5.2.5 Dissemination material on the Use of Water for Urban Agriculture
Work package 5.2

The aim of work package 5.2 is to contribute to a paradigm shift in wastewater management and sanitation towards a recycling-oriented closed loop approach. The work package is being implemented in three cities; Accra, Beijing and Lima, and includes the identification and integration of appropriate productive re-use of urban freshwater, storm and waste-water for agriculture into the policy and planning frameworks of these cities.

The deliverables of the work package follow a sequence of implementation. Based on a situation and stakeholder review (del. 5.2.1), working groups are formed, meet and are linked to the Learning alliances (del. 5.2.2), they receive training in multi-stakeholder action planning (del. 5.2.3 A), and are involved in, and informed on, specific research by consultants, MSc and PhD or action research linked to the demonstrations, (all under del. 5.2.4). Information has been disseminated in publications, magazines and newsletters (del. 5.2.5), and guidelines and related training material has been developed (del 5.2.3 B and C). The leading institutes here are ETC (WP coordinator), IWMI (Accra), IGSNRR (Beijing) and IPES (Lima), other institutions involved were WUR, IRC and NRI- GUEL.

As part of deliverable 5.2.4, this contains various materials on Accra

Contributing products included in this document are:

5.2.5 Ac Options For Simple On-Farm Water Treatment In Developing Countries. IWMI, WHO, IDRC, FAO. Guidance note for National Programme Managers and Engineers. *Third edition of the WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater in Agriculture and Aquaculture*
5.2.5 Ad Olufunke Cofie, Philippe Reymond and Liqa Raschid-Sally. Bringing wastewater treatment on the farm: Multi-purpose ponds in urban farming in Accra, Ghana. Powerpoint Presentation. Stockholm Water Meeting, 2009.
5.2.5 Ae Poster on Accra Demo; waste water use (Scientific Meeting in Lodz, 2010)
5.2.5 Af Poster on Accra Demo; urine storage and use (Scientific Meeting in Lodz, 2010)
5.2.5 Ag Poster on Accra PhD (Scientific Meeting in Lodz, 2010)

WEDC Developing knowledge and capacity in water and sanitation

Options Analysis for Water Demand Management

By

Sam Kayaga, Daan Van Rooijen & Ian Smout

SWITCH

Loughborough University

Integrated Resource Planning Framework

- A process in which a full range of both supply-side and demand-side options are assessed against a common set of planning objectives or criteria

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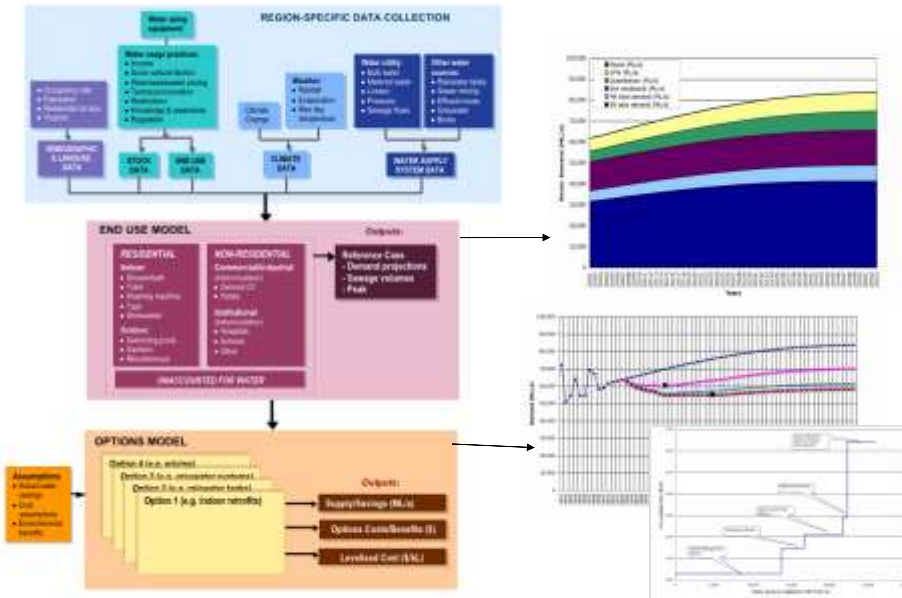
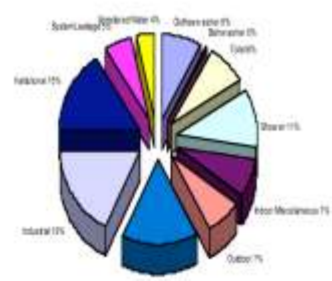
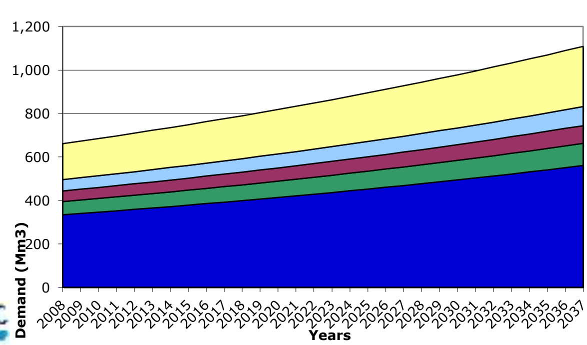
Integrated Resource Planning Framework



Key IRP Components 1



- Disaggregation of demand into end uses for accurate forecasting & targeting for potential savings



