International Center for Tropical Agriculture
Since 1967 Science to cultivate change

Spatial Targeting of Agricultural Intensification Investments

The use of spatial data for targeting SI investments

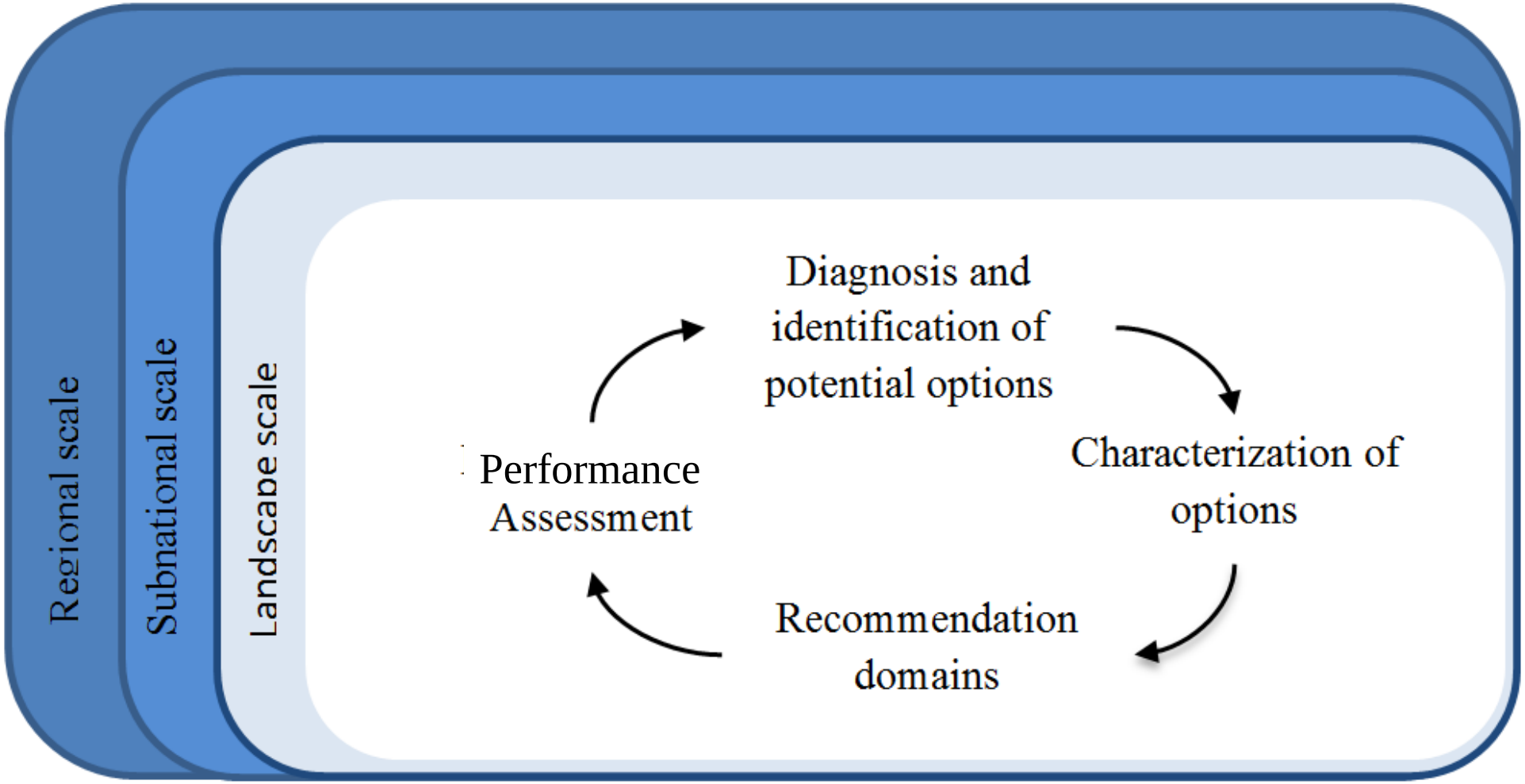
An Notenbaert, John Mutua, Evan Girvetz

Linking Household Surveys with Spatial Data Workshop

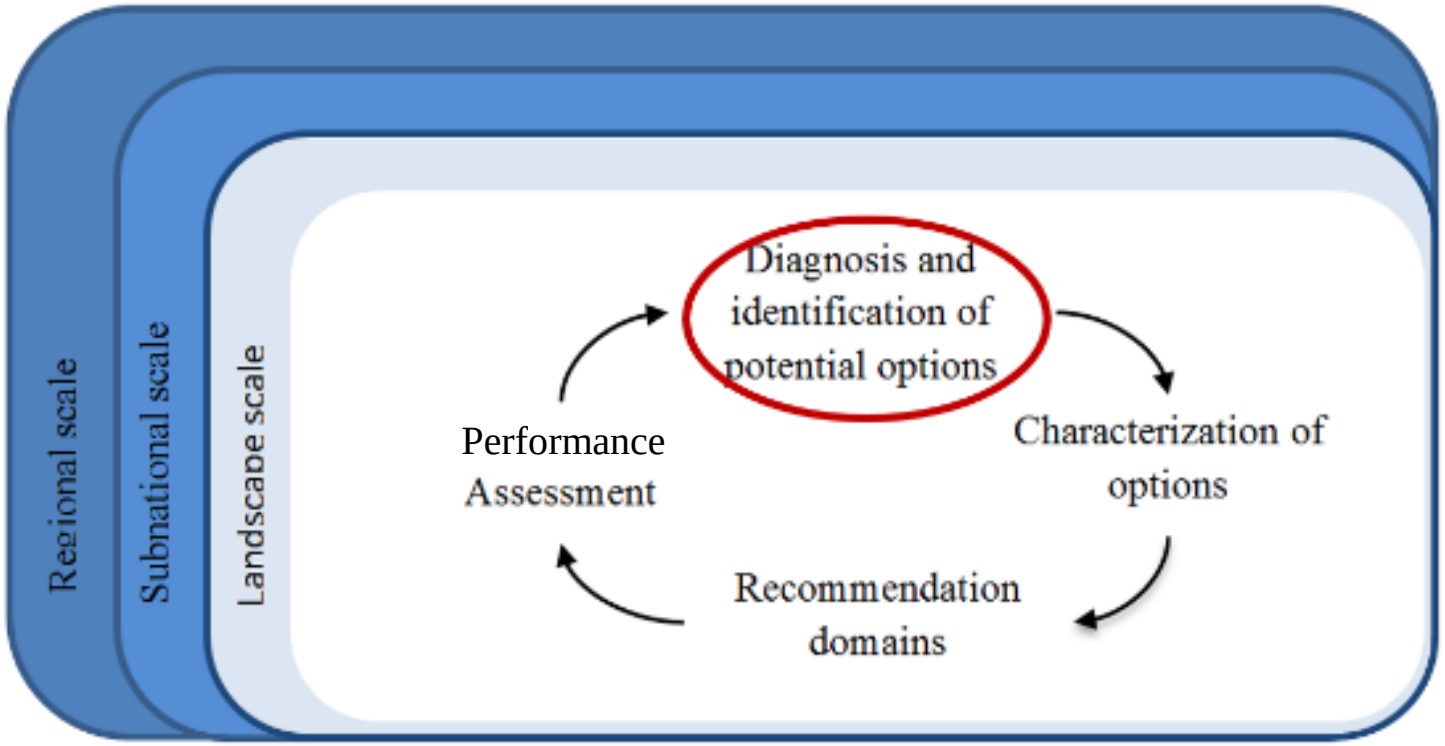
Arusha, TZ

27-28 September

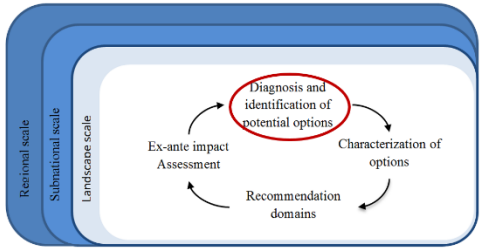
Example uses of spatially-explicit information in the different steps



