

CROSST and green manure cover crops (GMCCs) in Benin

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8th October 2019, 2nd Sustainable Intensification Conference,
Session 1.1 Simple Cropping Systems, Dakar, Senegal



Introduction

- Soil degradation poses a serious threat to food production and rural livelihoods in sub-Saharan Africa
- Unsustainable farming practices have resulted in soil degradation

Conventional farmer practice in the South of Benin (photo by: CIAT/Jessica Mukiri)

GMCCS technologies proven to improve soils :

- i. *Reduce soil erosion through soil coverage*
- ii. *Suppress weeds*
- iii. *Fix atmospheric nitrogen*
- iv. *Scavenge soil nitrogen*
- v. *Build soil structure*
- vi. *Improve soil/water quality*
- vii. *Reduce insect pests*



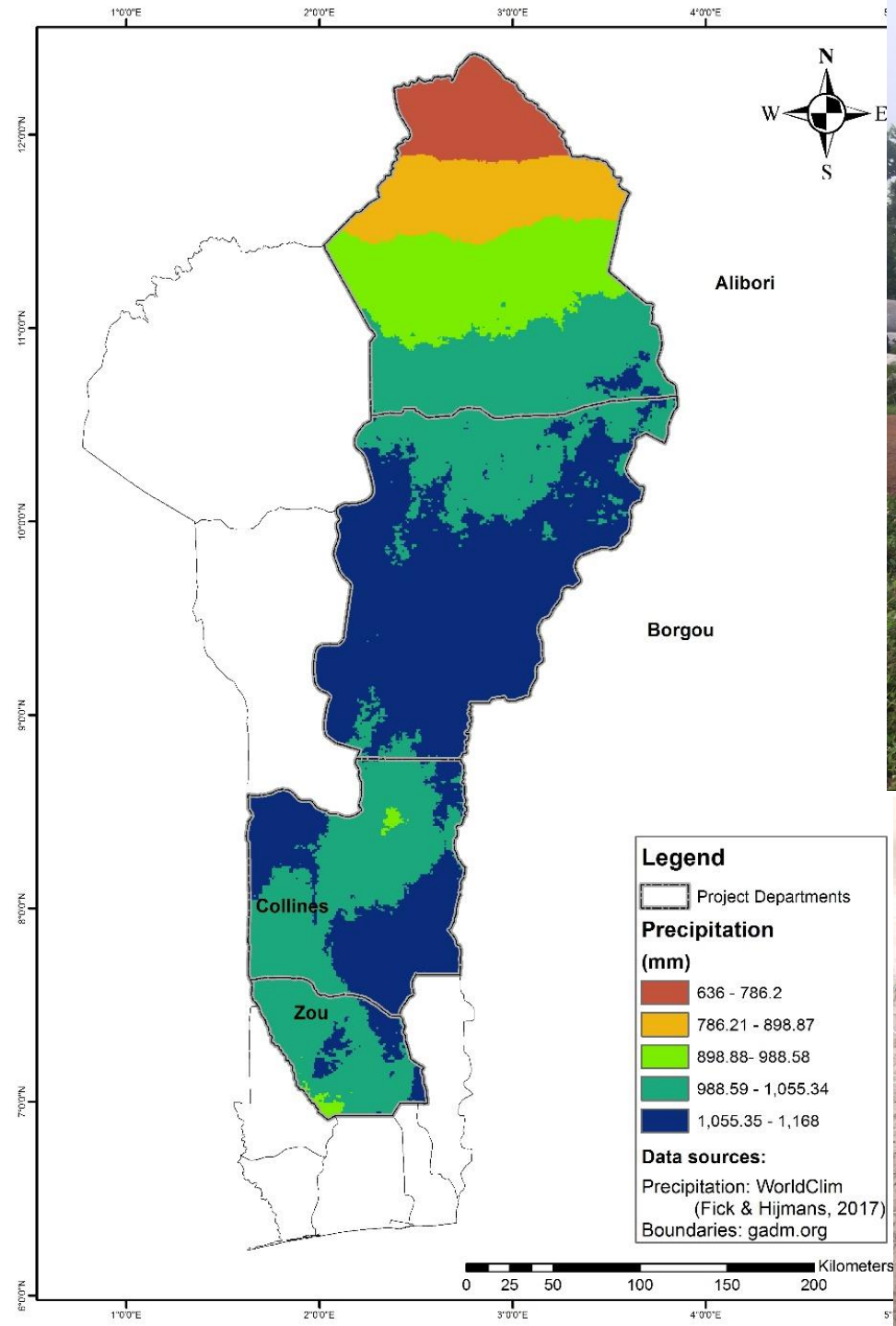
- Despite decades of research and development efforts uptake remains below expectations
- GLZ program ProSol in Benin promoting GMCCs to improve soil quality and reverse soil degradation .

