The Myth about Organic Farming in Africa and what it could be…

University of Natural Resources and Life Sciences (BOKU)
Department of Sustainable Agricultural Systems

„Smart“ Tropentag 2018

University of Ghent

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What the Hell is Organic Farming?

A Myth?

What is a Myth?

(Roland Barthes 1972)

…a connotation
that presents phenomena as natural conditions, when in fact they are **socially constructed**

The word “Myth” has of course also polemic sharpness

Myths in the Scientific World

Obviously there are some myths…

Freyer, B., Bingen, J., & Fiala, V. (2018).

Seven myths of organic agriculture and food research.

Organic Agriculture, 1-11

The Assist - The leading African Organic Myth

"Organic Farming is… what most African smallholders practice over decades"

… a famous ATSAF Member

Evidence?

Not sure!

A world view?

Organic from a Scientific Perspective

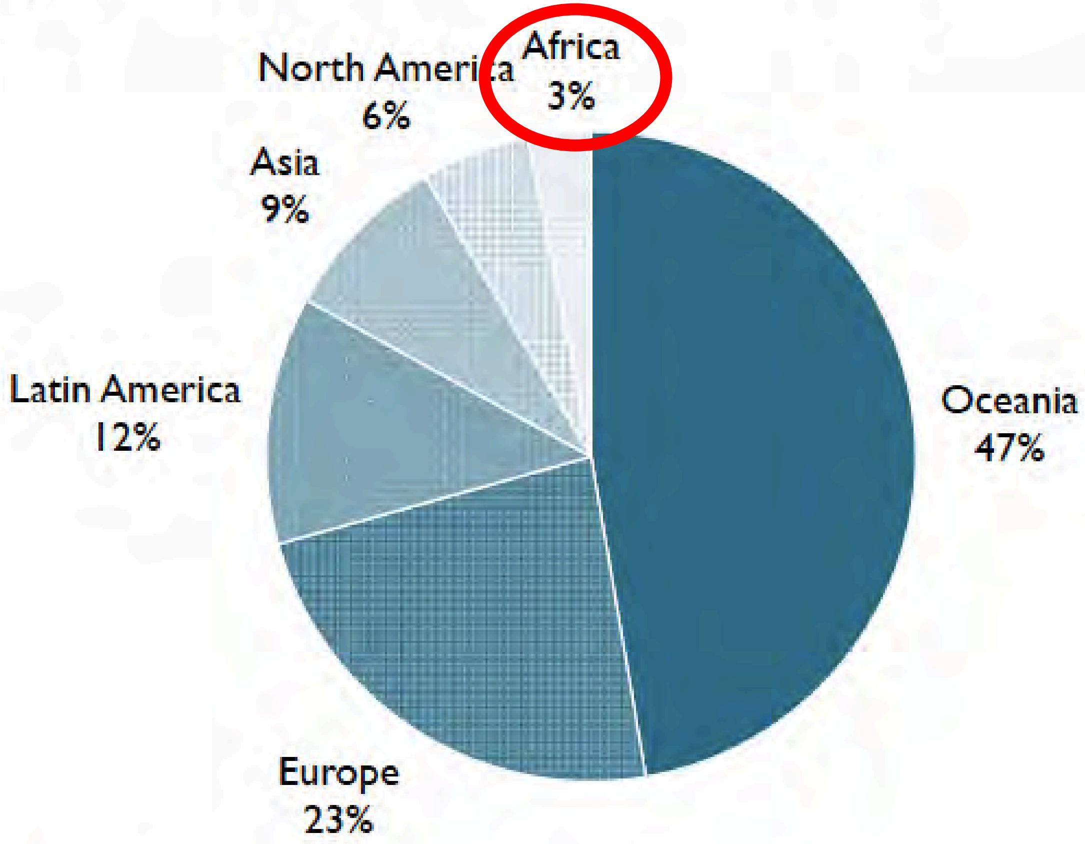
- Nothing else than a working hypothesis !!!!!!!
- In many ways
- So far – so simple!

Some Statistics about Organic Farming

Distribution of organic farmland 2016

Distribution of organic agricultural land by region 2016

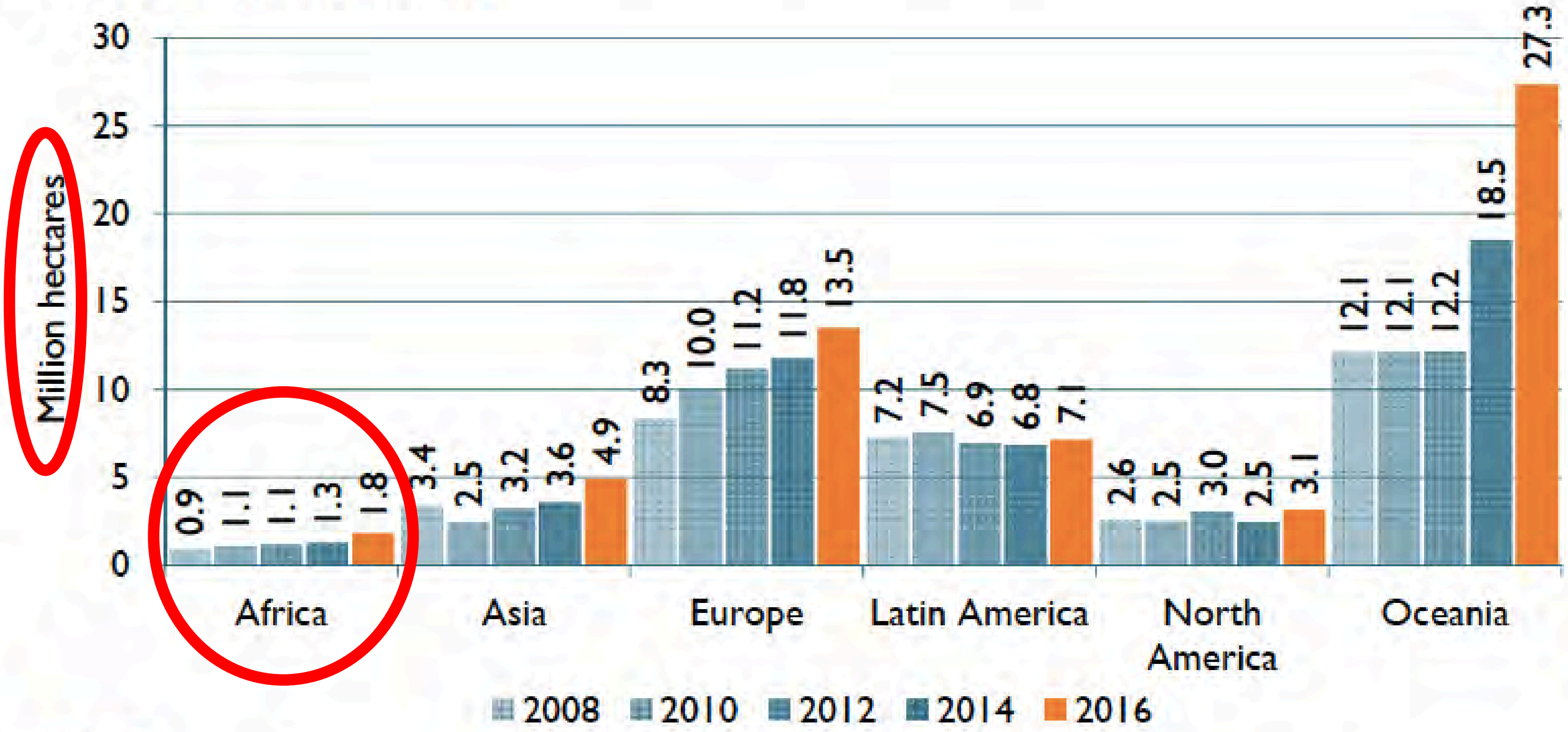
Source: FiBL survey 2018



World: Growth of organic farmland by continent 2016

Growth of the organic agricultural land by continent 2008-2016

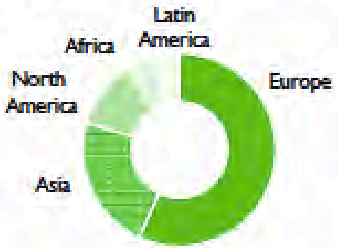
Source: FiBL-IFOAM survey 2008-2018

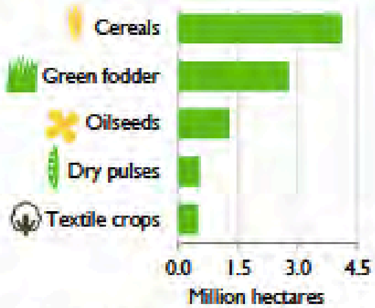


ORGANIC LAND USE 2016

10.6
Mio ha
arable land

Arable land constitutes 18% of the world's organic agricultural land, and 0.7% of the world's arable crop land. It increased by 6.2% over 2015.

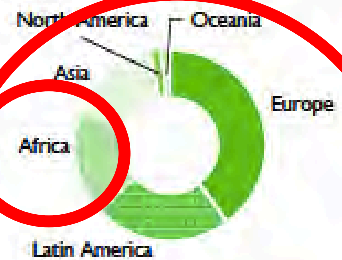


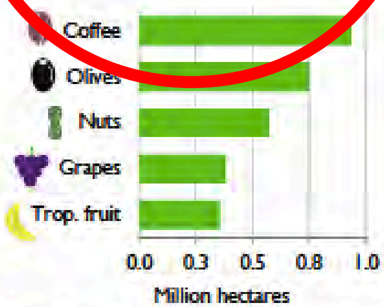


Organic arable land by region 2016
Organic arable land: Key crops 2016

+9%
more
permanent
crops

4.5 Mio ha, which is 2.8% of the world's permanent cropland, and a 8% share of the organic agricultural land.

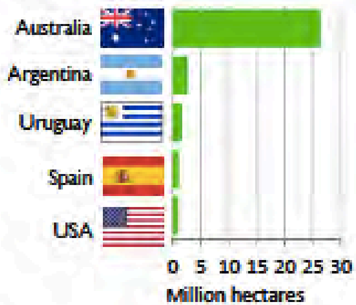




Organic permanent crops by region 2016
Organic permanent crops: Key crops 2016

66%
grassland

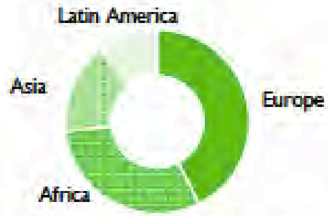
38 Mio ha of grassland, and an almost 17% increase compared with 2015.