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Key IRP components 2

- Consideration of a broad spectrum of viable options that satisfy service needs
  - o Water efficiency
  - o Source substitution
  - o Re-use
  - o Supply options
- Comparison of options using a common metric, boundary and assumptions

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Key IRP components 3

- Participation of the LA – recognising that water service provision interacts with
  - o Other natural resource management systems
  - o Other urban development systems
  - o Consumer preferences
- Adaptive management
  - o On-going learning process
  - o Initiatives decided upon, implemented and evaluated in repeated cycles

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The 5-step IRP Framework

Step 1: Plan overall process

Step 2: Analyse the situation
Demand forecasting

Step 3: Develop the response
Identify, design & analyse potential options

Step 4: Implement the response

Step 5: Monitor, evaluate & review

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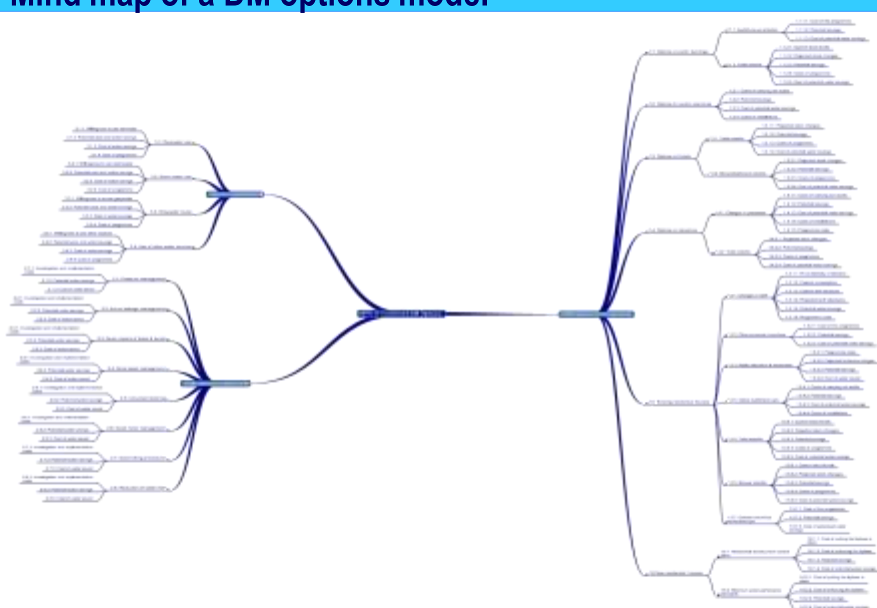
Mind map of a DM options model



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Model design

- Time frame is 30 years, 2010-2040
- 12 water demand management options modelled
- Designed for fictive city, but with realistic assumptions based on Accra & Alexandria
- Model layout still to be made more illustrative
- Non-revenue yet to be specified by:
  - Physical losses
  - Reduction in water theft (illegal connections)
  - Improved metering coverage
  - Improved billing procedures
  - Good practices of installation, maintenance & replacement of meters

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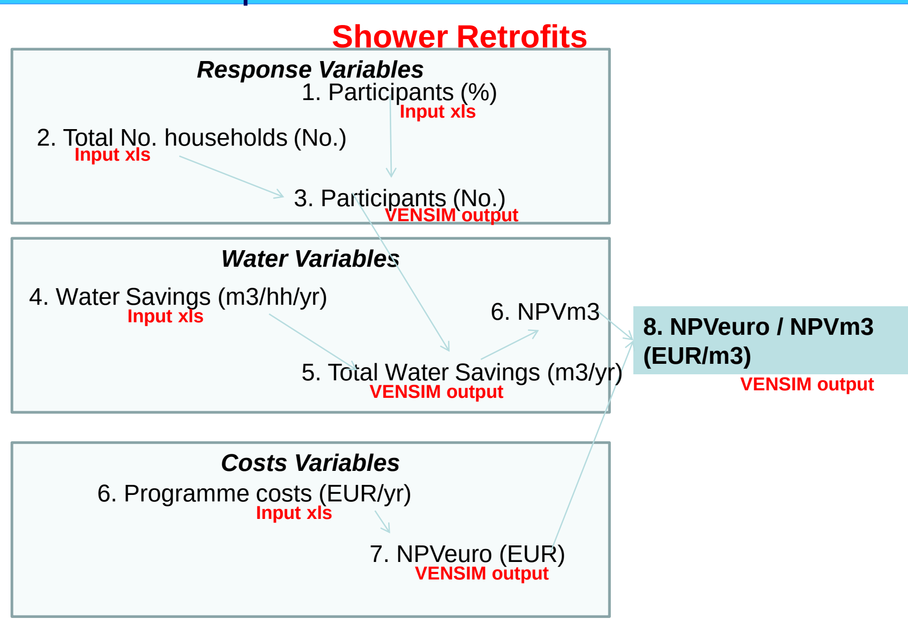
VENSIM WDM options model structure