Objective of the study was to assess agro-environmental and socio-economic impacts and trade-offs of GMCC integration in cropping systems in Benin

Methodology

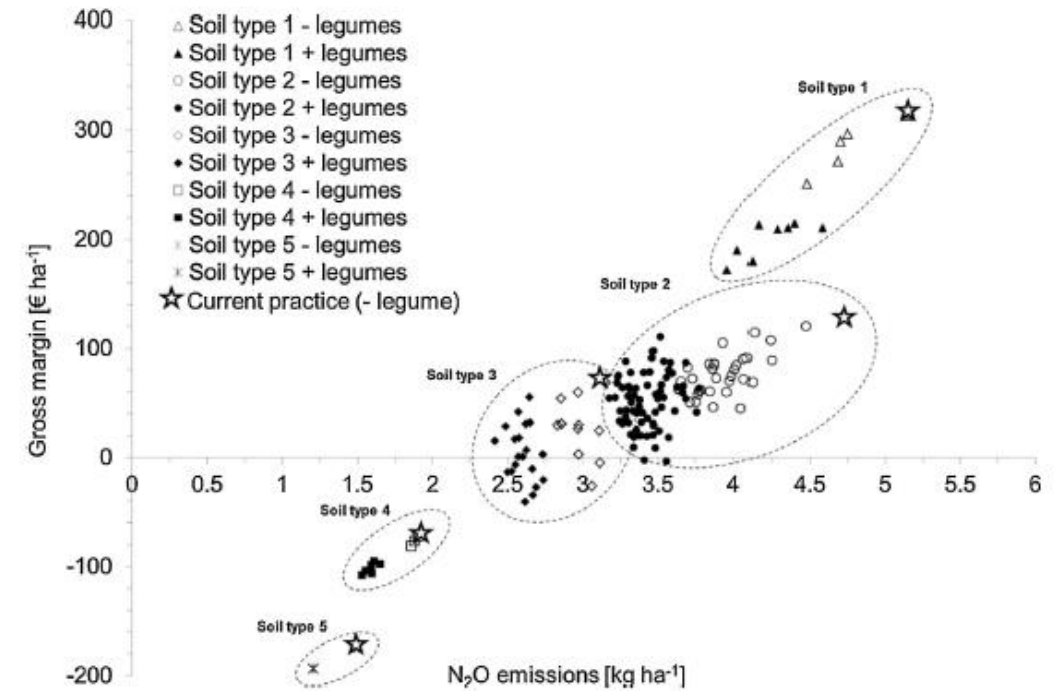
Sites and farming systems

	Alibori	Borgou	Collines	Zou
Agro ecological zones	Sudanian zone 1	Sudanian zone 2	Sudano-guinean zone on ferruginous soils	Sudano-guinean zone on ferralitic soils
No of cropping seasons		1		2
Land size (ha)		5-7		1.5
Cropping systems	Cotton, soybean rotation	Maize, maize/cotton	Maize, maize/groundnut	Maize, yam, and cassava
Livestock systems	Yes	Yes	No	No