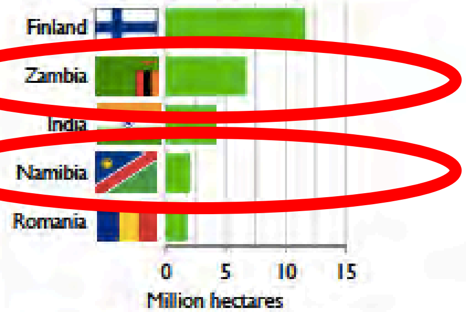


Organic permanent grassland by region 2016
Organic permanet grassland: The five countries with the largest areas 2016

39.3
Mio ha
of wild
collection

The organic wild collection areas are concentrated in Europe, Africa, Asia, and Latin America.





Organic wild collection by region 2016
Organic wild collection: The five countries with the largest areas 2016

FiBL www.fibl.org

Source: FiBL survey 2018 www.organic-world.net

The „**Now**“...

Some Key Challenges

(Frankfurter Schule)

… of African Agriculture

Mainly with a focus on the **production**

with a **Critical (Theory) Perspective**

Market demand

... And organic matter is leaving the system

... one rain

and the fertilizer is leaving the system

Farm yard manure prepared for cooking

... leaving the System

More than enough data...

Table 3. Annual soil loss by water erosion at Adiopodoume, Côte d'Ivoire.			
Crops	Slope (%)	Soil loss (t/ha per year)	
		Range	Mean
Cassava and yams	7	22–93	32
Maize	7	35–131	92
Groundnuts	7	59–120	82
Bare soil	7	69–150	138
Bare soil	4.5	34–74	60
Bare soil	20–23.3	266–622	570
Source: Roose (1977, table 14).			

(Ker, 1995)

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Assumptions	size m2	depth mm	kg ha-1	kg ha a-1	%
Reference plot size	10.000	300			
Amount of soil			3.900.000		
Nitrogen content			5.000		0,13
Phosphorus content			1.500		0,04
Potassium content			6.000		0,15
Soil erosion				80.000	2,05
Loss of nutrients					
Nitrogen loss				103	
Phosphorus loss				31	
Potassium loss				123	
Economic value		Euro kg-1	Birr kg-1	total Euro ha-1	total Birr ha-1
Nitrogen		0,8	22	82	2.297
Phosphorus		0,9	24	26	732
Potassium		0,6	17	74	2.068
Total			**63**	**182**	**5.097**
Equivalent wheat:22 kg N 1000 kg Wheat	kg wheat	Price Euro kg wheat	Price Birr kg wheat	total Euro	total Birr
Wheat equivalent	4.662	0,3	7,0	1.166	32.634
Total financial loss ha-1				**1.348**	**37.731**
	ha				
Total financial loss ha	1.000			**1.347.552**	**37.731.469**

Consequences

- "…continued cropping without sufficient inputs of nutrients and organic matter leads to localised but **extensive soil degradation** and renders many soils in a **non-responsive state**" !
- …"**unable** to benefit from the current yield gains offered by **plant genetic improvement**" !

(Tittonell & Giller, 2013)

Before we discuss yields per ha

... we should ask how many hectares will be left, if we continue like that?

Compaction and Powder...

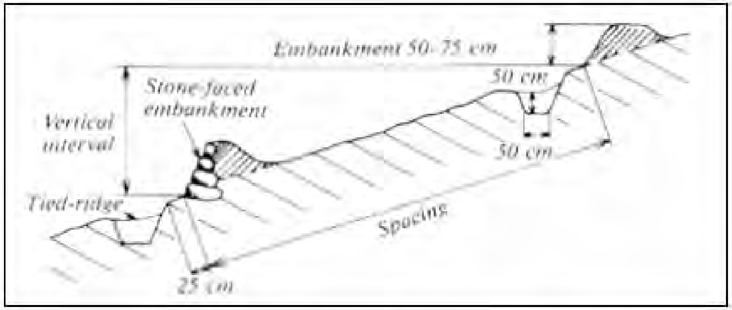
Labor, labor, labor...:

Ethiopian highland:

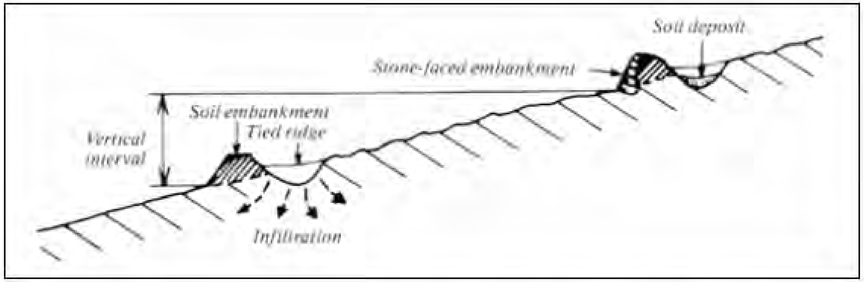
... up to 5-7 times ploughing of one field... !!!!

Forage for Oxen – (Europe 19th century approx. 25% of fields)

Stone bunds and some alleys....?



About every 50 m, a gap can be left open to allow oxen pulling ploughs to cross and reach their land.



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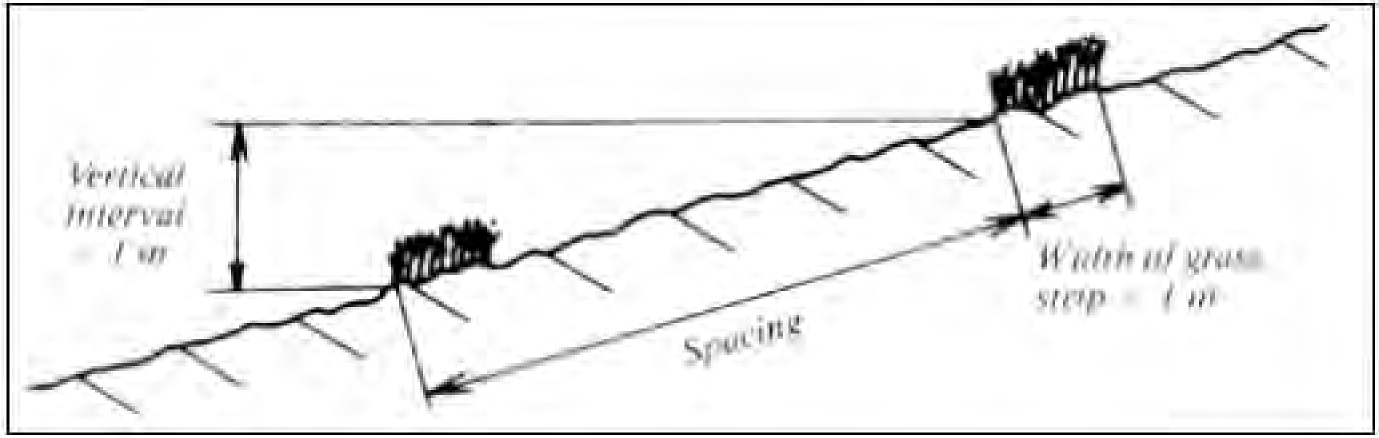
SPECIFICATIONS

Cross-section:



Source: Hurni et al. 2016: Soil and water conservation in Ethiopia

Deforestation even in “protected” areas...(MAU catchment Kenya

Highly relevant farm income…

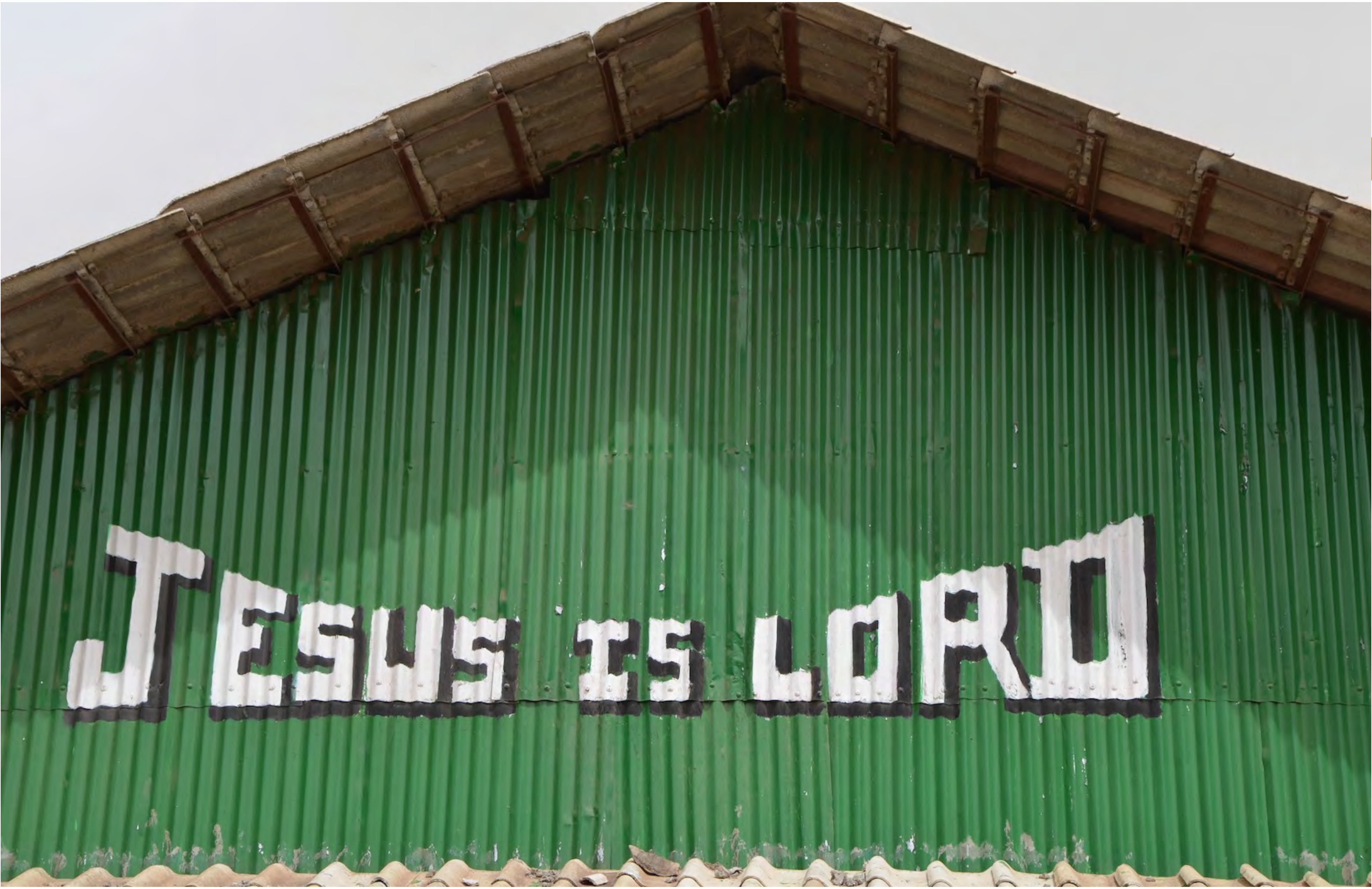
Time

Modes of Water Harvesting

“Water use efficiency”

... 170 religious days

(Christian Orthodox in Ethiopia)


JESUS IS LORD

Source: https://boingboing.net

Between yesterday and tomorrow

Youth is asking for new lifestyles!!!!!!!!!