STEP 1

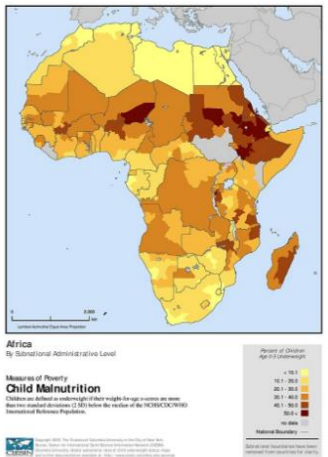


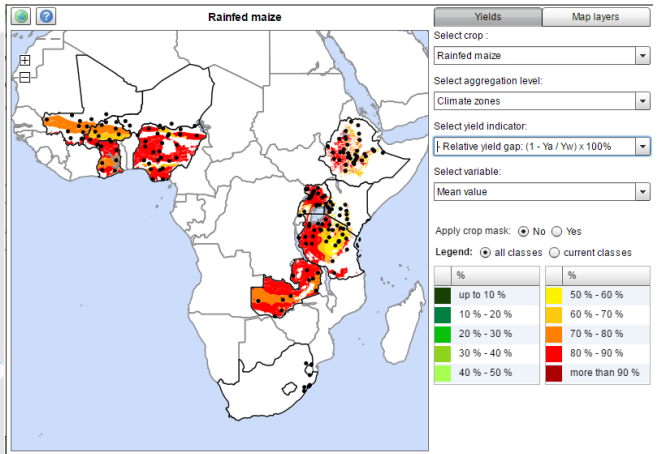
- Issues and problems
- Opportunities and potential solutions

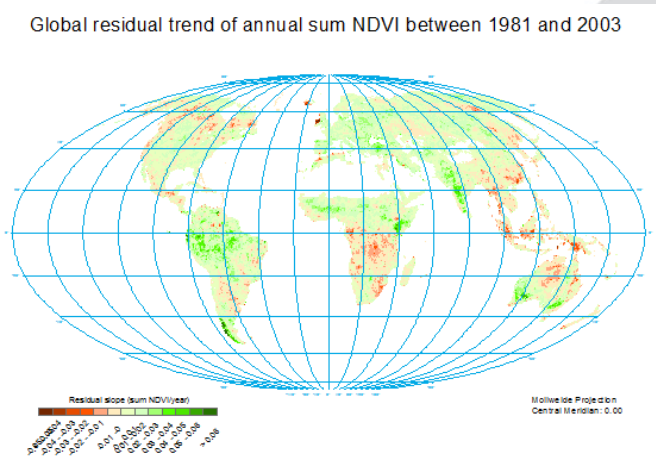


The NEED for Sustainable Intensification:

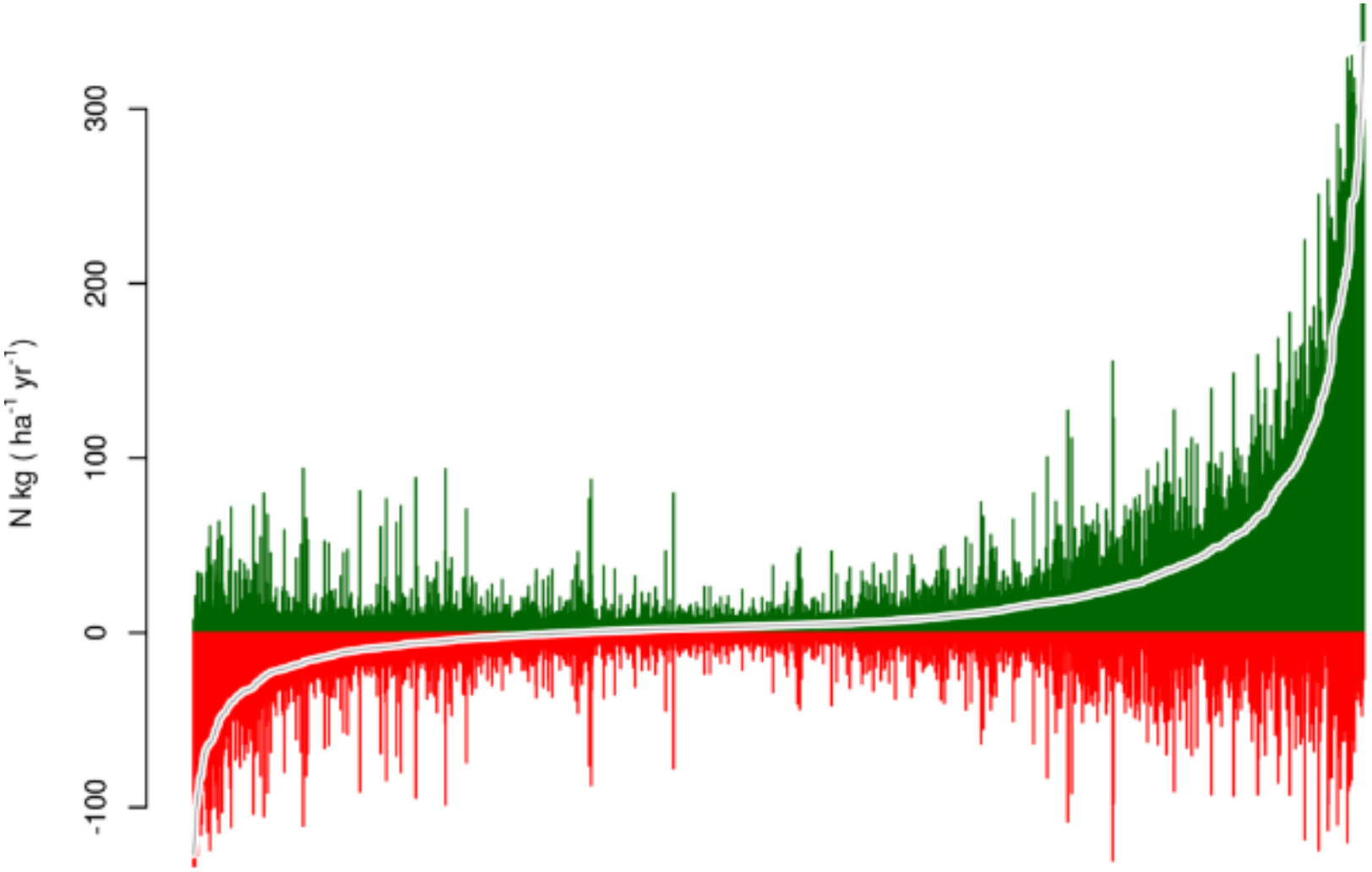
- Demand challenges:
  - Hunger
  - Malnutrition
  - Growing population
  - Urbanisation
  - Changing diets
- Supply challenges:
  - Low yields
  - Degraded lands (incl. nutrient losses)
  - Lack of land and water (expansion in vulnerable areas)
  - Climate change





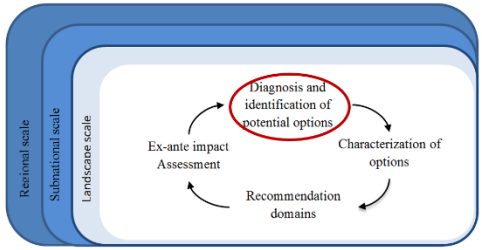


Another environmental indicator: N BALANCE



INPUTS:
- Fertilizer
- Manure
- Atm.deposition
- N fixation

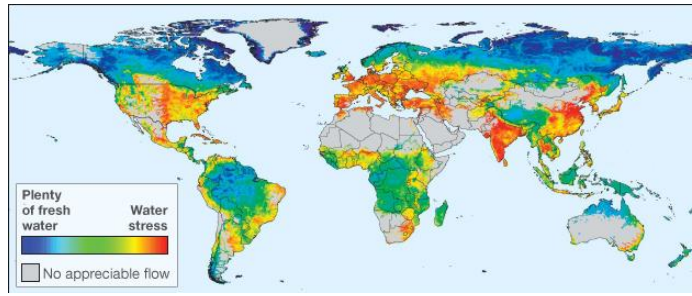
OUTPUTS:
- Crop
- Crop residue
- Leaching
- Gaseous loss
- Erosion



Potential for success of SI efforts

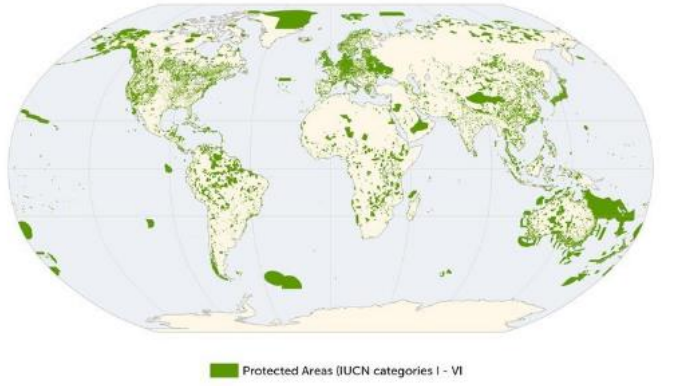
Potential for SI intensification depends on a number of factors, e.g.:

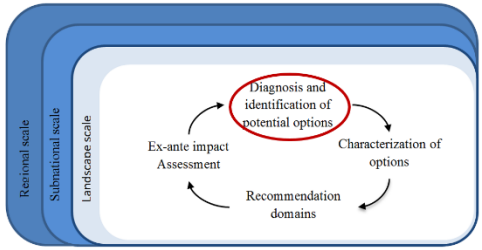
- Agricultural potential:
  - No soil limitations,
  - Water availability, …



- Socio-economic potential:
  - Good market access,
  - Access to labour,
  - Access to credit, …

- Low probability of high environmental costs
  - Protected areas,
  - Biodiversity hotspots,
  - Forests,
  - Erosion risk, …





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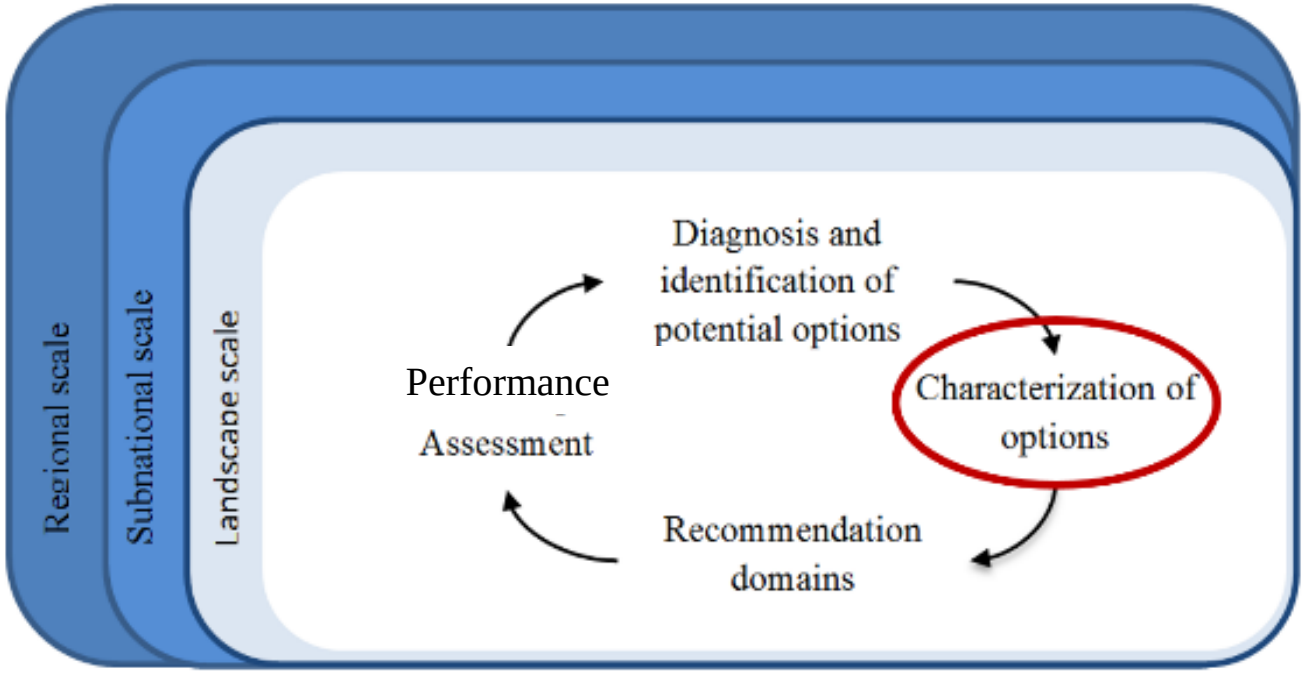
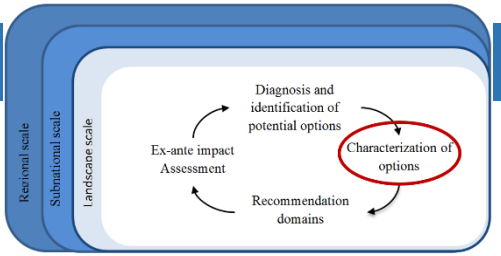
- Which indicators/metrics?
- Indicators vs. indices

STEP 2



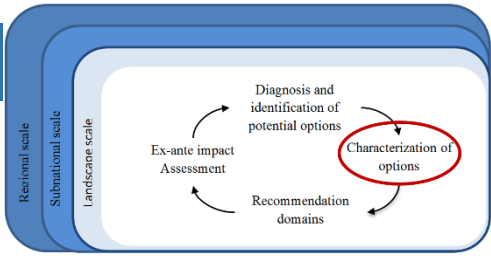
- Characteristics that affect the options' use and adoption.
- Context variables (bio-physical and socio-economic)
- Technology-specific characteristics such as the capital, labour, capacity and land requirements.



Wide variety of SI technologies

- Bridging the yield gap:
  - Zai pits, manure/fertilizer application, IPM, ISFM, …

- Transformational change
  - New production activities (Introducing legume rotations/intercrops, agro-forestry, irrigated vegetables, …)
  - Redesigning the farming system (dairy commercialization/intensification, …)



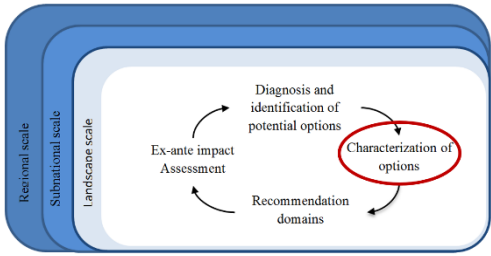
Suitability and adoption potential ~

Enabling conditions/costs:

- Biophysical conditions (land and soil requirements, water needs)
- input conditions (capital, labor, information)
- economic conditions (market access, demand, credit availability)
- institutional conditions (enabling policies, land tenure)
- cultural conditions (informal rules, access to fields and natural areas)

Direct and indirect outcomes

e.g. bio-physical suitability



BRACHIARA CULTIVARS SUITABILITY

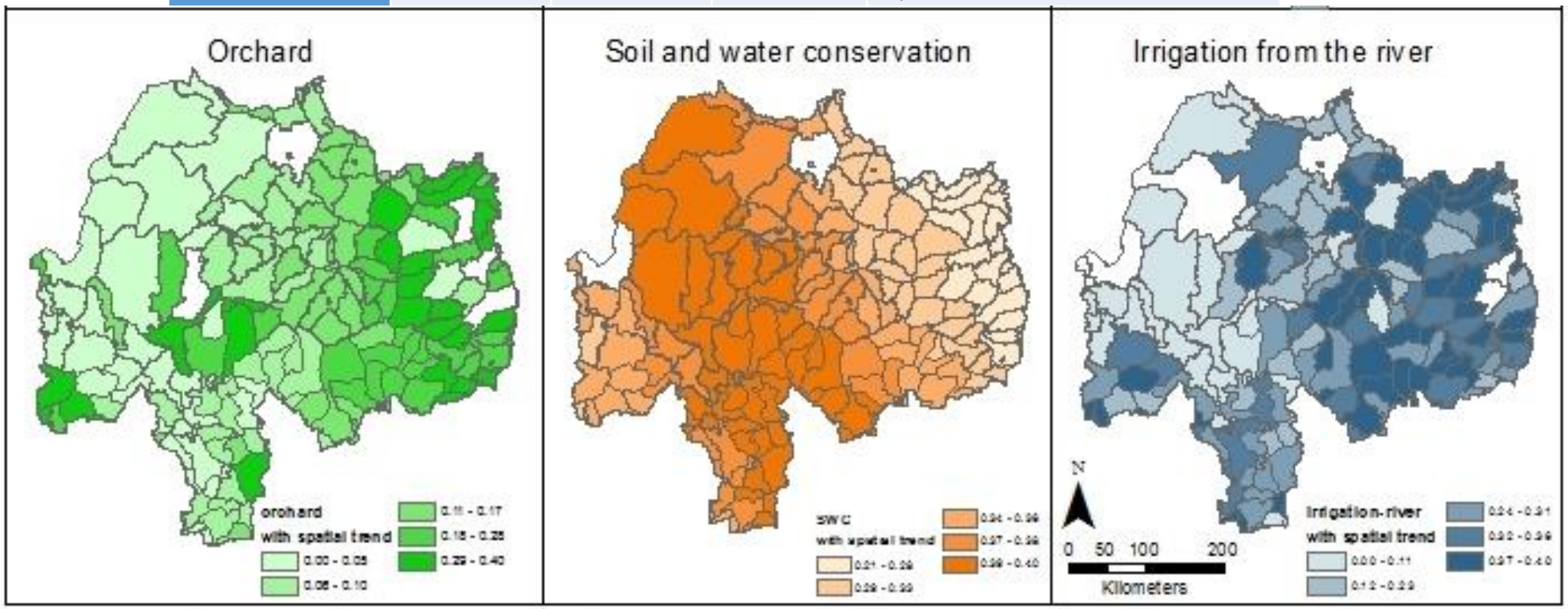
Science to Cultivate Change

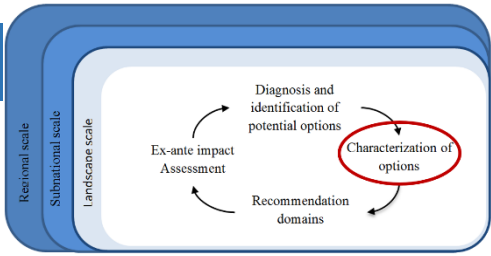
Cultivar	Precipitation	Temp	Fertility	pH	Texture	AEZ
Piata	> 600mm	>15º C	Moderate to high	4-8	light to heavy (but free-draining)	Semi-arid
Mulato II	> 700mm	>15º C	Moderate to high	4-8	light to heavy (but free-draining)	Semi-arid to sub-humid
Humidicola	> 800mm	>15º C	Low to moderate	4-8	light to heavy	Semi-arid to sub-humid
Napier grass (Kakamega)	> 1000mm	>15º C	High	4.5-7	light to heavy (but free-draining)	Sub-humid