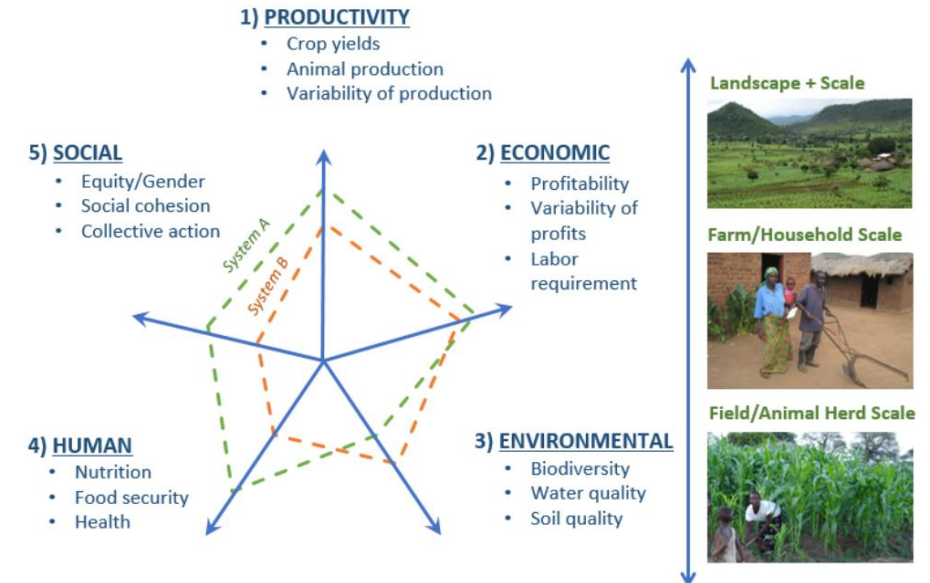


Why a new tool?

- Tool review
- Minimum data
- Adapted to specifications of Farming systems in Benin
- Why ex - ante modeling ?

