer applied (kg/ha)
mechanization_index	IFPRI	Index capturing access to farm machinery and equipment
adoption_CSA	IFPRI	Adoption of climate-smart agricultural practices (yes/no)
trade_exposure	FAO	Share of output sold in local, regional, or international markets (%)
employment_agri	FAO	Share of population employed in agriculture (%)
employment_offfarm	FAO	Share of population employed in off-farm sectors (%)

- **Data preparation (D) and Period covered (E)**

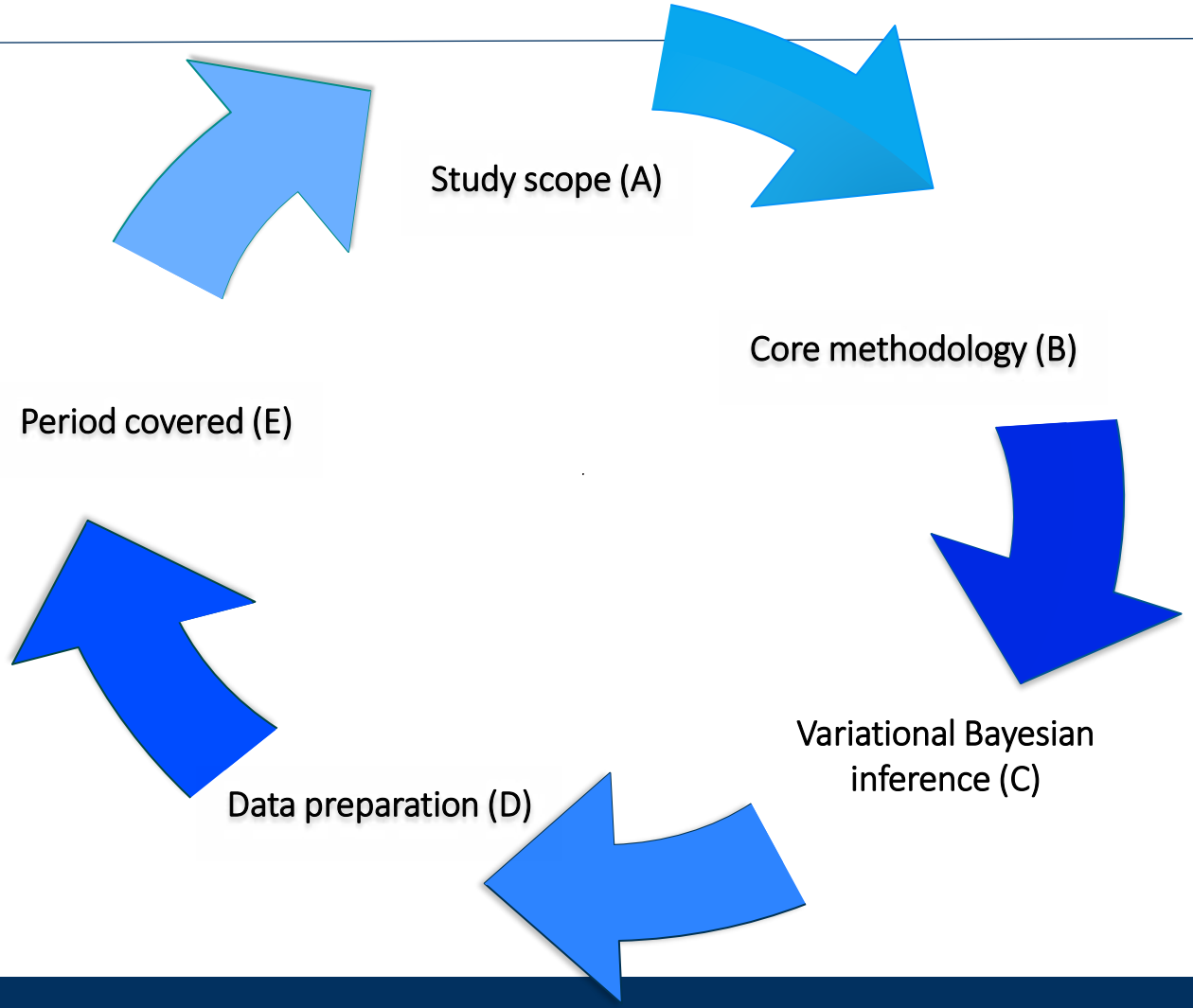
- Focus on low and lower-middle-income countries in SSA and Asia: **Ethiopia**, **Ghana**, **Tanzania**, **India**, **Bangladesh** and **Vietnam** .

