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Resource use efficiency, produce quality, plant biodiversity and externalities in UPA systems of Africa and Asia: From a *status quo* analysis to effective policy recommendations

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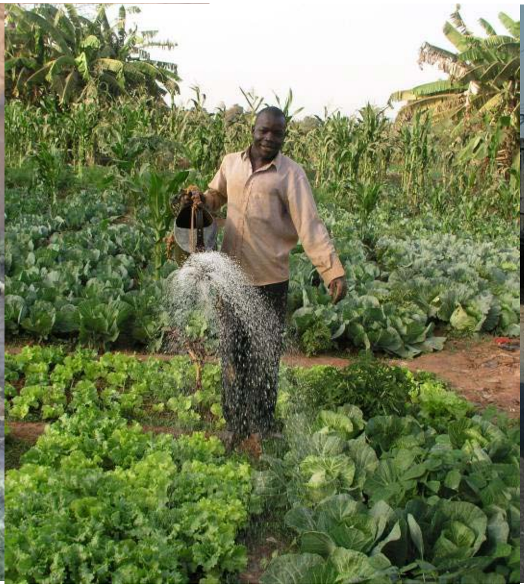
UPA – a widespread response to the food crisis


UPA – a widespread response to rural insecurity and war

Image source: own, afp. dpa

Extent of urban food production in Africa

City	Proportion of urban dwellers involved in UPA
Kano (Nigeria)	75
Ouagadougou (Burkina Faso)	36
Harare (Zimbabwe)	80
Nairobi (Kenya)	29
Mombasa (Kenya)	30
Dar-Es-Salaam (Tanzania)	44-70

Smith 2001, IDRC

Income effects of UPA along the marketing chain

Average income (US$) per week
(range reflects seasonal differences)

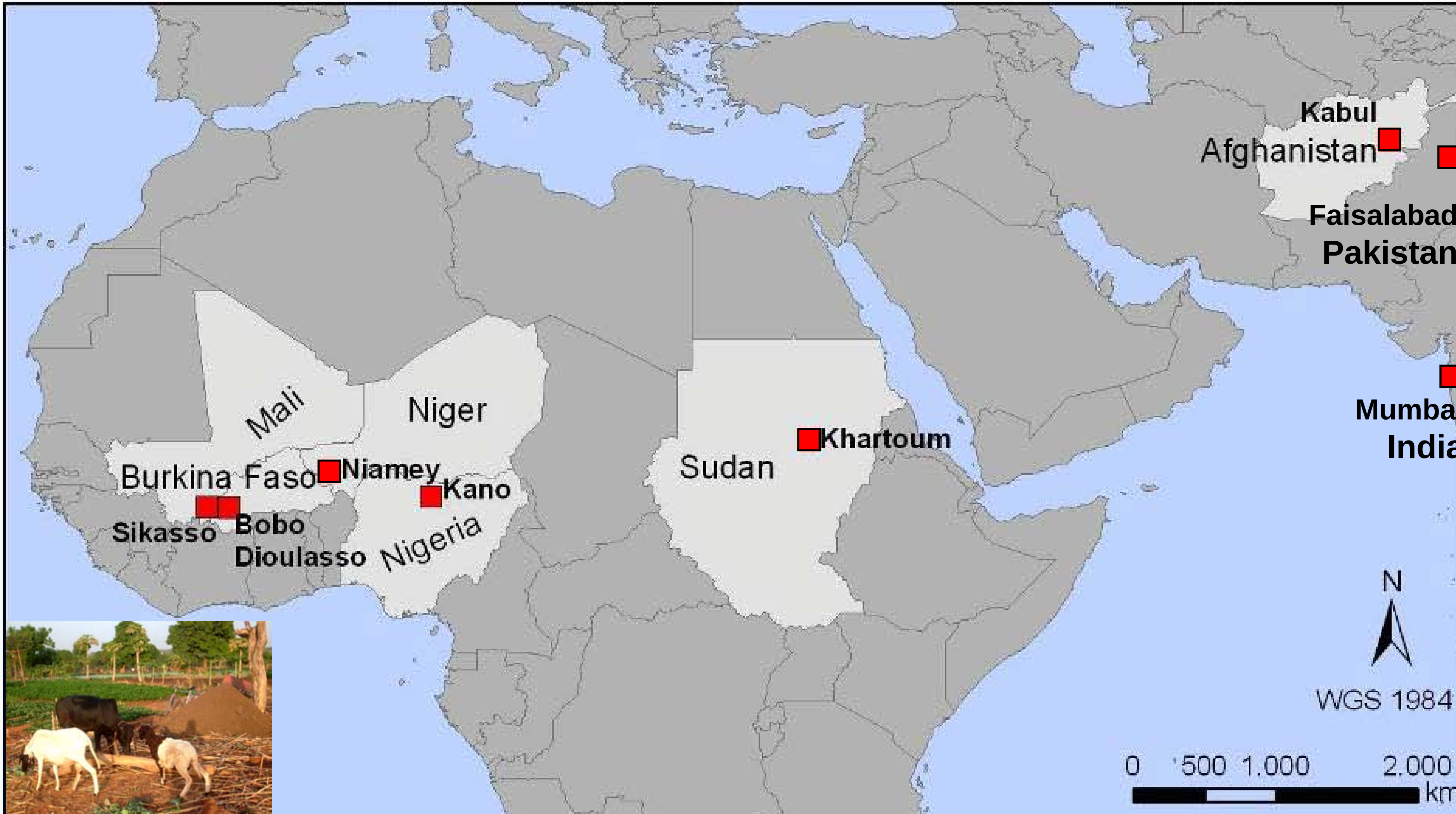
	Farmers	Wholesalers	Sellers
Number of observations	62	54	190
Average household size (adults and children)	4.7	5.2	4.6
Net profit from vegetable sales	17-23	80-108	9-25
Nonagricultural income	0-8	9	8
Contribution by other household members	15-16	35	6-11
Total household income per week	32-39	124-152	23-44

Note: n.a. = not available.

Source: IWMI, unpublished.

Drechsel et al., 2006

The UrbanFood research locations



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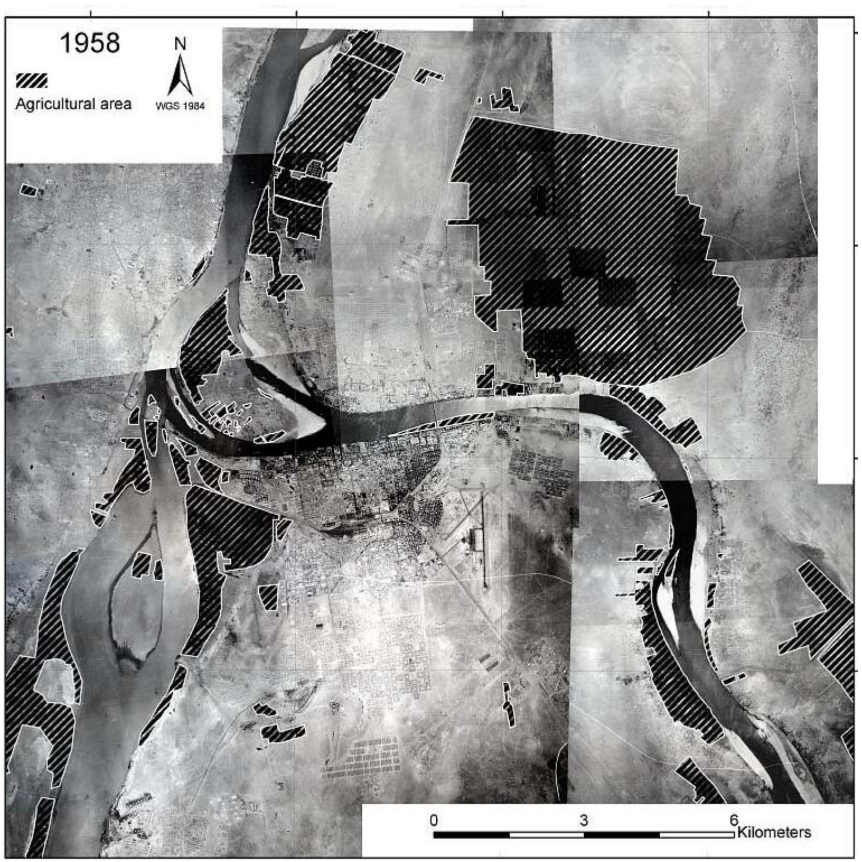
UrbanFood – Opportunities & Challenges

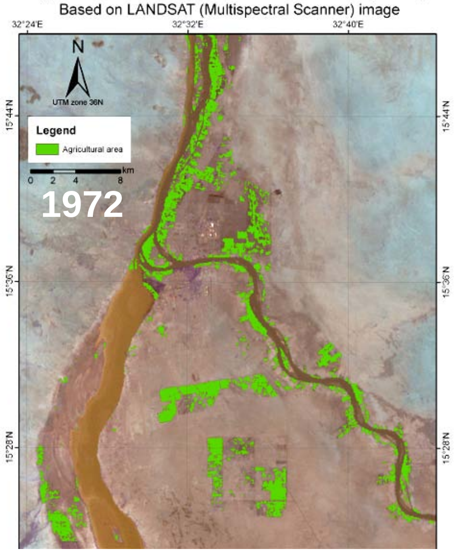
UrbanFood – Opportunities & Challenges



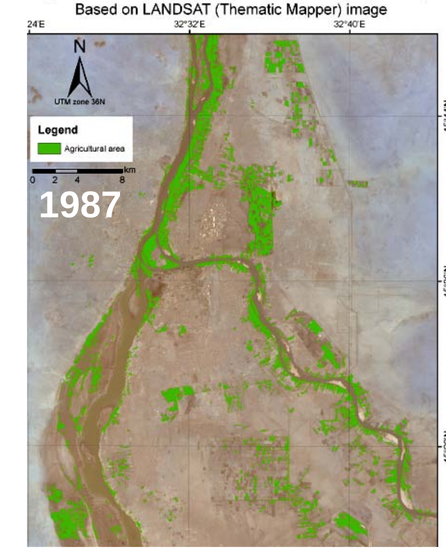

Spatial development of UPA (Khartoum, Sudan)



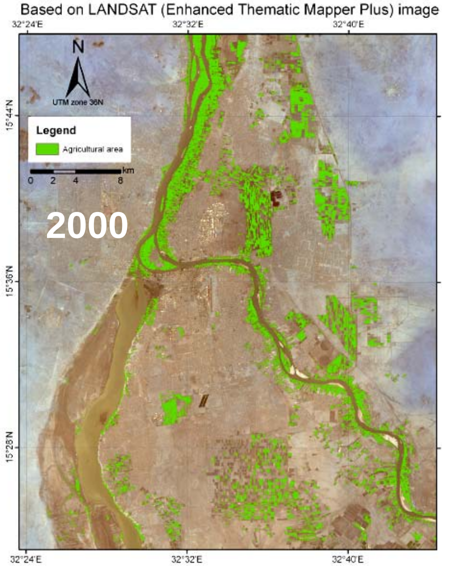
Agricultural area of Khartoum (Oct. 2nd, 1972)
Based on LANDSAT (Multispectral Scanner) image