Adoption

Factors influencing Adoption based on HH surveys and regression analysis

Variable at farm level (farm household survey)	Orchard	SWC	Irrigation from the river	Variable at woreda level
Landholding size	-0.3633014 (0.002)	-0.32609 (0)	0.8432849 (0.001)	Average landholding size*
Landholding size square	0.0098738 (0.469)	0.025805 (0.031)	-0.1226992 (0.006)	
average plot size	2.875819 (0)		-1.460356 (0.01)	Average plot size*
number of plots		0.077025 (0)	0.0933675 (0.001)	Land fragmentation*
Household size/landholding size			0.0124864 (0.018)	Population density*
female headed HH			-0.9771629	Proportion of female headed household*
Condition	slope>0	erosion>0	at least one flat plot	
p-value in bracket *taken from the Ethiopian Rural Economic Atlas (census data) ** other geographical layer (see data description in table 2)				





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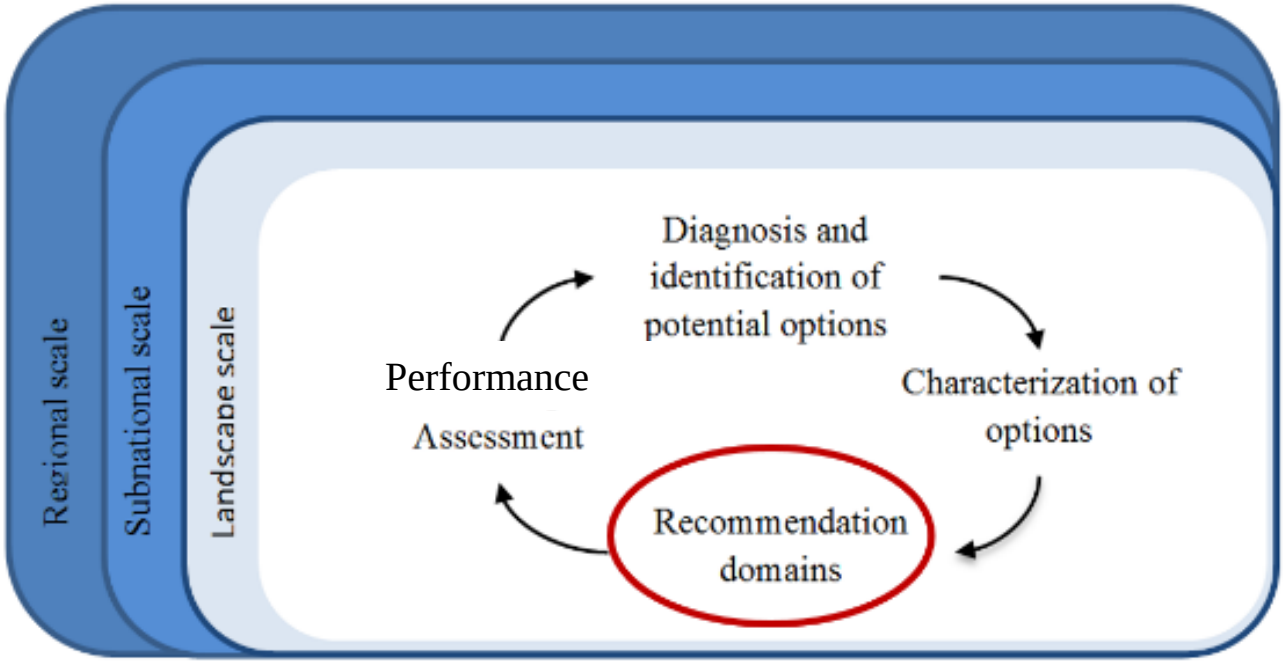
STEP 3



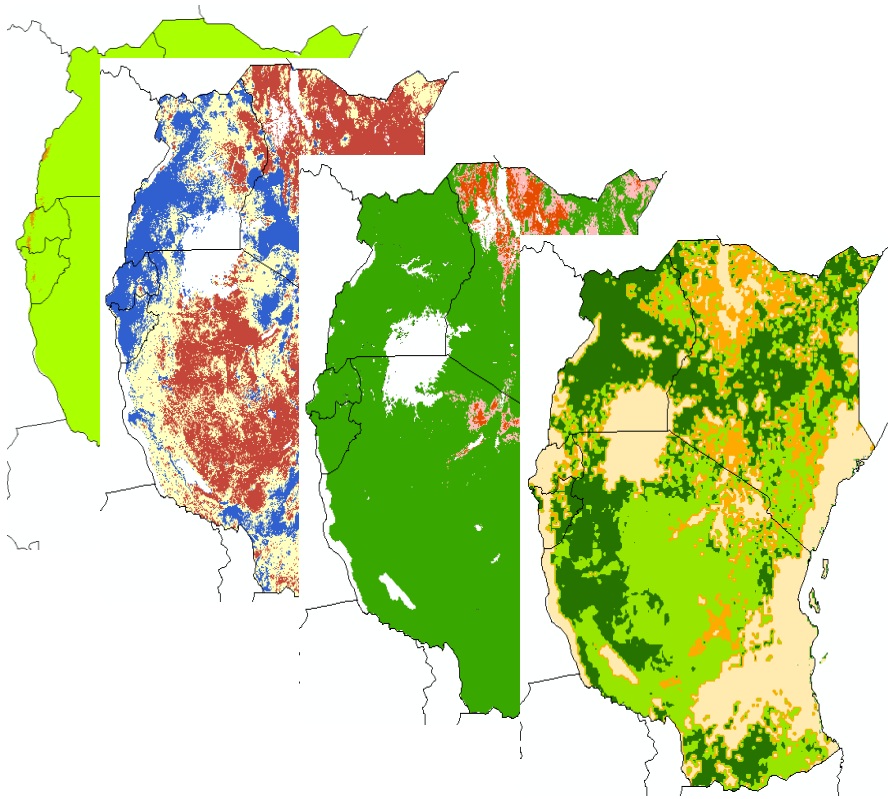
- Geographical targeting:
  - Suitability and Feasibility maps
  - Recommendation domains

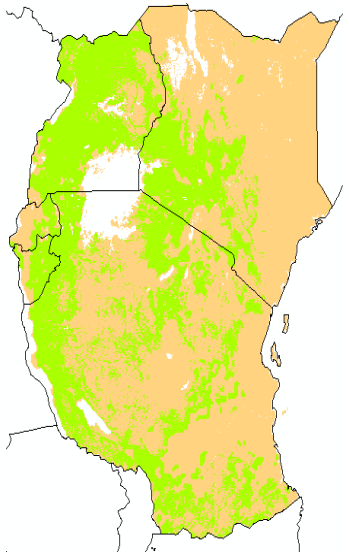
- (intra-)HH-level targeting

Suitability maps

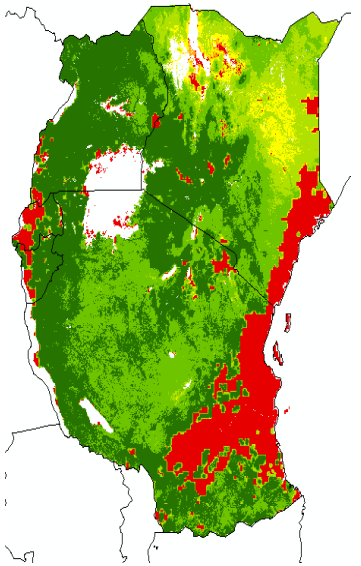
BRACHIARIA SUITABILITY

	Precipitation	Temp	Fertility (~ SOC)	pH	*Texture*	AEZ – growing season
Piata	> 600mm	>25º C	Moderate to high	4-8	*light to heavy*	Semi-arid
	600 - 2625 mm	*25-296 ºC*	*10-167 g/kg*	*4-8*	-	*11 – 52 weeks*





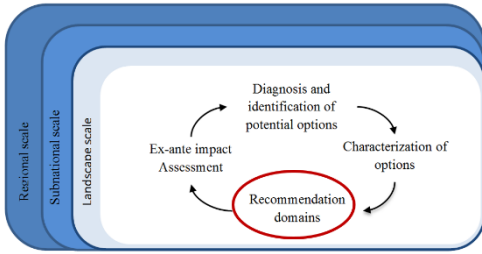
piata_01
suitable
not suitable



no
very low
low
medium
high
very high
perfect

TARGETING TOOLBOX

Science to Cultivate Change



01 Runs on Python

Targeting toolbox is an ArcGIS toolbox (.pyt) purely developed using Python programming language, ArcPy library.