A future with 2 acres???

Synthesis – a critical perspective on farming systems

- Diversified cropping systems: missing
- Alleys: missing; if available: managament deficits
- Animal manure / recirculation: missing
- Green manure / compost: missing
- pH regulation / liming, where necessary: missing
- Stone bunds etc.: sometimes – but! Who is transferring the soil back to the upper part? Soil enrichment at lower parts: tendency of compaction; attracting rodents
- Pastures: overgrazing, compaction, erosion
- Forests: missing, low diversification, dominance of Eucalyptus

By the way...

Western agricultural practices represent in many cases **similar deficits**!

Farmers from the North and Erosion...

Survey: 8100 fields belonging to 1879 farmers distributed across Bavaria (South Germany)

- "Farmers could easily observe the degree of recent erosion on their fields, even without modelling
- Only subsidized measures, like mulch tillage or organic farming, were applied but only at the absolute minimum that was necessary to obtain subsidies
- However, this did not achieve the reduction in erosion that would be possible if these measures had been fully applied
- **Farmers clearly did not consider erosion in their decisions"**

(Auerswald et al. 2018)

Who is responsible for that?

Critical theory...

(Max Horkheimer)

The politicians – locals, regionals, nationals, internationals?

The researchers – locals,...? Tropentag?

The adivsory services -...?

The capital...?

The big players – companies?

The NGOs...?

The ...?

All together? **! „The „circumstances“ !** (Karl Marx)

... make people as good as people make circumstances“

The Experts...

What we „know“

Or: "The theory determines what we can observe

(Werner Heisenberg)

The cars

Answers! The experts ... (rttta)?

Source: Frank S...

The experts ... (ratttatttta)?

On the way to the smallholder farmers...

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Ecological intensification

Integrated Pest Management

Evergreen agriculture

Conservation agriculture

Agroforestry

Integrated soil fertility replenishment technologies (SFRT)

Agroecology

Biodynamic agriculture

Permaculture

Comprehensive conservation agriculture

Integrated crop /farm management (ICM/IFM)

Organic agriculture

Conservation agriculture and sustainable intensification

Renewable Agriculture

Integrated Soil Fertility Management (ISFM)

Intensification (CSA)

Climate Smart

Sustainable intensification

Sustainable agriculture

Regenerative agriculture (RGA)

Low external input agriculture (LEISA)

Conservation tillage

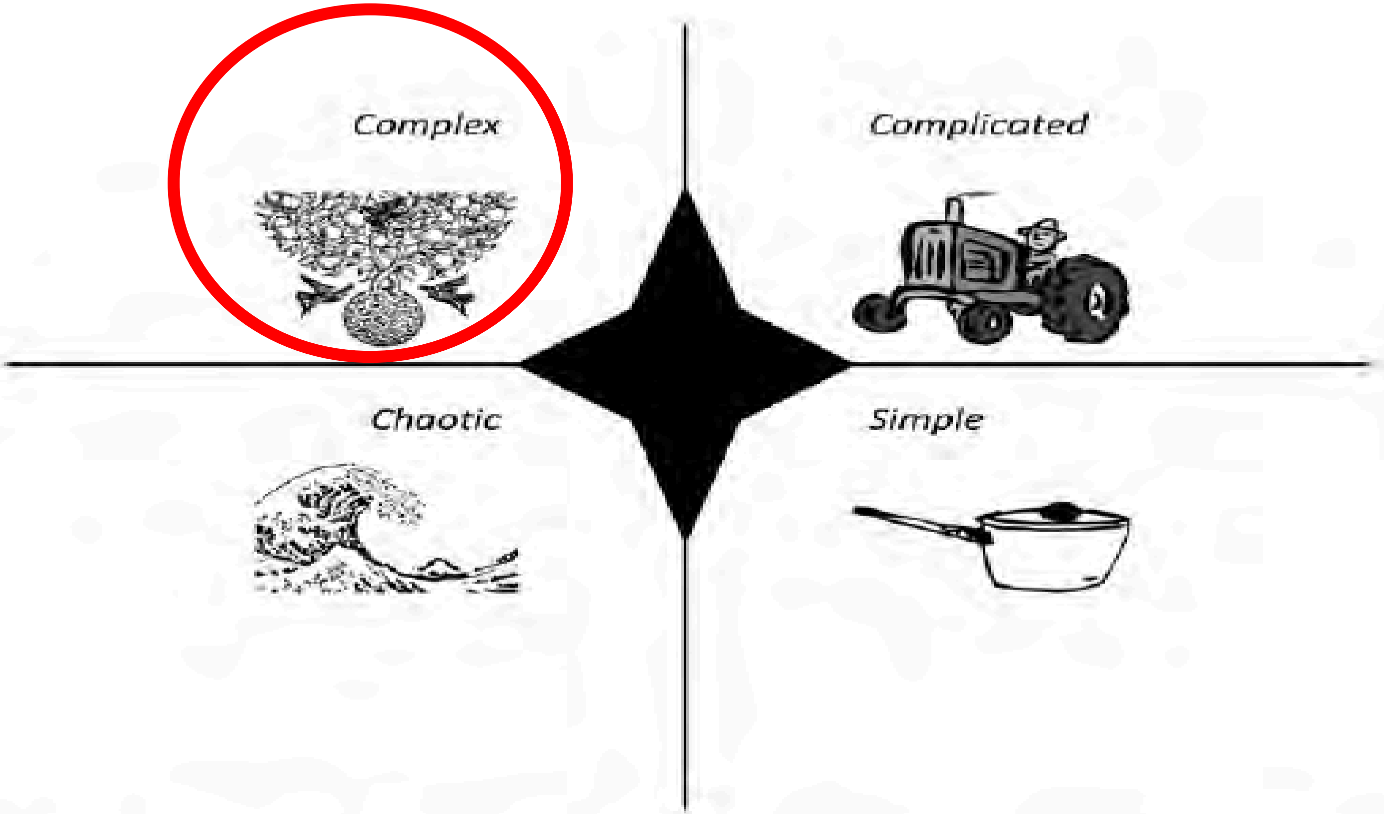
Conventional agriculture


Sorry but we have no idea
what you mean with all that!

The Systemic Approach
of
Organic Agriculture

1. **System type**
2. **Ethical foundations**
3. **Landuse type**
4. **Key questions**
   1. **Carbon and Nitrogen**
   2. **Biodiversity**
   3. **MOs**

... Organic? - In any case complex!



(McDougall, 2017)

Figure 19.1 Analogies for system types: preparing *garri* or *dhal* (simple system); building a tractor (complicated system); a rainforest (complex system); disaster situation such as a tsunami event (chaotic system)

Source: Snowden and Boone, 2007 (http://cognitive-edge.com).

The complex materiality of farming systems

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Cows
Climate
Pasture
Animals
Vegetables
Fertilizer trees
Chicken
Transport
Grass stripes
Roads
Slurry
Forest
Household
Fruits
Charcoal
Hedges
Compost
Housing
Roots
Mulching
Alley farming
Forrage plants
Agroforestry
Consumer
Plants
Stable
Farmland
Labour
Meadows
Bicycle
Soil tillage
Irrigation
Bees
Market
Income
Soil fertility
Medicinal plants

The Ethical Foundation – IFOAM Principles

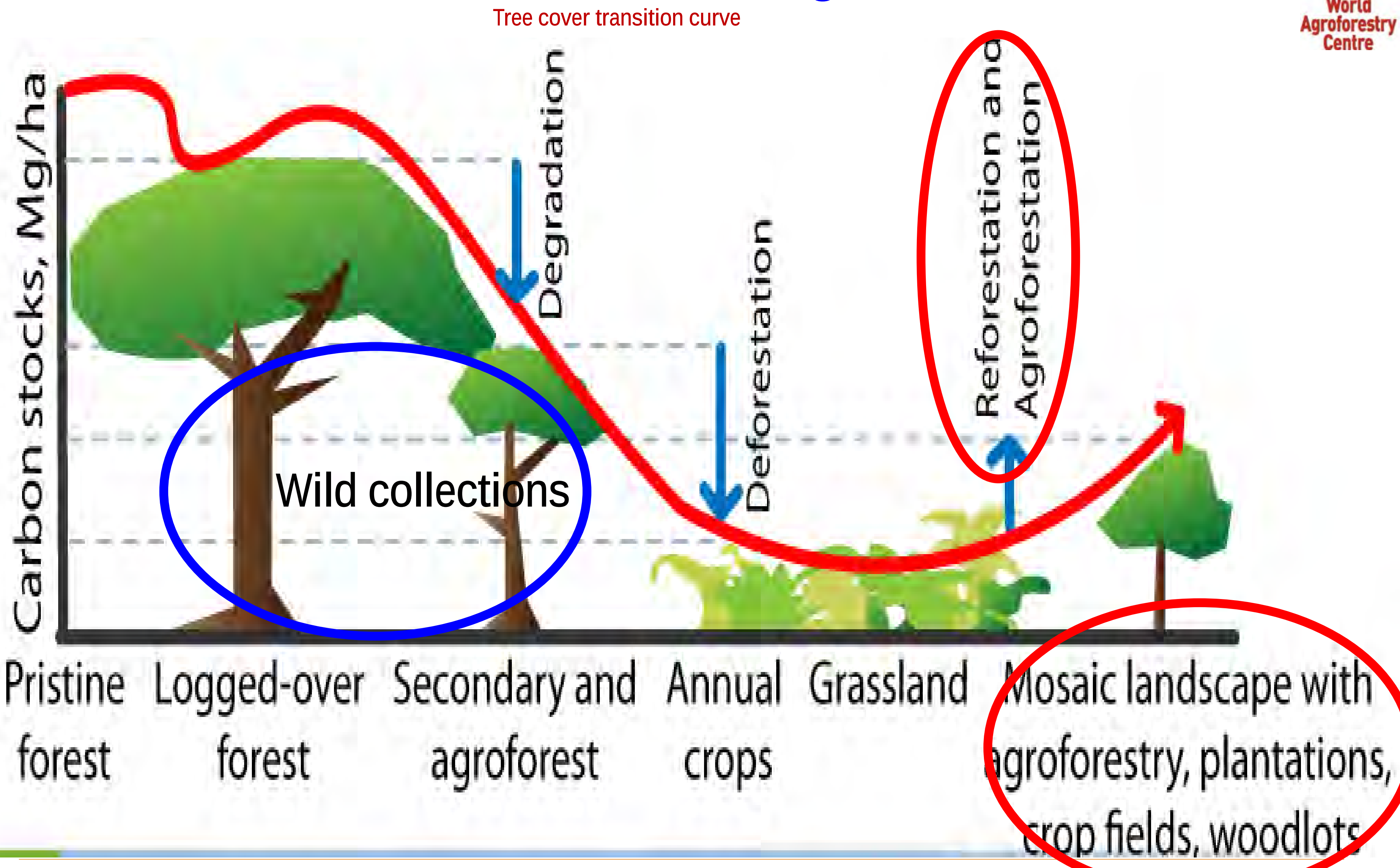
International Federation of Organic Farming Movements (> 178 member states):

