„Small-scale farmers adaptation to climate change – influencing factors, adaptation strategies and gaps"

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Brot für die Welt

Brot für die Welt – Evangelischer Entwicklungsdienst

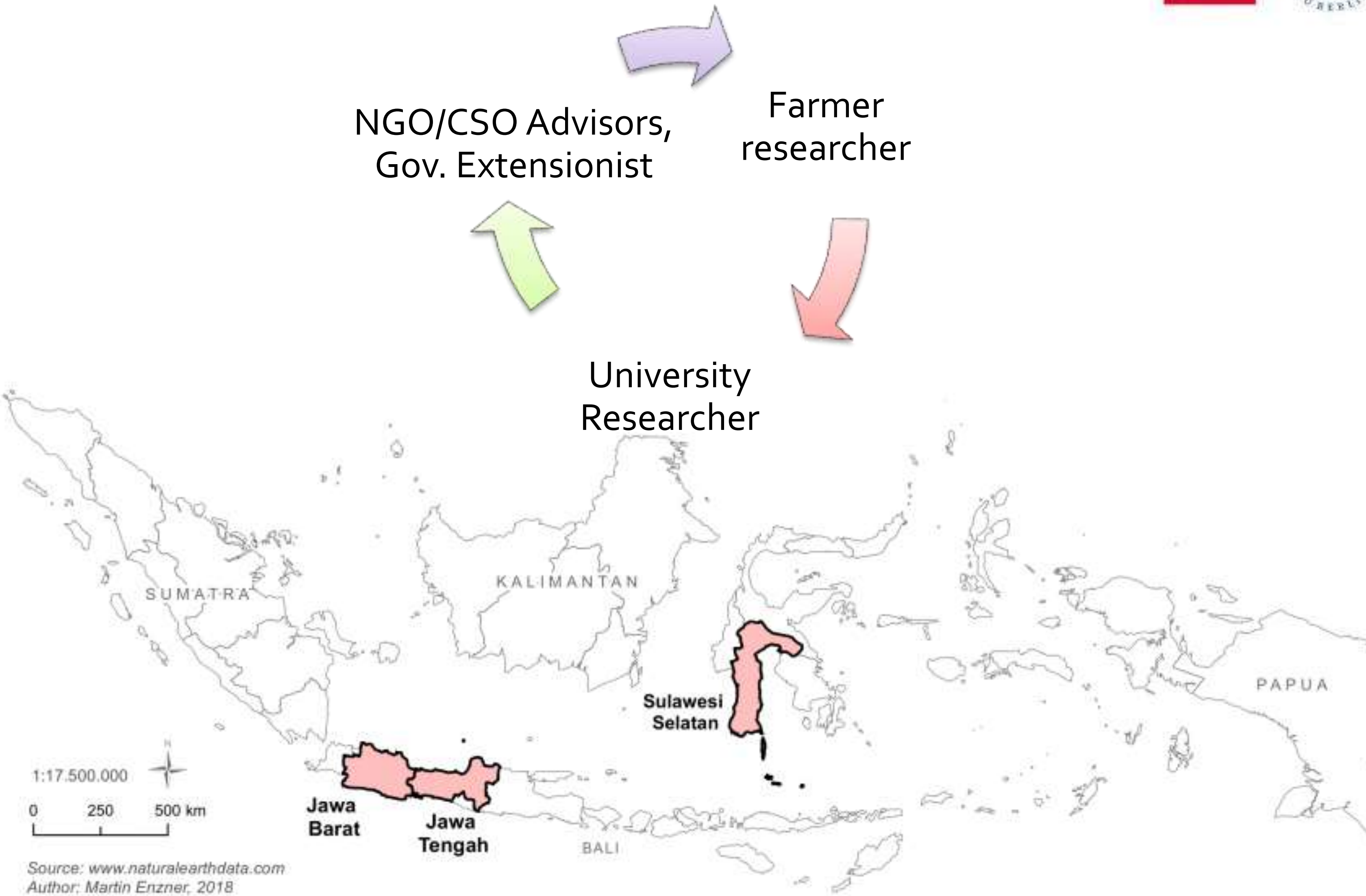
Climate resilient investigation and innovation project – South Sulawesi, West Java

Content

- Project partners and study area
- Overall goal of CRAIIP
- Sustainable Food systems and framing of concepts
- Examples of adaptation strategies

Albrecht Daniel Thaer 1752-1828: the „founder“ of agricultural science in Germany, first Professor of Agriculture: CROP ROTATION FIELD TRIALS

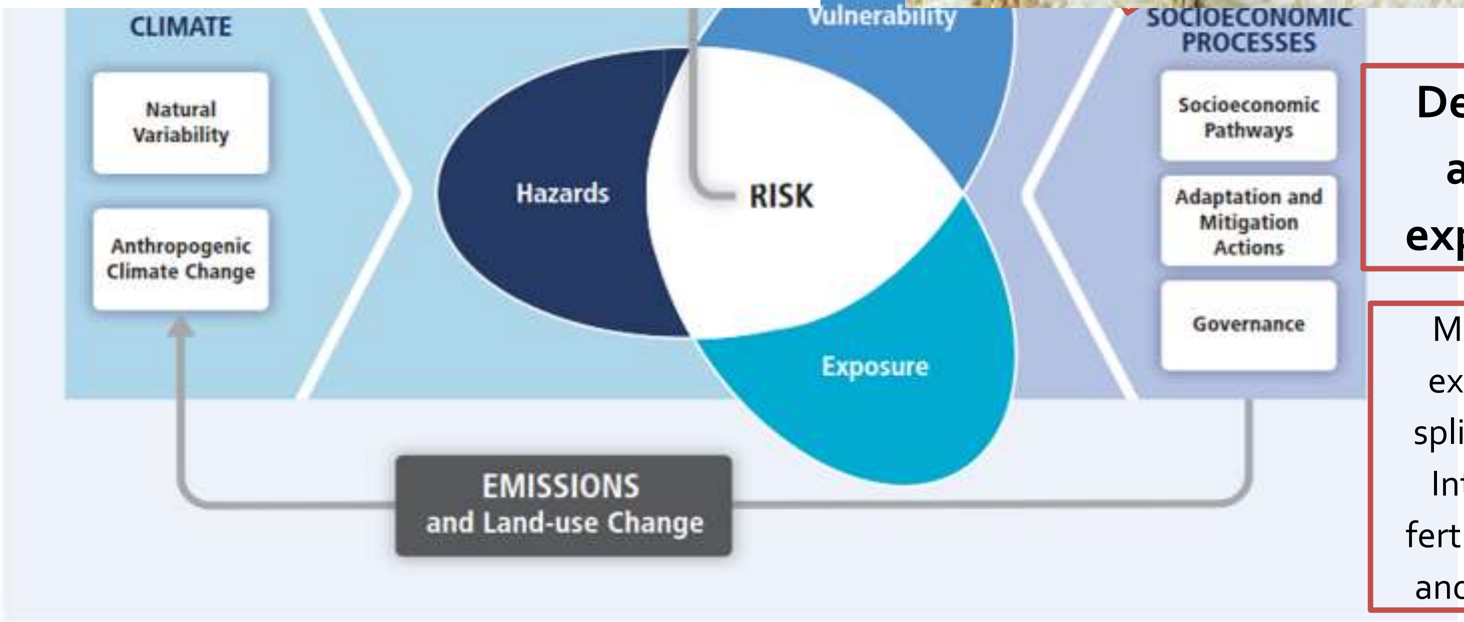
CRAIIP stakeholders and study area



CRAIIP partners and study area Sulawesi

CRAIIP partners and study area Java

Overall goal of CRAIIP

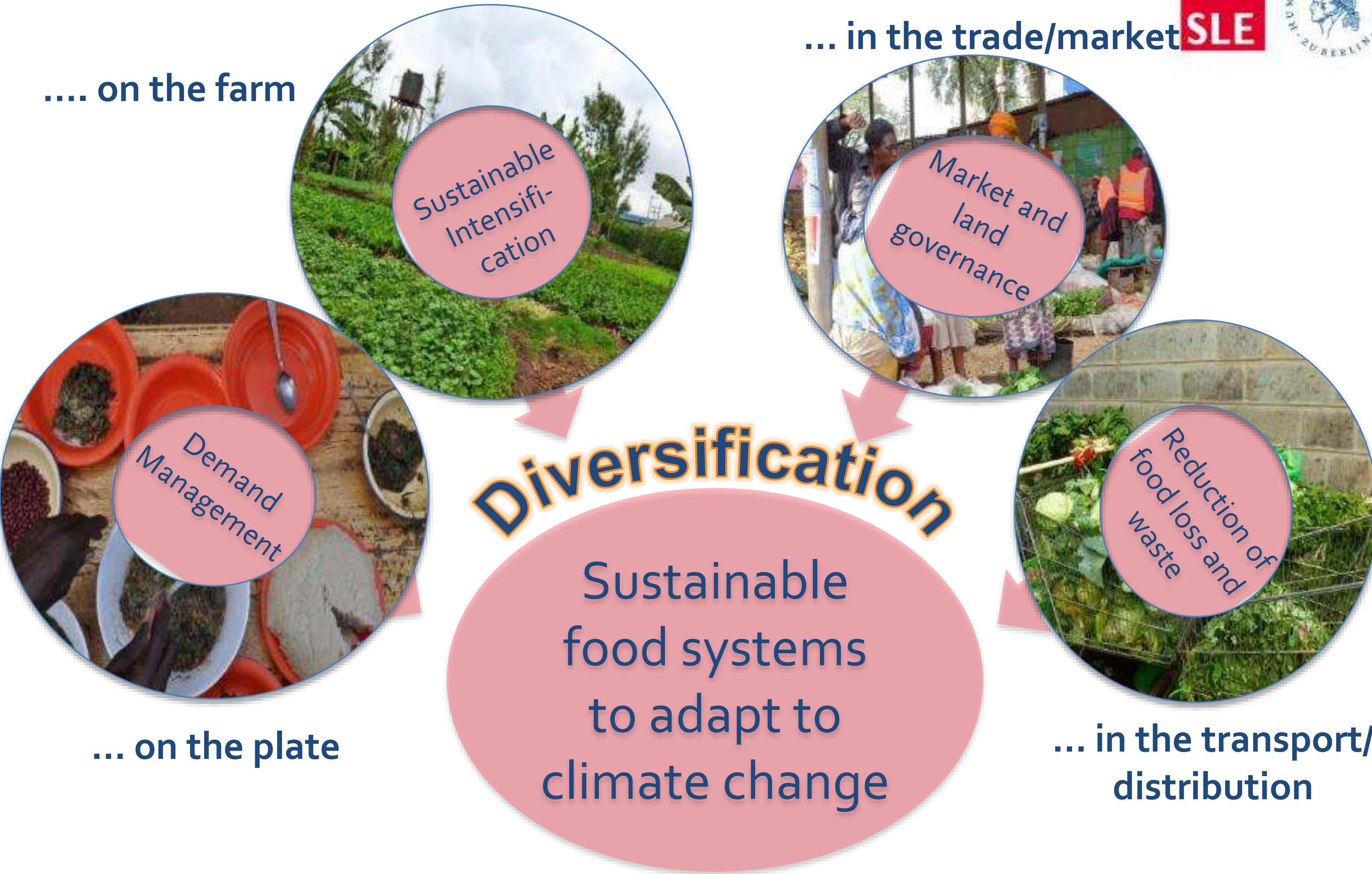


Demo plots and field experiments

Multi-factorial experiments in split-plot design: Integrated soil fertility strategies and variety trials

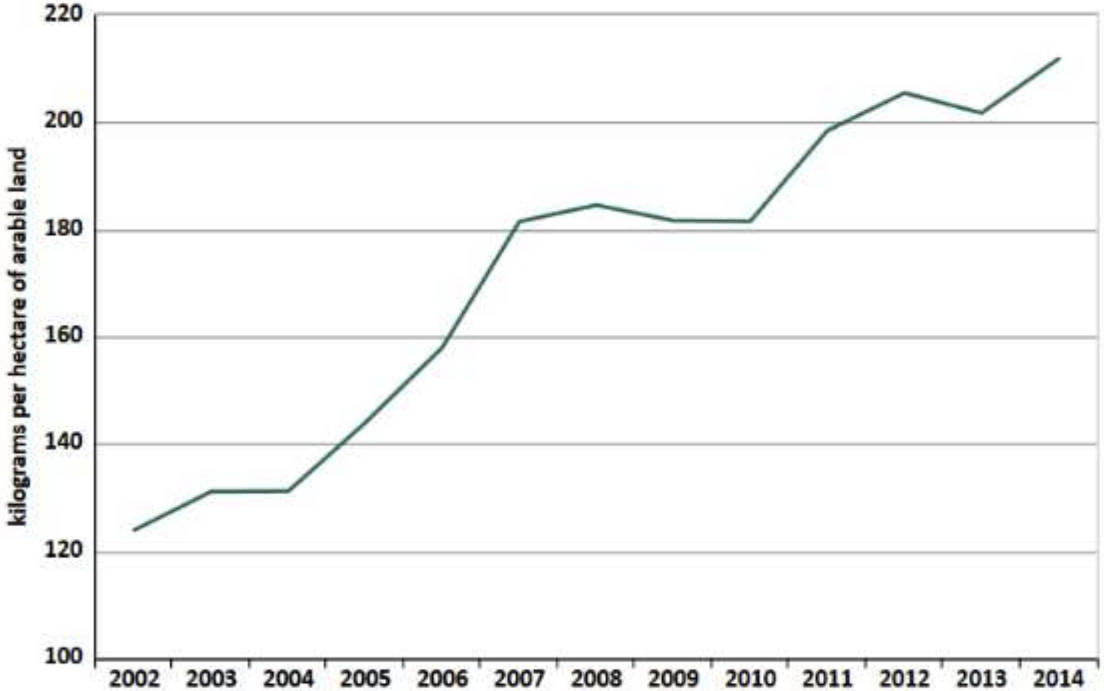
Farmers develop their adaptive capacity by adaptation learning to increase their resilience to climate change

Sustainable food systems and diversification at all levels

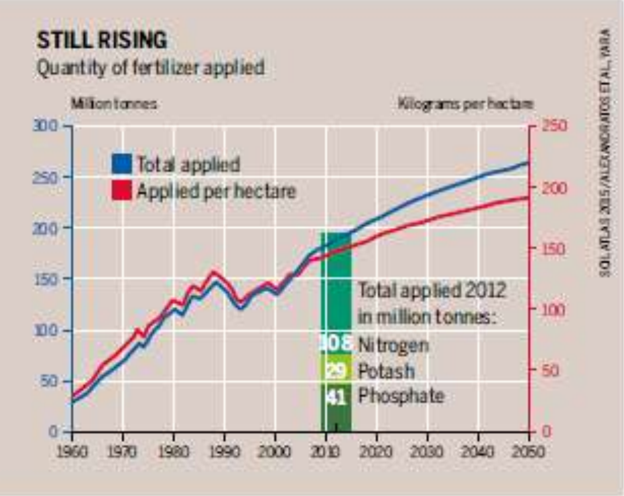


How to intensify on the farm?