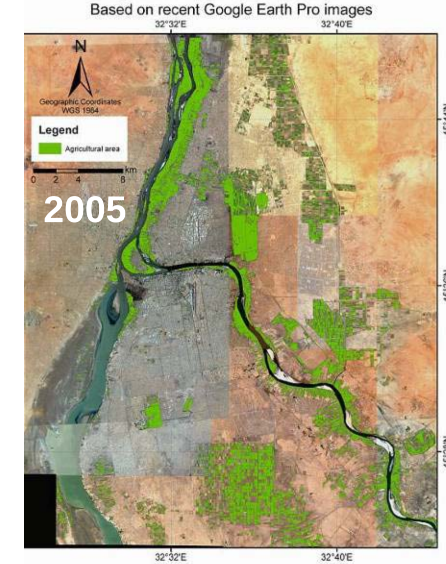
Agricultural area of Khartoum (Nov. 3rd, 1987)
Based on LANDSAT (Thematic Mapper) image



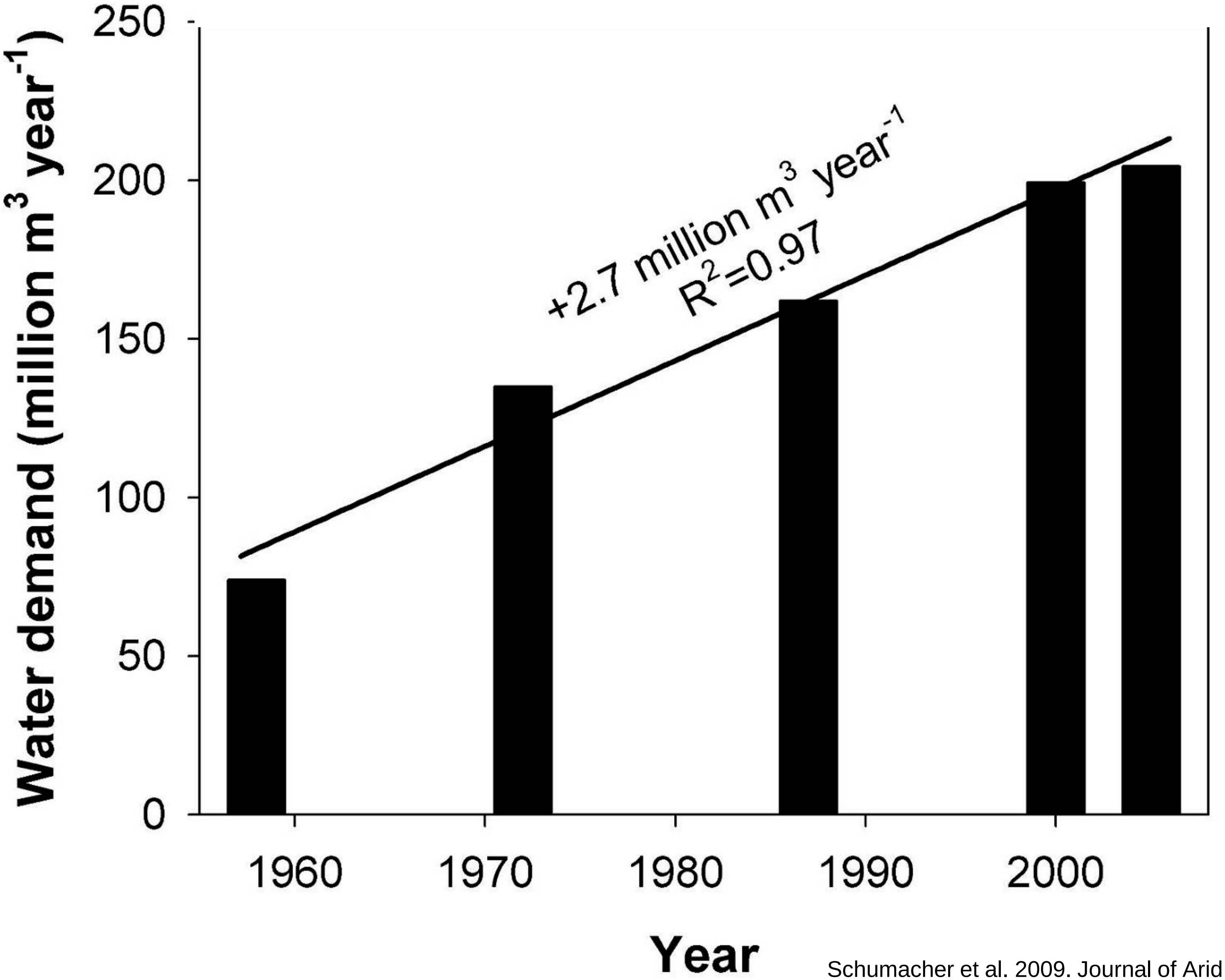
Agricultural area of Khartoum (Dec. 24th, 2000)
Based on LANDSAT (Enhanced Thematic Mapper Plus) image



Agricultural area of Khartoum
Based on recent Google Earth Pro images



UPA – Spatial dynamics & water demand



Schumacher et al. 2009. Journal of Arid Environments 73, 399-406.

Plant biodiversity

Plant biodiversity in UPA gardens
- Example: Niamey, Niger -

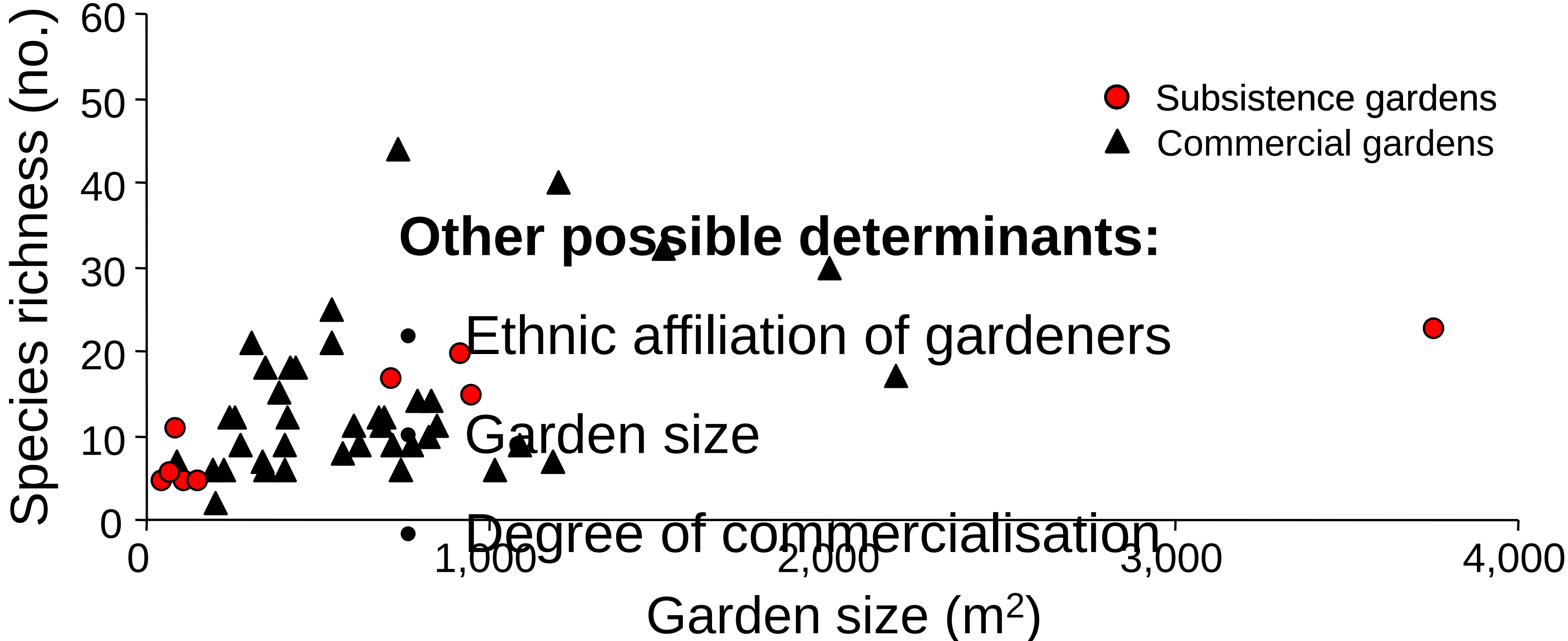
Mean plant species diversity in the cold, hot and rainy season 2007

Parameter	Cold season (n=51)	Hot season (n=51)	Rainy season (n=45)
Species richness	14.1	9.8	6.7
Species density	15.0	10.2	6.8
Shannon index	1.0	0.8	0.5

Bernholt et al. 2009. Agroforestry Systems 77(3), 159-179.