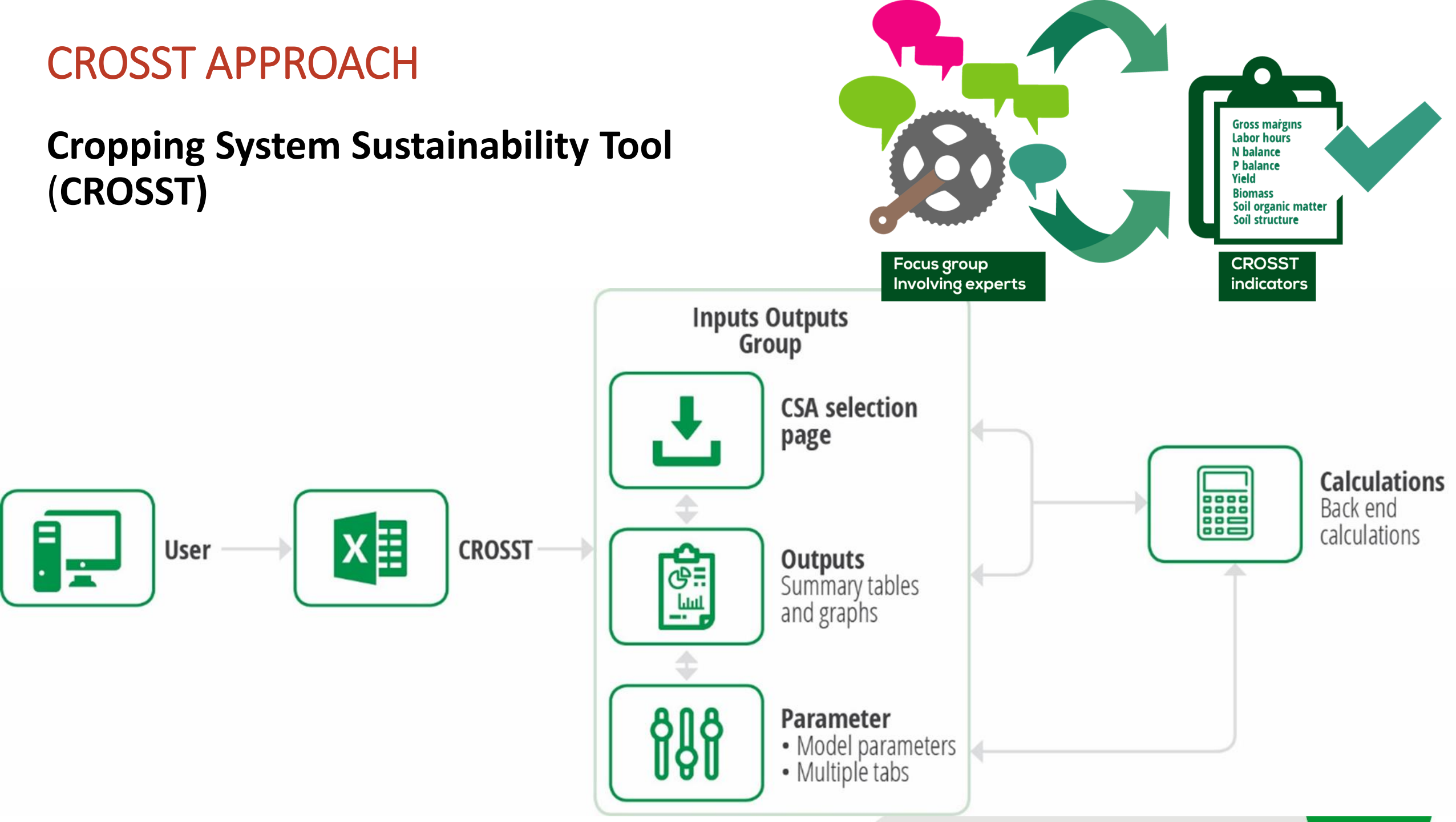


. 4. Nitrous oxide (N₂O) emissions plotted against gross margins for assessed cropping systems on 5 soil types in Brandenburg.



CROSST APPROACH

Cropping System Sustainability Tool (CROSST)



Indicators: Calculations and Parameters

Gross Margin

 : Gross Margin = Total Revenue – Total costs

 : price of inputs, grain, biomass

Yield and Biomass

 : avg of upper and lower range, residual effect of cropping sequence soil

 : upper and lower range yields, Harvest Index ,  % based on previous crop

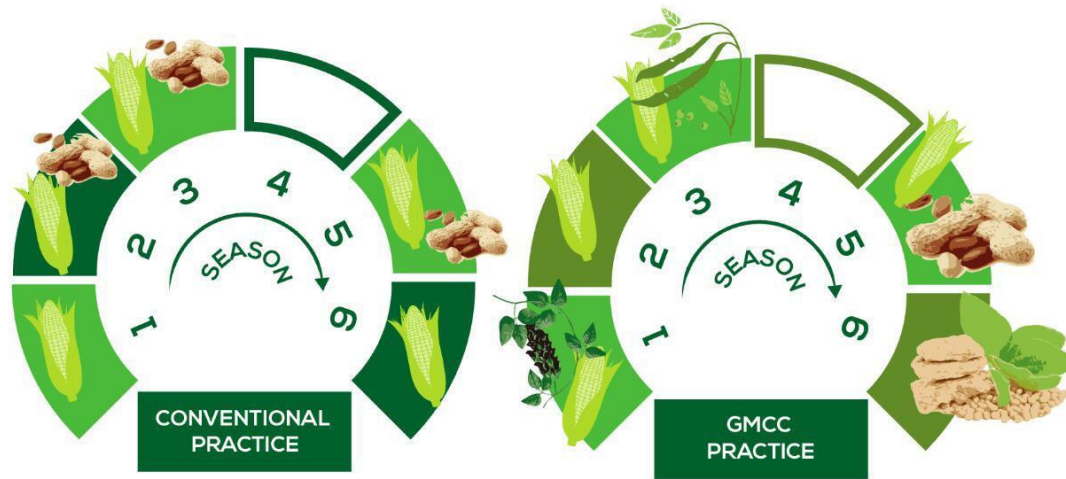
N balance

 : based on Nutrient Monitoring (NUTMON)

 : grain + biomass yield, n-conc in grain +biomass, agro ecology, inorganic + organic fertilizer, fertilizer response, n-fixation rates



- For each zone defined, one conventional system was compared to one improved system