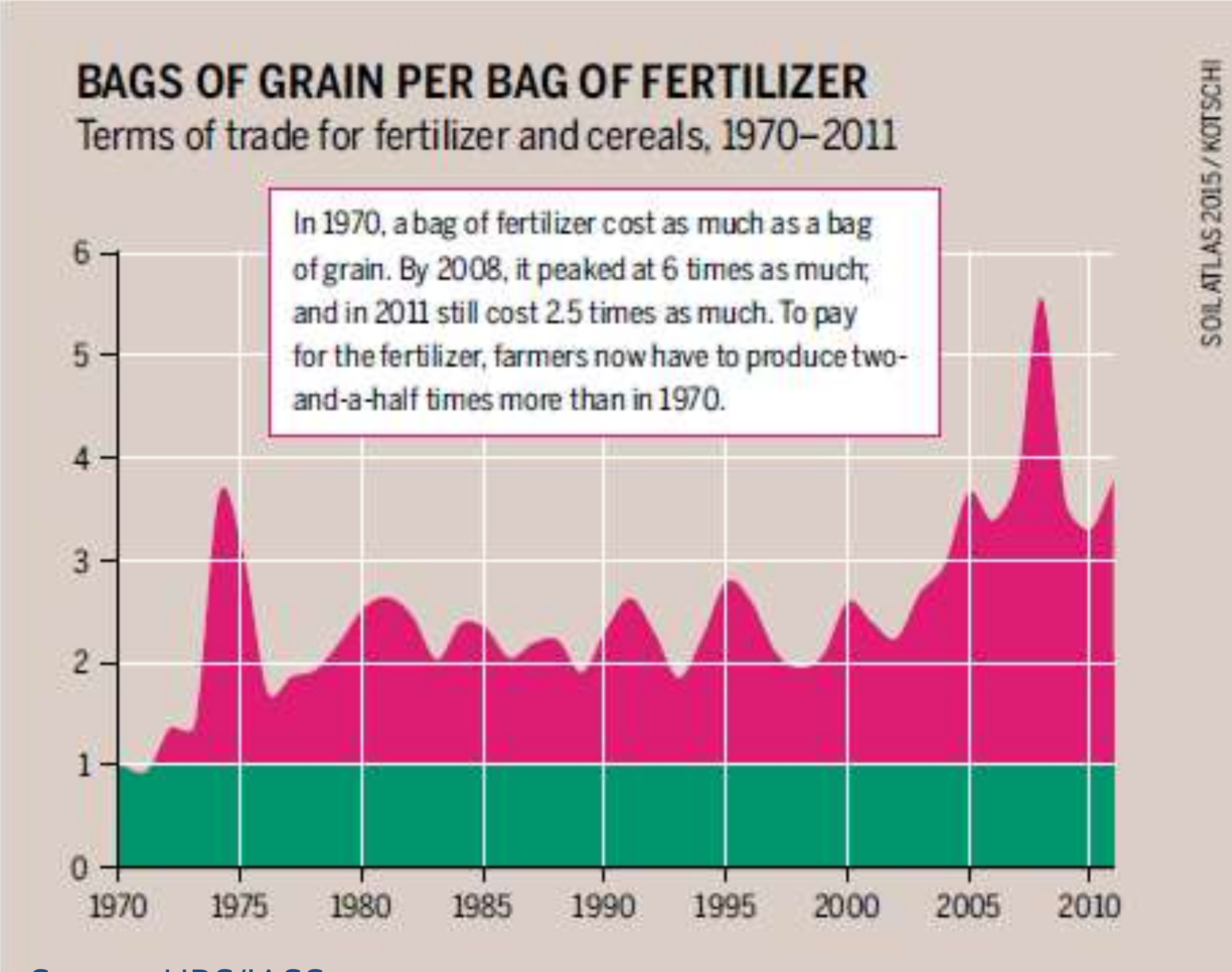
Fertilizer consumption in Indonesia



Source: https://knoema.com/atlas/Indonesia/Fertilizer-consumption

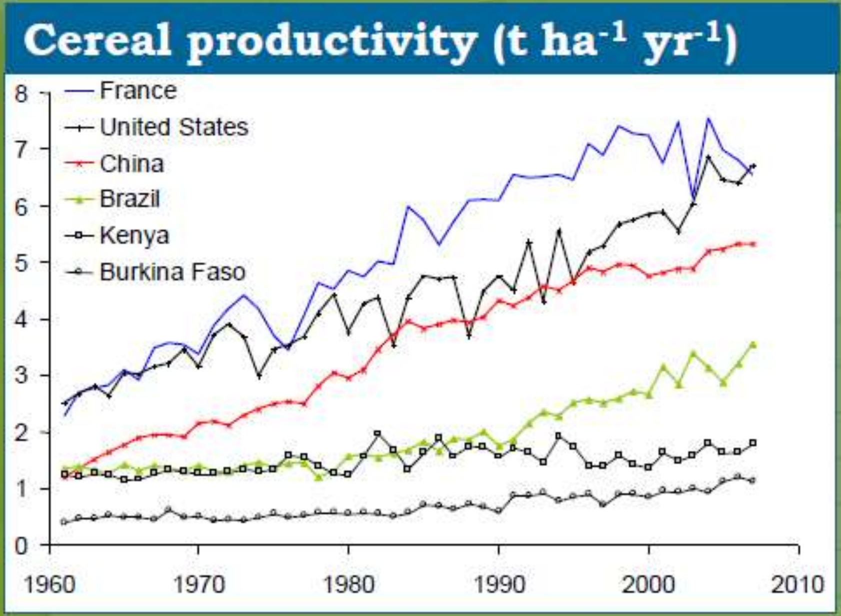


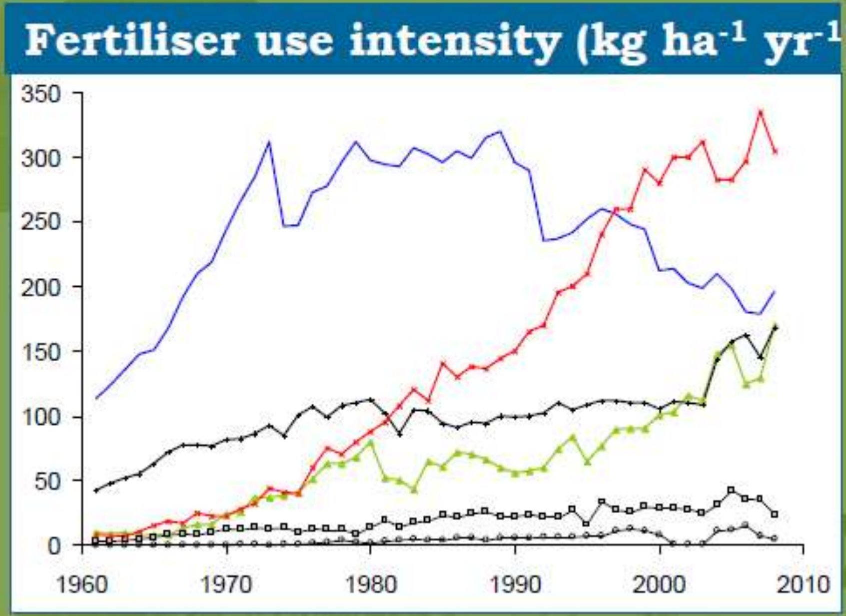
Source: HBS/IASS 2015



Source: HBS/IASS 2015

The green revolution





Fertiliser N use efficiency in China (Ju et al., 2009)

Year	Grain Production (M tonnes)	N fertiliser (M tonnes)	PFP_N (kg/kg)
1977	283	7.07	40.0
2005	484	26.21	18.5
% change	71%	271%	-54%

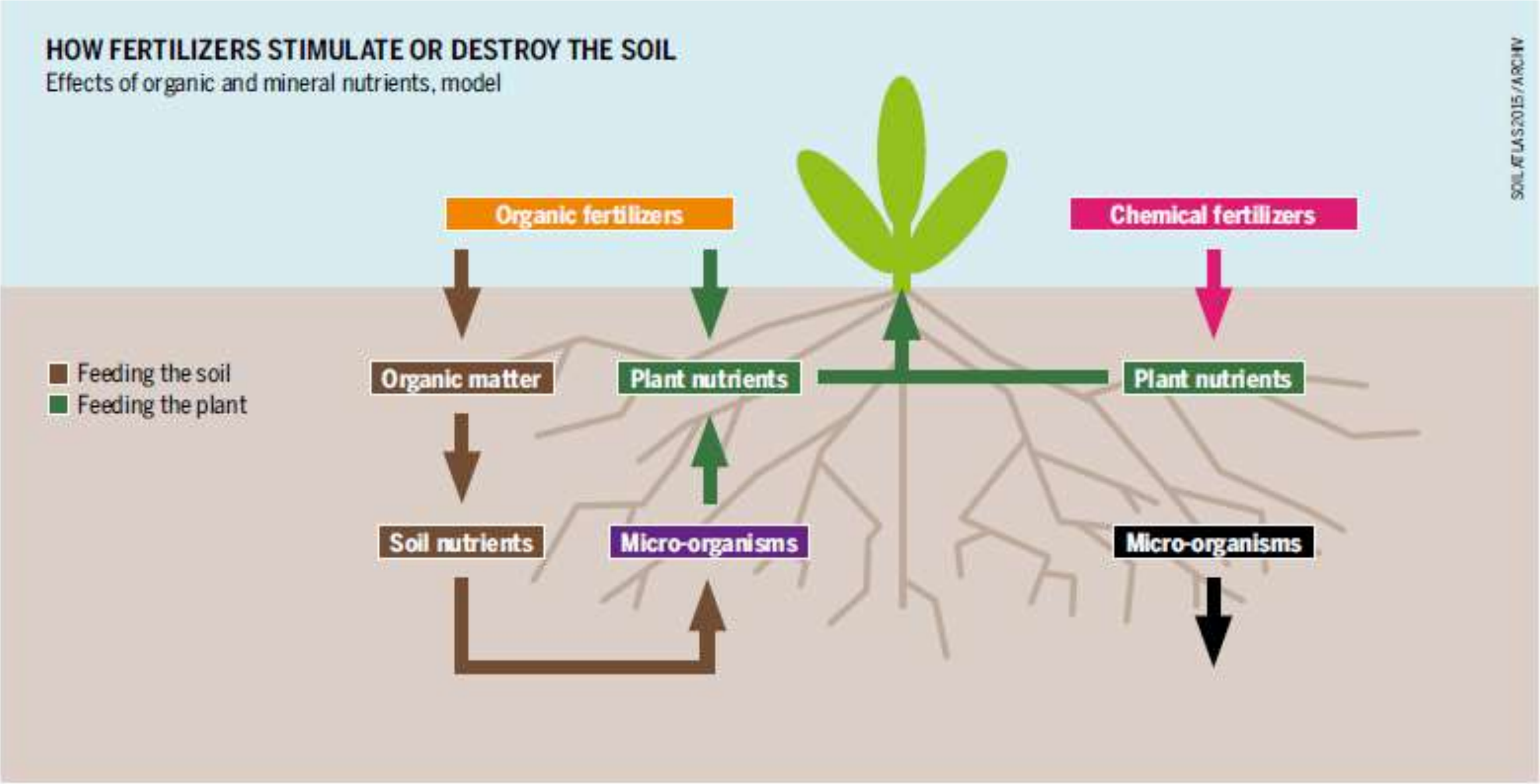
Source:Tittonell (2013)


© Petermann 2017

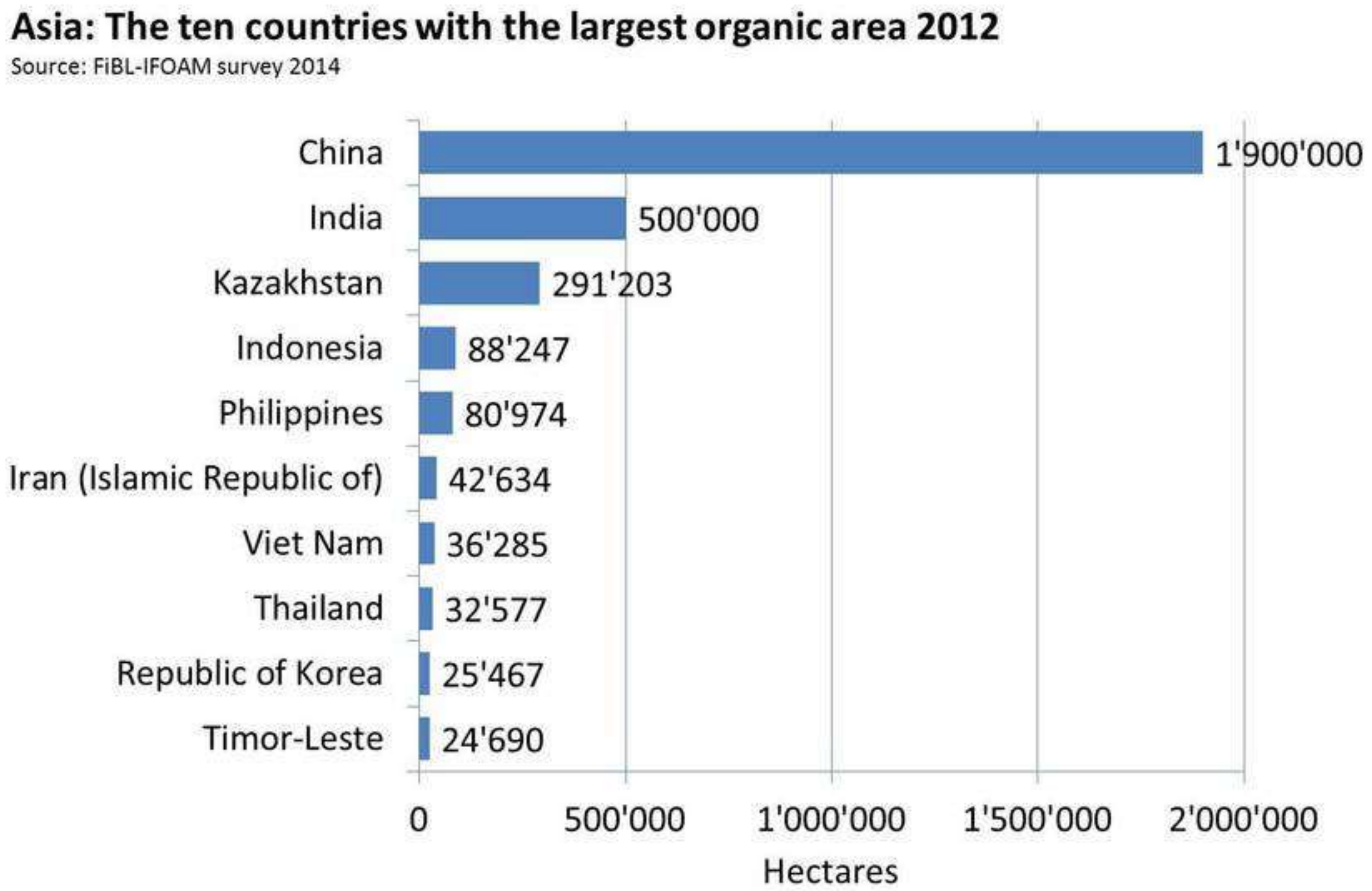

Soil improvement only works
with **living** roots and……
19 11 2013
© Petermann 2017