- Principle of Health
- Principle of Ecology
- Principle of Fairness
- Principle of Care

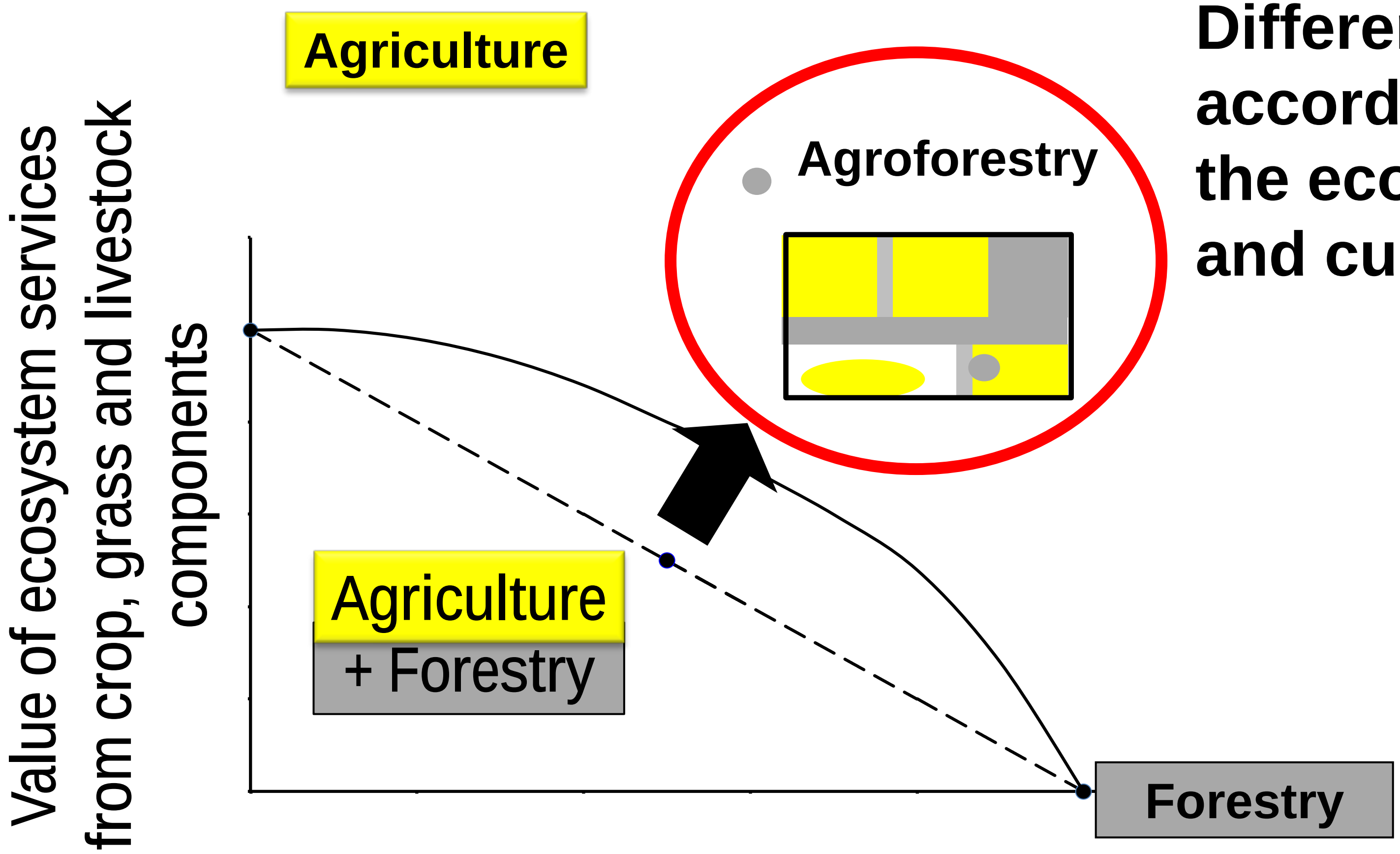
- Ethics ask what makes an action a morally good action. Their task is not to moralize, ideologize or to disseminate **ideological** convictions

(Pieper 1994)

Forest Transition Curve – Organic Landuse



Land Equivalent Ratios (LERs)



Different types according to the ecosystem and culture

Source: C. Dupraz, F. Liagre, AGROOF

How to feed the system with carbon / nitrogen?

Table 1. Quantity (dry matter, DM) and quality of organic inputs in natural and derived agricultural systems for the humid and subhumid tropics (modified from (Palm et al. 1996))

SYSTEM	Aboveground, DM Mg ha^{-1} y^{-1}	Quality[a] N g kg^{-1}	lignin g kg^{-1}
Forest	8–11	< 20	> 300
Shifting cultivation			
Cropping phase	3	< 25	50–100
Fallow phase (1–5 yr)	2–6	15–25	200–400
Fallow phase (5–10 yr)	5–8	15–20	> 300
Legume tree fallows (< 5 yr)	1–6[b]	20–30	> 200
Continuous cropping			
Cereal crop residues	3–9	< 25	50–100
Farm yard manure	2–10	7–23[c]	100–200
Biomass transfer	2–8	30–40	50–200
Legume cover crop	4–10[d]	30–50	50–100

[a]TSBF Organic Resource Database.
[b]Mafongoya, unpublished data; Schroth et al. (1995).
[c]Mugwira and Mukurumbira (1984).
[d]Drechsel et al. (1996).

How to manage biodiversity?

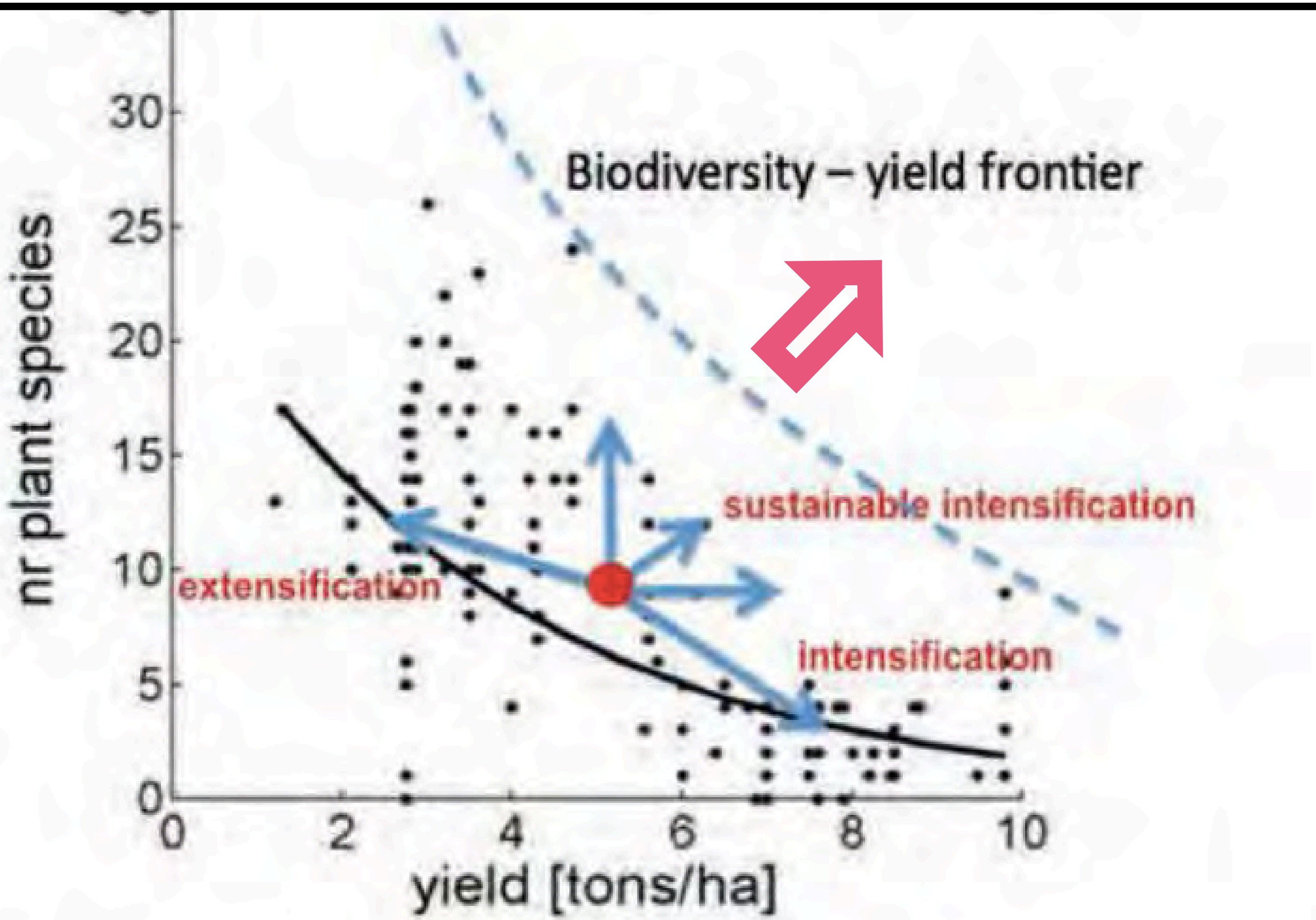
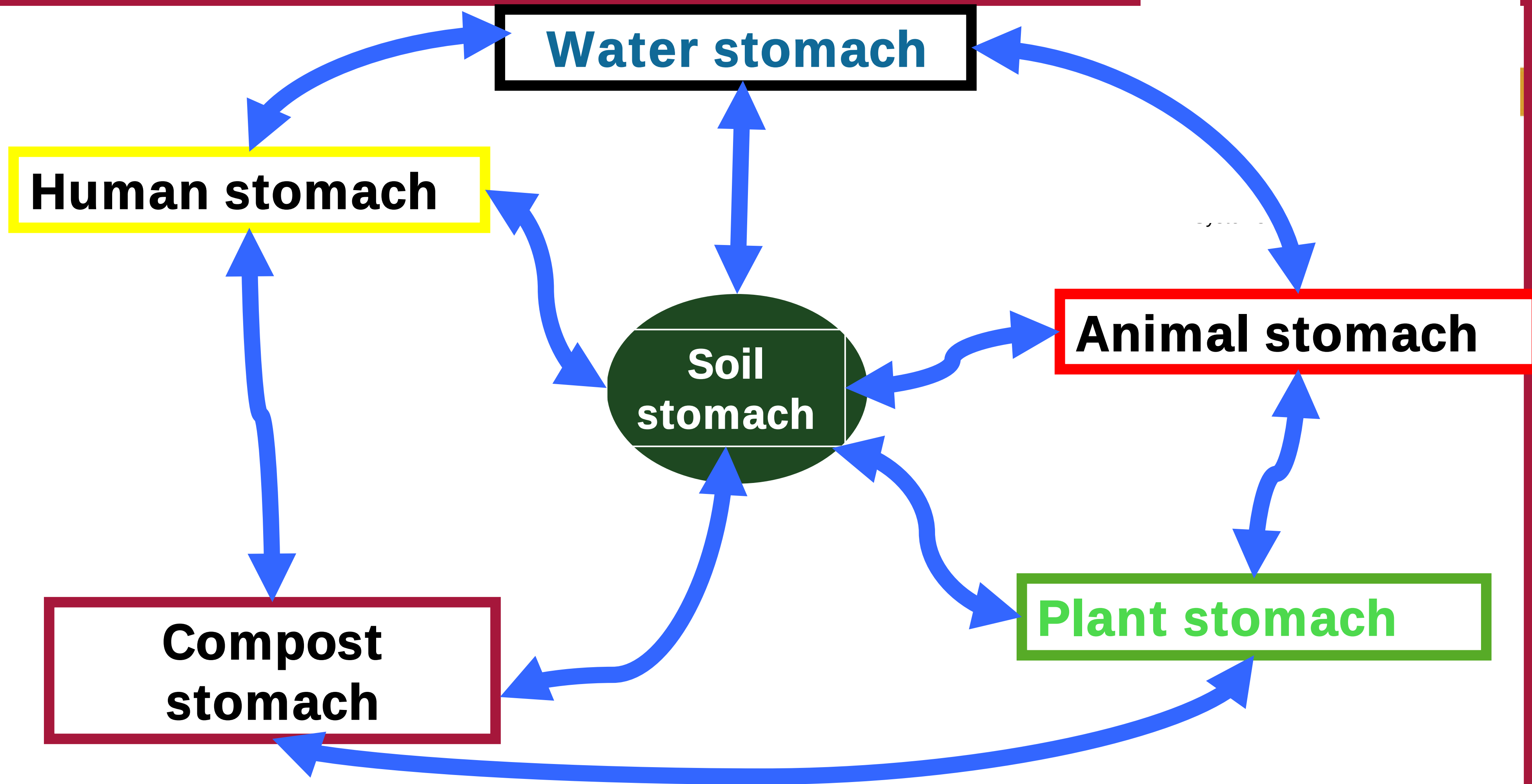