Conventional practice vs. GMCC practice in Collines



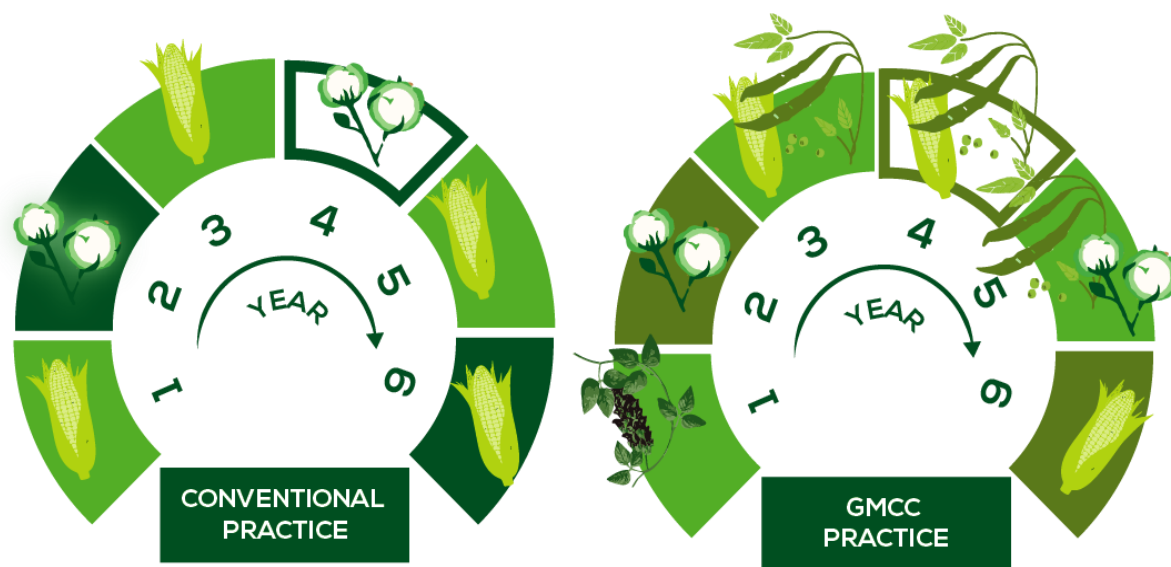
	Zone	Crops	Mineral fertilizer-1 type	Fertilizer-1 amount (kg/ha)	Residue-1 removal %	Residue-2 removal %	Manure input (t DM/ha)	Pesticide application	Herbicide application	Mineral fertilizer-2 type	Fertilizer-2 amount (kg/ha)	Crop-1 is harvested ?	Crop-2 is harvested?
Cropping System 3													
Season 1	SFerrugineux	Mais	NPK 15-15-15	150	Burn	Burn	0	None	None	None	0	TRUE	FALSE
Season 2	SFerrugineux	Mais/Arachide	NPK 15-15-15	150	Burn	Burn	0	None	None	None	0	TRUE	TRUE
Season 3	SFerrugineux	Mais/Arachide	NPK 15-15-15	150	Burn	Burn	0	None	None	None	0	TRUE	TRUE
Season 4	SFerrugineux	Jachère	None	0	Burn	Burn	0	None	None	None	0	FALSE	FALSE
Season 5	SFerrugineux	Mais/Arachide	NPK 15-15-15	150	Burn	Burn	0	None	None	None	0	TRUE	TRUE
Season 6	SFerrugineux	Mais	NPK 15-15-15	150	Burn	Burn	0	None	None	None	0	TRUE	FALSE
	Zone	Crops	Mineral fertilizer-1 type	Fertilizer-1 amount (kg/ha)	Residue-1 removal %	Residue-2 removal %	Manure input (t DM/ha)	Pesticide application	Herbicide application	Mineral fertilizer-2 type	Fertilizer-2 amount (kg/ha)	Crop-1 is harvested ?	Crop-2 is harvested?
Cropping System 4													
Season 1	SFerrugineux	Mais/Mucuna	None	0	0	0	0	None	None	None	0	TRUE	TRUE
Season 2	SFerrugineux	Mais	None	0	0	0	0	None	None	None	0	TRUE	FALSE
Season 3	SFerrugineux	Mais/Pois d'Angole	None	0	0	0	0	None	None	None	0	TRUE	TRUE
Season 4	SFerrugineux	Jachère	None	0	0	0	0	None	None	None	0	FALSE	FALSE
Season 5	SFerrugineux	Mais/Arachide	None	0	0	0	0	None	None	None	0	TRUE	TRUE
Season 6	SFerrugineux	Soja	None	0	0	0	0	None	None	None	0	TRUE	FALSE

- Farmer system: mineral application of 150kg/ha & burning of residues
- GMCC system 100 residue retention rate and no mineral