Plant biodiversity in UPA gardens

- Example: Niamey, Niger -



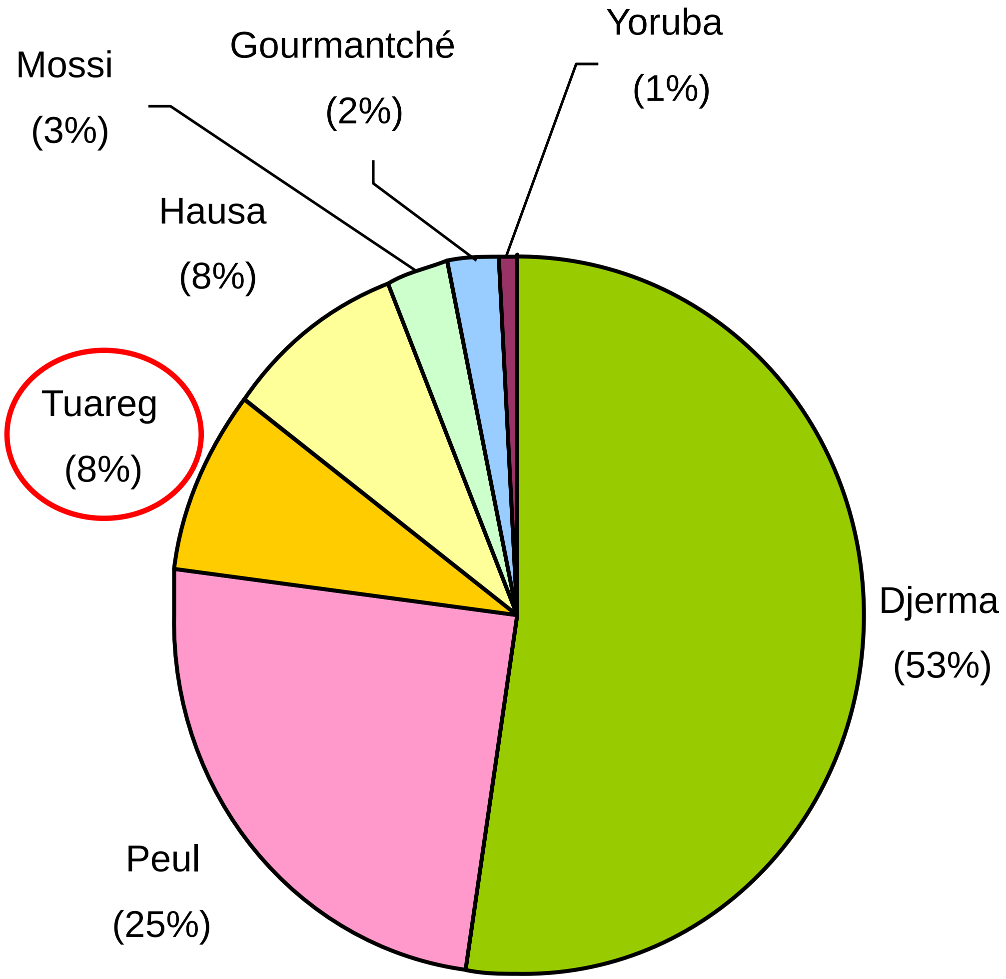
Other possible determinants:

- Ethnic affiliation of gardeners
- Garden size
- Degree of commercialisation

Bernholt et al. 2009. Agroforestry Systems 77(3), 159-179.

Plant biodiversity in UPA gardens
- Example: Niamey, Niger -

Highest species diversity found in gardens of nomads!



Bernholt et al. 2009. Agroforestry Systems 77(3), 159-179.

The irrigation water issue

Heavy metal distribution and balance

- Profile samples

- Vegetable, fertilizer and irrigation water samples
- Heavy metal analysis by AAS

- Atmospheric deposition

- Leaching of heavy metals

UPA – Quality of irrigation water

Irrigation water characteristics in Kano (Nigeria)

Metals	Conc (mg l^{-1})[a]	Limits[b]
Zn	8.3	2.0
Fe	4.8	5.0
Mn	0.6	0.2
Cr	28.4	0.1
Ni	1.2	0.2
Pb	28.5	5.0

[a] Kano State Environmental Planning and Protection Agency

[b] Pescod, M.B. 1992 Wastewater treatment and use in agriculture. Irrigation & Drainage Paper 47, FAO, Rome, Italy

UPA – Quality of irrigation water

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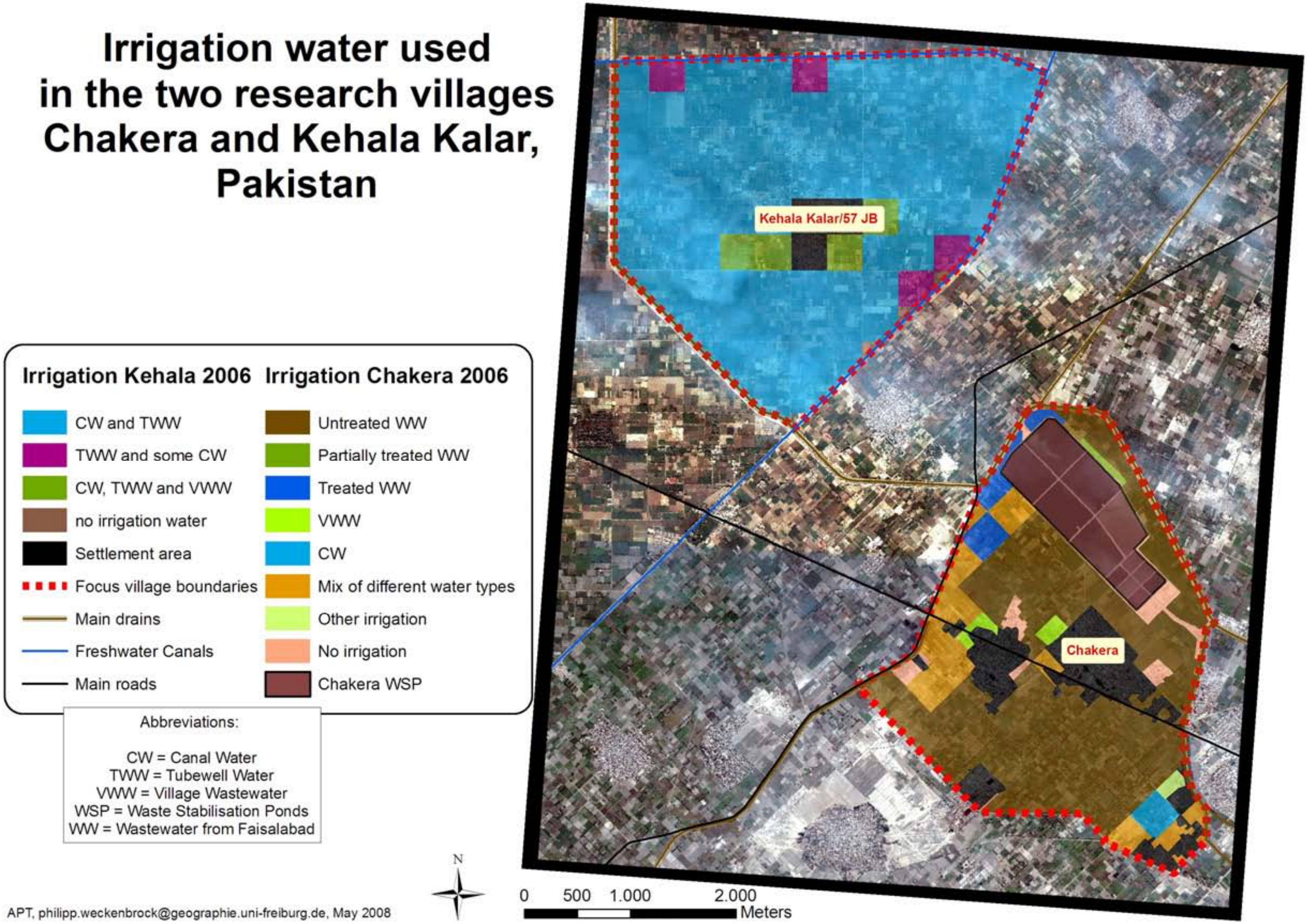
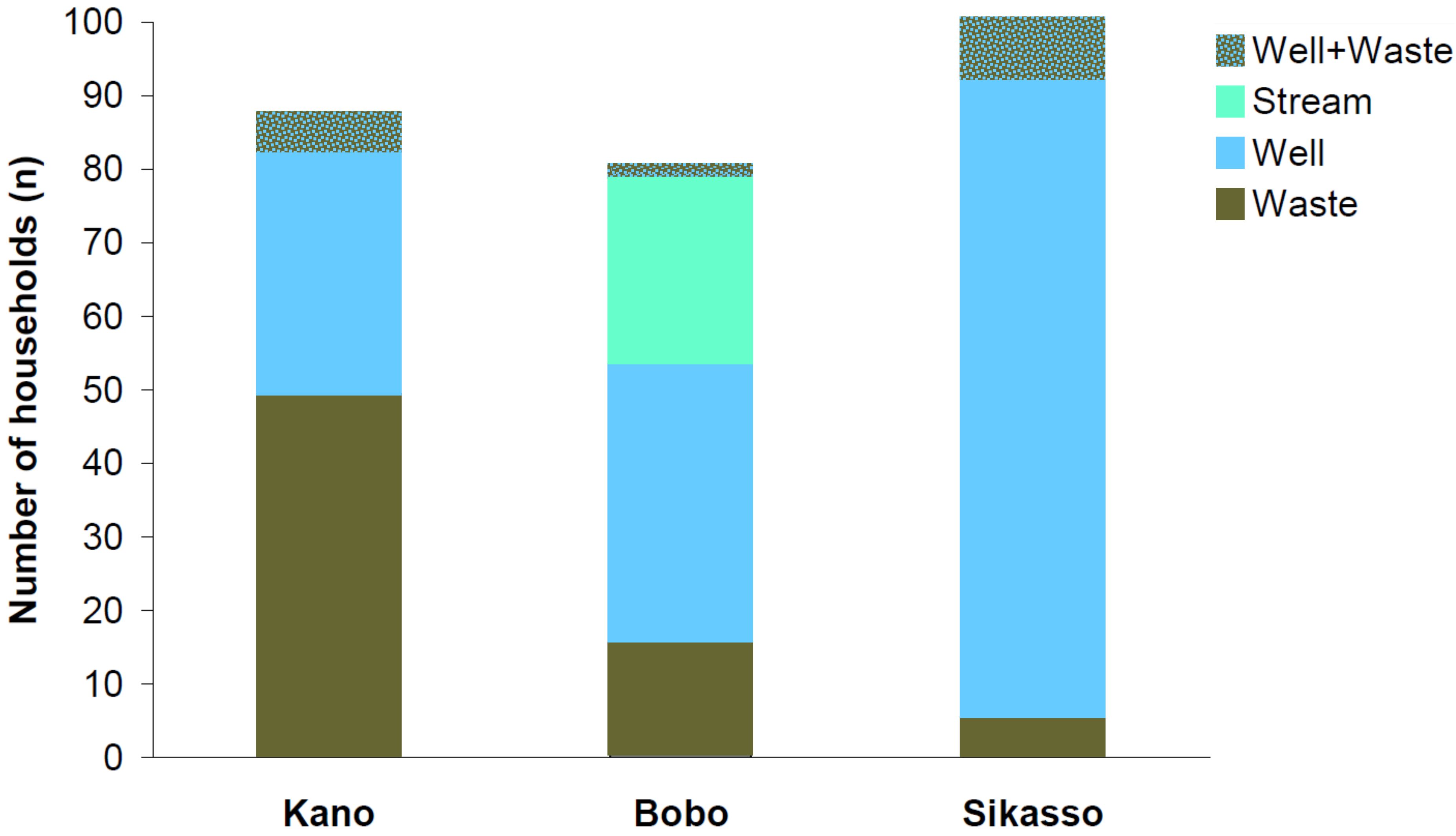
Weckenbrock, Drescher, Amerasinghe and Simmons, 2008.