02 Toolbox tools

It is made of three tools; *Land Suitability, Land Similarity* and *Land Statistics tool*.

03 Land Suitability Tool

Matches suitability criteria with a spatial database.
Suitability maps: areas where a specific strategy is likely to have a positive impact

04 Land Similarity Tool

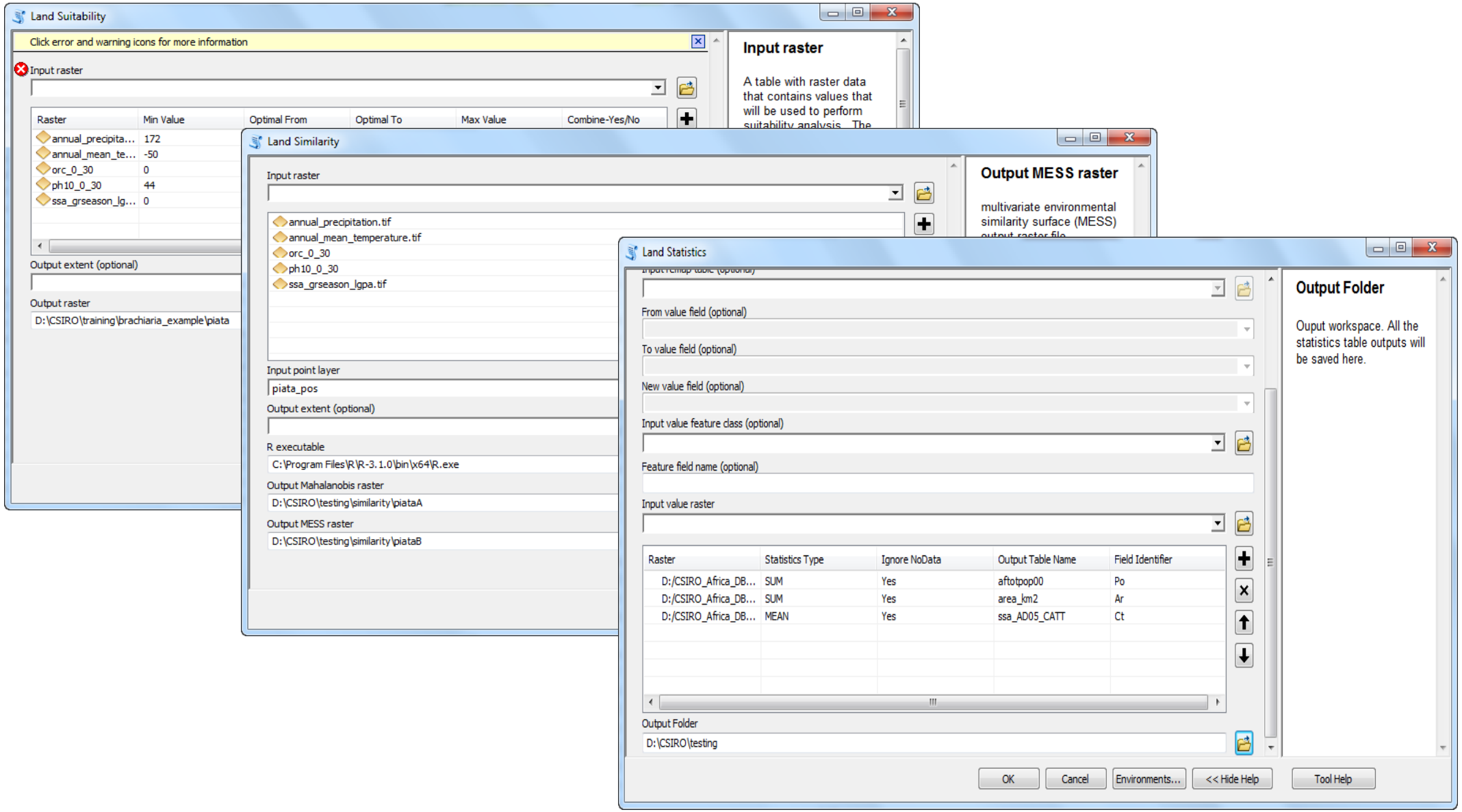
Estimates the potential for out-scaling using socio-ecological characterization and similarity analysis.
Similarity maps: indicating the wider applicability of the intervention

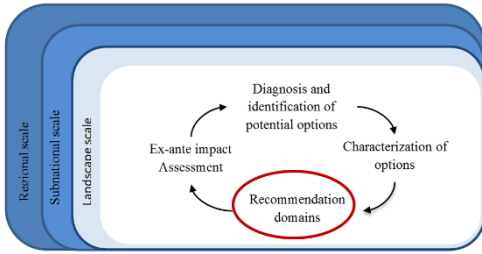
05 Land Statistics Tool

Calculates zonal statistics, e.g. total area/mean covered by human and/or livestock population,...
Output table: Statistics per suitability/similarity class

CIAT

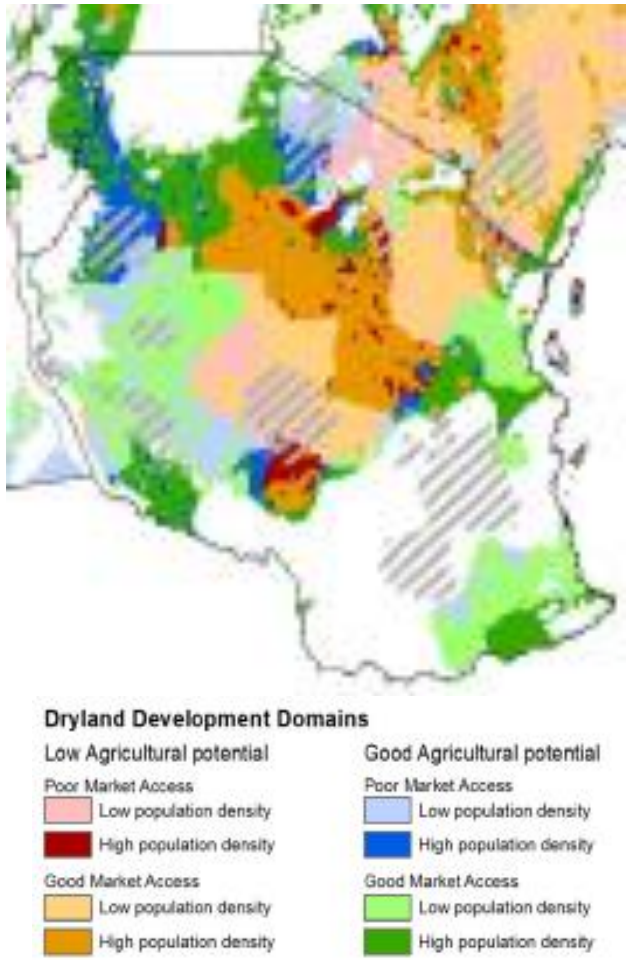
MORE ON WEDNESDAY PM





Or "domains"

Example: dryland development domains

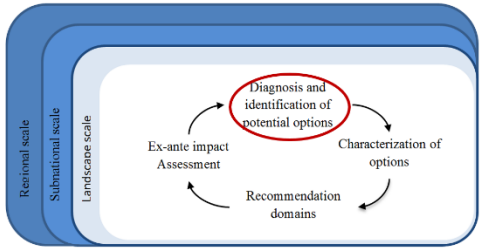


predicting the type of agricultural enterprises and development pathways

Domain	Ag. Potential	Market Access	Pop. Density	Potential strategies
LLL	Low	Bad	Low	Enhanced LS production
LLH			High	Diversification, Bio-fuel
LHL		Good	Low	Enhanced LS production, Diversification
LHH			High	Diversification, Bio-fuel, Exit
HLL	High	Bad	Low	Enhanced LS production, Large-scale agriculture
HLH			High	Diversification, Exit
HHL		Good	Low	LS production, Diversification, Large-scale agriculture
HHH			High	Diversification, Exit