Collines

			SEASON 1	SEASON 2	SEASON 3	SEASON 4	SEASON 5	SEASON 6	SUM	AVERAGE/ HA/SEASON
Cropping System - Conventional			Maize	Maize/ Groundnut	Maize/ Groundnut	Fallow	Maize/ Groundnut	Maize		
SFerrugineux	Gross margin	USD/ha	128	129	128	0	128	161	655	639.7
	Labor hours	h/ha	26	24	24	0	22	26	102	
	N Balance	kgN/ha	1	40	27	5	27	2	119	-18.3
	P Balance	kgP/ha	7	7	7	0	7	4	32	-1.2
	Yield1	kgDM/ha	1000	1000	1000	0	1000	1000	4000	
	Yield2	kgDM/ha	0	1000	1000	0	1000	0	3000	
	Biomass1	kgDM/ha	1000	1000	1000	0	1000	1000	4000	
	Biomass2	kgDM/ha	0	1000	1000	0	1000	0	3000	
	SOM/Soil structure									

			SEASON 1	SEASON 2	SEASON 3	SEASON 4	SEASON 5	SEASON 6	SUM	AVERAGE/ HA/SEASON
Cropping System - GMCC			Maize/ Mucuna	Maize	Maize/ Pigeon pea	Fallow	Maize/ Groundnut	Soya		
SFerrugineux	Gross margin	USD/ha	100	100	100	0	100	100	400	592.4
	Labor hours	h/ha	26	26	26	0	26	26	104	
	N Balance	kgN/ha	1	1	1	0	1	1	4	28.2
	P Balance	kgP/ha	7	7	7	0	7	7	28	-8.2
	Yield1	kgDM/ha	1000	1000	1000	0	1000	1000	4000	
	Yield2	kgDM/ha	0	1000	1000	0	1000	0	3000	
	Biomass1	kgDM/ha	1000	1000	1000	0	1000	1000	4000	
	Biomass2	kgDM/ha	0	1000	1000	0	1000	0	3000	
	SOM/Soil structure									



Conventional practice vs. GMCC practice in Borgou



Mucuna



Maize



Cotton



Pigeon pea

	Zone	Crops	Mineral fertilizer-1 type	Fertilizer-1 amount (kg/ha)	Residue-1 removal %	Residue-2 removal %	Manure input (t DM/ha)	Pesticide application	Herbicide application	Mineral fertilizer-2 type	Fertilizer-2 amount (kg/ha)	Crop-1 is harvested ?	Crop-2 is harvested ?
Cropping System 3													
Season 1	Soudanienne2	Igname	None	0	75	0	0	None	None	None	0	TRUE	FALSE
Season 2	Soudanienne2	Coton	NPK 14-23-14	150	75	0	0	None	None	None	0	TRUE	FALSE
Season 3	Soudanienne2	Mais	NPK 15-15-15	200	75	0	0	None	None	None	0	TRUE	FALSE
Season 4	Soudanienne2	Mais	NPK 15-15-15	200	75	0	0	None	None	None	0	TRUE	FALSE
Season 5	Soudanienne2	Coton	NPK 14-23-14	150	75	0	0	None	None	None	0	TRUE	FALSE
Season 6	Soudanienne2	Mais	NPK 15-15-15	200	50	0	0	None	None	None	0	TRUE	FALSE
	Zone	Crops	Mineral fertilizer-1 type	Fertilizer-1 amount (kg/ha)	Residue-1 removal %	Residue-2 removal %	Manure input (t DM/ha)	Pesticide application	Herbicide application	Mineral fertilizer-2 type	Fertilizer-2 amount (kg/ha)	Crop-1 is harvested ?	Crop-2 is harvested ?
Cropping System 4													
Season 1	Soudanienne2	Mucuna	None	0	0	0	0	None	None	None	0	TRUE	FALSE
Season 2	Soudanienne2	Coton	NPK 14-23-14	150	0	0	0	None	None	None	0	TRUE	FALSE
Season 3	Soudanienne2	Mais/Pois d'Angole	None	0	0	0	0	None	None	None	0	TRUE	FALSE
Season 4	Soudanienne2	Mais/Pois d'Angole	None	0	0	0	0	None	None	None	0	FALSE	TRUE
Season 5	Soudanienne2	Coton	NPK 14-23-14	150	0	0	0	None	None	None	0	TRUE	FALSE
Season 6	Soudanienne2	Mais	None	0	0	0	0	None	None	None	0	TRIF	FAI