UPA – Quality of irrigation water

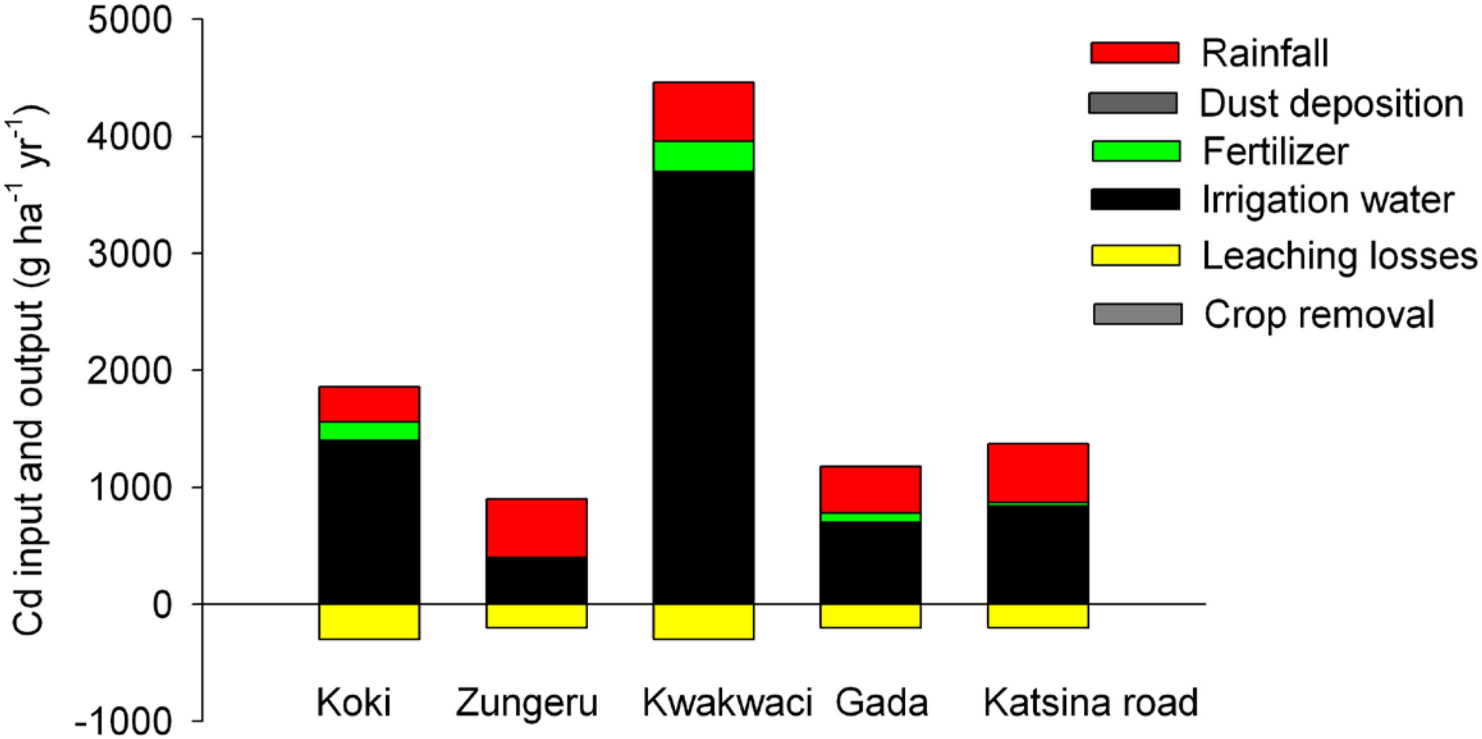


Weckenbrock, Drescher, Amerasinghe and Simmons, 2008.

Main sources of irrigation water



Heavy metal pollution and balance



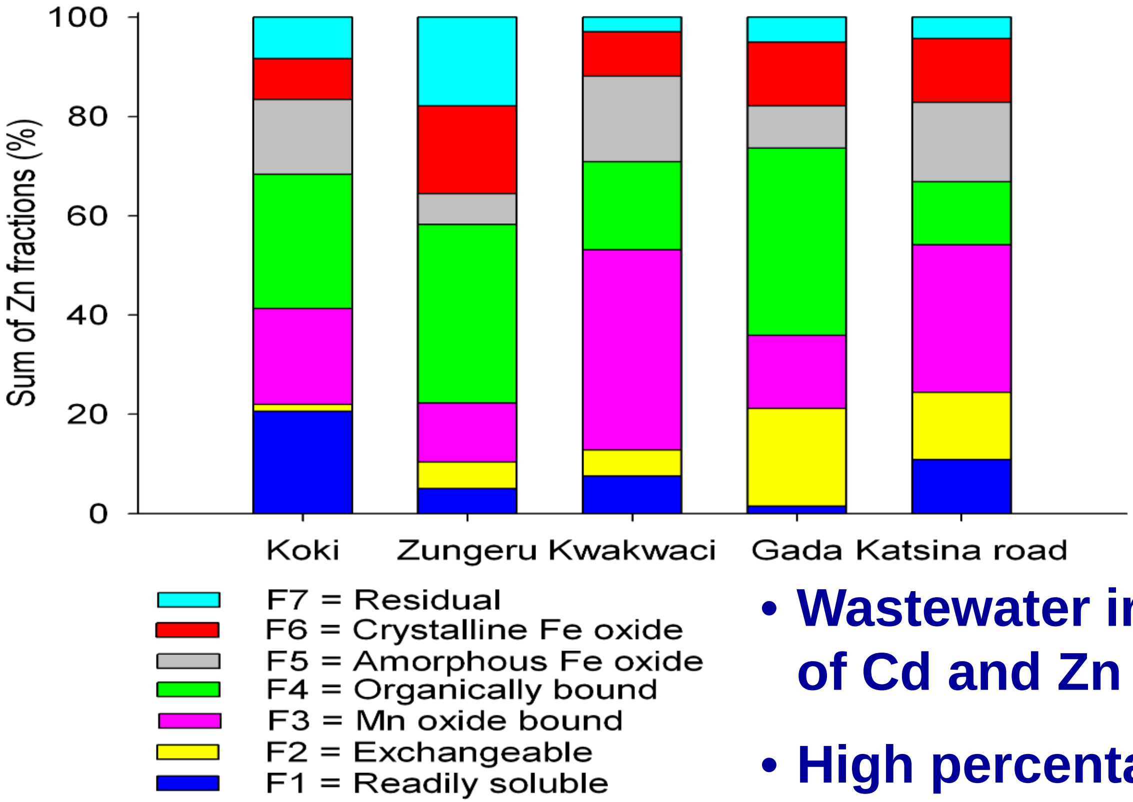
Koki	Zungeru	Kwakwaci	Gada	Katsina road
1559	699	**4158**	976	**1168**

HM pollution in Kano > Bobo-Dioulasso ≈ Sikasso

Positive HM balances in Kano

Cd: 0.98-1.56 kg ha^{-1} yr^{-1}; Zn: 9.2-35.8 kg ha^{-1} yr^{-1}

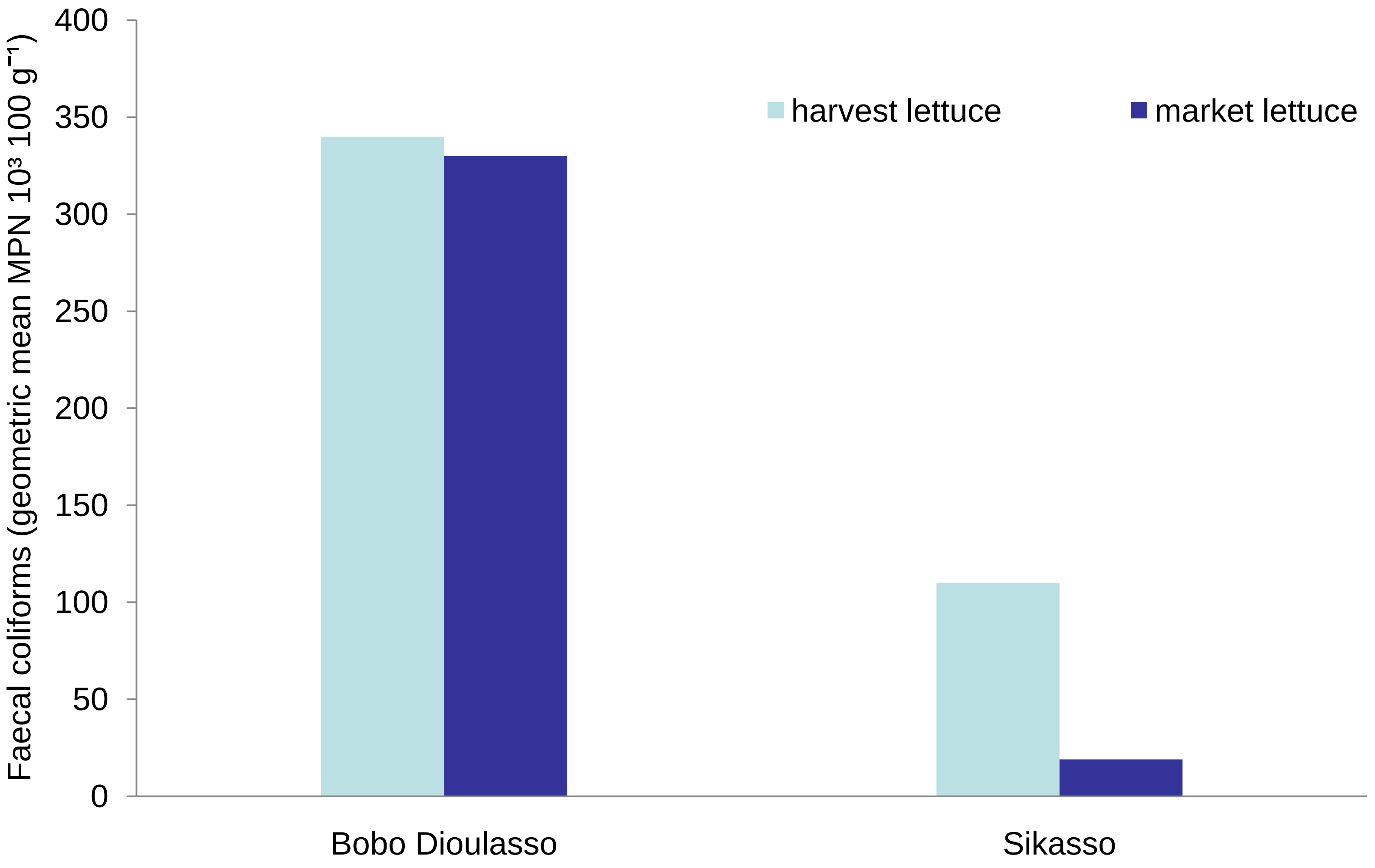
Distribution of Zn in the different geochemical fractions in vegetable garden soils of Kano



Nafiu et al. 2011. Environmental Monitoring and Assessment (in press). DOI 10.1007/s10661-011-2099-2.