........with sufficient protection of the ground surface!
07 11 2014

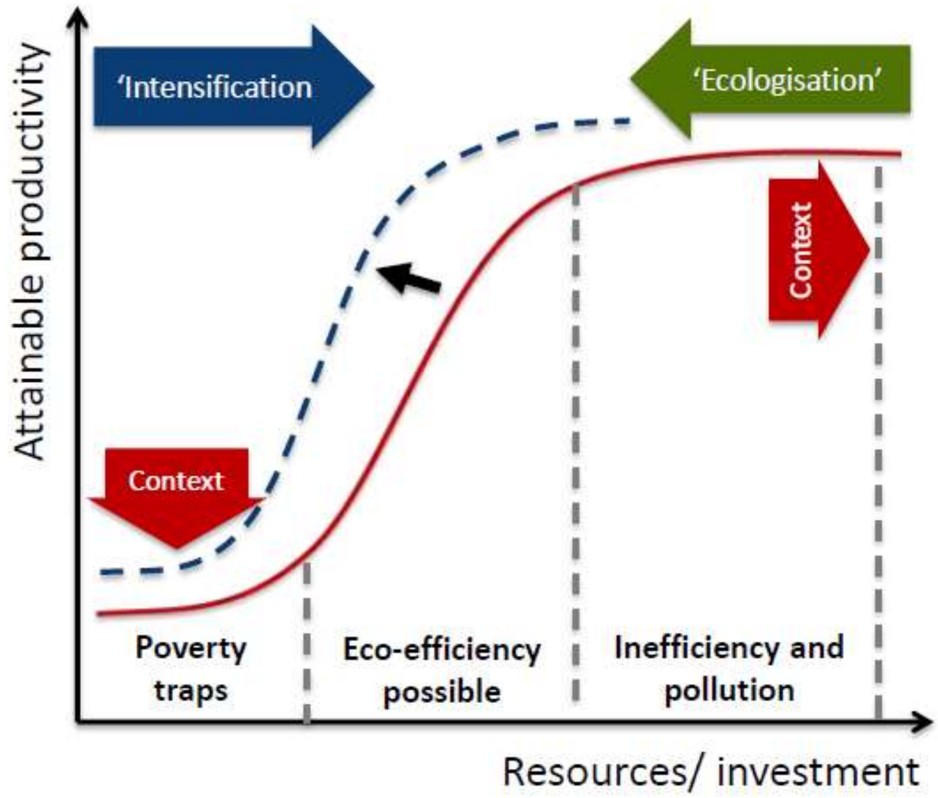
Organic fertilizers



Which countries are the organic agriculture “tigers” in Asia?



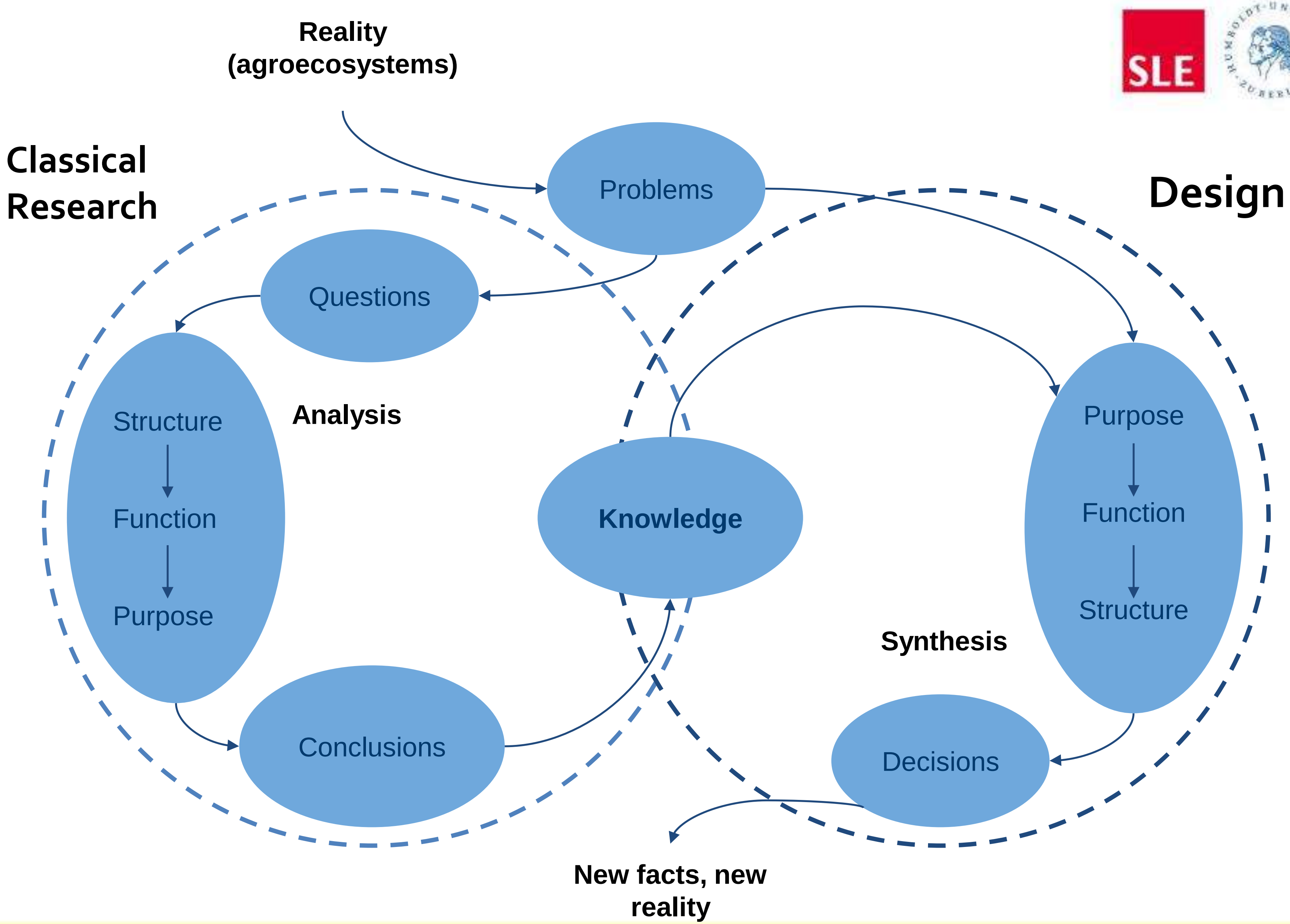
Intensify Global the South, Extensify the Global North , Detoxify everywhere (Tittonell)



'Ecologisation':
How to maintain productivity while reducing fossil fuel inputs?

'Intensification':
How to increase productivity in a sustainable, affordable way?

Source:Tittonell (2013)



Source: Tittonell (2013)

Same same… but different….

	Agroecology	Sustainable intensification	Climate-resilient agriculture
Definition	is the integrative study of the ecology of the entire food system, encompassing ecological, economic and social dimensions.	Producing more output from the same area of land while reducing the negative environmental impacts	Sustainable agriculture practices as on site-specific adaptation strategies based on the major risks and challenges local communities face aimed at reducing vulnerabilities and increasing the resilience of the smallholder production systems.
Sources	Francis et al 2003, Altieri 2005, FAO 2015	Pretty et al 2011	Action Aid, IFOAM
Based on	Principles of nature	economic and ecological targets (trade offs)	Context

Examples of Agroecological practices (diversification and soil management) known to affect soil and water dynamics

	Soil organic build up	>soil cover	Reduce ET	> water holding capacity	> infiltration	Microclimate amelioration	Reduction soil erosion	> water use efficiency
Diversification								
• Mixed or intercropping		✓	✓			✓	✓	✓
• Agroforestry	✓	✓	✓	✓	✓	✓	✓	✓
• Intensive sylvopastoral system	✓	✓	✓	✓	✓	✓	✓	✓
• Crop rotation	✓	✓			✓		✓	✓
• Local variety mixtures		✓						✓
Soil Management								
• Cover cropping	✓	✓	✓	✓	✓		✓	
• Green manures	✓	✓	✓	✓	✓		✓	✓
• Mulching	✓	✓	✓	✓	✓		✓	✓
• Compost applications	✓			✓				
• Conservation agricultura (organic -no till)		✓	✓		✓		✓	✓
Soil Conservation								
• Contour farming					✓		✓	
Grass strips/living barriers		✓			✓		✓	
• Terracing					✓		✓	

Source: adapted from Altieri 2017

Agroecological practices in Burkina Faso

Collection of rain water (roofs, catchment areas), run-off water (reservoirs, mini-dams) and groundwater (wells).

Alternance off-season vegetable production (thanks to water reservoirs) / cereals in wet season.

Seeds coating (clay soil, compost, cereal bran) before sowing in zaï holes to maintain humidity and avoid consumption by animals.

Mecanization of holes digging and fertilization with compost instead of ousehold waste.

Enrichment of compost: with trichoderma acting as fungicide or with natural phosphate.

Maintenance of organic matter and humidity in plots thanks to stone bunds, contour bunding…

Plantation of cereals in Acacia agroforestry parks (fertilizer tree species)

Biogas fabrication from animal excrements and use of effluents for fertilization.

Rotation cereals-legumes

Devices to collect and store water

Mecanized zaï holes and improved compost

Seeds coating and dry sowing

Anti-erosion devices

Bio digester

Enriched compost

Agroforestry

Soft / Hard / Green Adaptation in the value chain

	Planned Adaptation	Autonomous Adaptation
Hard	• Improved roadways • Improved Communication Infrastructure	• Improved food processing equipment • grain storage facilities • Water harvesting /irrigation
Green	• Restoration of mangroves • Drought- and saline-tolerant rice varieties • Floating Fields • Ecologically-based rodent management	• Sustainable land management • Water retention measures (mulching, zai farming) • Biological pest control
Soft	• Agro-meteorological learning • Credit and weather Insurances for Farmers • Better education and information of farmers	• Farmer-to-consumer direct marketing • Improve Cropping Patterns and Varieties • Better utilization of short season

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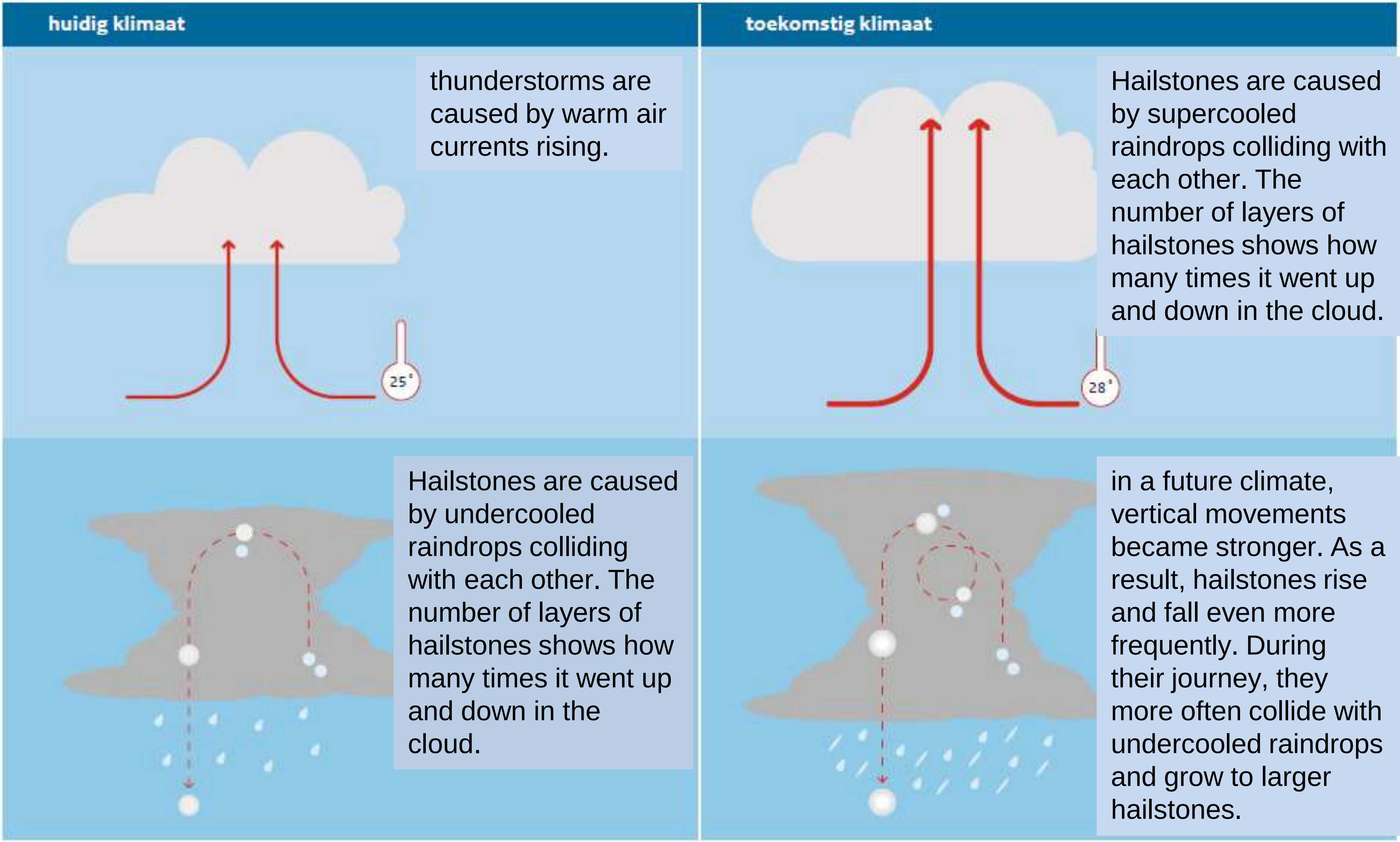
Weather extremes by higher temperatures