- Analyse data from **2018** to **2023**, marked by intensified digitalization and climate smart agriculture.

- Generate a synthetic dataset that replicates variables commonly available in both micro and macro level sources.

Data & methodology

A Robust causal approach (4/4)



Workflow of the proposed methodology

- **Step 0** Load and preprocess synthetic data
- **Step 1** Define outcome, treatment, and controls
- **Step 2** Estimate causal effect via DML with orthogonalized residuals
- **Step 3** Apply variational Bayesian inference for posterior estimation
- **Step 4** Visualize posterior distributions and conduct predictive checks

Results 1/2

Does access to training alone significantly improve household resilience?

The limited impact of stand-alone training

The effect is negligible and statistically insignificant

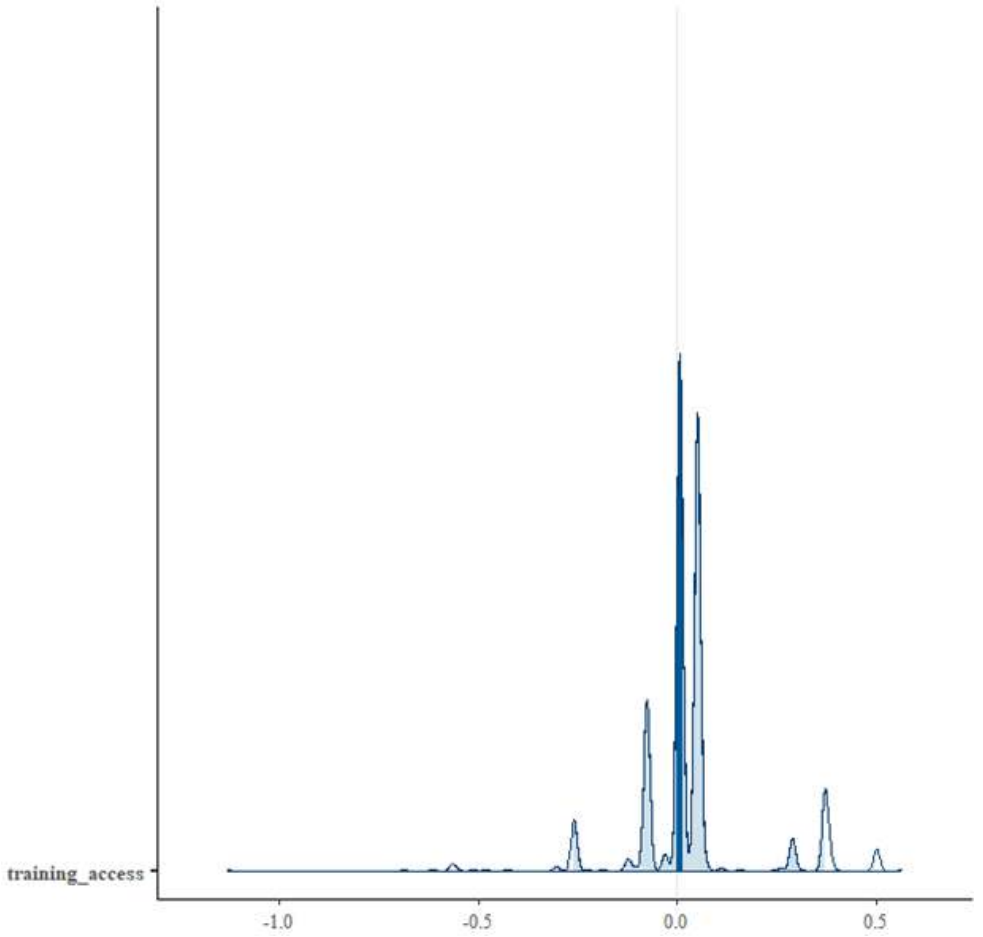
Estimated and significance testing of the effect of target variables