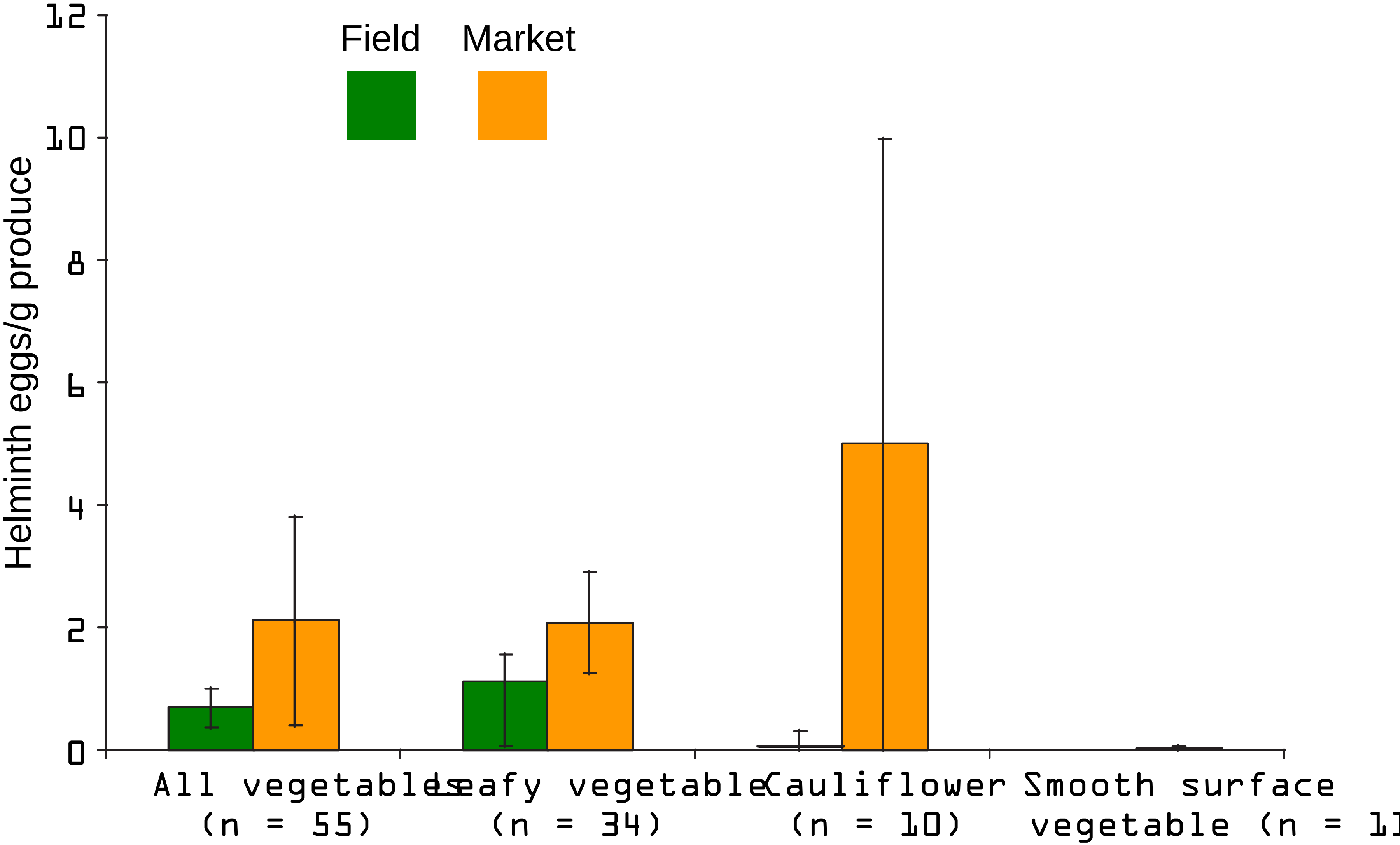
- **Wastewater irrigation = major input of Cd and Zn in Kano**
- **High percentage of mobile fractions of Cd and Zn in Kano soils → Risk of HM pollution**
- **Estimated dietary intake of Cd and Zn still within safety limits**

Contamination of lettuce by faecal coliforms in Bobo Dioulasso and Sikasso

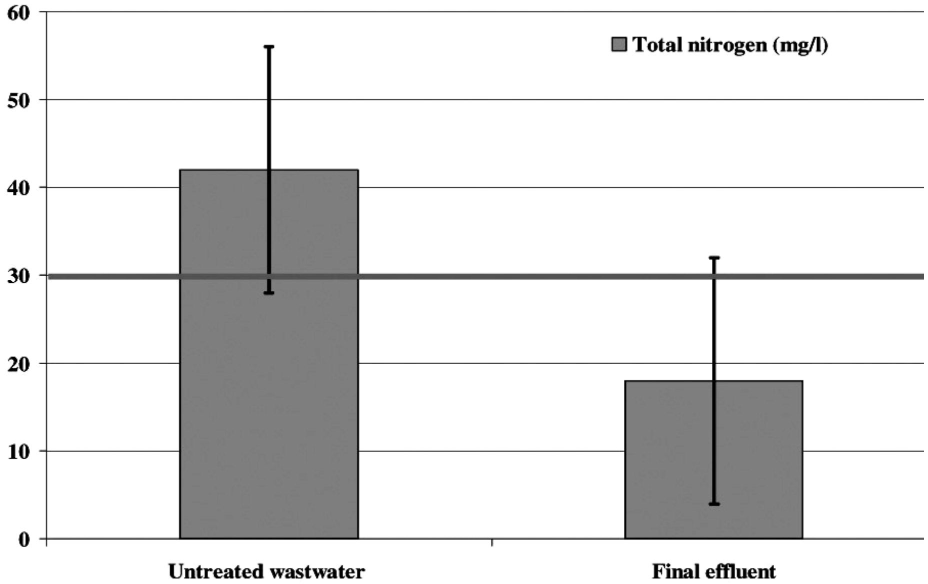


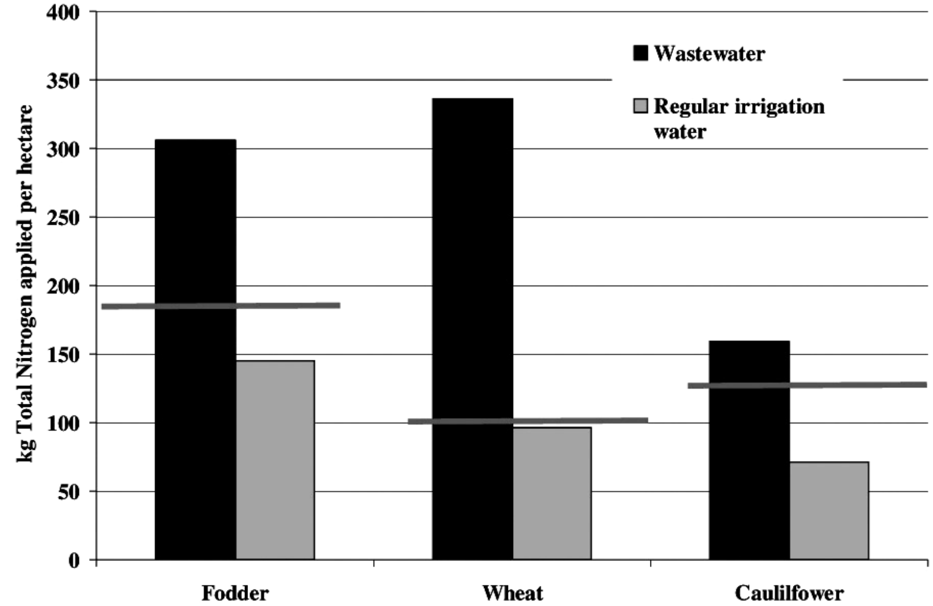
Mean helminth egg concentrations on different types of vegetables in the fields and on a market in Faisalabad during the period April 2004–March 2005 (Vertical bars represent 95% CI).

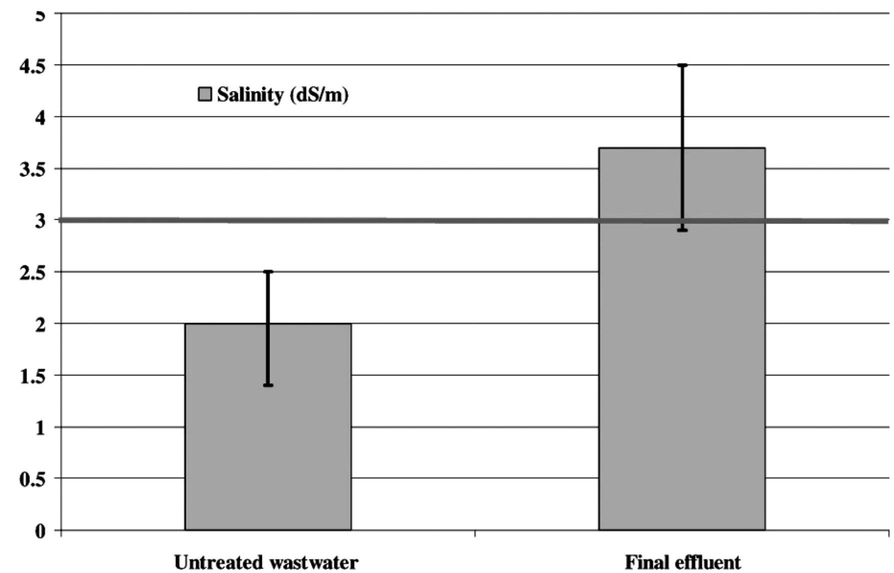
Ensink et al., 2007. Trop. Med. Intern. Health 12(2), 1-6.



Wasterwater use in Faisalabad, Pakistan







Clemett, A.E.V. and Ensink, J.H.J. 2006. Farmer driven wastewater treatment: A case study from Faisalabad, Pakistan. 32nd WEDC International Conference, Colombo, Sri Lanka, 99-104.