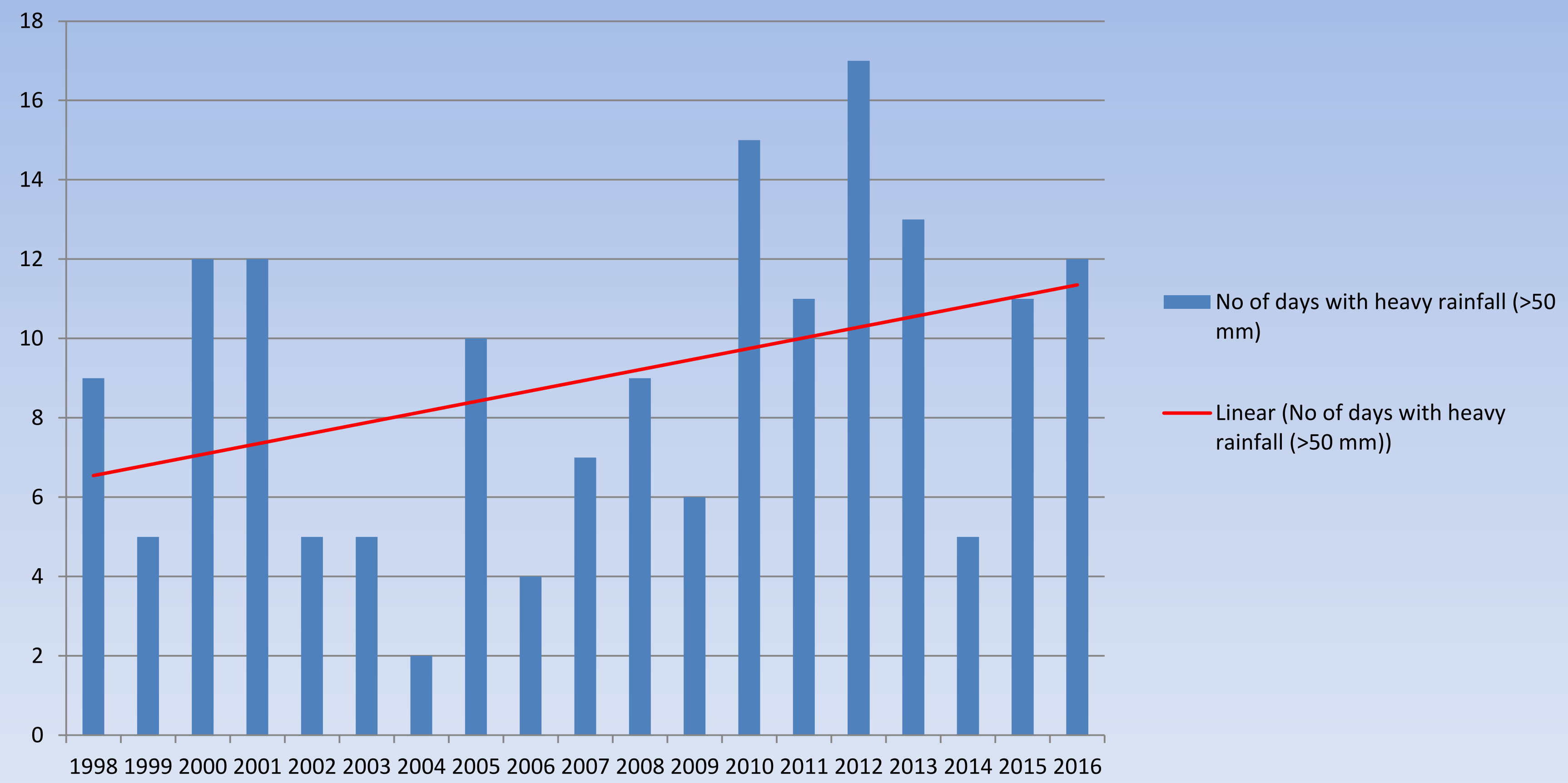
thunderstorms are caused by warm air currents rising.

Hailstones are caused by supercooled raindrops colliding with each other. The number of layers of hailstones shows how many times it went up and down in the cloud.

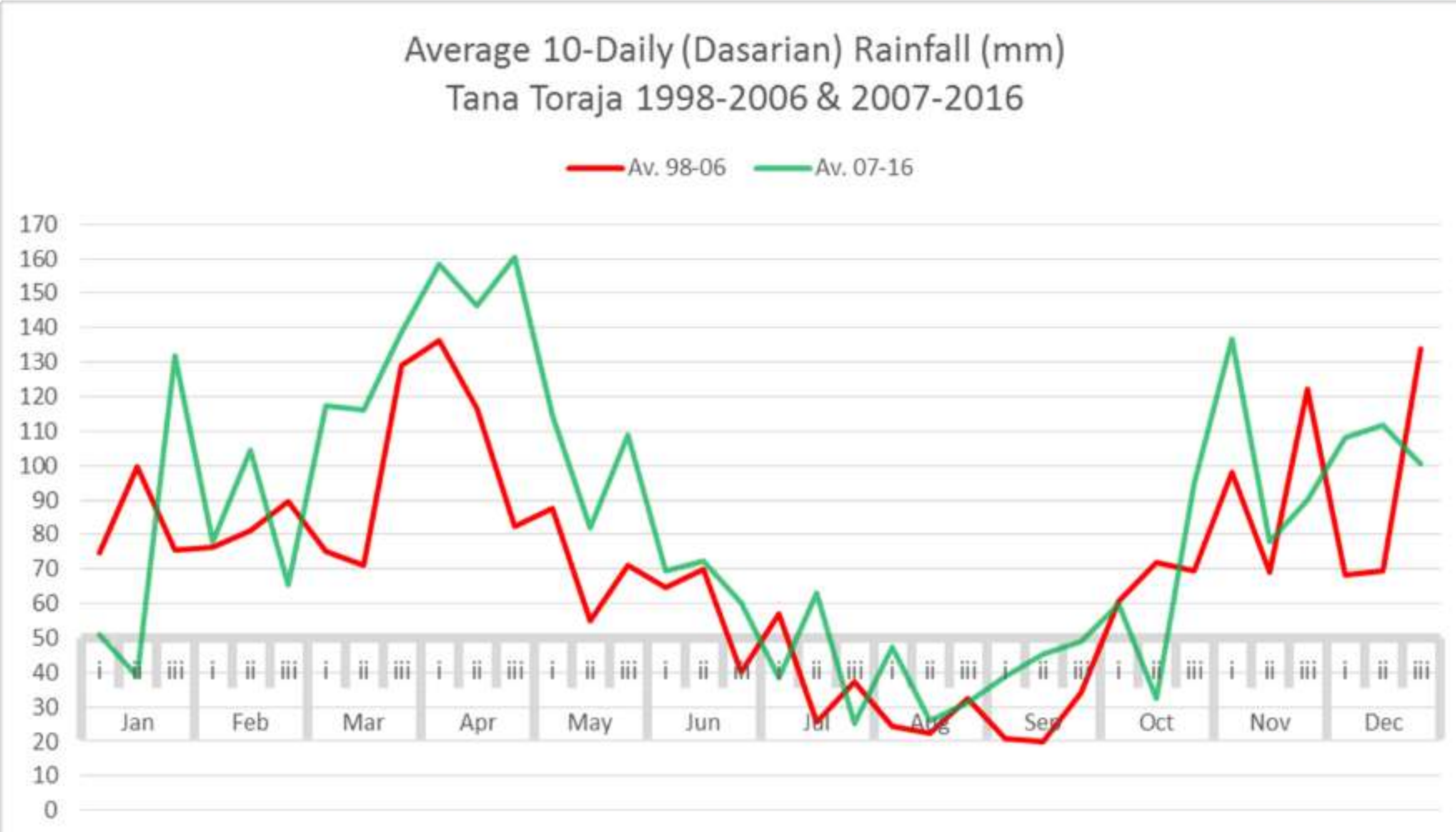
Hailstones are caused by undercooled raindrops colliding with each other. The number of layers of hailstones shows how many times it went up and down in the cloud.

in a future climate, vertical movements became stronger. As a result, hailstones rise and fall even more frequently. During their journey, they more often collide with undercooled raindrops and grow to larger hailstones.

No of days with heavy rainfall (>50 mm)

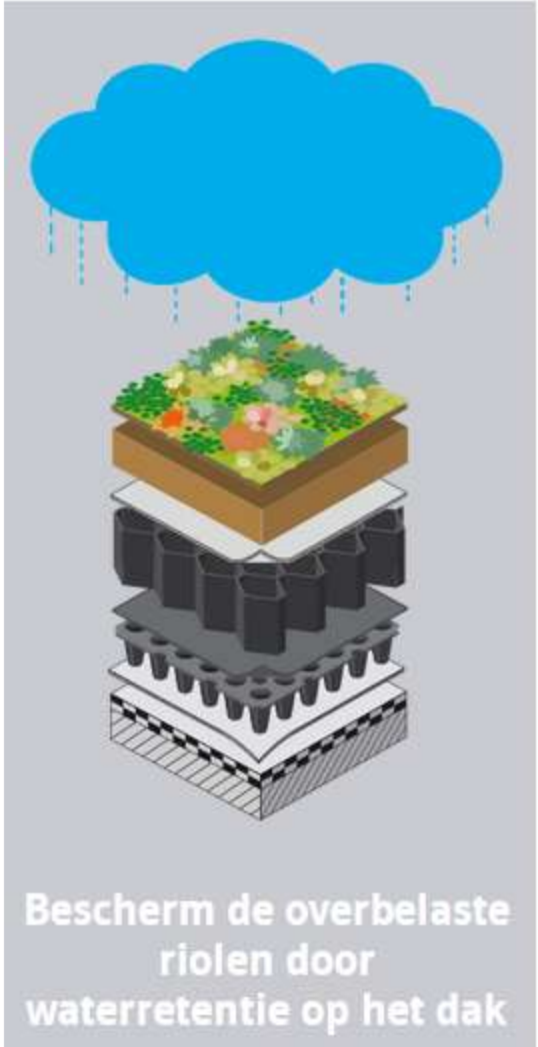


©analysed from BMKG data



Average 10-Daily (Dasarian) Rainfall (mm)
Tana Toraja 1998-2006 & 2007-2016
Av. 98-06
Av. 07-16
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Amsterdam Rainproof wil
regenwater benutten.



© Amsterdam Rainproof: elke druppel telt

Soft / Hard / Green Adaptation in the value chain

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Hard	• Improved roadways • Improved Communication Infrastructure	• Improved food processing equipment • grain storage facilities • Water harvesting /irrigation
Green	• Restoration of mangroves • Drought- and saline-tolerant rice varieties • **Floating Fields, SRI** • Ecologically-based rodent management	• Sustainable land management • Water retention measures (mulching, zai farming) • Biological pest control
Soft	• Agro-meteorological learning • Credit and weather Insurances for Farmers • Better education and information of farmers	• Farmer-to-consumer direct marketing/contract farming • Improve Cropping Patterns and Varieties • Better utilization of short season

Floating Fields

Description:

- organic fibres, water hyacinth, rice straw, azolla, coconut husk, bamboo or old rope (2x5m)
- **Crops that can be produced**: rice, leafy vegetables, okra, gourd, eggplant, pumpkins and onions
- Use as compost once decayed (5 years lifespan)

Benefits:

- Use of floodprone areas for production

Challenges:

- Investment, water management, rats

Sources:

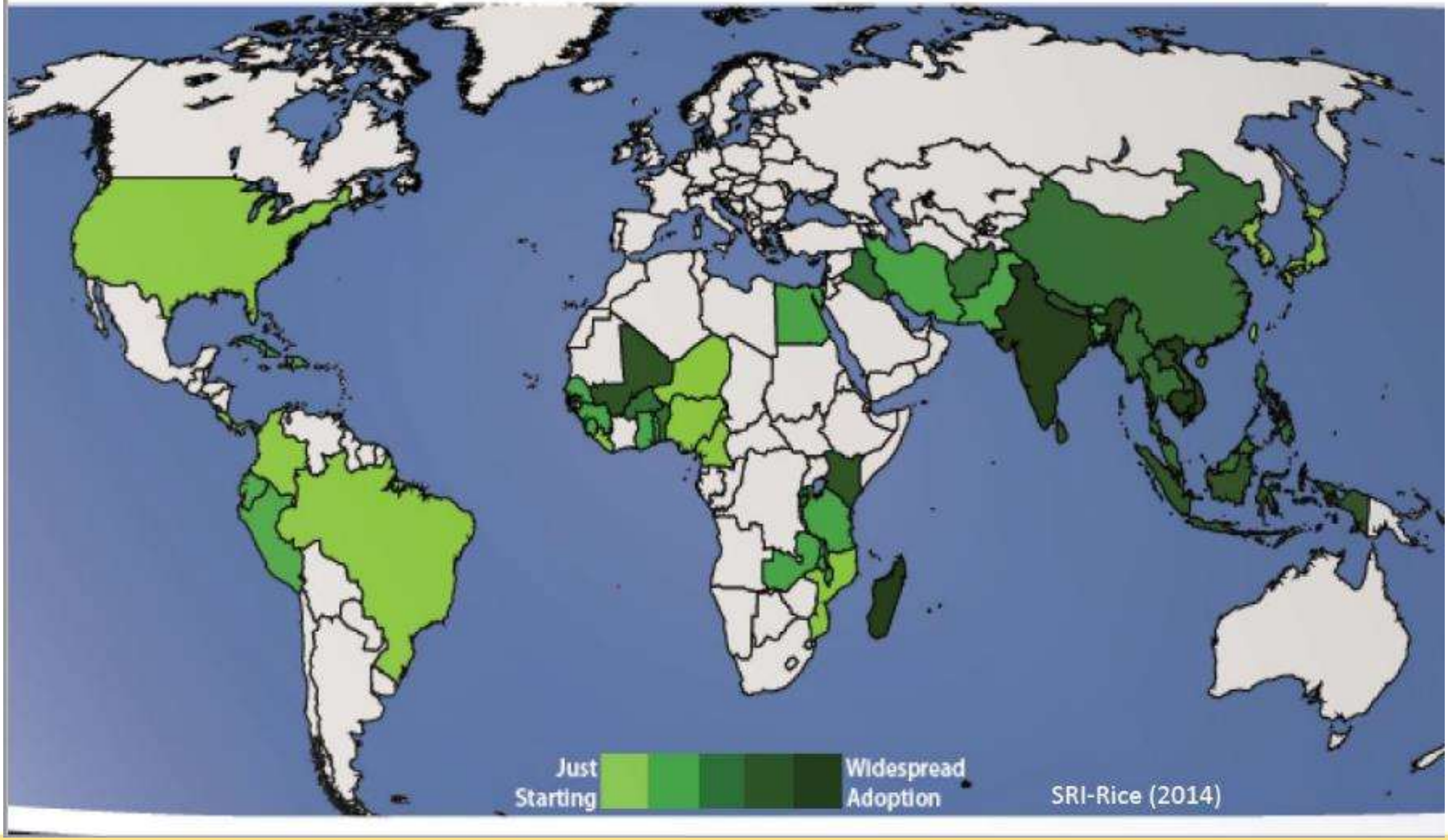
- IPPHTI: Floating fields in Pangandaran
- Practical Action Bangladesh