→ Agricultural strategies are likely to have the same relevance for areas falling in the same domain

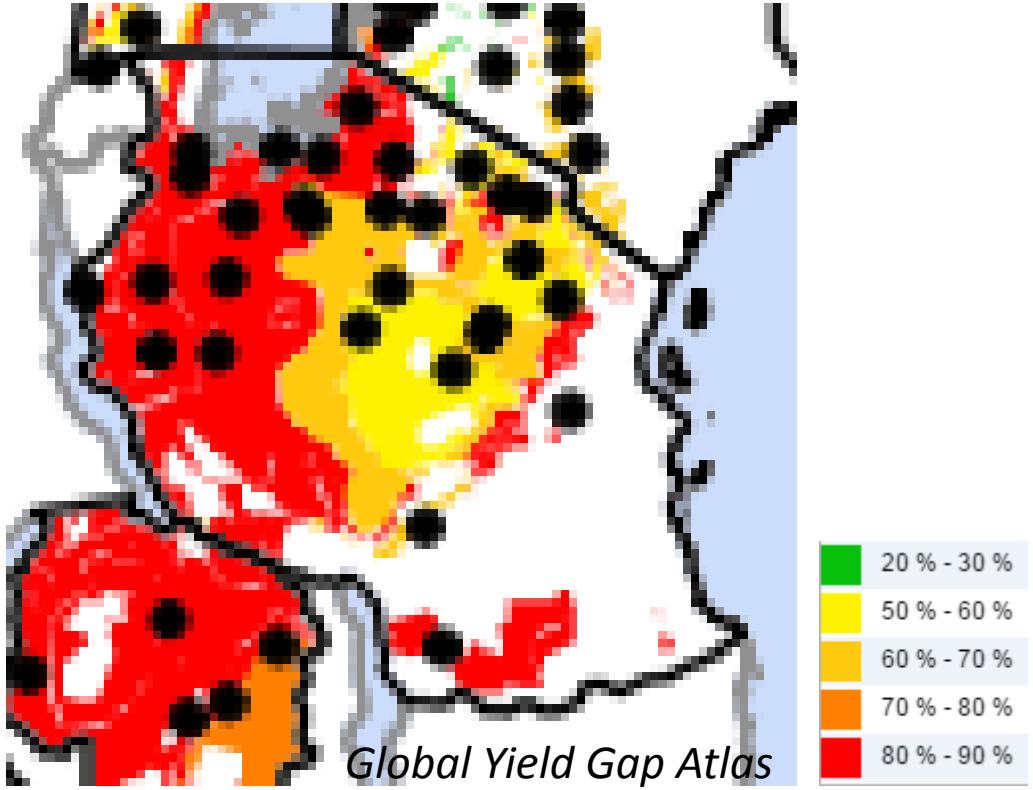
Aboud et al., 2012



NEED ~

Yield gaps

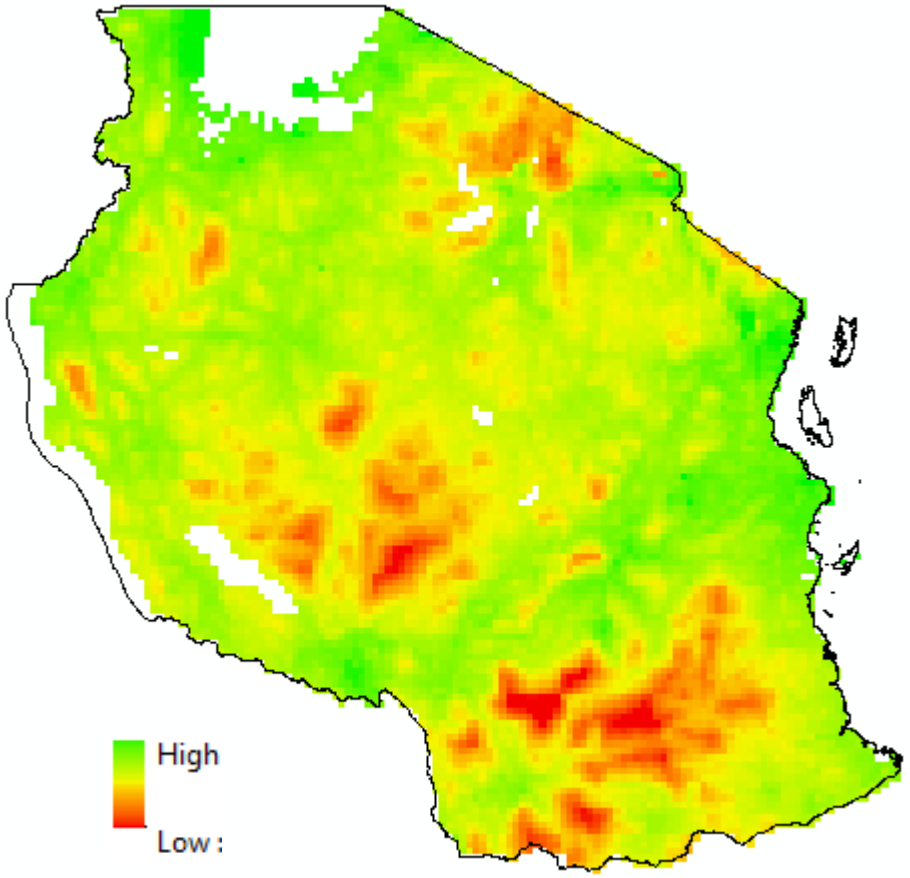
Maize



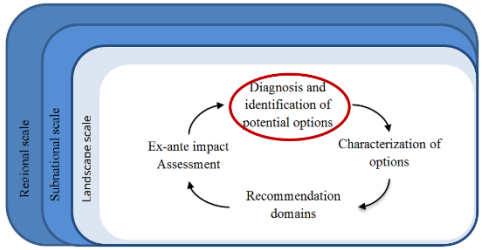
Global Yield Gap Atlas

POTENTIAL

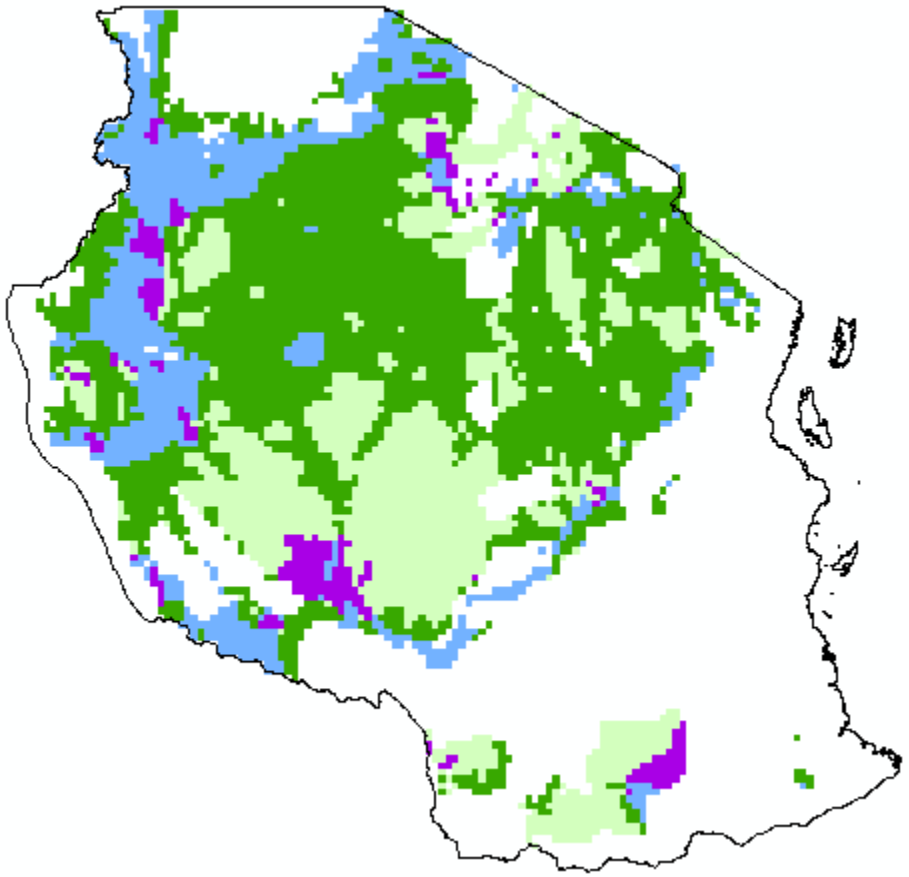
~ "index"