Sustainability – Matter balances

Nutrient fluxes at the garden and field scale

Gaseous losses

CH_4, CO_2, NH_3, N_2O

Inputs

Manure, mineral fertilizer

Outputs

Exported harvest

Leaching losses

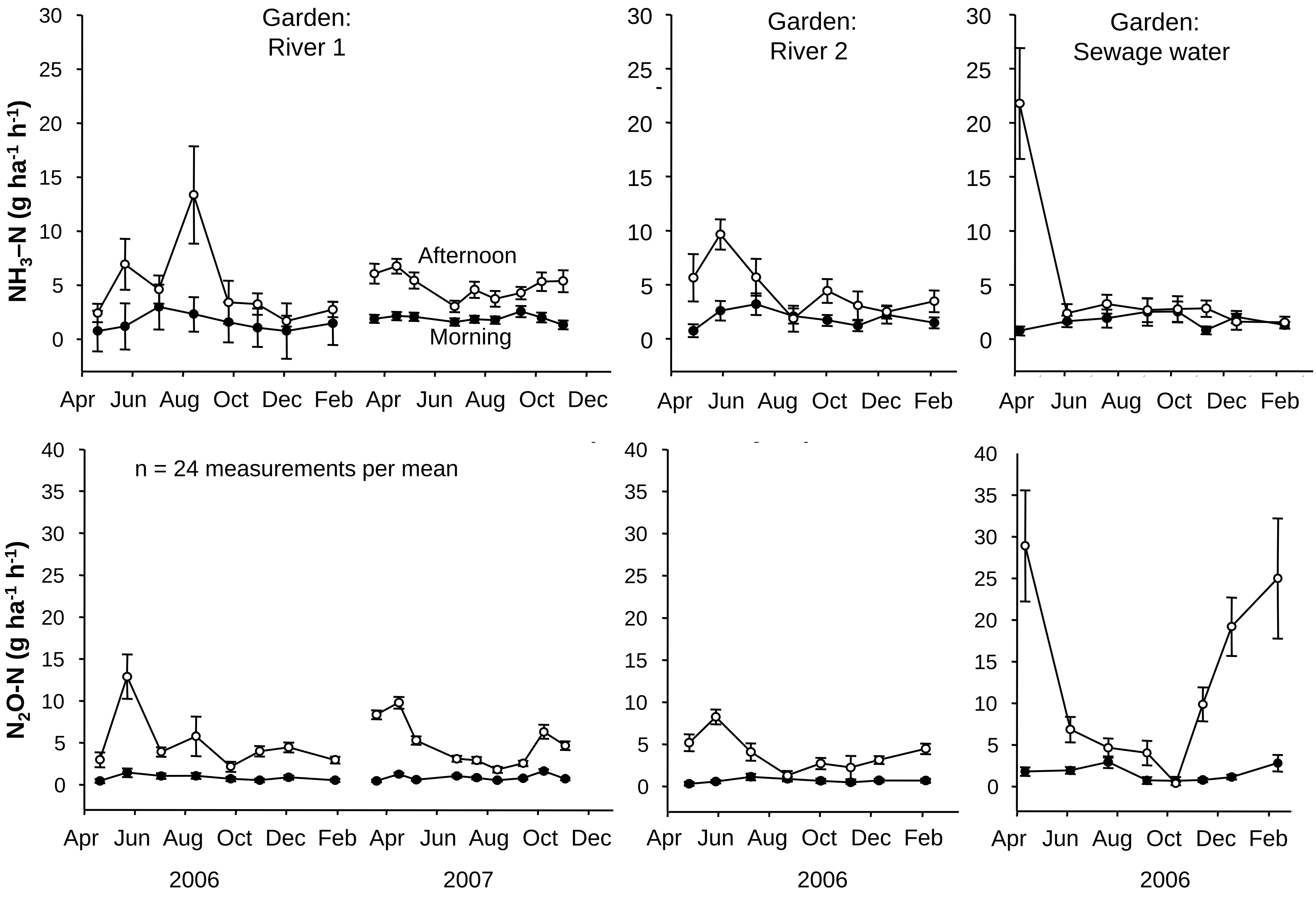
NO_3, P_{org}

Photo-accoustic multigas monitoring of gaseous C & N losses

Closed-chamber system

Gaseous N losses from three UPA gardens

- Example: Niamey, Niger -



Predotova et al. 2010. Field Crops Research 115, 1-8.

Total N balances of UPA gardens
- Example: Niamey, Niger -



	Horizontal N fluxes		Gaseous N losses			N leaching	Total N balance
Garden	Input (kg ha^{-1} a^{-1})	Output (kg ha^{-1} a^{-1})	Total (kg ha^{-1} a^{-1})	NH_3 (%)	N_2O (%)	NO_3-N (kg ha^{-1} a^{-1})	(kg ha^{-1} a^{-1})
River 1	470	100	53	52	48	6*	310
River 2	780	190	48	59	41	2*	540
Sewage water	3,820	830	92	32	68	7*	2,890

* values of rainy season 2007

Predotova et al. 2010. Field Crops Research 115, 1-8.

Total C balances of UPA gardens

- Example: Niamey, Niger -



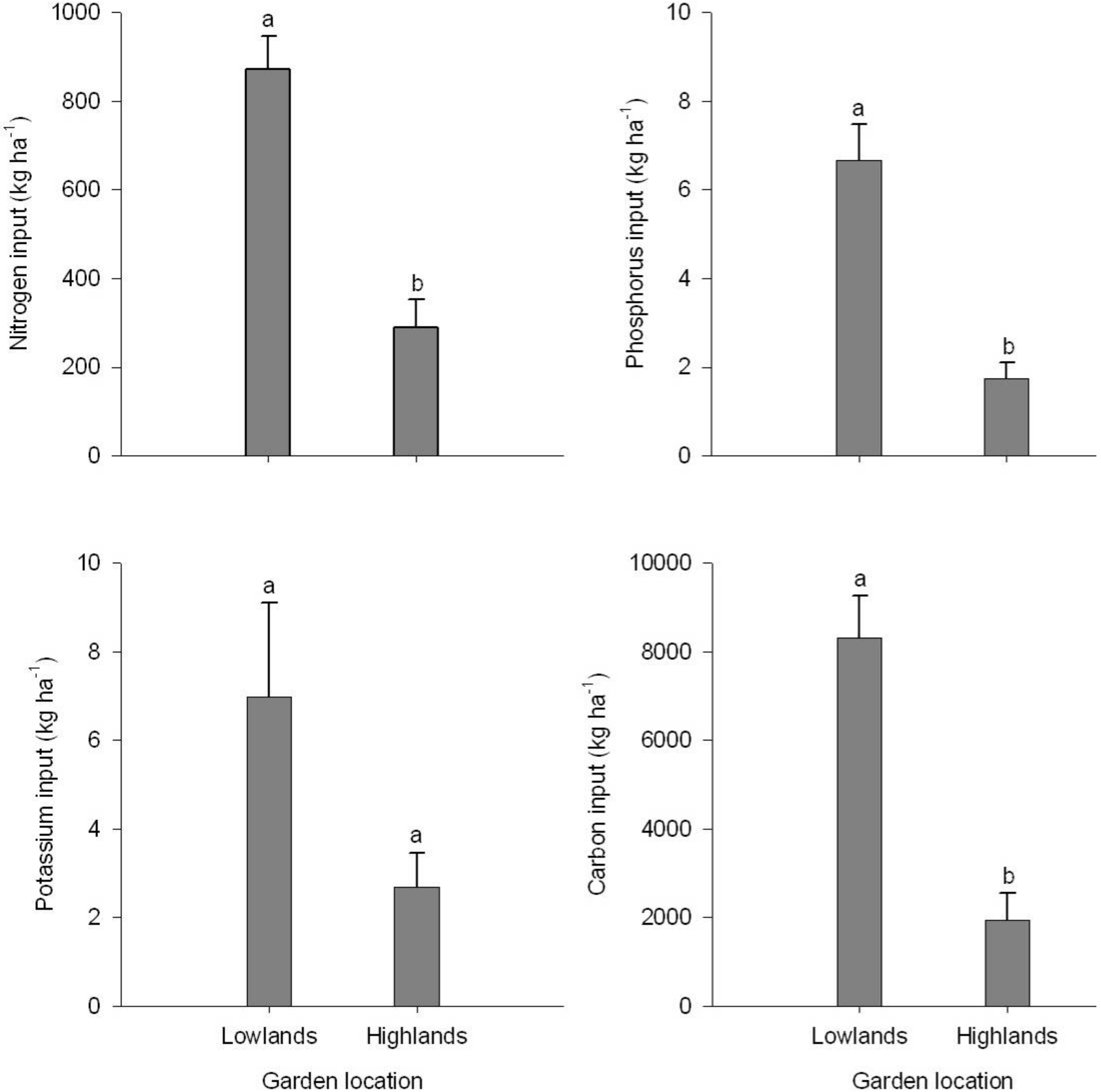

Garden	Horizontal C fluxes: Input – Fertilizer	Horizontal C fluxes: Input – Roots*	Horizontal C fluxes: Output	Gaseous C losses: Total	Gaseous C losses: CO_2	Gaseous C losses: CH_4	Total C balance
	(kg ha^{-1} a^{-1})			(kg ha^{-1} a^{-1})	(%)		(kg ha^{-1} a^{-1})
River 1	30,520	2,200	2,200	25,150	98	2	5,270
River 2	12,280	2,190	2,190	20,190	98	2	- 7,910
Sewage water	7,820	7,030	7,030	26,630	98	2	- 18,810

* Estimated to be equivalent to the harvested shoot C

Predotova et al. 2010. Field Crops Research 115, 1-8.