Building Rafts (IPPHTI Kustiwa)

Duck, Rat & Animal Protection

Spread and Adoption of SRI

More than 10 million farmers benefit from SRI methods in 54 countries (end of 2013)



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Ecologically-based rodent management

Description:

- Synchrony of cropping
- One trap-barrier system (TBS) with a lure crop planted three weeks early (20m x 20m)

© Singleton 2014

Benefits:

- Study revealed strong cost-benefit ratio of 25:1 on average
- Environmental effects by decreased use of toxic rodenticides
- Cohesion of farmers
- Health benefits

Challenges:

- Synchrony of cropping; landscape level approach beyond farm boundaries

Source:

- Singleton et al. 2004

Ecologically-based rodent management

Table 1. Summary of the impact of ecologically-based rodent management (EBRM) on crop yields ar
rice cropping systems in West Java, Indonesia, and the Red River Delta, Vietnam.

Impact	Country	Percentage (and number) of farmers adopting action			
		Before EBRM		In final year of EBRM	
		Control	Treatment	Control	Treatment
Management actions					
Rodenticide use	Indonesia	98 (60)	95 (60)	88 (50)	46 (50)
	Vietnam	77 (60)	85 (60)	50 (120)	19 (120)
Oil plus endosulphan	Indonesia	70 (60)	80 (60)	100 (50)	52 (50)
Crop yields	Indonesia[1]				
	Vietnam[2]				

[1] For six cropping seasons over 4 years with two replicates per treatment. For details see Jacob *et al.*,

[2] For six cropping seasons over 3 years (post-treatment only) with two replicates per treatment. For

Source: Singleton 2014

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Agrometeorological learning in Indonesia

Description:

- In Climate Field Schools (on a weekly basis) or Climate Science Shops with rainfall observers or farmer researchers: Climate diaries and season planning

Benefits:

- After 3 months farmers know how to quantify rainfall and temperature and not give only qualitative assessments

Challenges:

- Location of rainfall gauge, timing of measurement, stick to fix gauge, documentation

Source:

- Winarto et al 2016, IPPHTI/Kustiwa Adinata

Figure 5. Field observations by IPPHTI

STRATEGY: WHAT WE LEARNED?

WHAT ARE THE INDICATORS OF:
- Rain will start to fall?
- Rainy season will soon arrive?

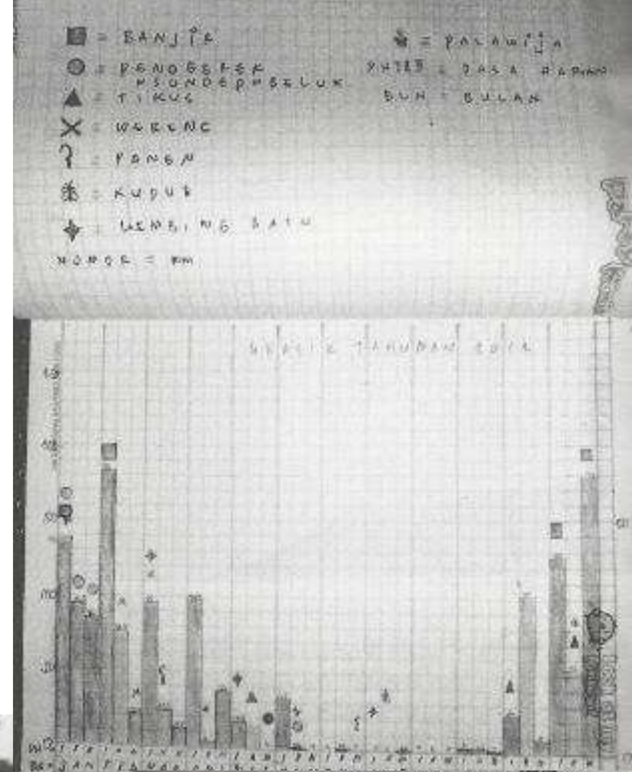
HOW MUCH RAINFALL PER MONTH? PER YEAR? (ml)

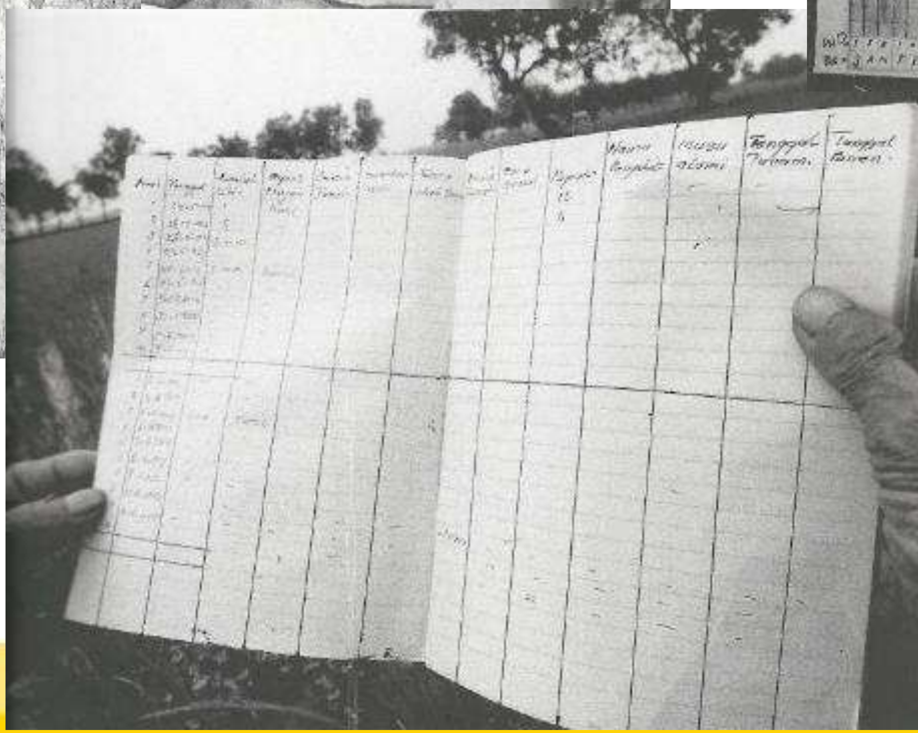
WHEN DO FLOODS OCCURED AND HOW MANY PER YEAR?
WHEN DOES DROUGHT HAPPENED?

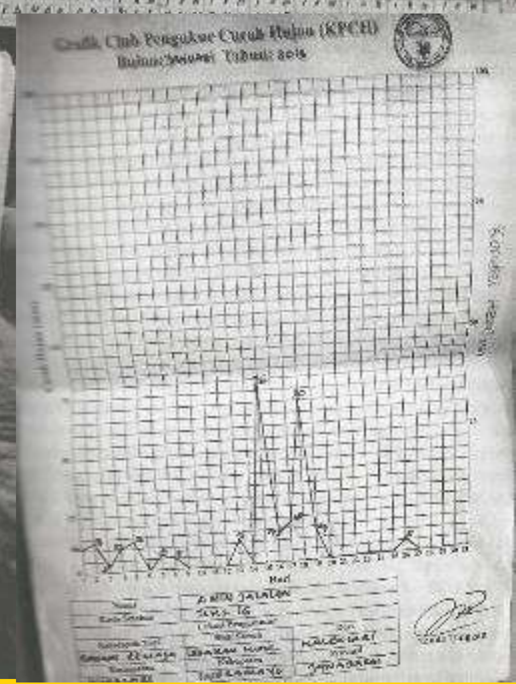
WHAT KIND OF PEST AND DISEASE THAT USUALLY OCCURS IN RAINY SEASON AND DRY SEASON?

ETC

Source: Presentation prepared for the regional symposium in Asia and the Pacific by Masroni Abdul Wakid, Nuasantara Farmer's Movement


= BANJIR
= TIKUS
= WERENG
= PANEN




Grafik Club Pengukur Curah Hujan (KPCH)

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Traditional and new (ecological) knowledge sharing

Description:

- Farmer groups hand down knowledge, practices through generations, more cohesion = more exchange; more diverse groups = more innovation

Benefits:

- Traditional and local practices are the main asset in remote rural areas. Fortunately, the local practices are responsive, dynamic and highly diverse; e.g. polyculture (crop rotation and intercropping).

Challenges:

- Should be more frequently merged with scientific knowledge

Source:

- Tengö et al 2004

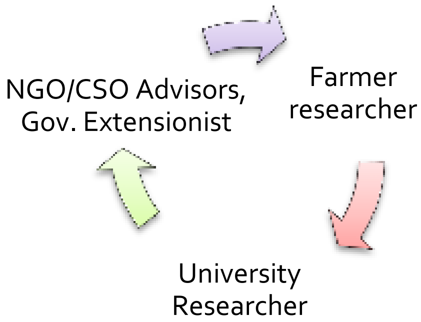
Effect of *Aegle marmelos* leaf extracts (5% water extract)

Buah Mojo (Aegle marmelos)
Bael fruit

- Mortality (%) after treatment: (24HAT) 32 % (48HAT) 50 % (72HAT) 76 % (96HAT) 74 % control: 0,0,2,4%
- hatching inhibition rate 70% over control
- Oviposition deterrence 55% over control

Source: Murasing et al (2017)

Researcher from UNHAS pass on knowledge to farmers



Topping Caramel Bhut Jolokia (C. Chinense)

Topping chili pepper plants for higher yield

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Biological post-harvest treatment

Description:

- Water bath at 50°C to treat French beans

Benefits:

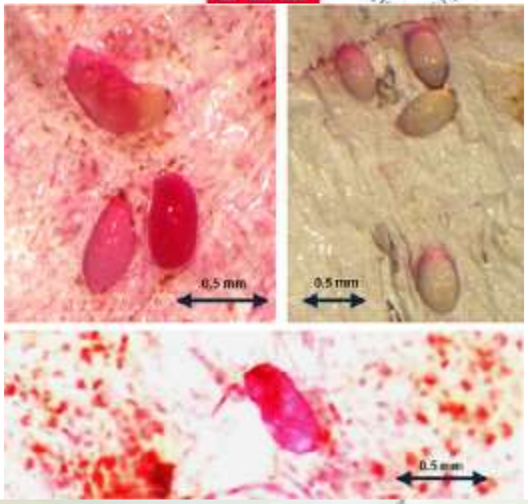
- Warm water treatments (15-5 min) have the potential to be used as a simple, non-chemical way to deactivate trips eggs (egg mortality rate of 100%)
- Bean Quality based on surface investigation was not negatively affected by the treatment

Challenges:

- Farmers need water and heat it up to 50°C

Source:

Speckhahn at icipe 2016



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Rainwater collection in Kenya and Uganda

Bob rainwater collection bags (1400 l) a trademark product developed by Relief International, help communities in collecting enough rainwater for domestic use as well as for gardening, low-cost (20-50 US$)

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Livelihood and climate trade-offs in Kenyan peri-urban vegetable production

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ARTICLE INFO

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Nitrous oxide emission intensity
Nitrous oxide emission
Soil fertility
Kenya

ABSTRACT

Trade-offs between livelihood and environmental outcomes due to agricultural intensification in sub-Saharan Africa are uncertain. The present study measured yield, economic performance and nitrous oxide (N_2O) emissions in African indigenous vegetable (AIV) production to investigate the optimal nutrient management strategies. In order to achieve this, an on-farm experiment with four treatments – (1) 40 kg N/ha diammonium phosphate (DAP), (2) 10 t/ha cattle manure, (3) 20 kg N/ha DAP and 5 t/ha cattle manure and (4) a no-N input control – was performed for two seasons. Yields and N_2O emissions were directly measured with subsampling

Integrated soil fertility management

Description:

- Randomized block design with four different fertilizer treatments and N_2O emission measurement (gas chamber system)