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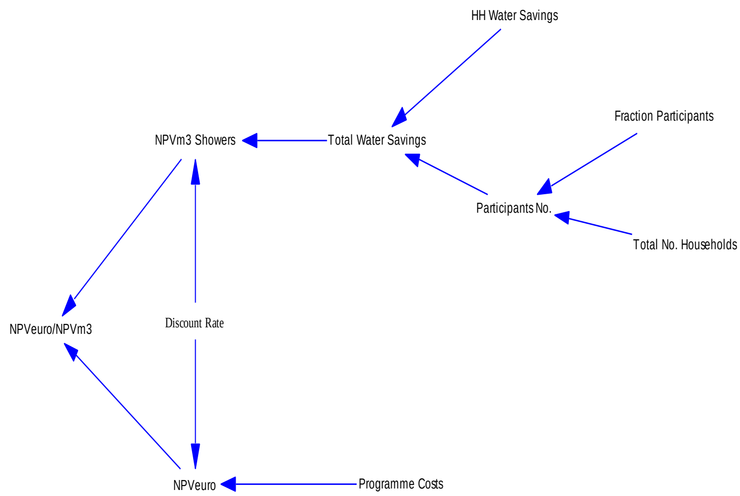
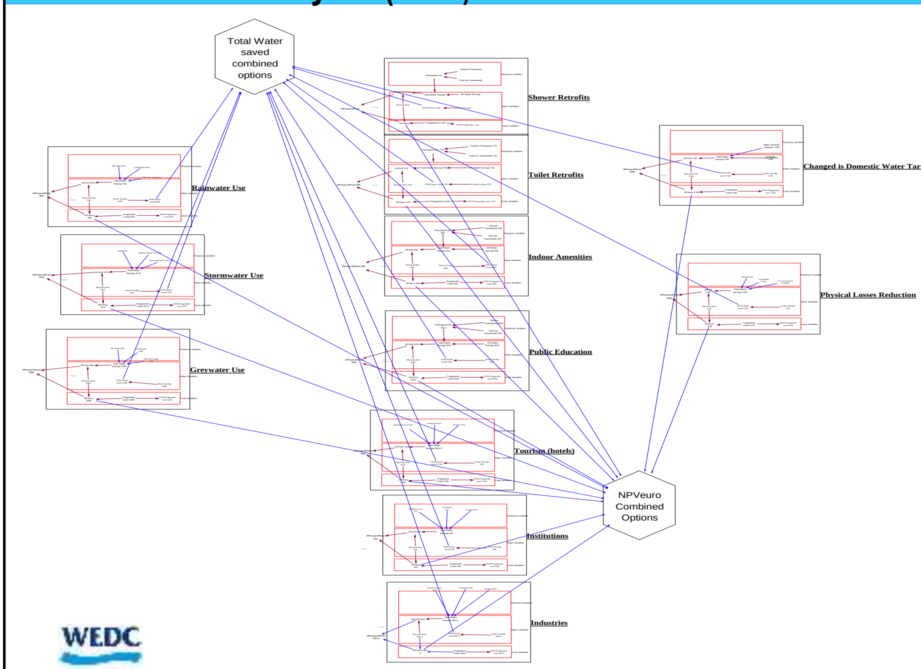
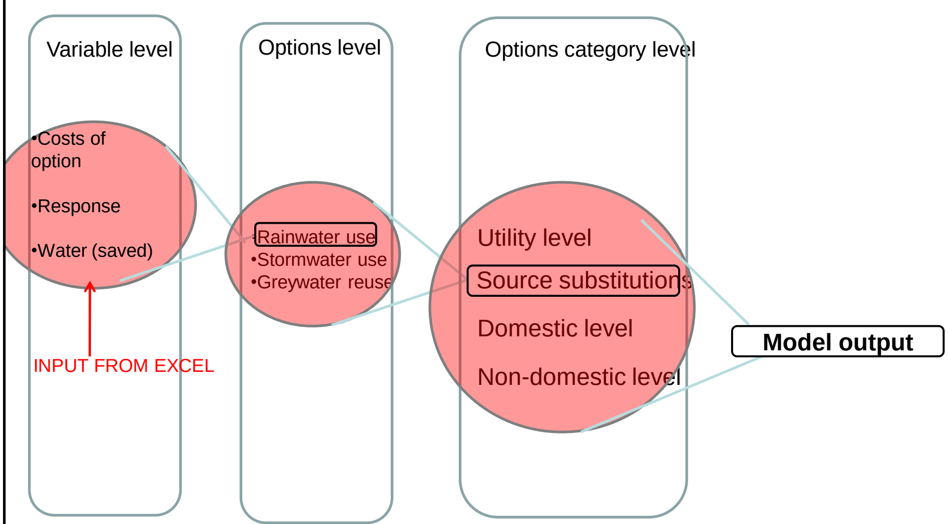
VENSIM layout / shower retrofits



VENSIM model layout (draft)