Figure 2-2: Sustainable intensification of biodiversity and yields
Source: Buckwell *et al.* (2014)

How to make „Friendship“ with MOs?



Organic Farming Practices – Main Orientations under (sub-) trop. conditions

1. **Carbon (... and Oxygen)**
2. **Nutrients**
3. **Water**
4. **Weeds and species diversity**
5. **Pest, Diseases and Beneficials „IPM_{OF} “**

Carbon (... and Oxygen)

- Crop rotation (>7 diverse crops) incl. **10-25% forage legumes**, relay-, intercropping, mulch material mixed into the upper layer...
- Crop specific **root systems**
- Graded **grassland** management intensities
- Agroforestry**,** **alley** and **hedges**, contour planting...

No go!

- Burning cow dung
- Burning residues (exceptions)
- Burning leaves and young branches from alleys

Alley cropping: Sesbania sesban and Maize Nigeria

Nutrients

- pH regulation
- Forage legume production (+grain legumes)
- Animal husbandry - manure / compost / slurry / biogas
- Recycling of food, forage and processing residues (OF production…)
- P-deficits must be covered via(rock-)phosphate (!?!) (see also K, S…)
- Micronutrients-deficits must be covered

No go!

- Nitrogen fertilizer
- But: often only DAP available!

Water

- … Roof harvesting
- Ridging
- Water harvesting via ponds and contour management
- When ever possible drip and sprinkler
- Controlled use of groundwater

No go / critical!

- Being part of an irrigation scheme with conventional farms due to contamination with pesticides, herbicides and mineral fertilizers

Weed control and species diversity

- Crop rotation / intercropping / mulching …
- Crop phenology (varieties)
- Planting density
- Tillage
- Hand hoe
- Mechanical weed control (MWC)

No go!

- Herbicides
- BUT: natural based herbicides are an option
- NOT to underestimate: MWC systems under **heavy rainfall conditions**

Pest, disease and beneficials “IPM_{OF}”

- Crop rotation / intercropping,…
- Breeding (tolerance, …)
- Mulching
- Hedges / biotop diversity
- Mechanical control
- Compost / Plant teas
- Natural based pesticides
- Pheromones...

No go!

- “classical” pesticides

OPEN questions e.g. mulching: Amount, quality, host for P & D, tillage

Classifications and Critical Statements

Types of „Organic“ , what might be confusing

Table 5
Summary of main significant ($p < 0.05$) characteristics of the different farm types.

Farm type	Name of farm type	Share	Household related	Resource endowment	Cropping practice	Social networks and information	Development outcome variables
1	Poorest, organic-by-default self-subsistence oriented	13%	-small -middle-aged heads -less educated heads	low -least land, assets and livestock owned -no credit access -lowest income -based on family labour	mainly 'organic by default'	-weakest social networks -least access to information	-poorest diets -most inequitable
2	Wealthiest, mixed and market oriented	31%	-most educated and literate heads	high -based on hired labour -ample off-farm activities -large size of rented land - highest credit access -highest income	mixed (both organic and conventional)	-strongest social networks -high access to information	-richest diets -equitable households
3	Moderately wealthy, organic and market oriented	22%	-highly literate heads	medium -smaller land sizes owned and rented	mainly organic -planting mainly pure stands	-strong social networks -highest access to information	
4	Poor, conventional and market oriented	9%	-youngest heads	low to medium -rely on rental land -moderate asset ownership -low remittance and pension income	conventional	-weakest social networks -poor access to information	-less diverse diets
5	Wealthy, organic certified and market oriented	25%	-oldest heads - least educated and literate heads -largest families	high to medium -largest farm sizes owned -no credit access -few assets and livestock owned -high farm income -limited off-farm activities	mostly organic certified		-moderately diverse diets -highly equitable

(Kamau, Stellmacher, Biber-Freudenberger, & Borgemeister, 2018)

Between „ethics and conventionalized“

... are the main challenges of Ag in general!

Table 3
The main challenges of organic farming in developing countries.

Challenge	References
Low yield	Seufert et al., 2012; de Ponti et al., 2012; Ponisio et al., 2015; Lyngbaek and Muschler, 2001; Cai et al., 2008; Kleemann, 2011; Kirchmann et al., 2008; Bergström et al., 2008; Aune, 2012; Connor, 2013; Lyngbaek and Muschler, 2001; Murphy et al., 2007; van Bueren et al., 2011.
Nutrient management	Lotter, 2015; Vanlauwe et al., 2014; Tittonell and Giller, 2013; Kirchmann et al., 2008; Aune, 2012; Connor, 2008, 2013.
Certification and market	Gómez et al., 2011; Beuchelt and Zeller, 2011; Smale et al., 2011; Hazell et al., 2010; Kirsten and Sartorius, 2002; Crowder and Reganold, 2015; Chiputwa et al., 2015.
Education and research	Giovannucci, 2006; Scialabba, 2000; Kleemann, 2011; Ponisio et al., 2015; HLPE, 2013; Ponisio et al., 2015; Seufert et al., 2012; Zundel and Kilcher, 2007.

(Jouzi et al., 2017)

Organic farming trials ...

Table 5
Actual total nitrogen (N) and phosphorus (P) contents of the inputs applied during the experimental period in the long-term farming systems comparisons trials at Chuka and Thika in the Central Highlands of Kenya. Note: Target was to have similar amounts of external N and P applied in conventional and organic systems, but due to varying nutrient concentrations in organic inputs, actual inputs may vary somewhat.

Site	Farming Systems	Year	Season	Crop	FYM	Compost[a]	DAP	PR	TSP	CAN[b]	*Tithonia* Mulch[c]	*Tithonia* plant tea	Total N applied	Total P applied
					Mg ha⁻¹	Mg ha⁻¹	kg ha⁻¹	kg ha⁻¹	kg ha⁻¹	kg ha⁻¹	Mg ha⁻¹	Mg ha⁻¹	kg ha⁻¹	kg ha⁻¹
Chuka	Conv-High	6	2	Potato	10.5	–	–	–	300	200	–	–	160	94
		7	1	Maize	3.9	–	200	–	–	100	–	–	113	60
		7	2	Cabbage	10.5	–	–	–	200	300	–	–	114	58
	Org-High	6	2	Potato	–	22	–	581	–	–	8.2	–	162 (173)[d]	118.5 (36.5)[d]
		7	1	Maize	–	22.7	–	364	–	–	5.4	3.9	246	133
		7	2	Cabbage	–	22	–	400	–	–	6	6	211	115
	Conv-Low	6	2	Potato	2	–	100	–	–	–	–	–	33	27
		7	1	Maize	5	–	50	–	–	–	–	–	63	32
		7	2	Kale/Swiss Chard	1	–	–	–	50	60	–	–	23	13
	Org-Low	6	2	Potato	4.5	–	–	200	–	–	2.72	–	48	45
		7	1	Maize	2.2	–	–	100	–	–	1.36	–	35	24
		7	2	Kale/Swiss Chard	4.5	–	–	90	–	–	1.2	1.2	21	13
Thika	Conv-High	6	1	Potato	14.1	–	–	–	300	200	–	–	124	83
		7	1	Maize	7.2	–	200	–	–	100	–	–	84	47
		7	2	Cabbage	11	–	–	–	200	300	–	–	184	67
	Org-High	6	2	Potato	–	24.4	–	581	–	–	8.2	–	131 (220)[d]	87 (41)[d]
		7	1	Maize	–	17.6	–	364	–	–	5.4	3.9	135	81
		7	2	Cabbage	–	24.4	–	400	–	–	6	6	290	100
	Conv-Low	6	2	Potato	2	–	100	–	–	–	–	–	[illegible]	[illegible]
		7	1	Maize	5	–	50	–	–	–	–	–	31	20
		7	2	Kale/Swiss Chard	1	–	–	–	50	60	–	–	24	14
	Org-Low	6	2	Potato	6.9	–	–	200	–	–	2.72	–	33	37
		7	1	Maize	5	–	–	100	–	–	1.36	–	38	24
		7	2	Kale/Swiss Chard	6.9	–	–	90	–	–	1.2	1.2	18	13

Conv-Low, conventional low input system;Conv-High, conventional high input system;Org-Low, organic low input system;Org-High, organic high input system; FYM, farm yard manure; DAP, di-ammonium phosphate; PR, phosphate rock; TSP, triple superphosphate; CAN, calcium ammonium nitrate.
FYM, compost and *Tithonia* inputs are on a fresh weight basis.