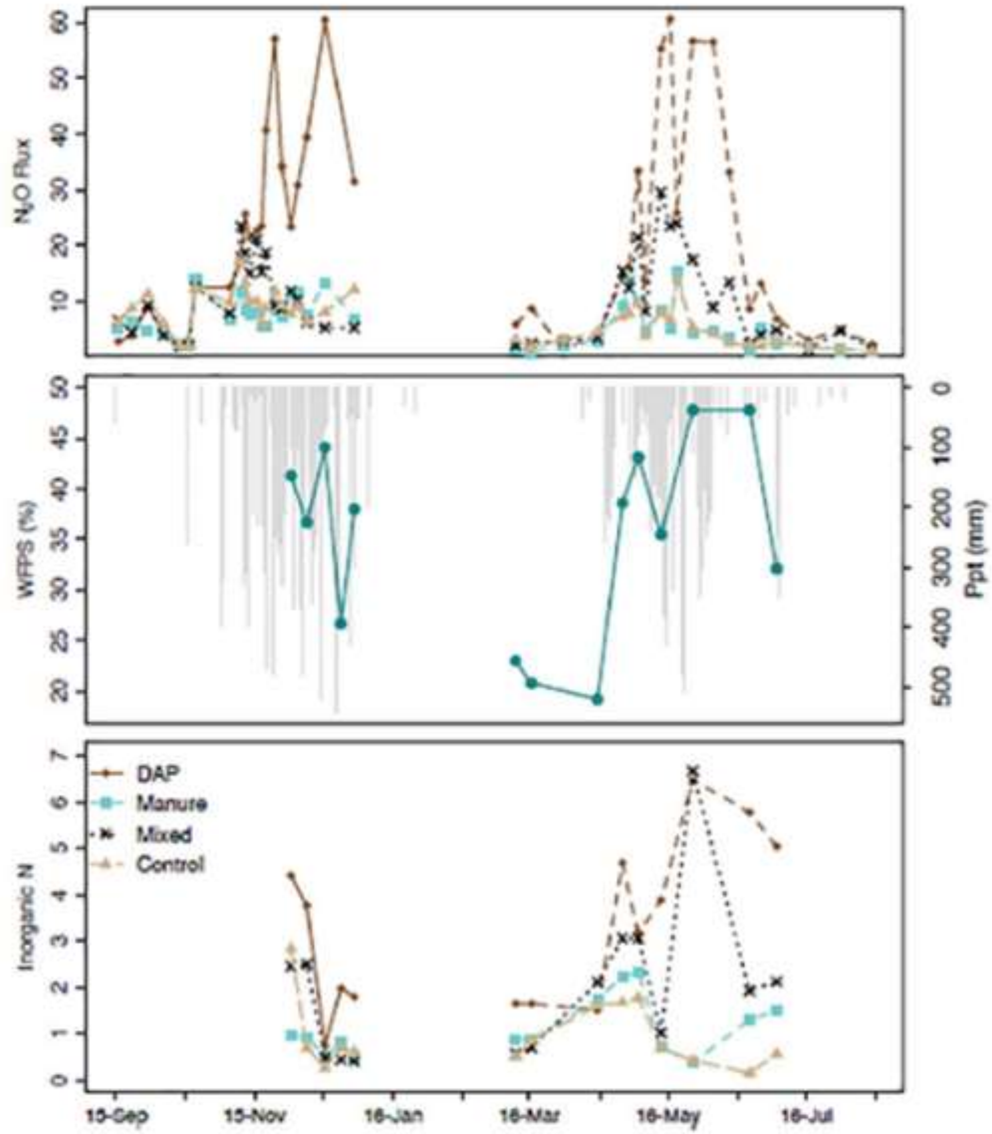
Benefits:

- Optimal livelihood-environmental trade-off: mixed DAP/manure

Challenges:

- Convince farmers to apply a fertilizer mix; develop new policies and programmes in Kenya

Source: Kurgat2017



Integrated soil fertility management

Description:

- Randomized block design with four different fertilizer treatments and N_2O emission measurement (gas chamber system)

Nitrous oxide emission intensity (N_2OI) and nitrous oxide emission economic intensity (N_2OEI) for each treatment.

Treatment	N_2OI (g N_2O-N kg^{-1})	N_2OEI (g N_2O-N USD^{-1})
DAP	0.2 ± 0.1ab	1.1 ± 0.3a
Manure	0.1 ± 0.0a	1.0 ± 0.3a
Mixed	0.1 ± 0.0a	0.6 ± 0.0a
Control	0.4 ± 0.3b	3.3 ± 0.6b

Data are the mean of three replicates with standard deviations. Lowercase letters, within columns, indicate significant differences at $p < 0.5$. The exchange rate was 1 USD = Ksh 103.85 on 2 January 2017.

Source: Kurgat 2017

Azolla-Rice-Duck-Fish System

Description:

- Rice plants 20kg/ha, compost, azolla 2 t/ha, 400 ducks, 5000 tilapia

Benefits:

- **Which system gives highest rice yields?**
- **Which system has highest costs?**
- **And highest profit?**

Challenges:

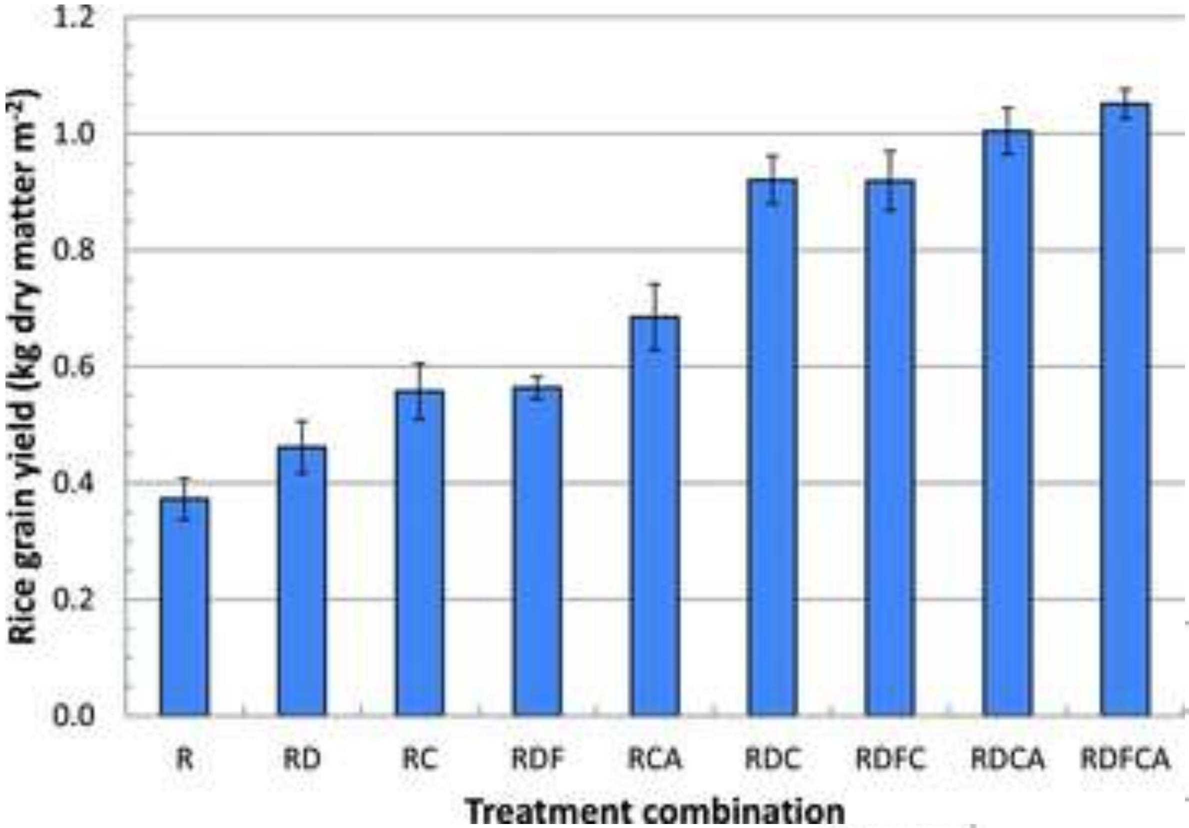
- Investment costs, community-based system

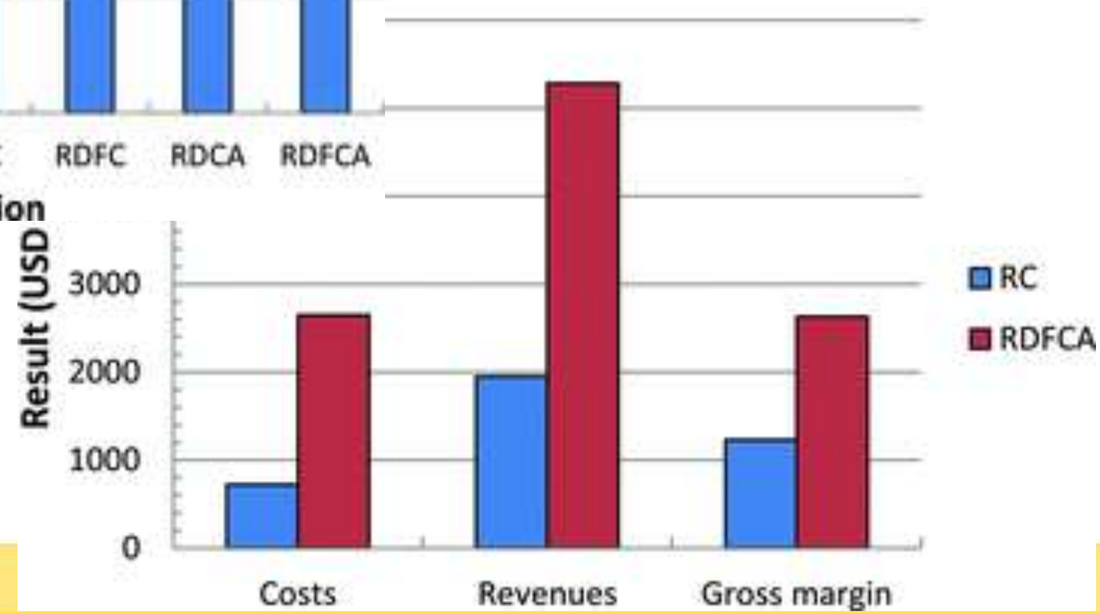
Source:

- Khumairoh et al 2012

© Azolla propagation in Ciganjeng village, Kustiwa Adinata (IPPHTI) and Prof Tualar (UNPAD), Foto: Stöber 2017

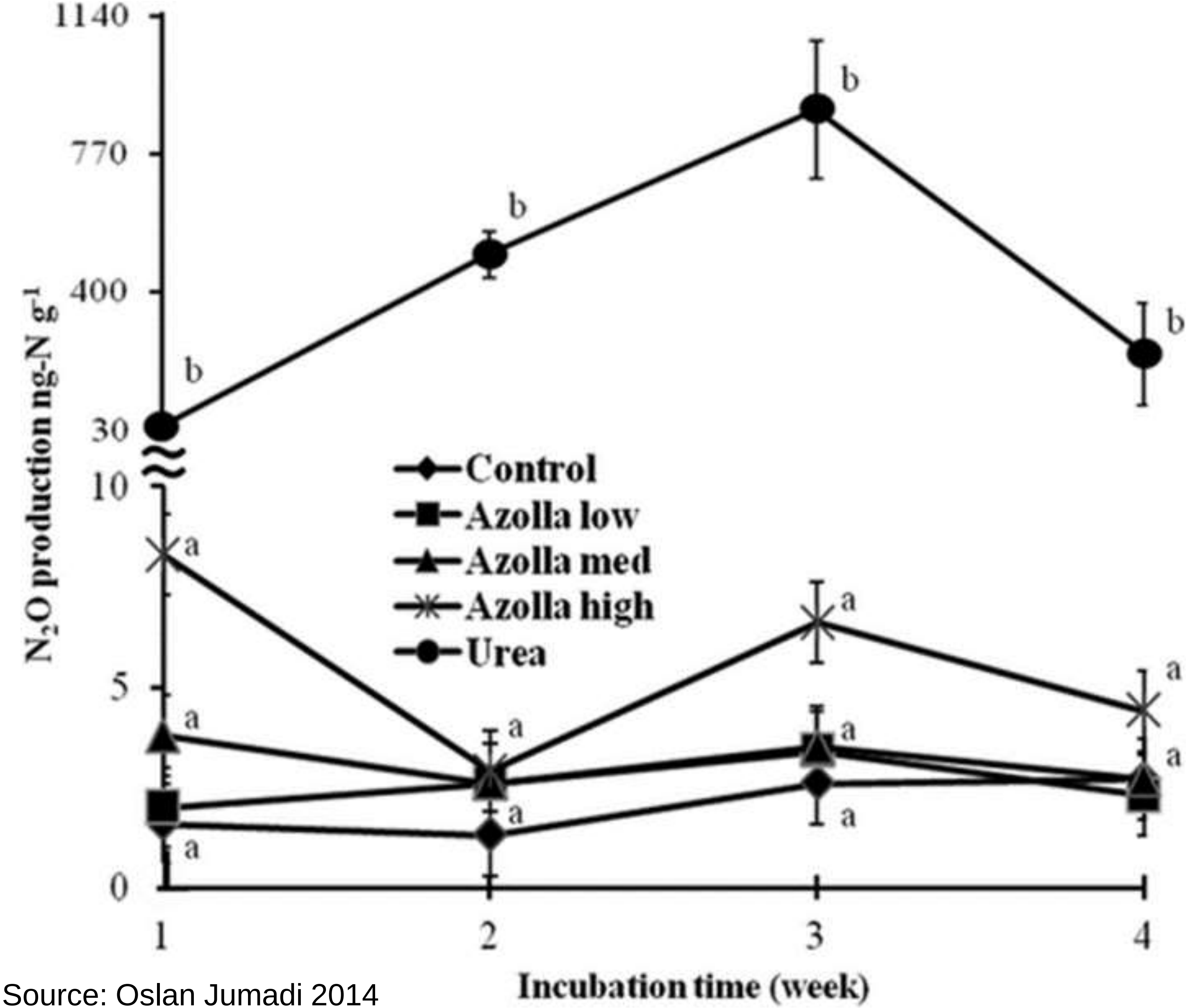
Azolla-Rice-Duck-Fish System





© Khumairoh et al 2012

© Stöber: Azolla Pond, Pak Ujang, Village Pamotan, Java Barat



Source: Oslan Jumadi 2014

Soft / Hard / Green Adaptation in the value chain

	Planned Adaptation	Autonomous Adaptation
Hard	• Improved roadways • Improved Communication Infrastructure	• Improved food processing equipment • grain storage facilities • Water harvesting /irrigation
Green	• Restoration of mangroves • Drought- and saline-tolerant rice varieties • Floating Fields • Ecologically-based rodent management	• Sustainable land management • **Water retention measures (biochar, mulching, zai farming, agroforestry**) • Biological pest control
Soft	• Agro-meteorological learning • Credit and weather Insurances for Farmers • Better education and information of farmers	• Farmer-to-consumer direct marketing • Improve Cropping Patterns and Varieties • Better utilization of short season

Biochar from risk husk as organic fertilizer

© WOCAT 2014

© Westernfarmpress

Description:

- Rice husks, unfilled grains, leaves are pyrolised and used as a soil amendment in rice seed beds and vegetable gardens.
- Terra Preta Latin America , Pol Pot Regime Cambodia

Benefits:

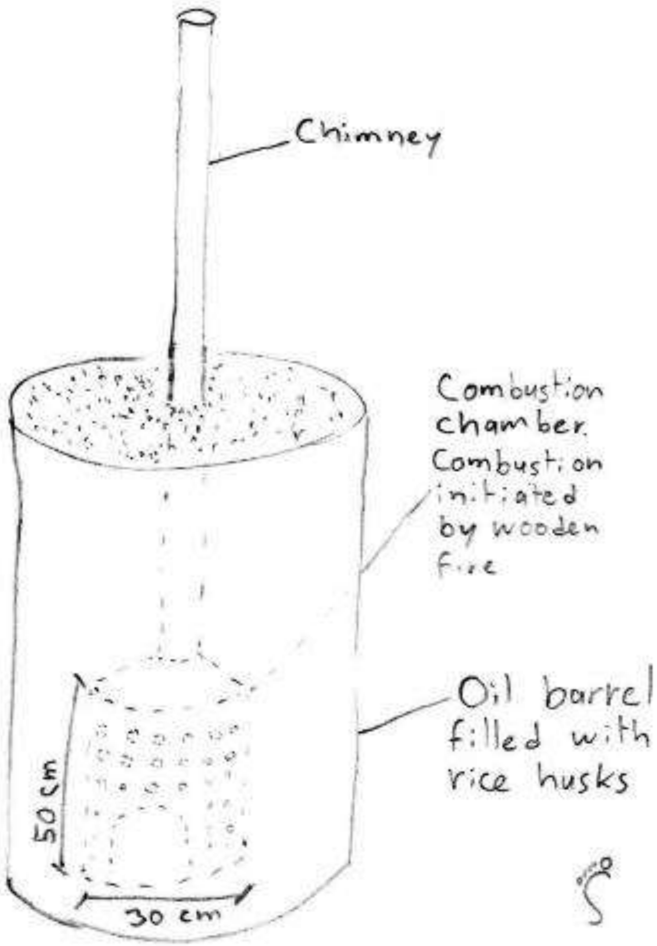
- buffers and raises pH, esp. sandy soils
- Enhance soil structure, water holding capacity, reduced leaching of nutrients, slow nutrient release behaviours
- Less insect damage
- Yield increase compared to liquid fert. only

Challenges:

- The energy produced during the pyrolysis is wasted - can be used to power engines
- Increased workload to produce and biochar
- Substrates not always abundant

Source: WOCAT 2014

Biochar production



© WOCAT 2014 Cambodia

© re:char Kenya

Biochar and wood vinegar : liquid smoke 2% concentrate

Liquid smoke very rich in macro and micronutrients (Mangan, zinc,..)

© IPPHTI, Kusitwa Adinata 2018

Mecanized zaï holes and improved compost

Description:

- Small planting pits 20-30 cm in width, 10-20 cm deep and spaced 60-80 cm o 10,000/ha; dug into hardpan or degraded soils; filled with compost

Benefits:

- increase production by about 500 %
- manure attracts termites under the pit and termites transform hardpan into soil

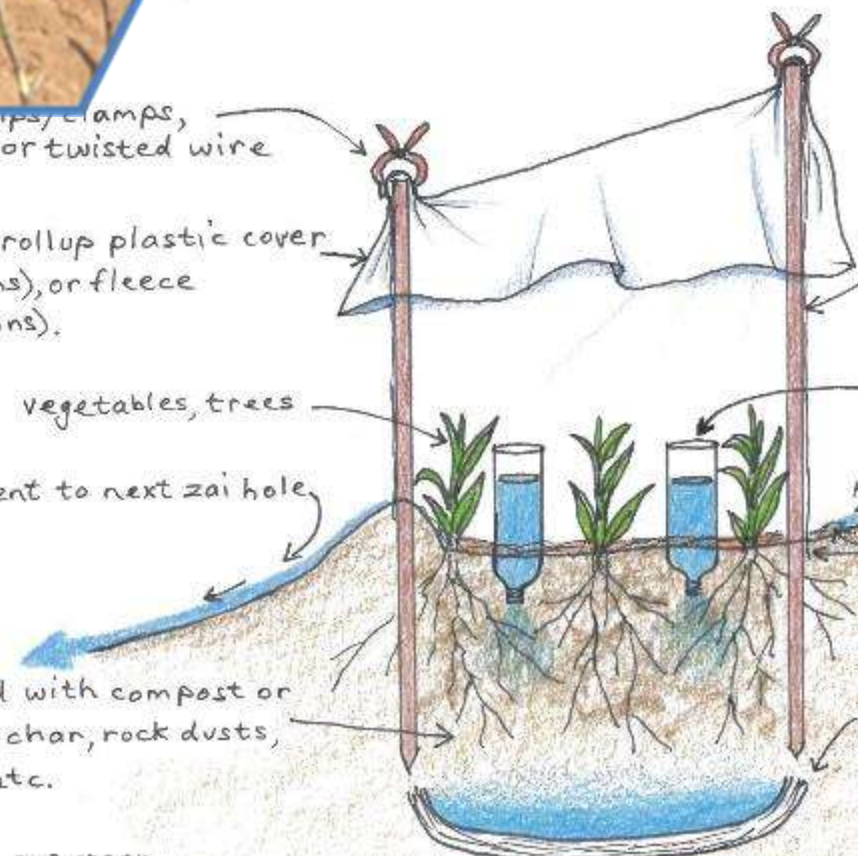
Challenges:

- 300 to 450 hours/ha labour intensive plus 250 hours for compost
- Size and position of the pits is integral to their success

Source:

Danjuma et al 2015

©http://sustainabilityquest.blogspot.com/2011/12/northeast-india-sri-to-zai-holes.html


De luxe zai hole
r long rectangular bed. Larger designs may need a taller
stake and more bottles or cans for watering.
amps,
or twisted wire
Removable or rollup plastic cover (cold conditions), or fleece (hot conditions).
Plastic (clear polythene) or fleece walls attached with staples or drawing pins to stakes.
vegetables, trees
Plastic bottles or cans or drip irrigation. Could use human urine as a liquid fertilizer.
water catchment to next zai hole
H2O
mulch of partly decomposed compost – gives off CO2
soil enriched with compost or manure, biochar, rock dusts, burnt bone etc.
Water barrier. Around 20 sheets of newspaper – holds water, but allows slow drainage. Depth ·2– ·8 metres according to likely root depth. (dry areas or well-drained soils)
David Clode 30 Sept 2011

Agroforestry

Description:

- Integrate trees and shrubs with crops and/or livestock

Benefits:

- reduces soil and water erosion
- improves water management
- reduces crop output variability

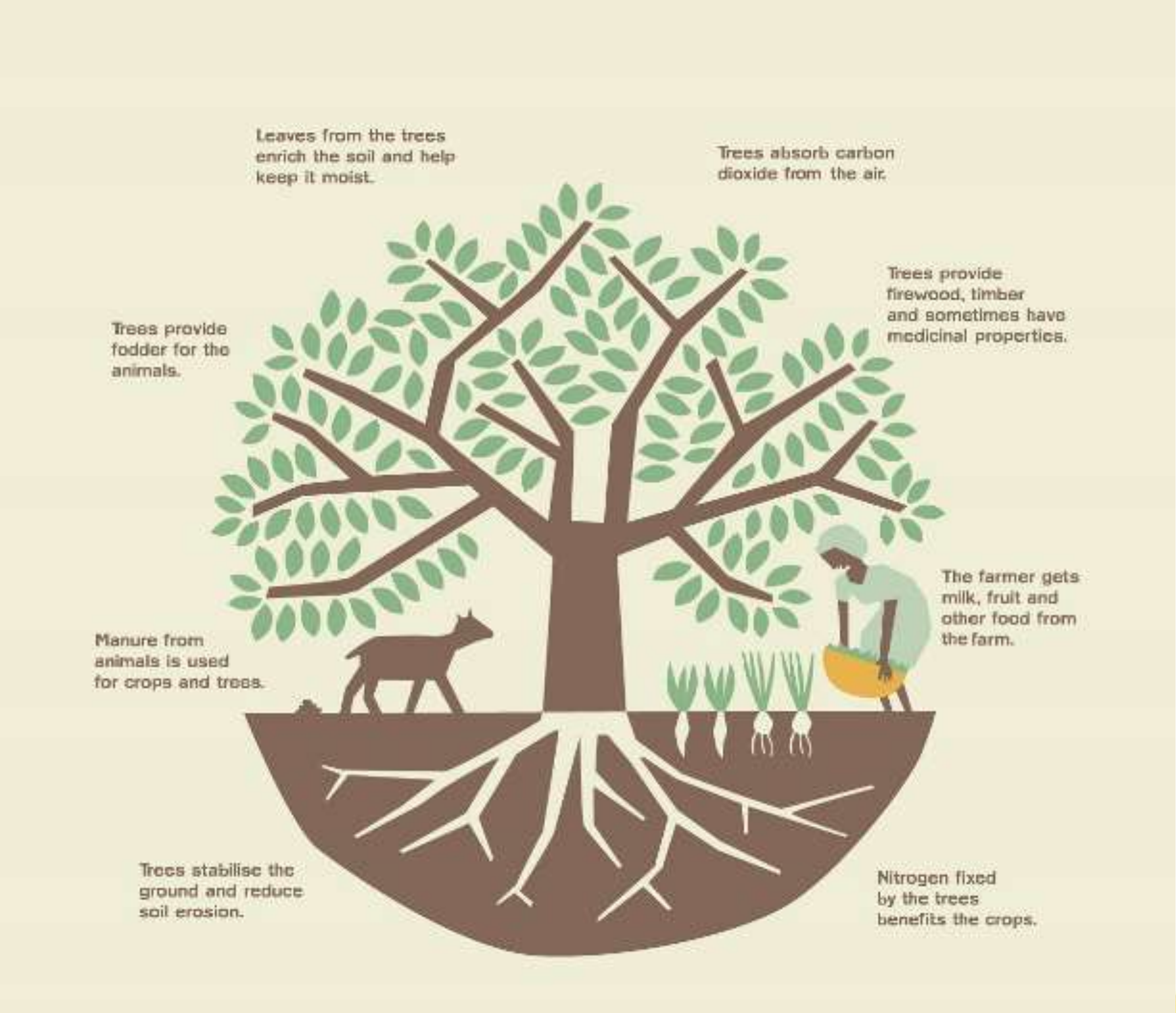
Challenges:

- availability of suitable tree seeds and seedlings and costs of seedlings
- additional labour/investment needed to supply trees and bushes with water and care until roots are firmly grounded

Source: McCarthy 2011

© greentumble

A rule of thumb: Farmer requires at least 2 function from a tree



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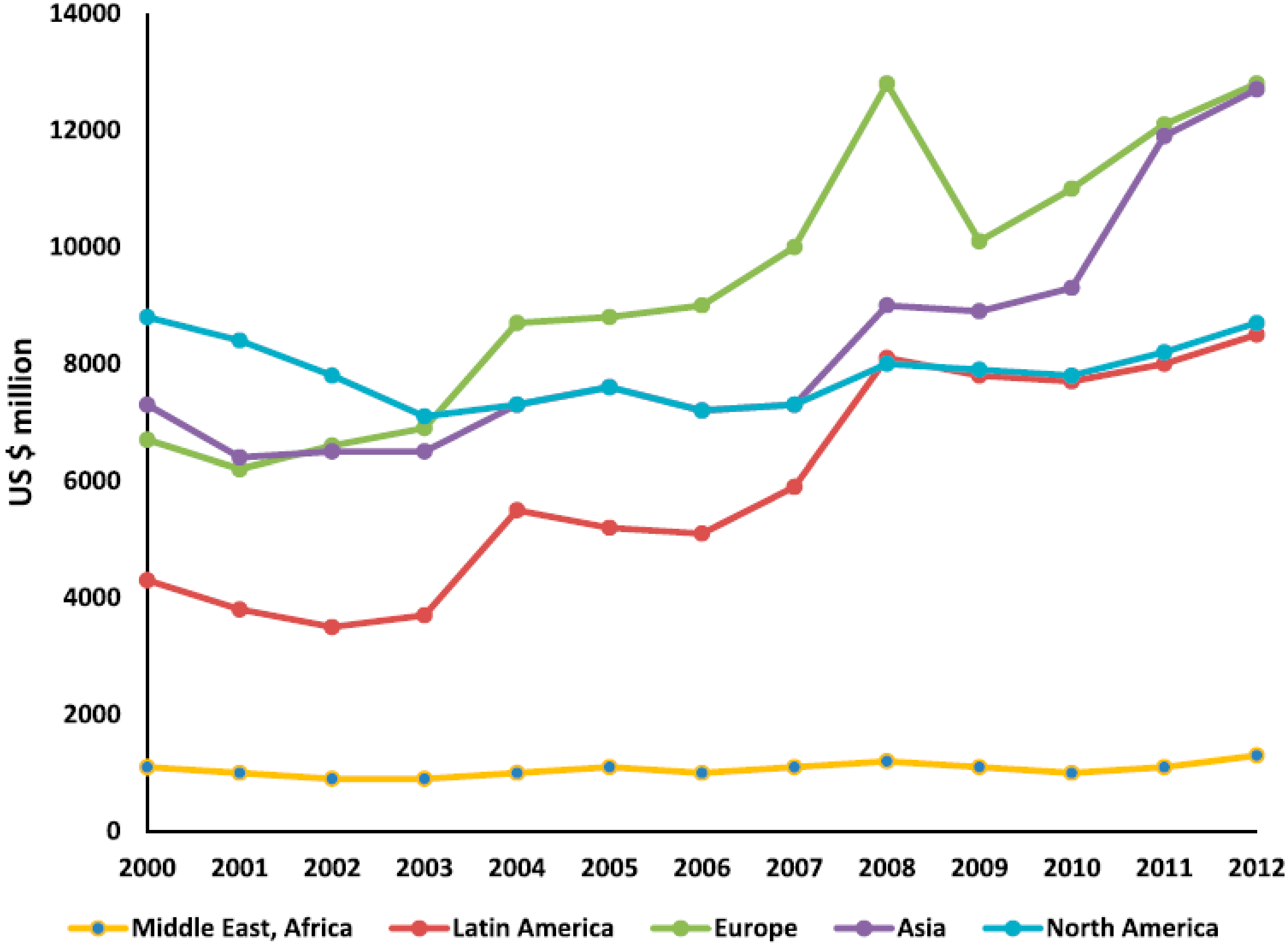
Global pesticides sales on the rise