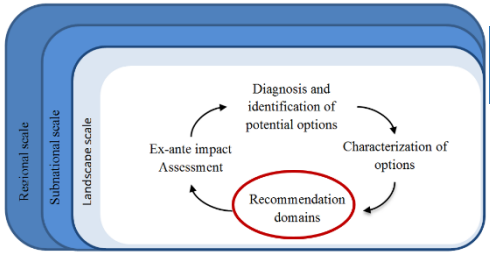
LGP + Market Access + pop.dens



Sustainable Intensification investment domains



Domain	NEED	POTENTIAL	Strategy
HH	High	High	Promote appropriate innovations
HL	High	Low	Provide incentives (e.g. infrastructure and market development)
LH	Low	High	High probability that (spontaneous) SI is already happening; support this process
LL	Low	Low	Keep at low level of intensification



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- Suitability maps: 0/1 vs. continuous gradient
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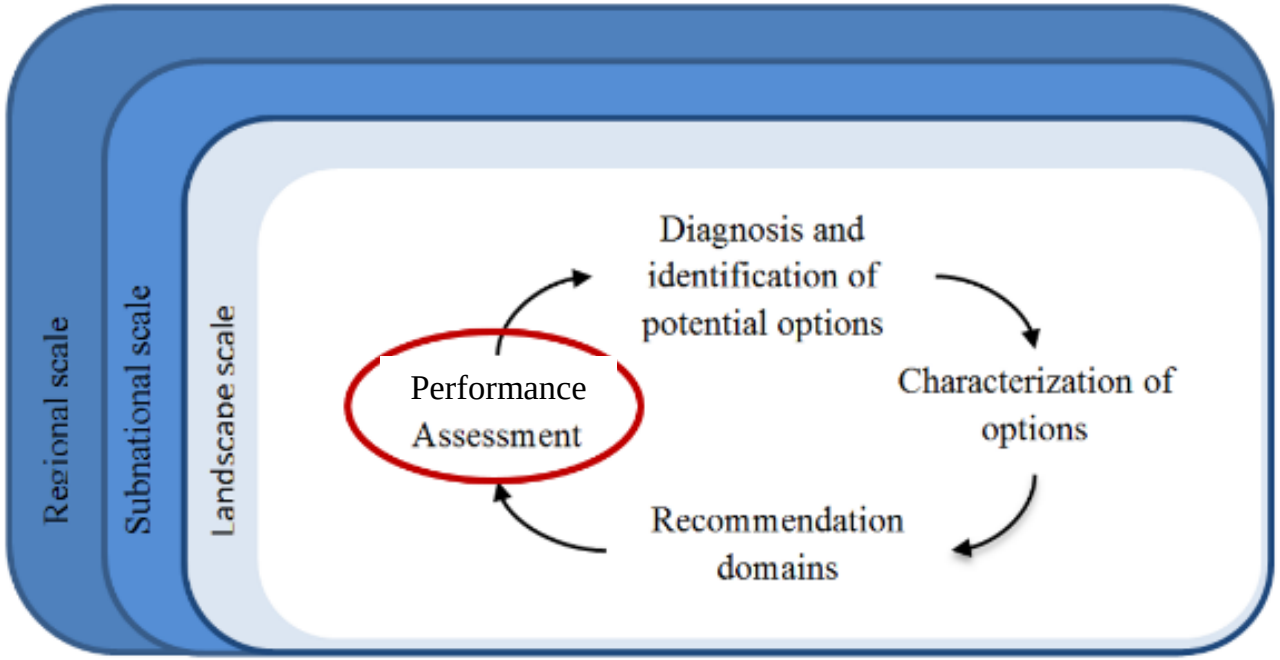
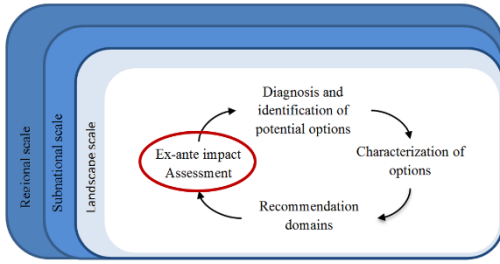
~ narrowing down/zooming in vs. “zoning”

STEP 4



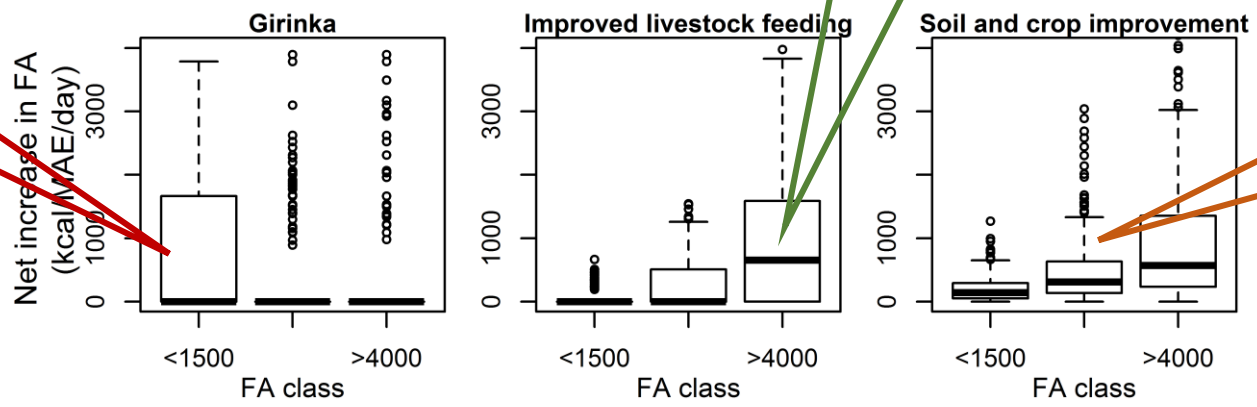
- Explore ‘what ifs’ (evidence-based discussion around the potential impacts and trade-offs
- Consider both the temporal and spatial scales of the impacts