[a] Compost preparation starts with the indicated amount of Fresh FYM.

[b] Applied as top-dress to all crops except in potato where it is applied at planting. Under high input topdressing was done in [illegible] low input topdressing was not done or it was done once for specific crops.

[c] *Tithonia* mulch is applied after crop germination as starter N.

[d] Extra nutrients supplied from mulch (applied at 2 Mg ha⁻¹), maize stover residues applied at 2 Mg ha⁻¹ and *Mucuna* average rate of 10.3 Mg ha⁻¹ at Chuka and 16.7 Mg ha⁻¹ at Thika during potato season. No *Mucuna* was intercropped with maize during maize season hence no *Mucuna* biomass was incorporated.

M.W. Musyoka et al. / Europ. J. Agronomy 86 (2017) 24–36

Nutrient and carbon sources?

(Musyoka et al., 2017)

Not an organic – but informative!

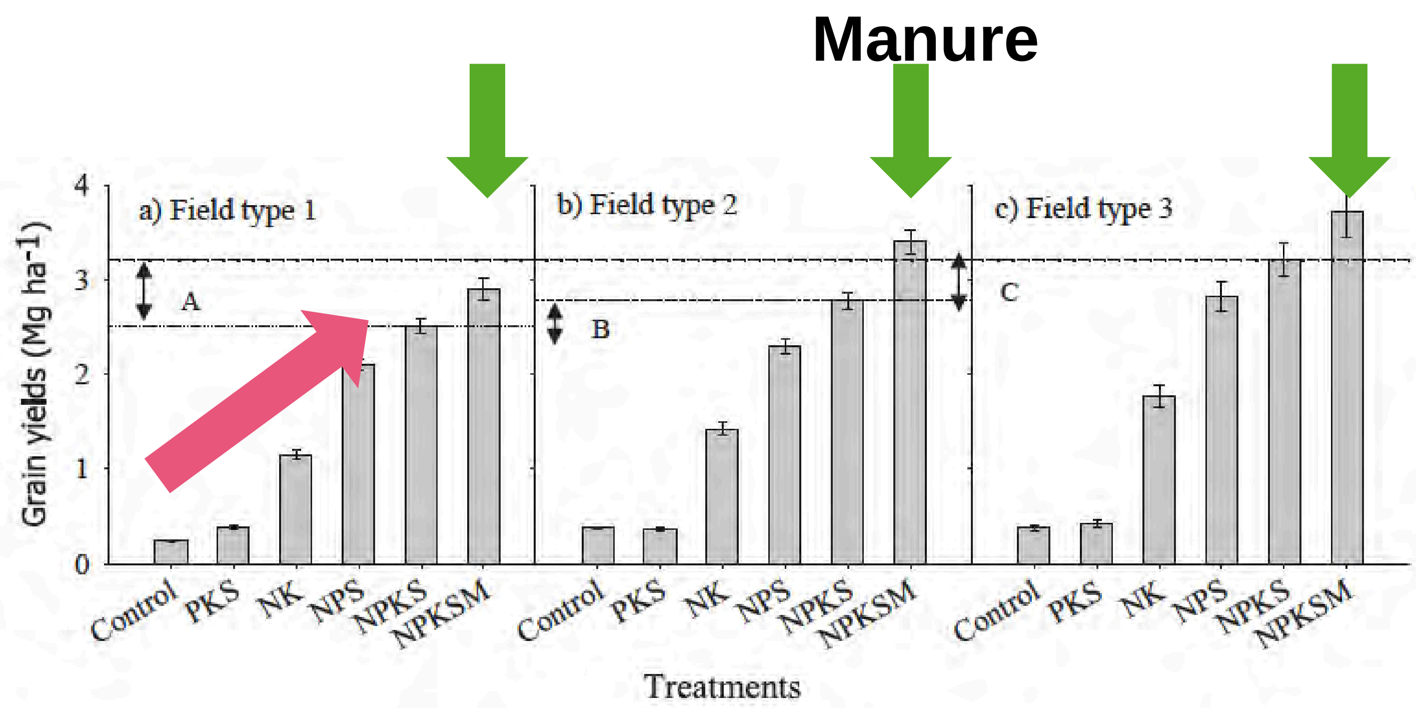


Fig. 2. Maize grain yields as influenced by nutrient management when (a) SOC < 0.4%, N = 20 fields, (b) 0.4% < SOC < 0.6%, N = 16 fields, and (c) SOC ≥ 0.6%, N = 4 fields. Yield gaps A, B and C are a function of inherent soil fertility, defined here by SOC, in an area with field sites receiving similar rainfall. These yield gaps are based on yield differences between the NPKS treatments. Errors bars are standard errors of means.

Nitrogen: 110 kg ha-1

Manure 5t ha-1: 55 kg N, 7.5 kg P, 35 kg K, 4.5 kg Mg, 9 kg Ca, 0.1 kg Cu,1.425 kg Mn, 4.05 kg Fe and 0.575 kg Zn ha−1

(Kafesu et al., 2018)

Inorganic – organic

Trials with manure non adapted to the smallholder farming system:

100 kg N and 15 t manure ha-1 (Zingore 2016)

Table 2. Initial, final and cumulative maize yields as influenced by long-term application of fertilizer and manure under variable soil fertility conditions in Zimbabwe

Soil type	Field type	Treatment	Yield (t /ha)		
			2002/03	2010/11	Cumulative*
Clay	Standard	Control	2.13	0.69	10.78
		N	2.90	2.33	17.04
		NPSCaMgZnMn	6.18	2.95	29.69
		N+manure	4.24	7.34	37.09
	Depleted	Control	0.74	0.60	6.61
		N	0.82	2.17	12.34
		NPSCaMgZnMn	2.12	3.77	25.02
		N+manure	3.56	5.57	34.49
Sandy	Standard	Control	0.95	0.56	5.37
		N	1.52	0.94	8.78
		NPSCaMgZnMn	2.33	2.00	16.33
		N+manure	3.35	3.85	23.77
	Depleted	Control	0.24	0.14	1.15
		N	0.31	0.57	2.24
		NPSCaMgZnMn	0.81	1.10	6.26
		N+manure	0.98	2.28	12.43
	SED		0.24	0.29	2.57

*Exclude data for one season that was unavailable due to late harvesting.

Fine tuning...

„Organic matter“

Techniques

more or less well known!

(with reference to **non-organic trials**)

(data mainly from sites > 800mm a-1)

Again: Starting point...

- **C/N status:** Low N, C, high C/N ratios, high erosion, etc ...
- **Nutrient status:** where added: leaching / imbalances / K:Mg, etc...
- **Biodiversity:** endangered at variety, species and habitat level etc....

(Hailu et al. 2015)

Carbon – an Approximation

Carbon demand: to maintain **1 % organic C** in a sandy loam soil in the sub-humid tropics:

- approx. 7 t DM ha a-1 **low** quality residues (roots, stems) or
- approx. 10 t DM ha a-1 **high** quality residues (green manure leaves)

(Janssen, 1993)

Potential DM:

- Agroforestry: approx.: 1-10 t DM ha-1 a-1
- Cow dung: approx.: 1-5 t DM ha-1 a-1
- Crop rotation: forage legumes: above ground: 1-15t DM ha-1 + below ground: 1-4 t DM ha-1 (4 year rotation)
- = **5 - >10 t DM ha a-1**

C:N, lignin:N, polyphenol:N and (lignin+polyphenol):N ratios

High quality organic inputs are low in lignin (<15%) and polyphenol (<3%) and high in %N (C/N<10)...

...necessary to increase

- **soil microbial activity**
- **P and micronutrient availability**
- **and soil buffering capacity**
- **...**

(Mafongoya et al., 1997b; Snapp, 1994)

% N

Low quality materials having the opposite characteristics...

- Crop residues and animal manure are of low quality as they fall below critical N content of 1.8±2.0% and immobilize N temporarily
- ... E.g.: Incorporation of maize stover: reducing maize yields by 3±30%in the first three season

(Palm et al., 1996)

BUT! **Living" soils react differently** – if high quality of other residues are available **the so called „low"quality is also of high value**...through adding additional **soil fertility functions**