Manure use for brick making in Khartoum, Sudan

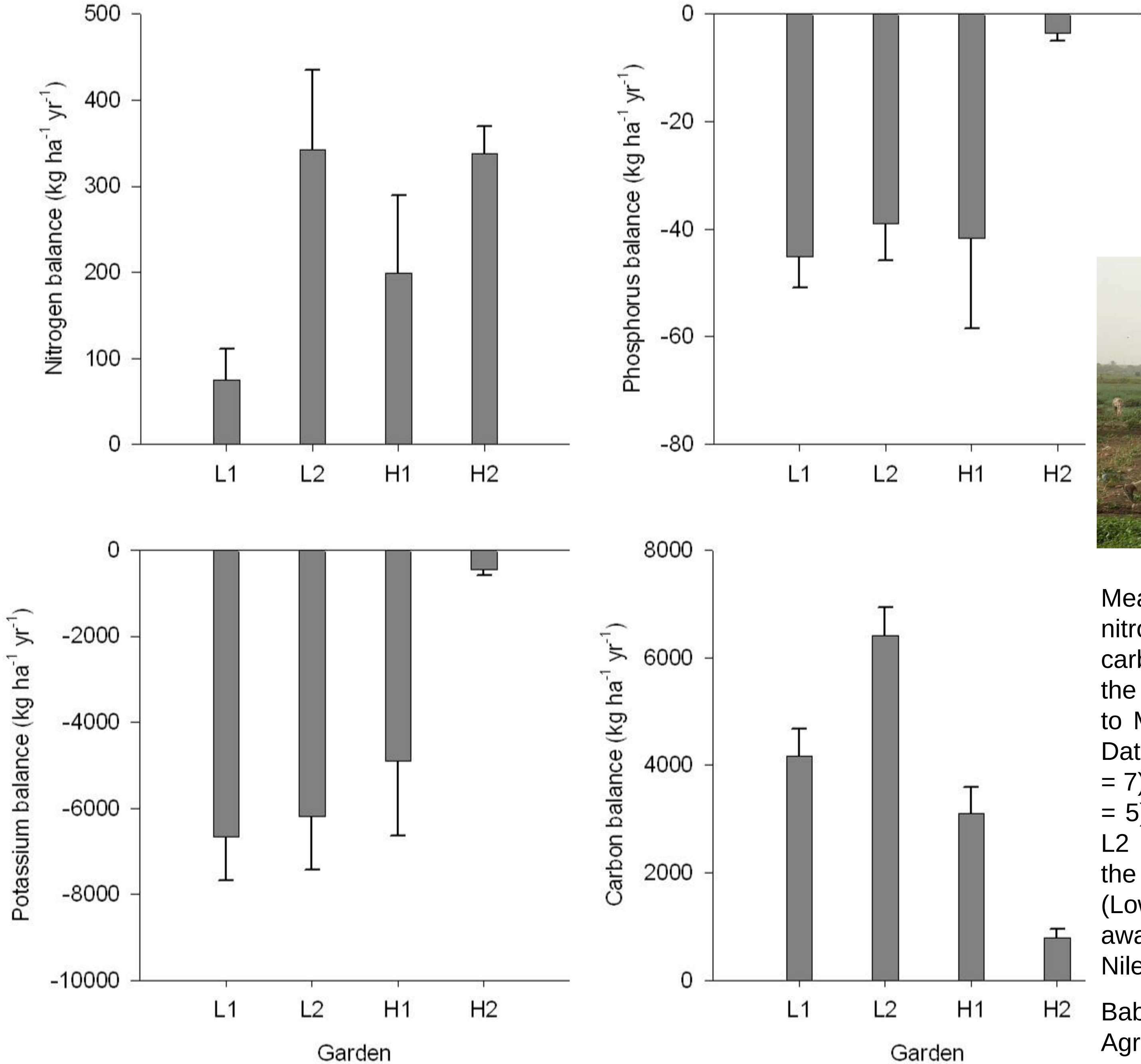
Matter deposits from the river Nile in Khartoum, Sudan



Mean annual amounts of nitrogen, phosphorus, potassium and carbon deposited as inputs in 2008 from the River Nile flood sediments on *Gerif* soils in Khartoum, Sudan. 'Lowlands' refer to gardens adjacent to the banks of the River Nile (L1 and L2; n = 4) and 'Highlands' refer to gardens away from the banks of the River Nile (H1 and H2; n = 6).

Babiker et al., Nutrient Cycling in Agroecosystems (submitted).

Horizontal matter balances in vegetable gardens of Khartoum, Sudan



Mean annual horizontal balances of nitrogen, phosphorus, potassium and carbon in vegetable gardens during the study period from October 2007 to March 2010 in Khartoum, Sudan. Data presented are means for L1 (n = 7), L2 (n = 5), H1 (n = 7) and H2 (n = 5) plus one standard error. L1 and L2 denominate gardens adjacent to the banks of the River Nile (Lowlands), and H1 and H2 gardens away from the banks of the River Nile (Highlands).

Babiker et al., Nutrient Cycling in Agroecosystems (submitted).

Average net return, total return and total cost for farms and kilns (in SDG[1]), Gini-coefficient, benefit cost ratio (B/C), and land share of total cost for farms and kilns in urban Khartoum, Sudan, 2009.

Items	**Red brick kiln owners (n = 45)**	**Urban farmers (n = 15)**
Average total return	147,761.00	8,267.00
Average total cost	116,559.00	3,718.20
Average net return	31,202.12	4,626.00
Gini coefficient	0.37	0.49
B/C	1.27	2.22
Land share of total cost (%)	6.00	29.00

[1] SDG (New Sudanese Pound) ≈ 0.4 US$

Source: Formal survey 2009

Mean annual amounts of nitrogen, phosphorus, potassium and carbon deposited as inputs in 2008 from the River Nile flood sediments on *Gerif* soils in Khartoum, Sudan. ‘Lowlands’ refer to gardens adjacent to the banks of the River Nile (L1 and L2; n = 4) and ‘Highlands’ refer to gardens away from the banks of the River Nile (H1 and H2; n = 6).

Babiker et al., Nutrient Cycling in Agroecosystems (submitted).

Conclusions & Recommendations

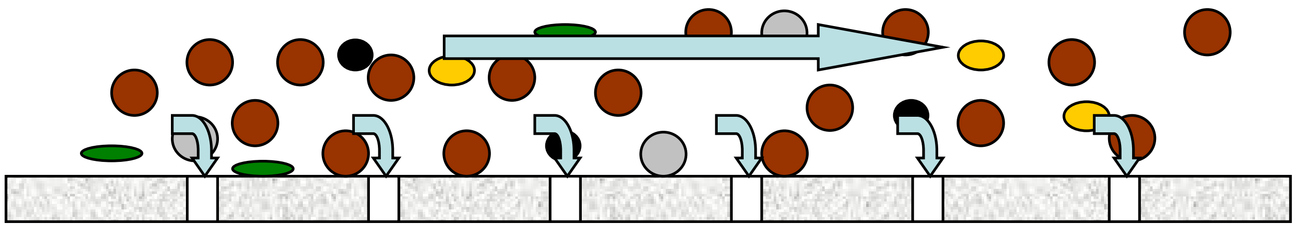
Urban and peri-urban agriculture (UPA) can make an important contribution to supplying food and income opportunities to the rapidly growing urban populations of developing countries, but its role strongly varies between locations.

- Negative externalities of UPA need careful analysis and consistent action to derive effective recommendations (policies) fostering the sustainability of the systems and securing product safety and finally consumer health.
- Carbon and nutrient balances strongly vary between and within locations. While N balances are often excessively positive leading to N losses via volatilisation, C-balances heavily depend on the use of manure.
- A thorough unterstanding of the biophysical, economic and social sustainability of UPA systems may also allow us to derive important conclusions for the farm-level adoption of improved soil fertility management options in the vast rainfed systems across semi-arid Africa and parts of Asia.

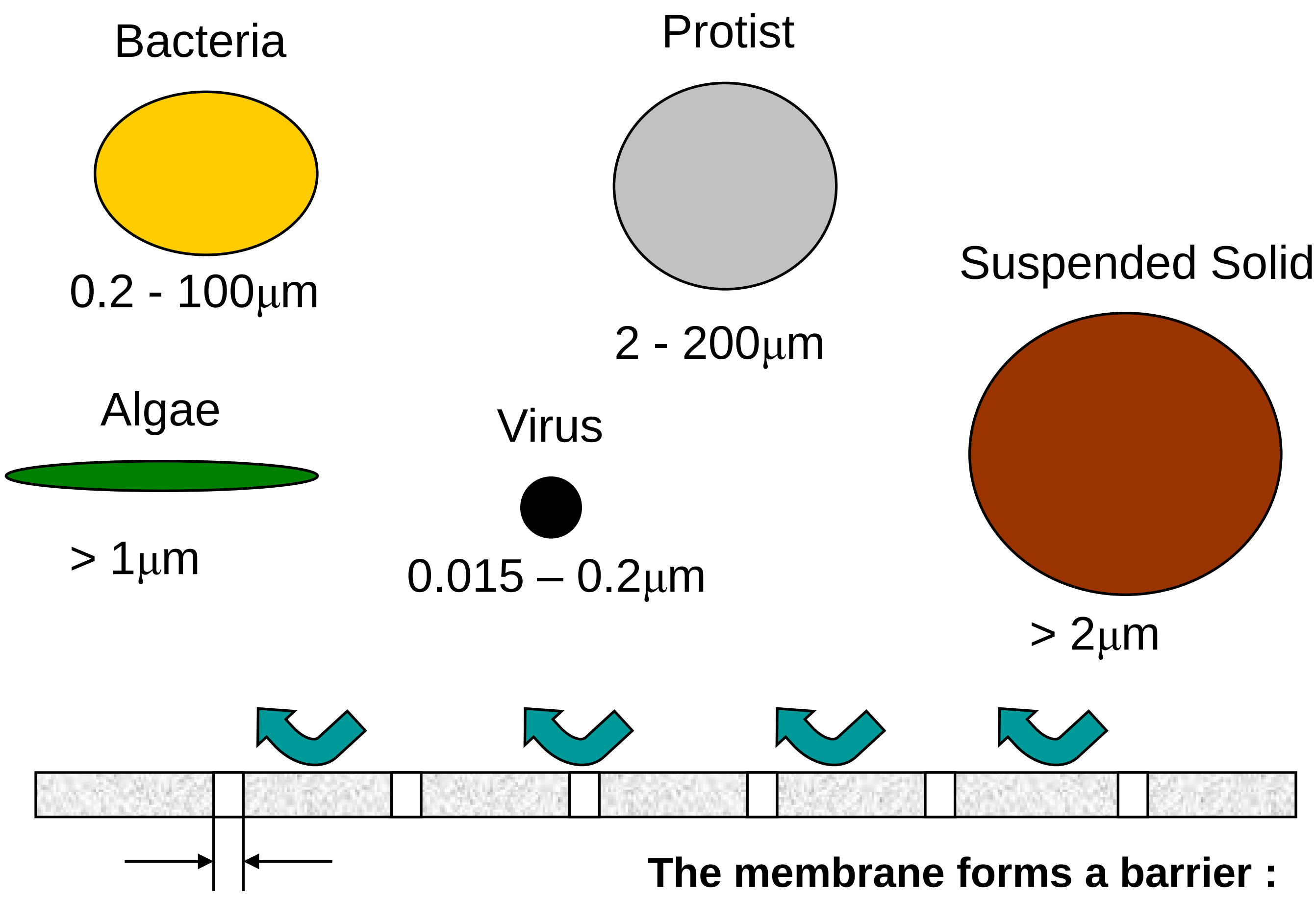
Use of membrane filtration: Cross-flow filtration for cleaning up wastewater

=> From ISO norms to sustainable cloth production: a call for concerted legislative action!