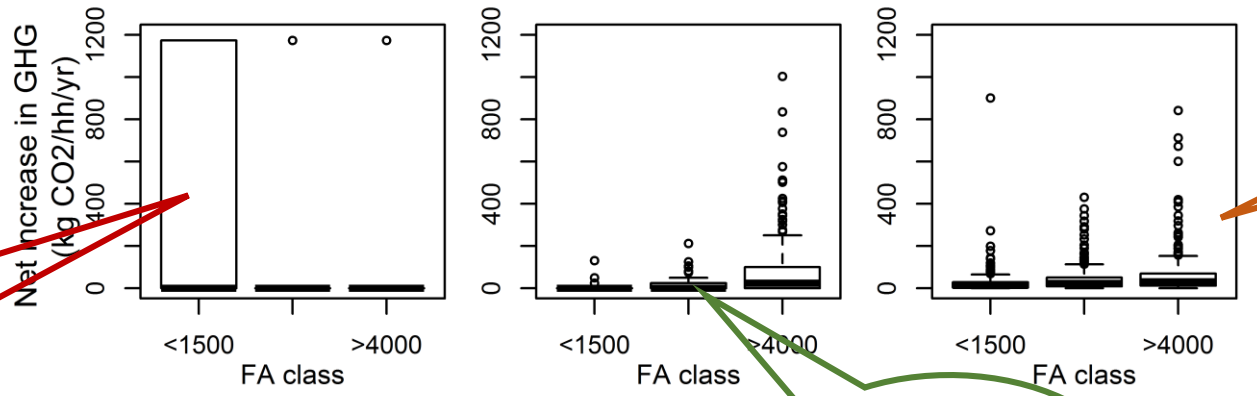


The impact of SI policies in Rwanda

3 HH "types" ~ FA

3 Scenarios:
- Girinka (cows 4 farmers)
- Feeding
- S-C improvement





Pro-poor

Benefits Better-off HHs

Moderate Benefits For all

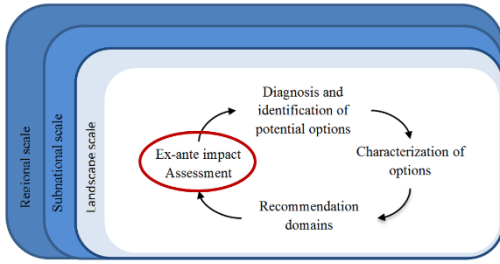
Marginal GHGe increases

GHGe increase

Only small GHGe increases

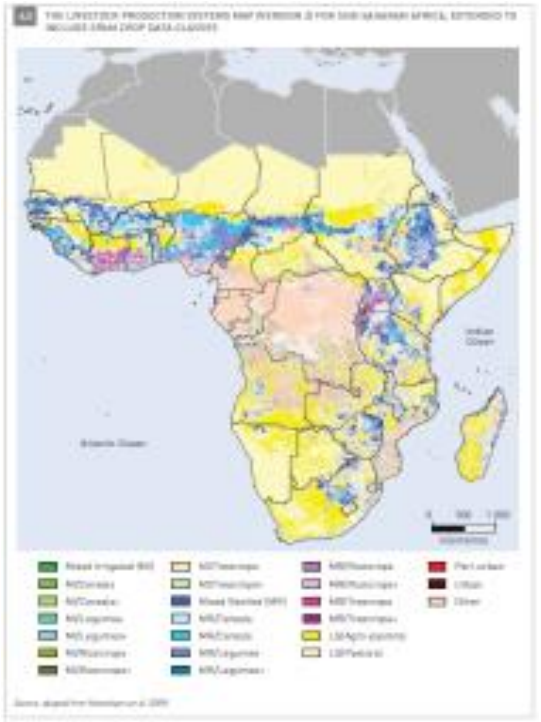
Different potential impacts and trade-offs on different sections of the farm household population.

Paul et al., forthcoming



GHG emissions in the developing world

Livestock production systems



GIS

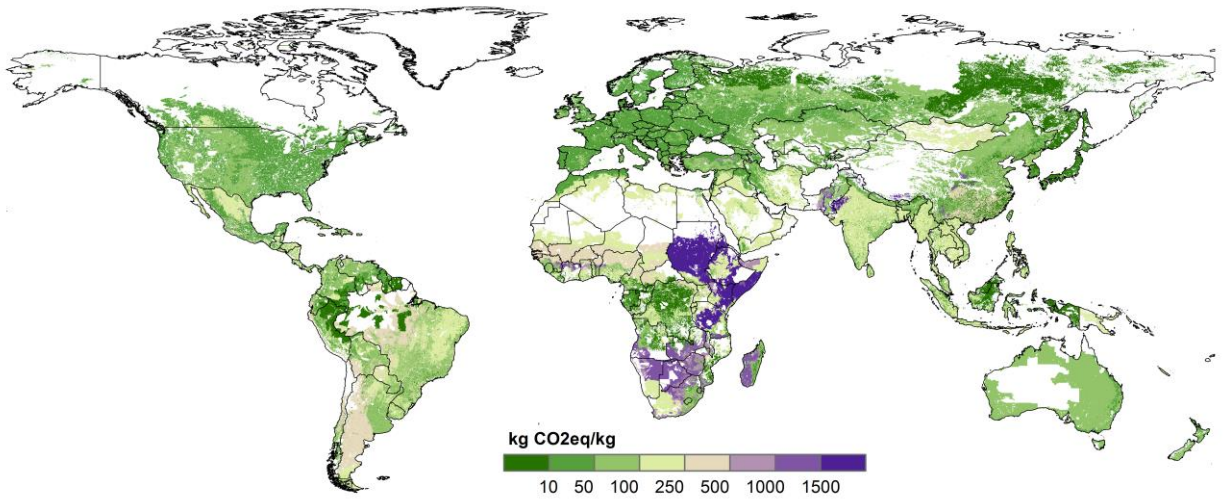
Animal numbers

HH surveys / Expert opinion

Animal characteristics
Feed baskets

Process-based modeling

Estimates of:
- Livestock productivity/production
- GHG emissions



Herrero et al., 2013

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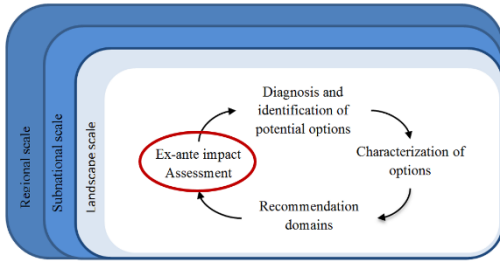


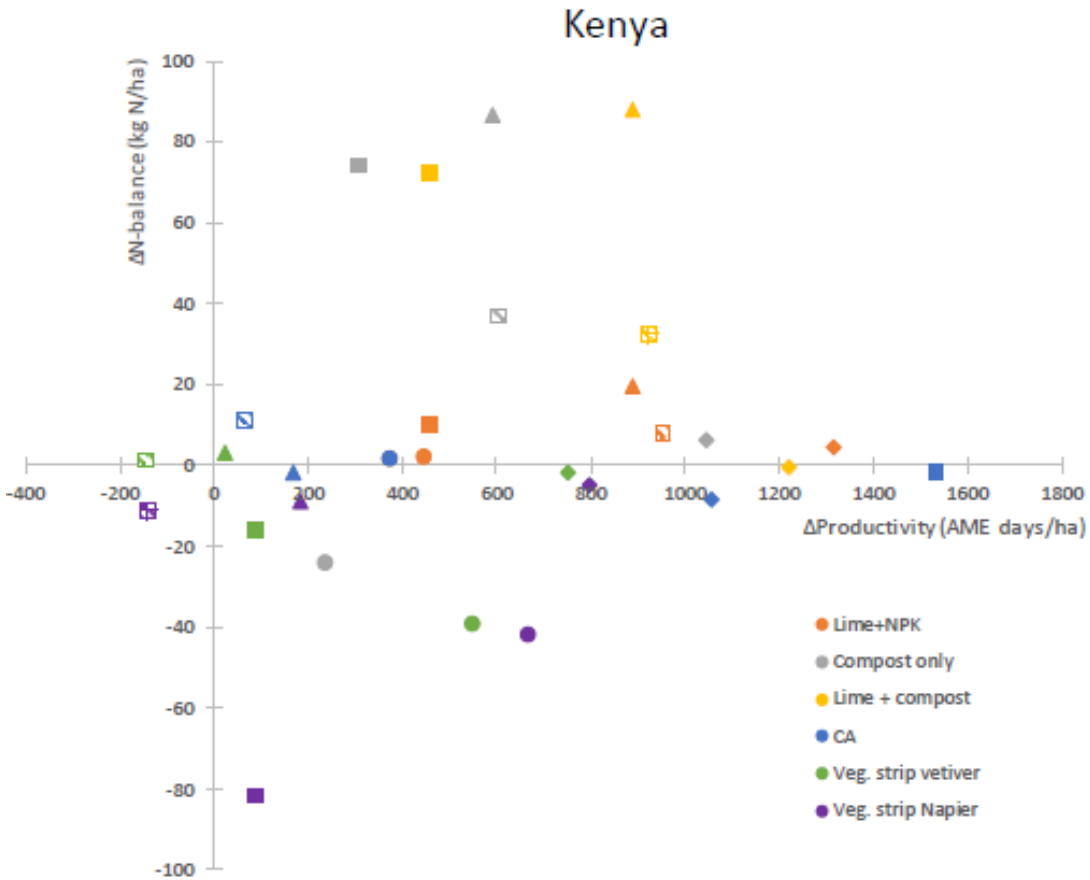
CSA rapid assessment - methodology

Stakeholder workshops → Farming system types → **Case study farmer interviews**

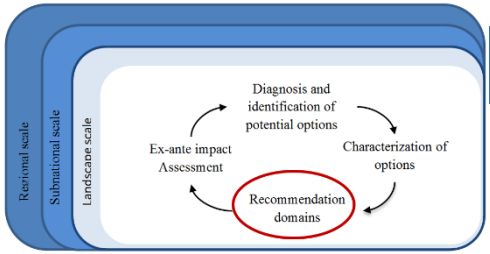
Soil technology shortlist

Input data

Modelling CSA indicators for baselines and scenarios



□=poor female-headed household, Δ=Small mixed subsistence, ◊=Mixed commercial dairy, □ with patterns=Medium commercial horticulture and ○=Large commercial



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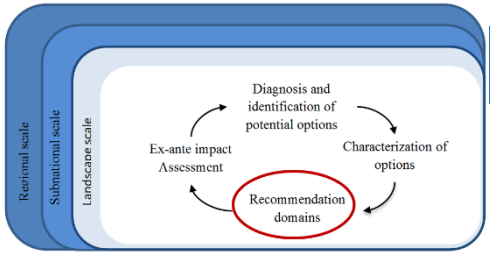
- Suitability maps: 0/1 vs. continuous gradient
- Suitability maps vs. development domains
- Synergies and trade-offs (at three levels):
  - Stakeholders
  - Objectives
  - Scales
- Within zone/type variability



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