Source: Lamichhane et al. 2016

Innovative cropping systems

- Biological
- Cultural
- Mechanical

Source: Lamichhane 2016

Innovative cropping practices	References
Biological:	
Biocontrol agents	Ellison et al. 2008; Furlong et al. 2008; Tanner et al. 2015
Cultural:	
Crop rotations	Vasileiadis et al. 2011,
Intercropping	Damicone et al. 2007; Baidoo et al. 2012;
Alternative tillage	Kumar et al. 2013
Companion planting	George et al. 2013
Cultivar mixtures	Raboin et al. 2012; Tooker and Frank 2012
Cover crops	Motisi et al. 2009
Mulching	Farooq et al. 2011
Biofumigation	Motisi et al. 2009
Buffer strips/Grass strips	Moreau et al. 2006,
Combination repellent and attractive species ("push-pull")	Cook et al. 2007, Hassanali et al. 2008
Planting hedges	Morandin et al. 2011
Plant defense elicitors	Thakur and Sohal 2013
False or stale seedbed	Boyd et al. 2006
Mechanical:	
Innovative mechanical weed control	Van Der Weide et al. 2008
Robotic weed control	Slaughter et al. 2008
Applications of unmanned aerial vehicles for weed management	Peña et al. 2013

Biological pest and diseases control in Chili

Description:

- Thrips a major sucking insect pests can reduce chili yields up to 50%, whiteflies and aphids major problem

Benefits:

- 50% reduction without sacrificing the level of production through FFS
- Whiteflies: maize as barrier plant, Trap crops (chil variety), repellent crops (lemon grass sereh) and attractant traps (methyl eugenol from basil and tea tee)

Challenges:

- Imidacloprid (neonicotinoid) often more effective

Source:

Mariyono 2013, Gosh 2014, Kardinan 2014, Amalia 2014, Friarini 2016

© Rahmansyah Dermawan, UNHAS

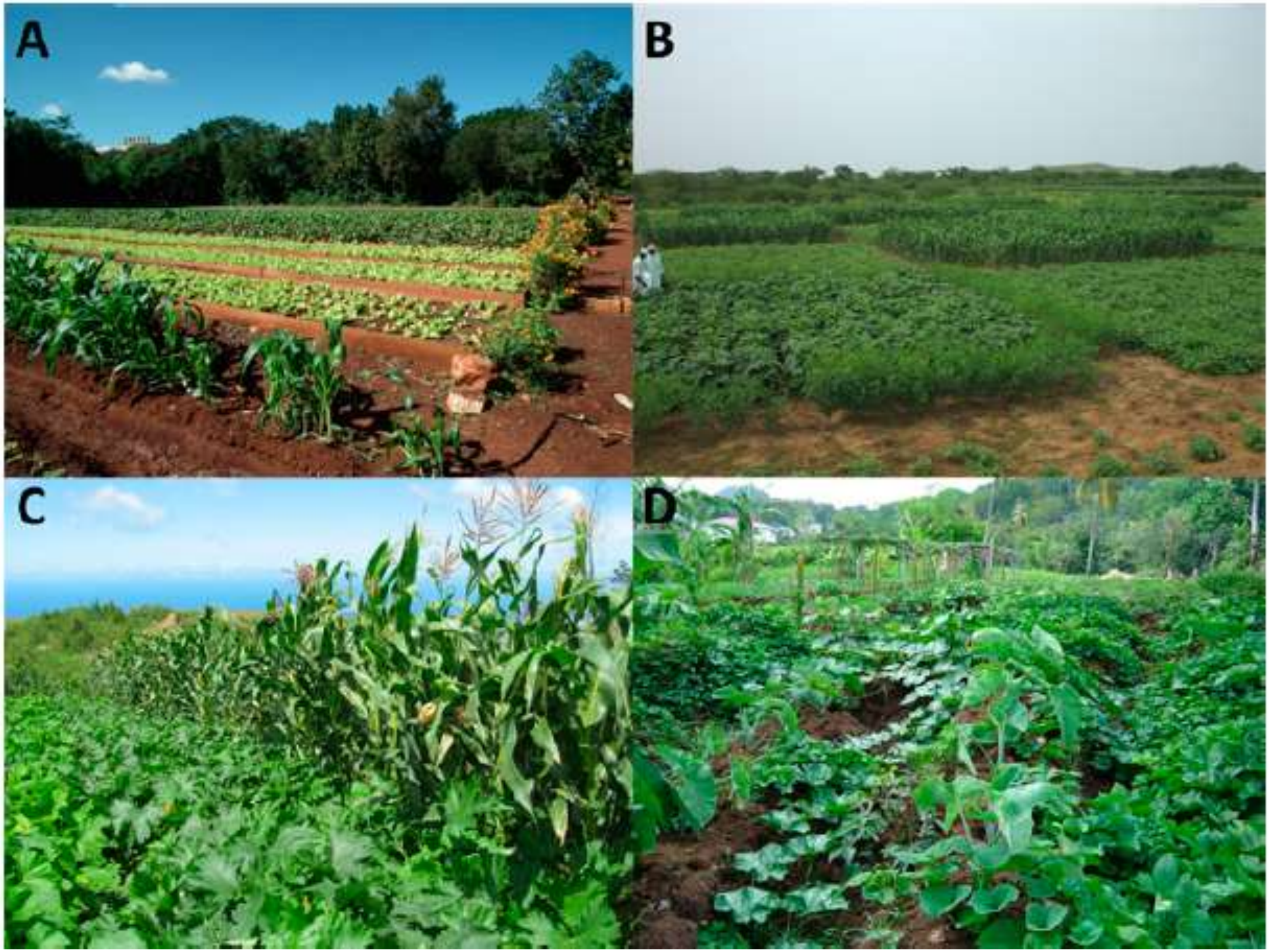
TABLE 3 Change in farmers' perceptions of the importance of pests, diseases and natural enemies on chili pepper

	Before FFS			After FFS		
Rank	Pests	Diseases	Natural enemies	Pests	Diseases	Natural enemies
1	Bugs	Curling leaves	Birds	Whiteflies	Curling leaves	Wasps and bees
2	Caterpillars	Decayed fruit	Dragonflies	Bugs	Fruit spoiled	Dragonflies
3	Fruit flies	Anthracnose	Ants	Caterpillars	Anthracnose	Spiders
4	Grasshoppers	Rotten root	Grasshoppers	Fruit flies	Spotted leaves	Coccinellid beetles
5	Curling leaves	Bacterial wilt	Spiders	Aphids	Gemini viruses	Grasshoppers

Note: Rank 1 stands for the most important pest/disease/n.e. and rank 5 stands for least important.

Source: Mariyono 2013

Barrier plants, mixed cropping in Europe



Apps for diagnosis of pests and diseases

PLANTIX IS A MOBILE CROP ADVISORY APP FOR FARMERS, EXTENSION WORKERS AND GARDENERS AROUND THE WORLD.

Plantix can diagnose plant diseases, pests and nutrient deficiencies affecting your crops.

Using just a simple smartphone picture, Plantix image recognition is able to detect more than 240 plant pests & diseases automatically.

Every picture improves Plantix image recognition. By uploading pictures, you can help farmers all over the world grow smart - start now!

Plantix puts you in touch with a large community for exchanging knowledge about topics like crop cultivation, disease control and best practices.

I recently downloaded your app. It's a great idea. It's like a portable lab.

Maharashtra, India


ICAR-National Bureau


Online Plant Clinic


Dr. M. Pratheepa

Rice Bug

Leptocorisa spp.

insect

In a Nutshell

- Rice bug causes the most damage during the filling of the grains
- They feed on the content of the developing grains
- They cause unfilled or empty grains and discoloration

Hosts:

- Rice

Symptoms

This pest causes the most damage during milking stage, that is the filling of the grains. Immature and adult rice bugs both feed on rice grains. Rice bugs suck out the contents of developing grains from pre-flowering spikelets to soft dough (endosperm) stage, therefore causing unfilled or empty grains, discoloration and erect panicles. Depending on the growth stage of the rice grain, the feeding can result in empty grains or small, shriveled, deformed grains with a spotty discoloration.Sometimes with an offensive smell.

Trigger

Rice bugs are found in all rice environments. Woodlands, extensive weedy areas near rice fields, wild grasses near canals, and staggered rice planting favors high population densities. More active when monsoonal rains begin. Warm weather, overcast skies, and frequent drizzles favor its population build-up. They are less active during the dry season.

Biological Control

Spray aromatic (like lemongrass) soap solution to expel the rice bug. Use "prahok" (local 'cheese' in Cambodia) near the field to attract the rice bug and kill it. Use a mosquito net in the early morning or late afternoon to remove the rice bug, crush it and put it in water then spray it to expel other rice bugs. Encourage biological control agents: Some wasps, grasshoppers and spiders attack rice bugs or rice bug eggs. Indiscriminate insecticide use disrupts biological control, resulting in pest resurgence.

Chemical Control

Always consider an integrated approach with preventive measures together with biological treatments if available. Use insecticides such as fipronil or abamectin depending on the application equipment available, cost of the insecticide, experience of the applicator, or presence of fish. The benefits of using an insecticide must be weighed against the risks to health and the environment

Preventive Measures

- Begin scouting the field daily at pre-flowering
- Remove other host plants such as crabgrass, goosegrass and beans
- Preserve beneficial insects by spraying less insecticide
- Applications of fertilizer and water encourage rice to grow and develop
- Synchronous planting also helps to reduce rice bug problems

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Consumer-producer direct marketing

Description:

- Direct marketing to consumer by selling at roadside
- Contracts with supermarkets, hospitals, restaurants

Benefits:

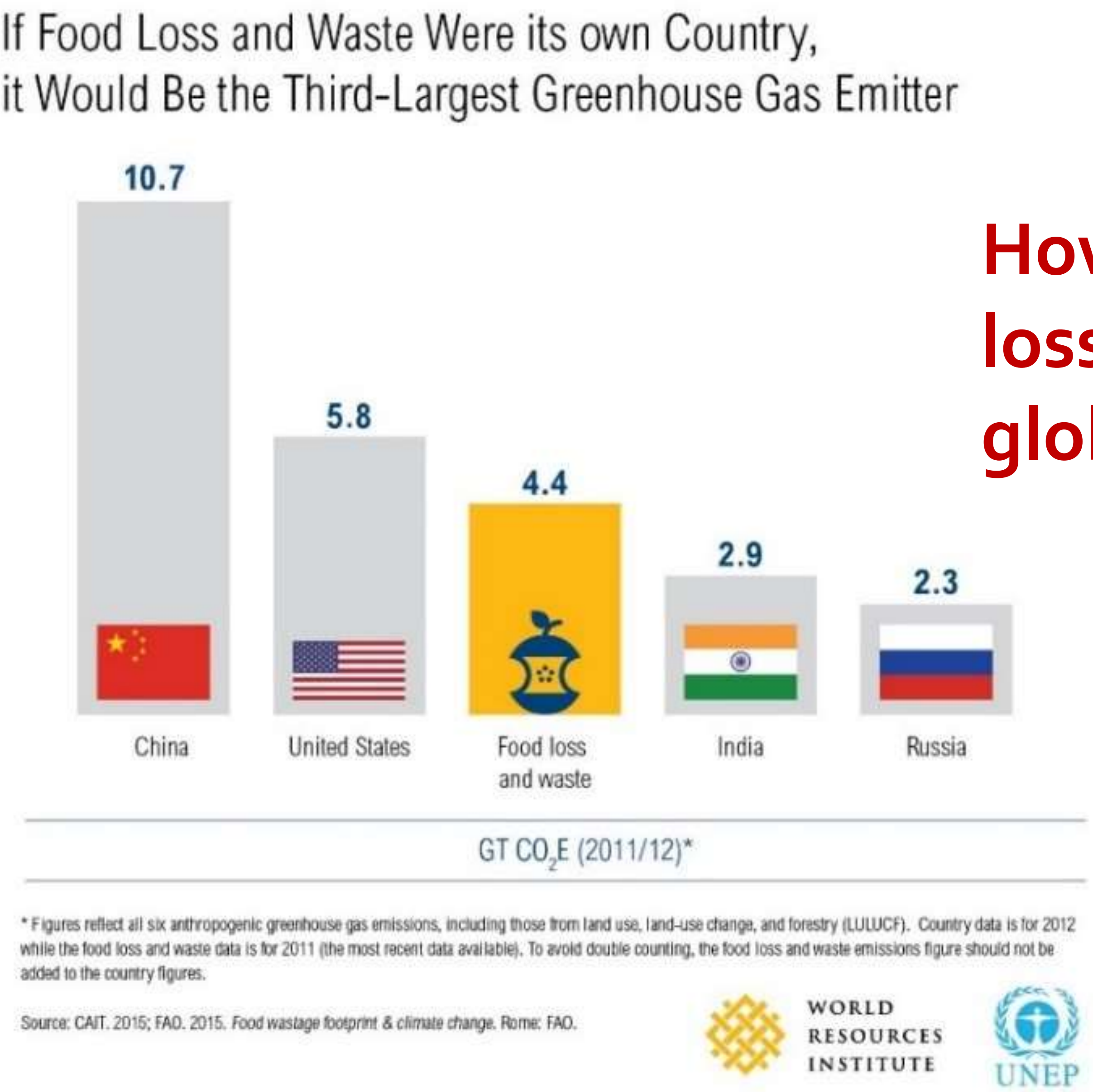
- Highly perishable goods can be directly sold through fair contracts
- Reduction of **post-harvest losses**

Challenges:

- Cancellation of orders
- Sale on Commission, up to 20% loss
- niche value chain, needs strong farmer groups to counterbalance bargaining power
- Supermarket keeps safety margin

Source:

- Mayr 2016



How much food loss and waste globally in %?

Sustainable value chain development

Input suppliers → **Farmer** → **Processor / Transporter** → **Trader** → **Consumer**

Production stage: (Input suppliers, Farmer)

- Optimize input use efficiency: economic benefits versus environmental trade-offs
- Improve productivity
- Reduce harvest losses
- Use of renewable energies and fuels

Post-farm stage: (Processor / Transporter, Trader)

- Improve energy efficiency
- Shorter transport
- Reduce waste and losses
- Use of renewable energies and fuels

Consumer stage: (Consumer)

- Dietary choices
- Healthy diets (meat consumption in Global North)
- Reduce waste and losses
- Use of renewable energies and fuels

Source: adapted from Mayr, Humboldt-Universitaet zu Berlin (2016)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Genetic Intensification

- Saline-tolerant varieties: Mendawak
- Flood Tolerant varieties: Inpari43
- Rice with reduced Methane emissions

Conclusion

- Climate change increases the intensity and frequency of weather events with impacts on agriculture
- Smallholders are important actors to be better integrated in the value chain
- Smallholders are requested to (ecologically) intensify
- Agrometeorological learning increase farmers capacity to adapt to climate change
- Diversification at all levels plays a major role in building climate-resilience of smalholders

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