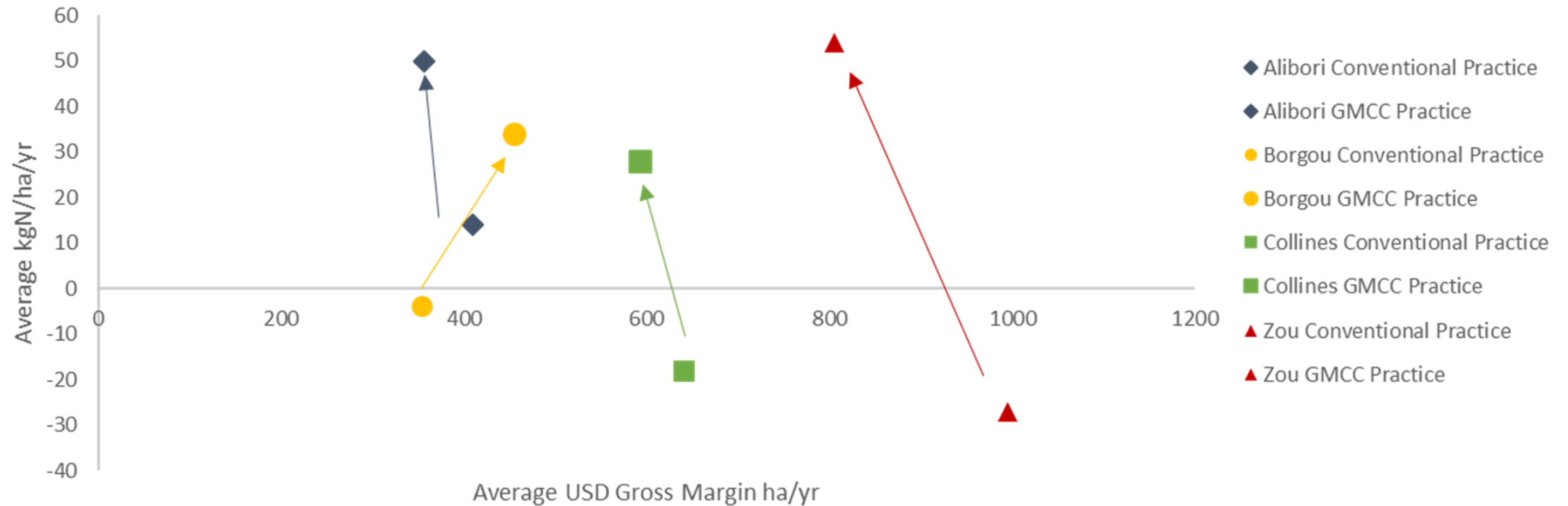
- Farmer Practice: 150 kg/ha cotton & 200kg/a for maize per + burning of residues
- GMCC :No residue burning and only cotton received fertilizer at 150kg

Borgou

			YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	SUM	AVERAGE/ HA/YEAR
Cropping System - Conventional			Maize	Cotton	Maize	Maize	Cotton	Maize		
Soudanienne2	Gross margin	USD/ha								354.4
	Labor hours	h/ha								
	N Balance	kgN/ha								-3.8
	P Balance	kgP/ha								7.9
	Yield1	kgDM/ha								
	Yield2	kgDM/ha								
	Biomass1	kgDM/ha								
	Biomass2	kgDM/ha								
	SOM/Soil structure									

			YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	SUM	AVERAGE/ HA/YEAR
Cropping System - GMCC			Mucuna	Cotton	Maize/ Pigeon pea	Maize/ Pigeon pea	Cotton	Maize		
Soudanienne2	Gross margin	USD/ha								445.1
	Labor hours	h/ha								
	N Balance	kgN/ha								33.7
	P Balance	kgP/ha								-2.4
	Yield1	kgDM/ha								
	Yield2	kgDM/ha								
	Biomass1	kgDM/ha								
	Biomass2	kgDM/ha								
	SOM/Soil structure									