% Polyphenols

Palm et al. 2001

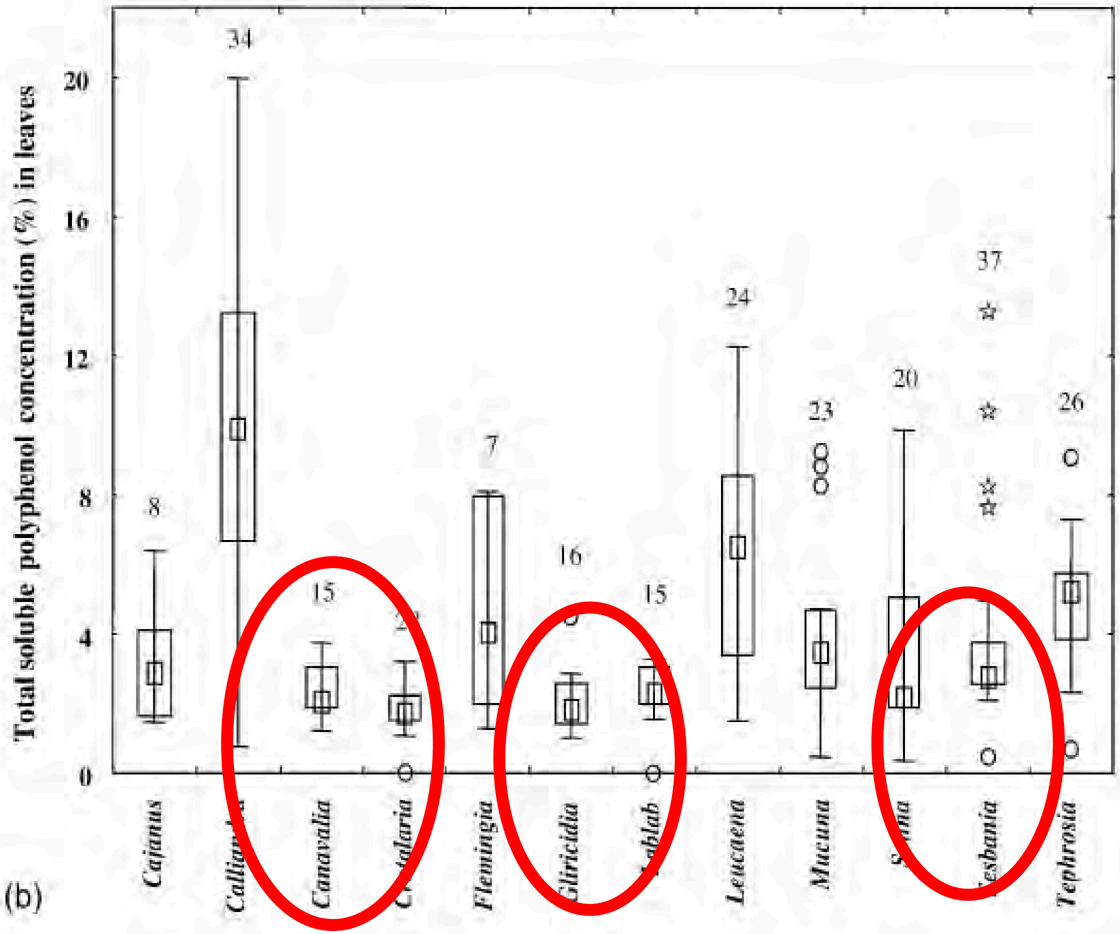


Fig. 4. The median polyphenol concentrations (TAE: tannic acid equivalents), ranges, and outliers of the entries in ORD of the fresh leaves from selected plant families (a) and legume genera (b). Legends are the same as for Fig. 1.

% N in leaves

Palm et al. 2001

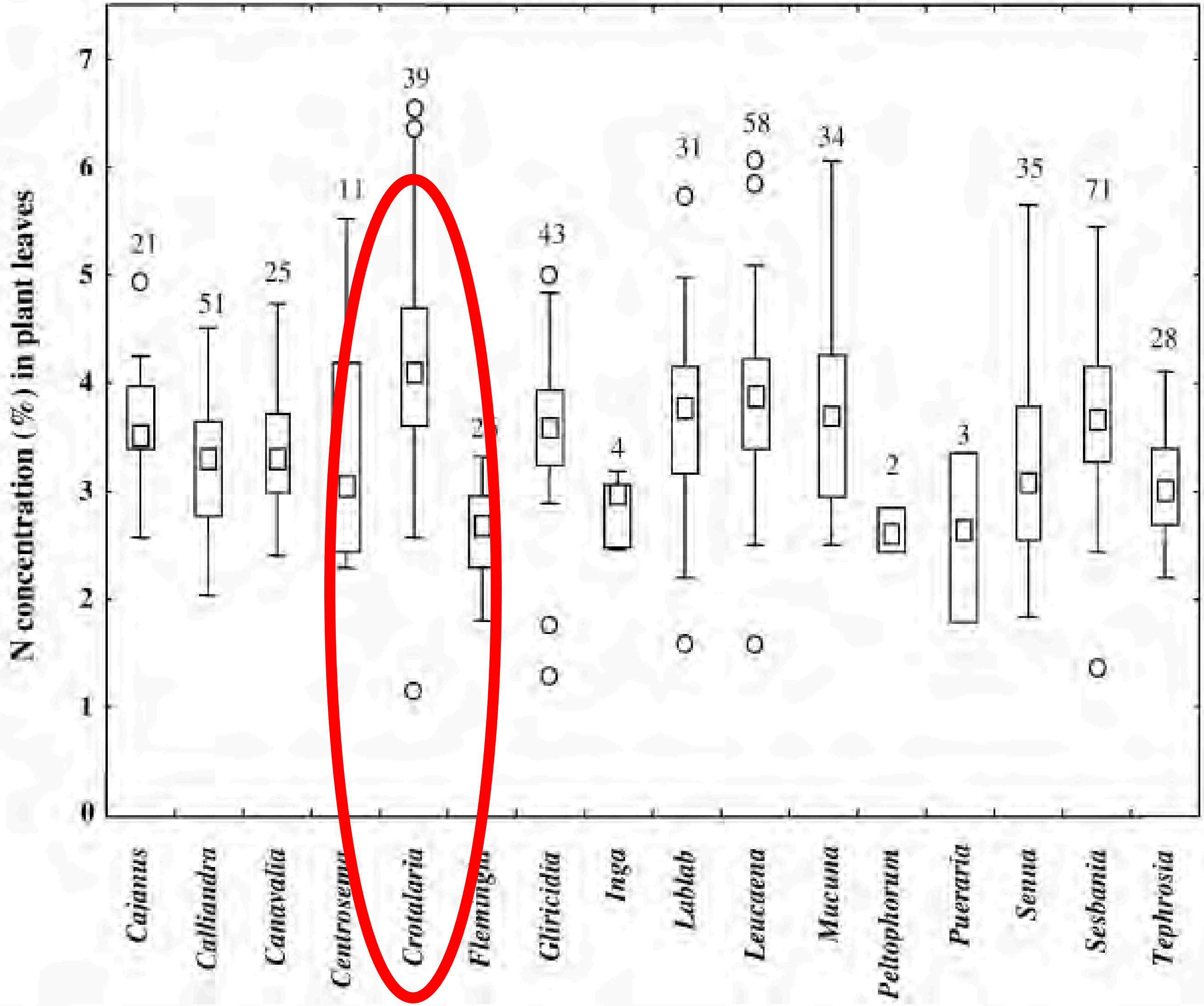


Fig. 3. The median N concentrations, ranges, and outliers of the entries in ORD of the fresh leaves from selected legume genera. Legends are the same as for Fig. 1.

% P

Palm et al. 2001

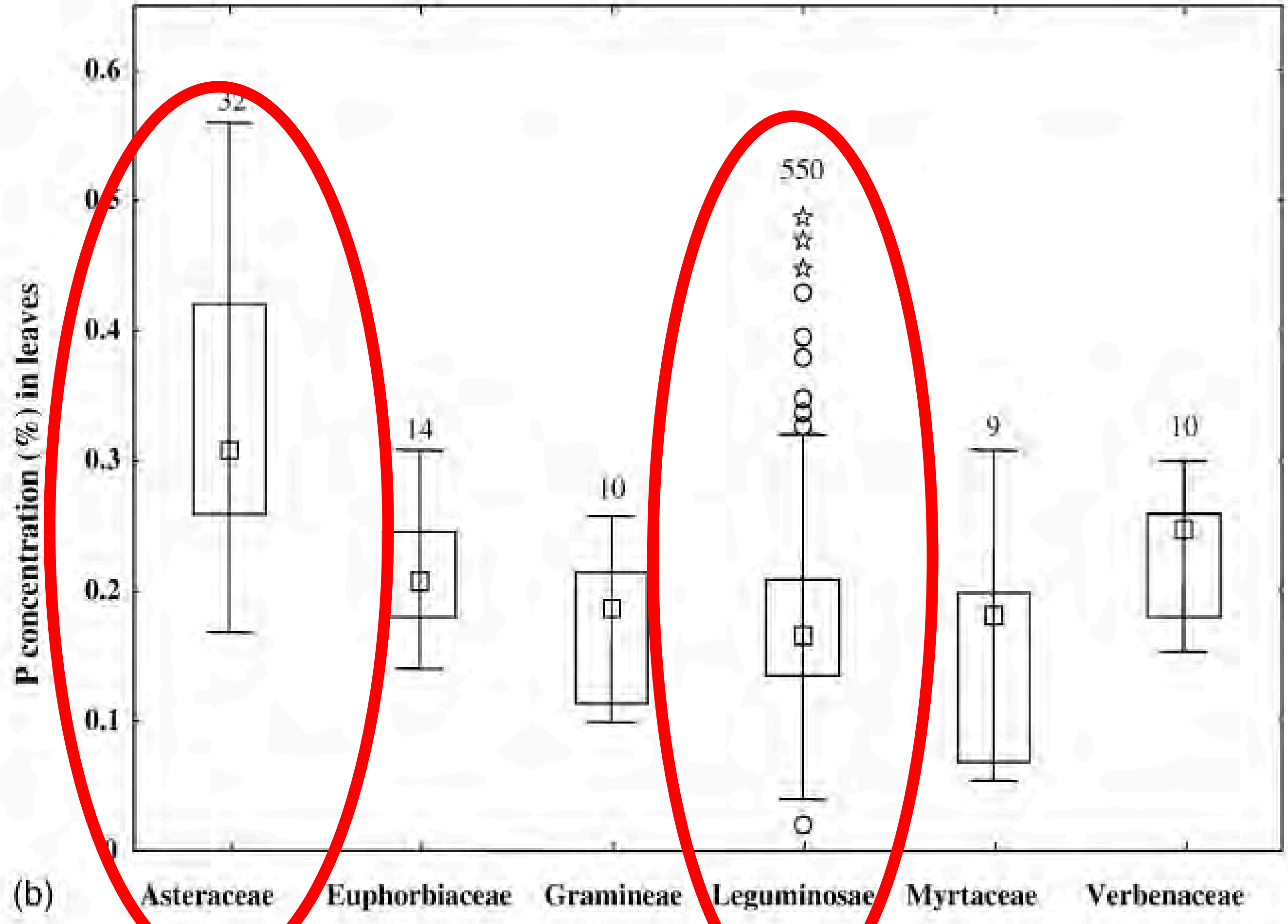


Fig. 2. The median N (a) and P (b) concentrations, ranges, and outliers of the entries in ORD of the fresh leaves from selected plant families. Legends are the same as for Fig. 1.

Nutrient content of prunings

Table 2. Annual nutrient yield (kg/ha) of hedgerow prunings (4 m between rows, exclusive of woody material) of four fallow species alley cropped on a degraded Alfisol in southern Nigeria.

Species	P	K	Ca	Mg
Acioa barterii	2.0	19.7	12.3	1.9
Alchornea cordifolia	7.0	55.7	42.1	8.3
Gliricidia sepium	10.6	253.4	73.7	15.7
Leucaena leucocephala	14.6	192.8	114.9	10.7

Note: Yields measured in 3rd year after establishment; total of five prunings.
Source: B.T. Kang, unpublished data.