	Estimate	Std Error	tvalue	Pr(>|t|)
training_access	-0.1561	0.3236	-0.482	0.63

Posterior estimates from the variational Bayesian regression model of household resilience

	Estimate	Std Error	Conf.Interval
(Intercept)	50.1792	0.595709	[49.5639; 50.7945]
training_access	0.006216	0.06611	[-0.25922; 0.371551]
household_size	0.050829	0.075877	[-0.03359; 0.119661]
farm_size	0.02735	0.091521	[-0.12637; 0.134211]
digital_access	-0.34026	0.371774	[-0.73962; -0.0895]
educationSecondary	-0.74992	0.264352	[-1.13771; -0.48877]
educationTertiary	0.408087	0.710616	[-0.21045; 0.914868]
enterprise_income	0.000235	3.64E-05	[0.000202; 0.000288]
csa_adoption	0.113377	0.356187	[-0.43894; 0.55154]
market_access	-0.5668	0.234663	[-0.80027; -0.27118]
credit_access	-0.55236	0.052053	[-0.58747; 0.132257]

Posterior distribution of training effect (VB)



Results 2/2

What does drive resilience? → Complex picture of the drivers of resilience → Positive drivers, surprising & negative associations

Estimated and significance testing of the effect of target variables

	Estimate	Std Error	tvalue	Pr(>|t|)
training_access	-0.1561	0.3236	-0.482	0.63

Posterior estimates from the variational Bayesian regression model of household resilience

	Estimate	Std Error	Conf.Interval
(Intercept)	50.1792	0.595709	[49.5639; 50.7945]
training_access	0.006216	0.06611	[-0.25922; 0.371551]
household_size	0.050829	0.075877	[-0.03359; 0.119661]
farm_size	0.02735	0.091521	[-0.12637; 0.134211]
digital_access	-0.34026	0.371774	[-0.73962; -0.0895]
educationSecondary	-0.74992	0.264352	[-1.13771; -0.48877]
educationTertiary	0.408087	0.710616	[-0.21045; 0.914868]
enterprise_income	0.000235	3.64E-05	[0.000202; 0.000288]
csa_adoption	0.113377	0.356187	[-0.43894; 0.55154]
market_access	-0.5668	0.234663	[-0.80027; -0.27118]
credit_access	-0.55236	0.052053	[-0.58747; 0.132257]

- **Resilience is multidimensional**
  - Enterprise Income.
  - Tertiary education.
  - Digital access.
  - Market & credit access.
  - Secondary education.

Key findings & conclusion

The need for integrated pathways

❖ **Integrated pathways framework**

💵 **Financial Support**
(credit, grants)

📡 **Digital Access & Literacy**
(Bridging the connectivity divide)

🌱 **Practical Application**
(CSA adoption support)

🤝 **Market Linkages**
(Connecting to stable, profitable markets)

❖ **Policy implications**

💵 **Move from siloed training projects to multi-dimensional strategies.**

📡 **Address the entire ecosystem in which MSMEs and smallholders operate.**

Work in progress

- ✓Apply the methodology to real & large scale .
- ✓Conduct long-term evaluations.
- ✓Investigate the heterogeneous effects.
- ✓Refine the integrated skills framework.

THANK YOU FOR YOUR ATTENTION

QUESTIONS?