Trade off of gross margin *versus* N balance in four study zones of Benin

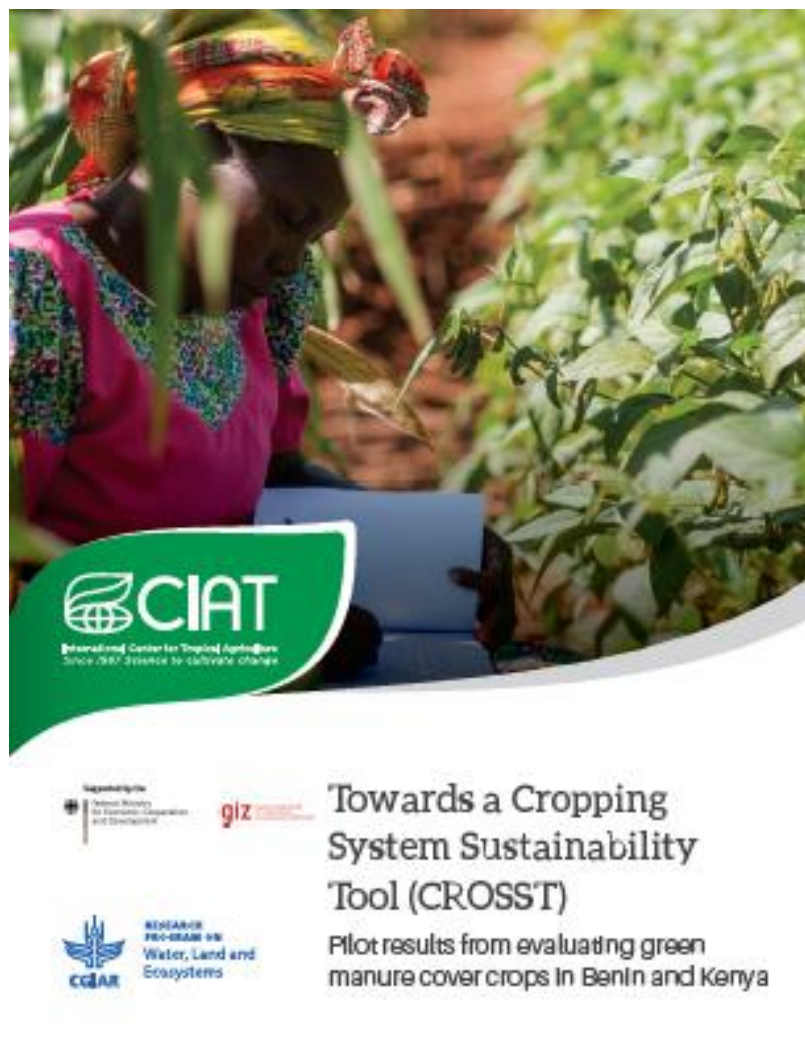


Conclusions

- GMCC technologies improve soil structure/soil organic matter
- N balances were positive in GMCC systems even with limited use of inorganic fertilizers
- In Borgou GMCC had a higher gross margin compared to conventional farming systems **+7%**
- % difference gross margin (**A: - 13% C: - 7% Z: - 19%**)
- The P balance is not directly improved by GMCCs would need organic or inorganic fertilizers
- CROSST can serve as a decision-support tool for development agencies, implementing partners, and local stakeholders when designing sustainable cropping systems

Way forward

- CROSST still requires further refinement such as using agriculture census data and validating results
- Stakeholder validation of outputs and inputs in all target areas, sensitivity and plausibility checks, and ground-truthing is required
- Health indicator to be included to reflect GLZ program objectives, e.g., health benefits from avoidance of pesticides and herbicides through GMCCs.
- Move CROSST to a friendlier user interface to enable usability by non-research partners.



Mukiri J; Diogo RVC; Gbedjissokpa SGM; Kinyua M; van der Hoek R; Sommer R; Paul B. 2019. Towards a cropping system sustainability tool (CROSST) - Pilot results from evaluating green manure cover crops in Benin and Kenya. Working Paper. CIAT Publication No. 479. International Center for Tropical Agriculture (CIAT). Nairobi, Kenya. 35 p. Available at: <https://hdl.handle.net/10568/102440>

Link to CROSST:
<https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/86009C>

Thank you!

Special thanks to the Benin GIZ ProSOL team:

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