Impact of Leucaena L. biomass on maize yield

Tree prunings (leaves + soft stems): **2.9% N**

Tree rows with 4m distance and trees all 25cm:

- = **6 t DM ha-1 a-1 DM / 174 kg N ha-1 a-1**

- 1 kg N: **mulched = 5 kg maize**
- 1 kg N: **incorporated = 10 kg maize**

= **174 kg N: plus 870 – 1.740 kg maize**

(Kang & Wilson, 1987) (Atta-Krah, Sumberg, & Reynolds, 1986)(Kang et al. 1981)

Effect of mulch and fertilizer on yield (kg ha-1) on cotton in Zaire

Year	Without	fertilizer	With	fertilizer
	unmulched	mulched	unmulched	mulched
1953-1954	200	1117	440	1434
1955-1956	186	1464	797	1977
1956-1957	124	986	706	1344

cited in Ker 1995

Organic matter quality – pH

- ... „prunings of young shoots of *Calliandra calothyrsus, Cassia siamea, Flemingia congesta, Grevillea robusta, Gliricidia sepium, Leucaena diversifolia and Leucaena leucocephalam* resulted in **increased soil pH** and **decreased exchangeable aluminium** content“

(Wong, Gibbs, Nortcliff, & Swift, 2000)

- Organic materials: contribution to soil **pH**, K, C and N
- Cattle manure: superiority in terms of **soil properties**

(Mugwe, 2007)

Methodological issues – not only these!!!

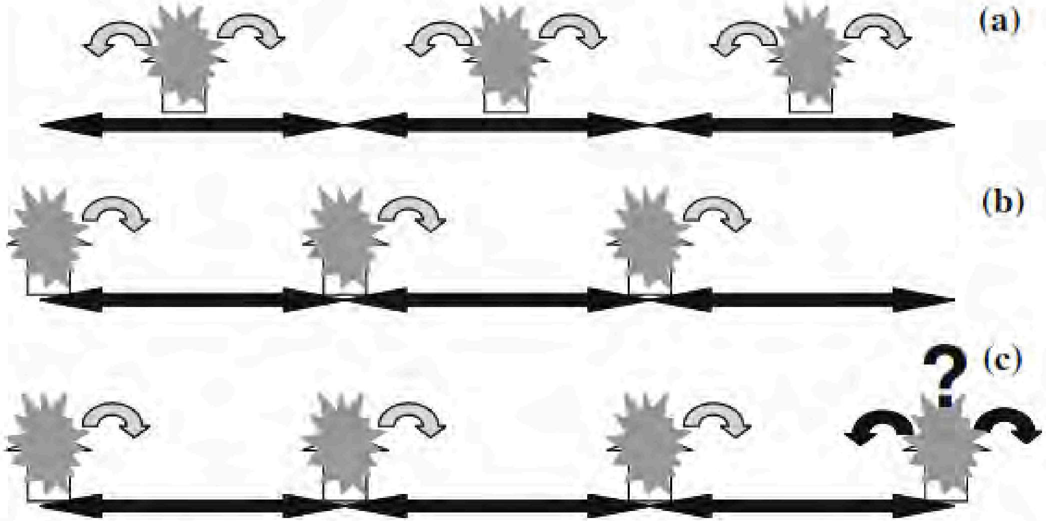


Figure 1. Schematic demonstration of hedgerow vs. interrow arrangement and pruning application. (a) Hedgerows in middle of interow space, prunings equally split to both sides; (b) hedgerows at one side of interrow space, prunings applied to one side; (c) hedgerows to either side of interrow spaces with one hedgerow in excess and questionable application of prunings (black arrows at the right).

(Hauser, Nolte, & Carsky, 2006) ±

Organic matter quality - Nitrogen

- Low quality stover residue (Maize: C to N ratio of 42:1)(1.2 t C ha-1) **can reduce N-leaching** from high amounts of N fertilizer (120 kg N ha-1)(maize yield level 2-4 t ha-1)

(Mafongoya et al., 1997b)

- Incorporation of prunings into the soils **can improve N recovery** ... due to reduced losses of N through ammonia volatilization

(Costa et al. (1990); Glasner and Palm (1995), in Snapp et al. (1998, 188))

- **Green manures** and **legume tree prunings** decompose quickly and may release **between 70% and 95% of their N** within a season under tropical conditions

(Giller and Cadisch, 1995)

Organic matter quality – mulch

- Mulch Treatments: Crop residues (0, 0.5, and 2 t DM ha^{-1}):

  - … **induced total dry matter** (TDM),
  - **increased yields in cereals up to 73%** for the Sahel compared with a maximum of 16% in the wetter Sudanian and Guinean zones ... due to
    - ...**improved P availability**
    - **...a protection of seedlings against wind erosion**
    - **...a decrease in peak temperatures by 4 ^{0}C and**
    - **...increased water availability**

(Buerkert, Bationo, & Dossa, 2000)

Management of organic matter

- A **high quality organic input** (*Tithonia diversifolia*) can be **comparable to or more effective than inorganic P through increasing P availability in the soil**

(Nziguheba, Palm, Buresh, & Smithson, 1998)

- **Positive yield impact of 2t DM ha green manure** (***Tithonia diversifolia***, *Dolichos lablab and Tephrosia vogelli*)+ 46 kg P2O5/ha and incorporation (surface mulch / **15cm**, 30cm) on following wheat yield

(Birech & Freyer, 2007)

- Organic materials at 60 kg N ha-1, versus organic materials (30 kg N ha-1) plus inorganic fertilizer (30 kg N ha-1) ($p \leq 0.05$) /sole inorganic fertilizer: **higher maize yields with organic fertilizer + inorganic fertilizer than that from sole inorganic fertilizer treatment**

(Mugwe, 2007)

Pathways are „organic"...

Citations ... Under most conditions, simultaneous interventions are needed that address both crop productivity and SOC status

„mineral" fertilizers alone result in **yield declines** over time, ...

- applying fertilizer in combination with **tree prunings**,
- **high biomass intercrops with different qualities**,
- or **farmyard manure,**

allowed yields and SOC conditions to stabilize, or further increase

(Bationo, Buerkert, Sedogo, Christianson, & Mokwunye, 1995; Vanlauwe, Barrios, Robinson, Asten, et al., 2017)

Pathways are „organic“...

Citations... „Interventions addressing crop productivity are **‘friends’ of natural resource integrity**:

- **„only if substantial amounts of organic inputs with the right quality characteristics (e.g., high N content, low lignin, and soluble polyphenol contents) are applied“**

(Palm et al., 2001)

Technology

In between – an option

Transdisciplinary, participatory action research...

Postmodern smallholder … why not?

xxxx

Weed roboter

Animal manure

Animal manure – nutrient dynamics

- **Quality highly variable:** differences in feeding ratios and digestability -chemical composition of manure, rates and frequence of manure application

(Delve et al., 2001)

- Relevant qualities**: Phosphorus and cations (Ca and Mg)**

(Grant, 1967)

- Focus on favourable **C:N** and **N:P** ratios!

(Sileshi, Nhamo, Mafongoya, & Tanimu, 2017)

- Quality feed diets (low in lignin and polyphenols) result in **more N being excreted in the urine than faeces**

(Somda et al., 1995)

Animal manure – nutrient dynamics

BUT:

- N in **manure** from animals fed with **tannin rich feeds**: very **resistant to mineralization** in the soil
- Tannin rich feeds**: increase the amount of N excreted in the faeces** as compared with urine
- Urine: N is **lost quickly** through volatilization

(Mafongoya et al., 1997d)

Modern technology for cooperatives...

Modern technology for cooperatives...

Going organic (matter)

Activity		Increase	Decrease	No change
Tillage				X
Mineral fertilizer				P, liming! K? Microntr.
FYM, slurry		X		X
Compost		X (see Vermicomp)		
Crop rotation		X		
Forage prod.		X		X
Herbicides			X	
M. Weedcontrol		X		
Pesticides				X (natural PM /IPM)
Alley		X		X

Increase of Labor and Investment !

Summary – of course preliminary

It is a **puzzle** to put all the information together !!!

- Over the last decades **many trials** informed about organic matter management in detail
- **BUT:** Need for **precise field protocols** to enable an overall systematic assessment
- Organic farmers (and others too...) can learn a lot from **already done science**, if they want to optimize their system

There is no real/true life (solution)
in the wrong (system)

(Theodor W. Adorno)

The problems that exist in the world
cannot be solved
with the same ways of thinking
that they have created

(Albert Einstein)

... matter

To solve all these interwoven challenges (erosion, biodiversity, climate,...)

All!

farming systems need the organic matter approach and any technical investment

Still a hypothesis?

Re-setting the system ... See organic guidelines

Organic matter

Forage legumes (>10%) Inter- / relay cropping	Faeces / Urine / Slurry	Alley cropping / hedges
		Mulch / forage / material / food
	„Semi-zero-grazing“	

N; C/N; C/P; K; root system	Feed quality – starch / proteins / minerals	C/N; root system Polyphenol; Lignin; pH

Adapted tillage / mechanical weed control / IPM_{of} / water harvesting

+ rockphosphate, K_2SO_4, micronutrients, lime, inoculation…

There is no Plan B!

Source: Udo Lindenberg

Pierre Bourdieu's "capital" theory

- Human
  - Knowledge
    - Economic
      - Spiritual
        - Religious
          - Natural
            - Psychological
              - Social
                - Cultural
                  - Educational...

…social innovations are of relevance for technical & economic system transformations...

How it could be

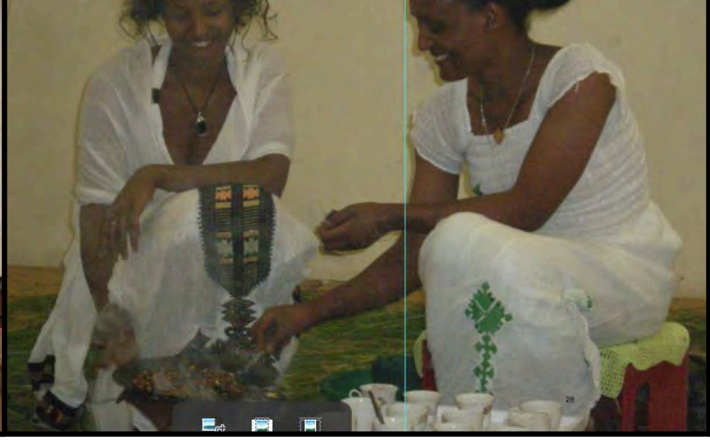
The African continent could be

- 100% food self sufficient
- conserving their richness of environmental resouces and beautiness
- a net exporter of high quality agricultural products

So what is now organic?

A real **Green** ®evolution?

Organic (matter) matters!


Thank you for your patience!

Thanks to the many scientists providing me excellent material!

Wish you inspiring talks and discussions at

„Smart“ Tropentag 2018 in Ghent!

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