Tangential water flow across membrane surface keeps particles in suspension, prevents settling and blocking of the membrane

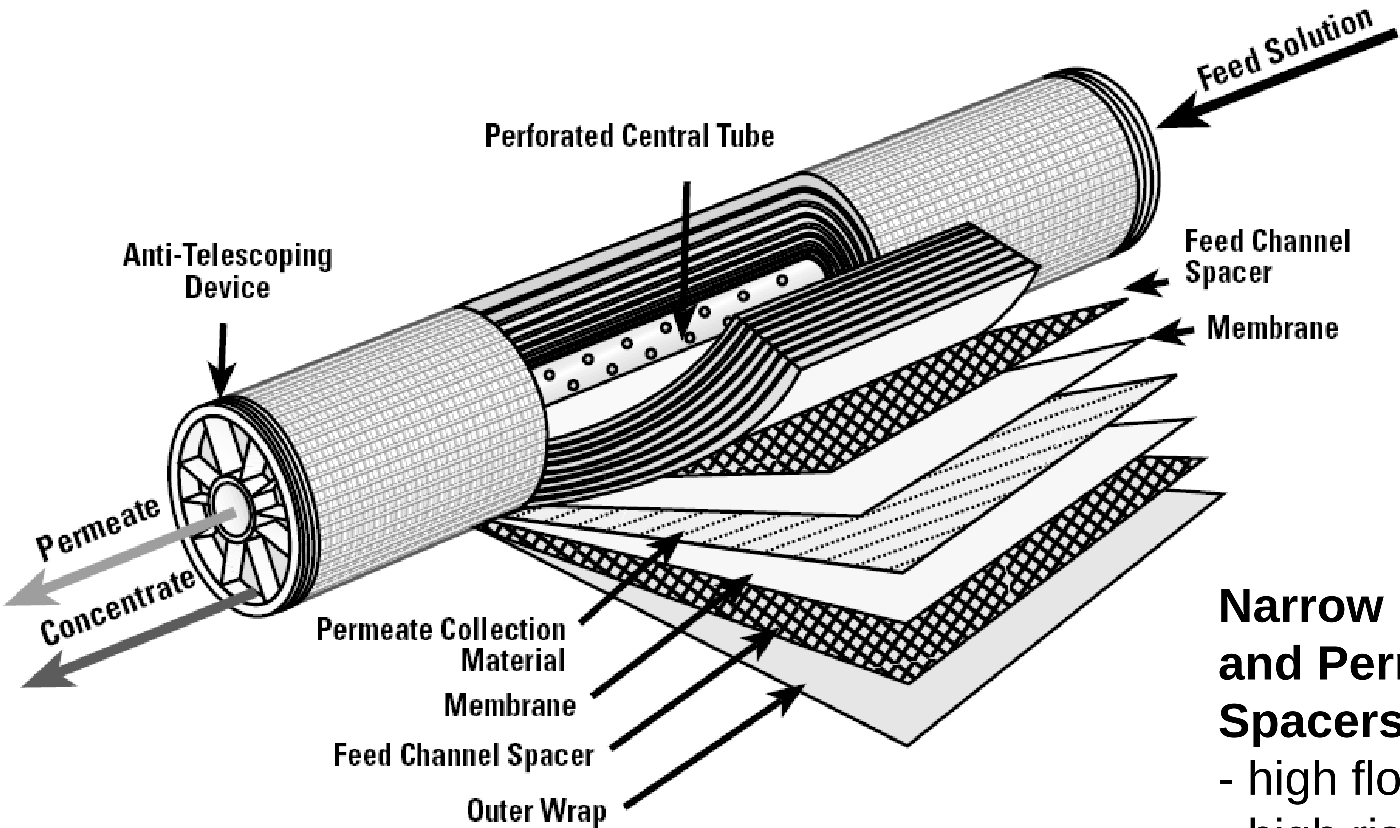


Membrane capabilities



The membrane forms a barrier :
Particle size bigger than the pore cannot pass through the membrane.

Disadvantages of conv. membrane designs - Spiral wound



Narrow Feed Channel and Permeate Channel Spacers :

- high flow restriction
- high risk of fouling
- difficult to clean
- high grade pre-treatment necessary

Disadvantages of conv. membrane designs – Hollow Fibre

Membrane fouling at top

Fibers cannot move at the top flange (air scour), limited water flow velocity at top flange

Membrane fouling at bottom

Fibers cannot move at the bottom flange (air scour), limited water flow velocity at bottom flange

Membrane fouling at top

Manual cleaning necessary

High risk of breaking fibres

Reference: Desalination and Water Purification Research and Development Report No.103

Disadvantages of conv. membrane designs – Flat Sheet

Permeate Outlet

Modules

Permeate Outlet of Single Plates

Membrane

Membrane Fouling

Areas in the Corners of the Membrane Plate are difficult to clean due to low Water Flow Velocity

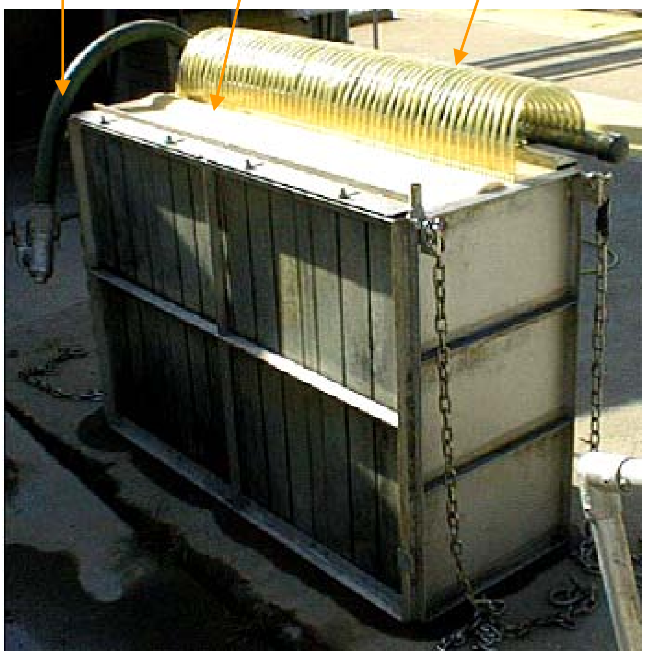
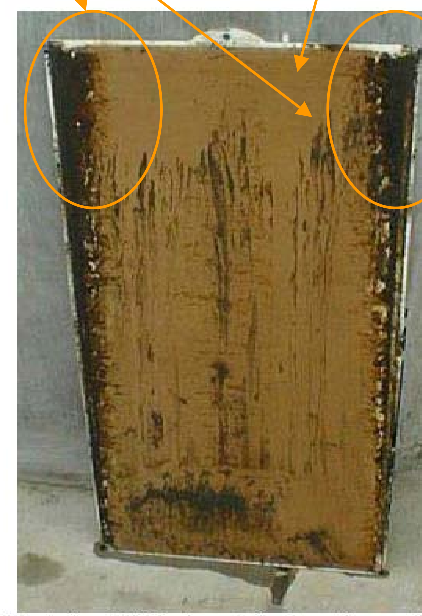


Plate / Frame UF Assembly

Kubota Type 510 Membrane (single sheet)

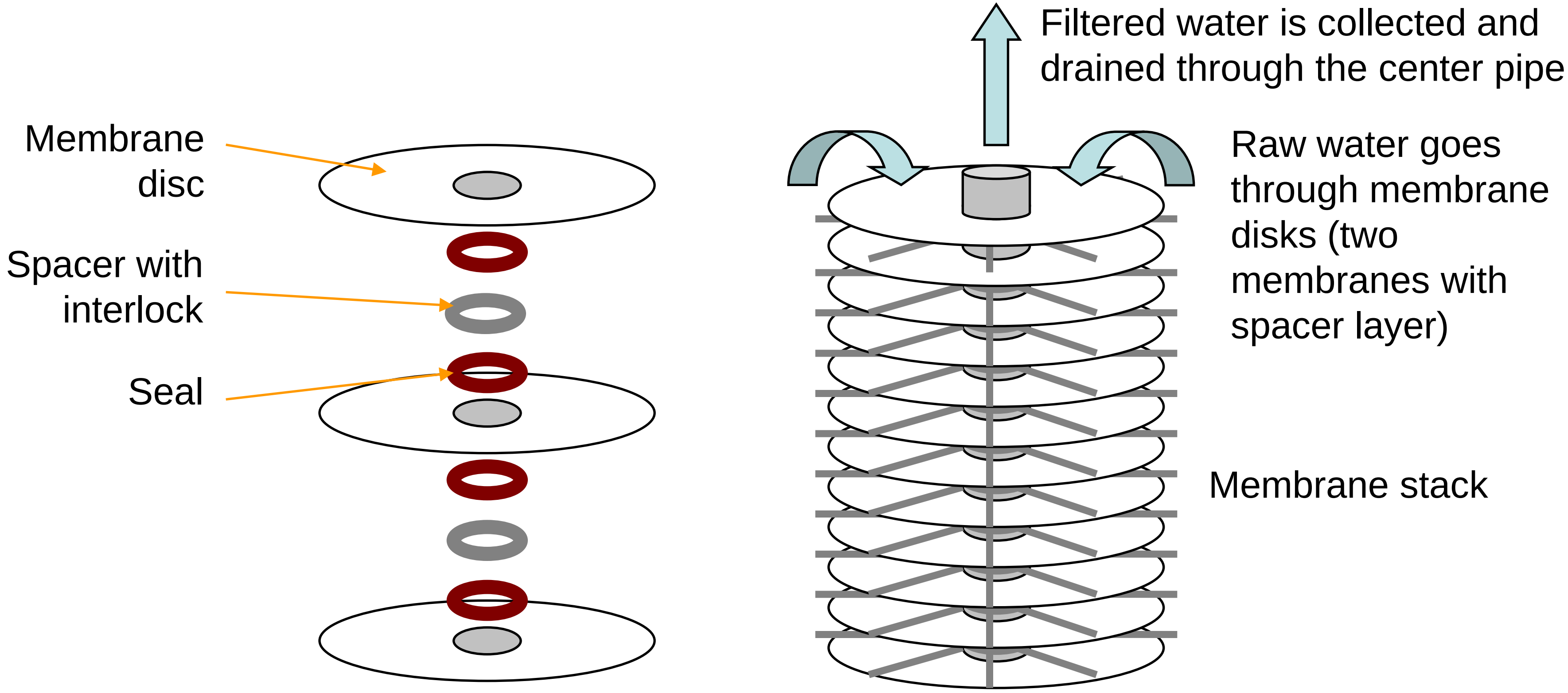
Single Plate



Kubota Type 510 Membrane (after 2 months operation)

Membrane Fouling

A new alternative: The filter (membrane) stack



→ The spacer avoids dead space on the membrane surface and membrane stack !

→ The disc-shaped design allows for an even flow velocity across the membrane surface!

The filter (membrane) stack before and after cleaning

Fouling

Easy cleaning

Recover complete

Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung

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