Structure of the VENSIM model



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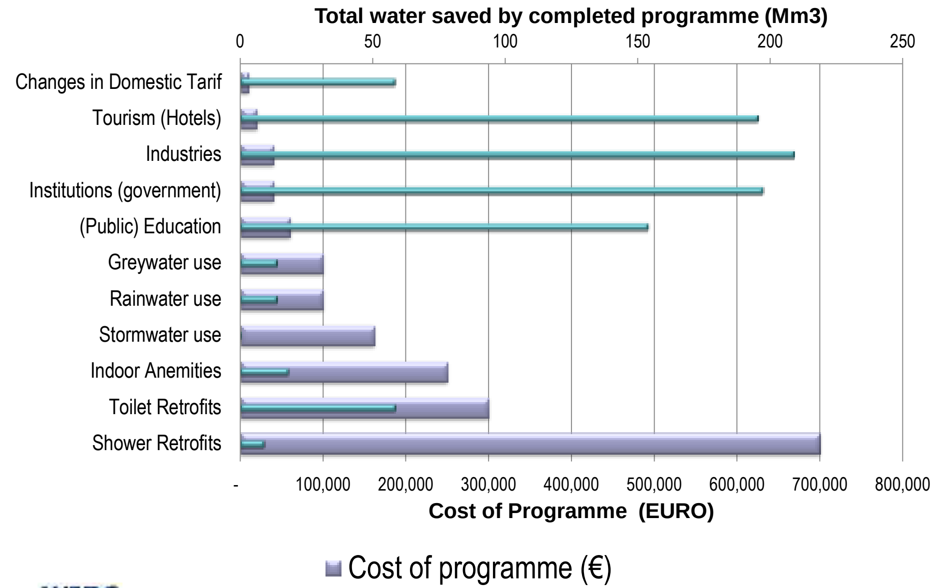
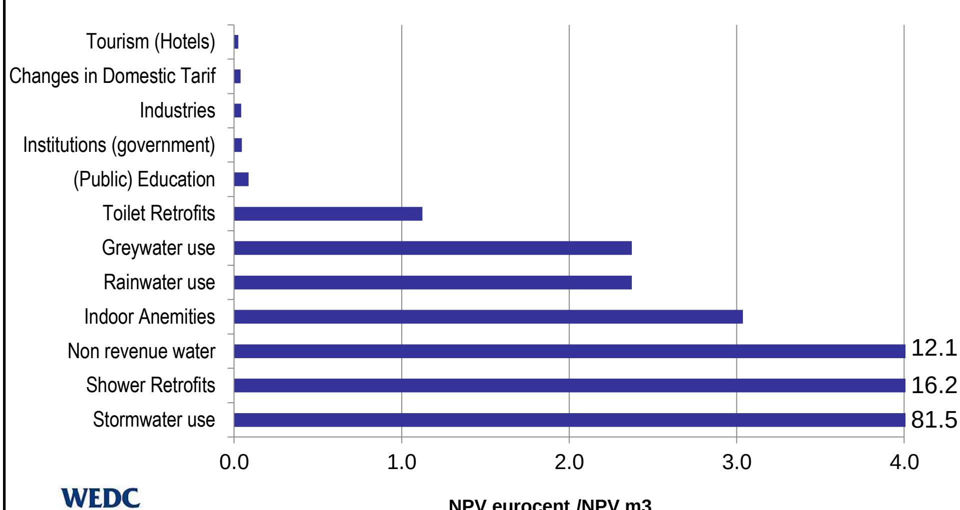
Results

WEDC

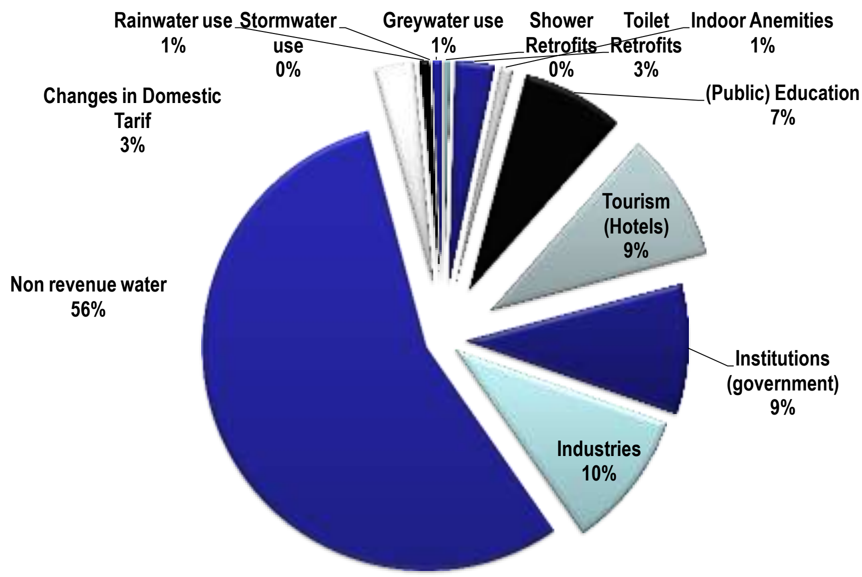
Programme costs vs. water savings



Costs effectiveness of programmes



Share of WDM option in total potential water volume saved



WEDC

Spreadsheet layouts

Times series and constant value-input spreadsheet for VENSIM

WDM Options	*discount rate:*	7%	Time step	0	1	2	3	4	5	6
USER INPUT	VENSIM INPUT	CALCULATED	YEAR	2010	2011	2012	2013	2014	2015	2016
general data	households	800,000								
END USE LEVEL										
Shower Retrofits										
Participants	%	25%	1	1%	5%	10%	15%	20%	25%	25%
Water savings	litres/hh/d	5	2							
	m3/hh/year	1.8	3							
	m3/year	365,000	4	14,600	73,000	146,000	219,000	292,000	365,000	365,000
	total (m3)	10,234,600	5							
	NPVm3	3,649,392	6							
Costs	total in EUR	700,000	7	200,000	200,000	100,000	100,000	100,000	0	0
	NPV EUR	590,822	8							
Unit cost	NPV EUR/NPVm3	0.162	9							
Toilet retrofits										
Participants	%	20%	1	1%	4%	8%	12%	16%	20%	20%
Water savings	litres/hh/d	40	2							
	m3/hh/year	15	3							
	m3/year	2,336,000	4	93,440	467,200	934,400	1,401,600	1,868,800	2,336,000	2,336,000
	total (m3)	65,501,440	5							
	PVm3	23,356,106	6							
Costs total	EUR	300,000	7	100,000	100,000	100,000	0	0	0	0
	NPV EUR	262,432	8							
Unit cost	NPV EUR/NPVm3	0.0112	9							
Indoor Anemities										
Participants	%	10%	1	0%	2%	4%	6%	8%	10%	10%
Water savings	litres/hh/d	25	2							

WEDC

Spreadsheet layouts

Summary of water savings

Water Savings m3/year		0 2010	1 2011	2 2012	3 2013
End Use Level					
Shower Retrofits		14,600	73,000	146,000	219,000
Toilet retrofits		93,440	467,200	934,400	1,401,600
Indoor Anemities		29,200	146,000	292,000	438,000
(Public) Education		186,880	951,219	1,936,682	2,957,314
Tourism (Hotels)		121,400	1,235,852	1,572,622	2,134,572
Institutions (government)		122,500	1,247,050	1,586,871	2,153,913
Industries		129,917	1,322,552	1,682,947	2,284,320
	sub total	**697,937**	**5,442,873**	**8,151,522**	**11,588,719**
Source level					
Rainwater use		8,760	89,177	113,477	154,027
Stormwater use		400	4,000	5,000	6,667
Greywater use		8,760	89,177	113,477	154,027
	sub total	**17,920**	**182,354**	**231,955**	**314,720**
Utility Level					
Changes in Domestic Tarif		0	1,701,078	1,731,697	1,762,868
Non revenue water		41,322,222	41,322,222	41,322,222	41,322,222
	sub total	41,322,222	43,023,300	43,053,920	43,085,090

WEDC

Advantages of VENSIM (over a spreadsheet based model)

- Visualization of relationships between parameters & variables
- With each time step parameters can change; you can play with them..
  - You can explore and better understand interaction between system components
- Sensitivity analysis – easy to do.
- Automatic generation of parameters (with units) and equations used
- Error messages when units are not compatible, when values become unrealistic during modeling, etc.
- Can be used to carry out object-oriented modeling

VENSIM facilitates getting a deeper understanding of the effect of any system and its dynamic

WEDC

SWITCH

Further information

- www.switchurbanwater.eu
- s.m.kayaga@Lboro.ac.uk and
- i.k.smout@Lboro.ac.uk

Thank you for your attention

Bringing wastewater treatment on the farm: Multi-purpose ponds in urban farming in Accra, Ghana

Olufunke Cofie[1*], Philippe Reymond[2] and Liqa Raschid-Sally[1]
[1]International Water management Institute; [2]Swiss Federal Institute of Aquatic Sciences; [*]Corresponding author (o.cofie@cgiar.org)

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Conclusion
Perspectives

Urban farmers use ***wastewater*** for irrigation

↓

HEALTH RISKS

↓

WHO guidelines for wastewater use in agriculture (2006)

↓

MULTIPLE BARRIER APPROACH

Necessity to improve on-farm water quality: non-treatment options

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From farm to fork investigations

↓

•**Faecal coliforms** and **helminth eggs** concentrations

from irrigation water on lettuce

So SWITCH follow up:

Participatory on-farm wastewater treatment

•Participatory Design
•Monitoring pathogen removal and nutrient recovery

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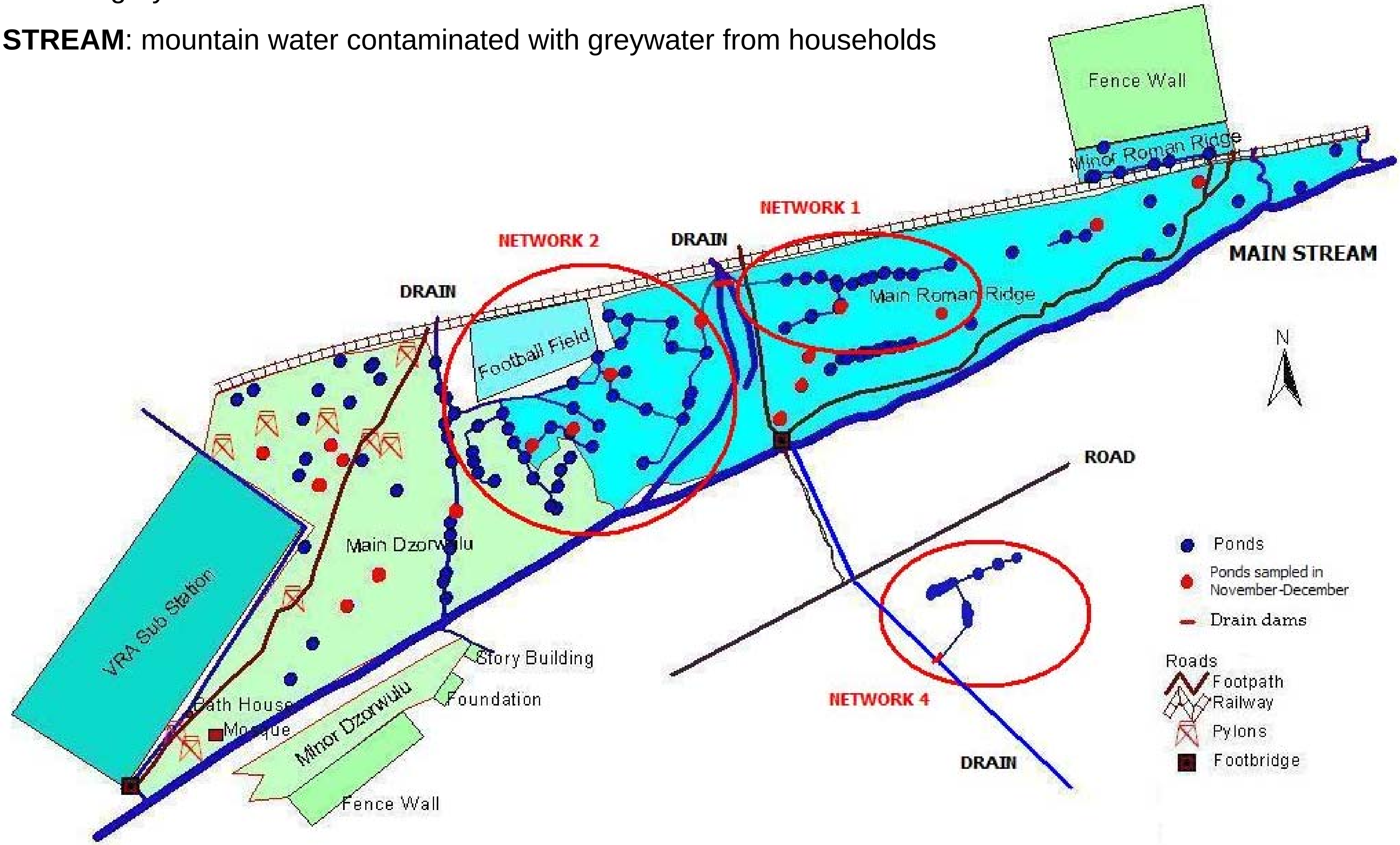
Three settings in Dzorwulu-Roman Ridge, Accra site:

1. **Ponds-trenches networks**: water is derived from a drain according to *communicating vessels* principle
2. **Individual ponds**: water is pumped from a stream
3. **Direct fetching in the drain**: drain is blocked to get sufficient water depth

DZORWULU – ROMAN RIDGE FARMING AREA

DRAIN: greywater from households

STREAM: mountain water contaminated with greywater from households



ROMAN RIDGE FARMING AREA


HONDA

CHARACTERISTICS OF NETWORKS

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	Network 1	Network 4
Source of water	*greywater (dam on a drain)*	*greywater (dam on a drain)*
Number of farmers	~ 10	2
Number of ponds	14	5
Total length of trenches (m)	169.7	52.6
Total volume of water (m3)	43.3	11.9
in ponds	24.2	10.7
in trenches	19.1	1.2
Related farming area (ha)	~ 0.7	~ 0.3
Related number of beds	~ 250	110
Max watered surface (ha)	~ 0.4	~ 0.16
Average volume of ponds (m3)	1.7 *(1.1)**	2.1 *(0.7)**
Average surface of ponds (m2)	5.5 *(3.5)**	6.8 *(3.5)**
Average depth of ponds (m)	0.4 *(0.04)**	0.4 *(0.1)**
Average width of trenches (m)	0.5 *(0.1)**	0.3 *(0.1)**
Average depth of trenches (m)	0.3 *(0.1)**	0.15 *(0)**
Average length of trenches/pipes (m)	11.4 *(5.5)**	10.5 *(4.5)**

** Figures in parenthesis are standard deviations.*

- Water flows continuously, so retention time is short

CHARACTERISTICS OF INDIVIDUAL PONDS

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	Pond Y	Pond H
Water source	*Stream*	*Stream*
Length (m)	4.2	*Irregular shape*
Width (m)	3.9	*Irregular shape*
Surface (m2)	16.4	17.0
Depth when full (m)	0.9	0.9
Volume of water when full (m3)	11.8	12.3
(calc. with corr. factor = 0.8)		
Max. watered surface (m2)	314	350
Max. n° of beds watered	22	25

- Water is stored 2-3 days in the ponds, so retention time is longer

OBJECTIVES

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Main objective was to test on-farm storage ponds as a means to achieve some reduction in pathogen concentration before application to crops

-Identify **farmers' constraints and motivations** for design modifications.

- **Analyse pathogen concentrations** in networks and individual ponds

- Propose **appropriate design modifications** and validate them

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- **Field observations, informal discussions, experience gained while implementing design modifications**

- Measurements

- Sampling **daily**

- Comparison of concentrations **in different points in the network**, from the source to the last pond

- Microbiological analysis: ***Faecal coliforms*** and ***helminth eggs***

- Chemical analysis: ***Dissolved oxygen (DO)***

- On site parameters: ***pH, Temperature, Conductivity***

- Observation of influencing factors:

    ***watering practices, crop development stage, manure management, rain, runoff*.**

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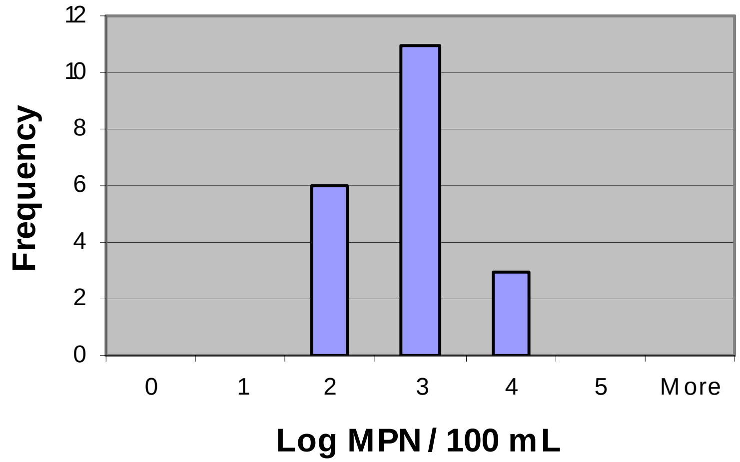
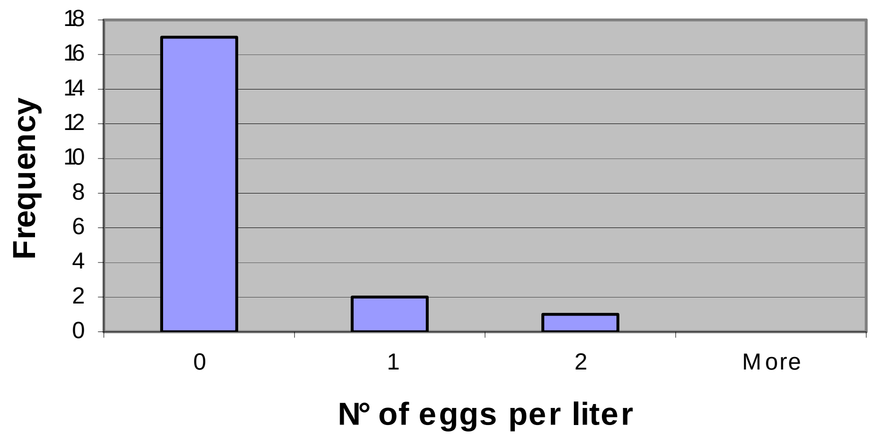
Histogram of faecal coliform concentrations



Histogram of helminth eggs concentrations



EXTENT OF FC NATURAL REMOVAL

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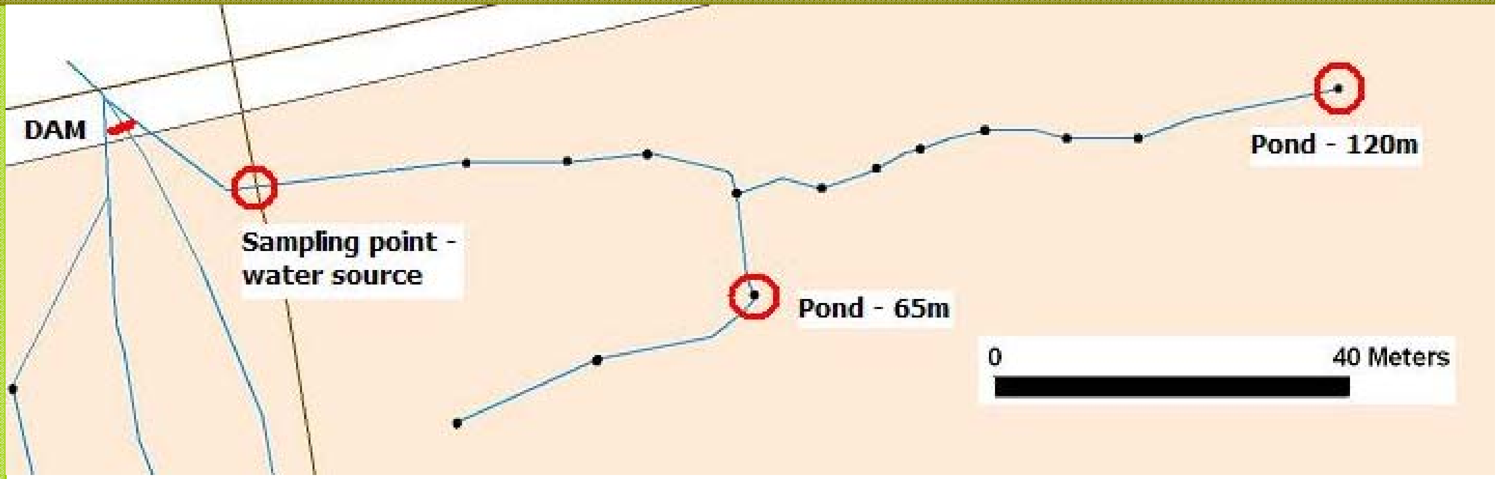

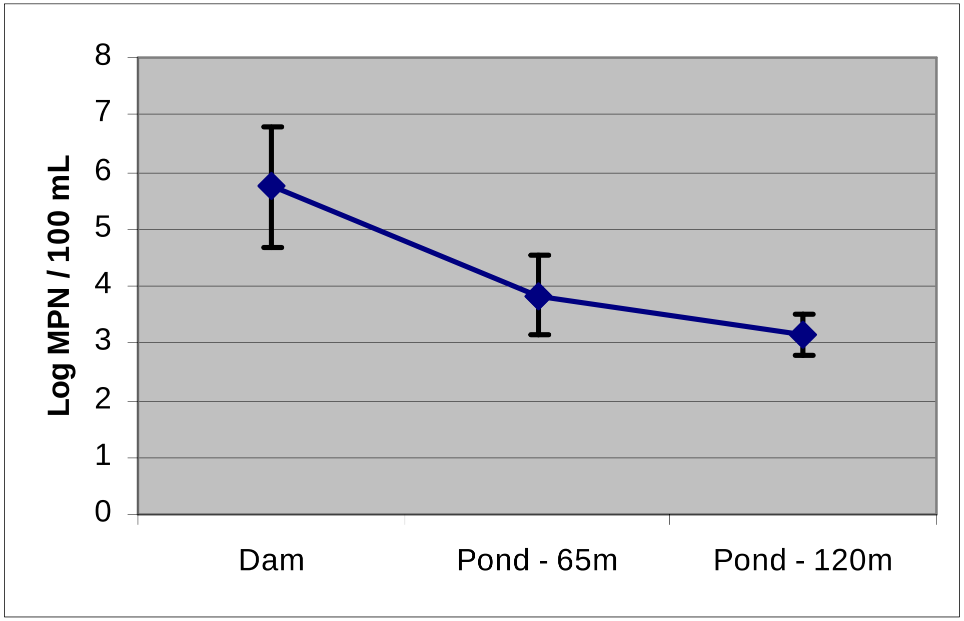

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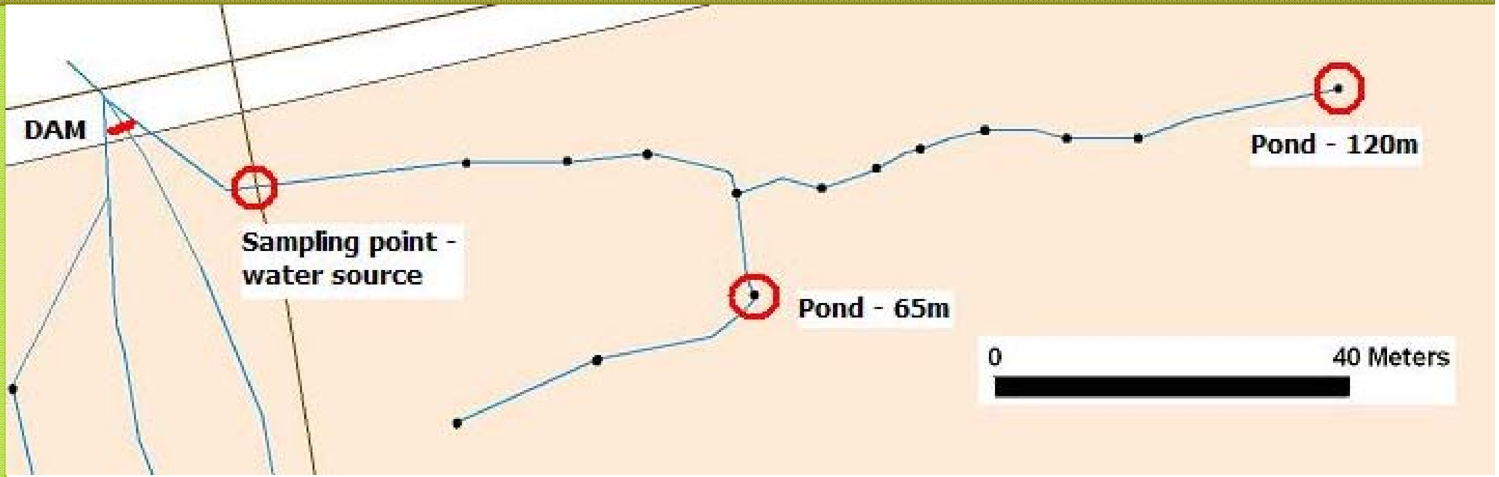
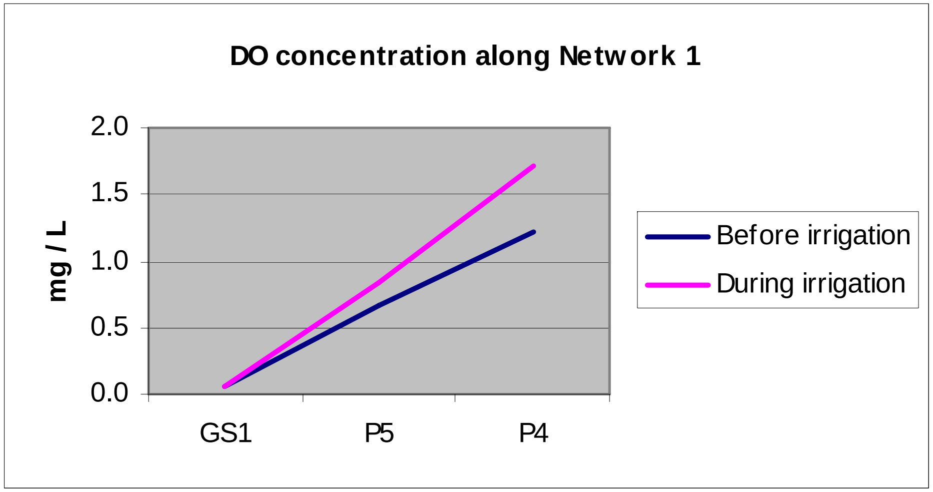


Note: Network 1 was at that time half covered with macrophytes *(Pistia)*



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	Average *(25 samples)*	**StDev**
Temperature (°C)	27.1	0.6
pH	7.1	0.3
Conductivity (microS/s)	1007.8	38.9
Dissolved oxygen (mg/L)	0.9	0.6

NETWORK 4: EXTENT OF CONTAMINATION

- Introduction
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- **Network 4**
- Individual ponds
- Constraints & motiv.
- Design modifications
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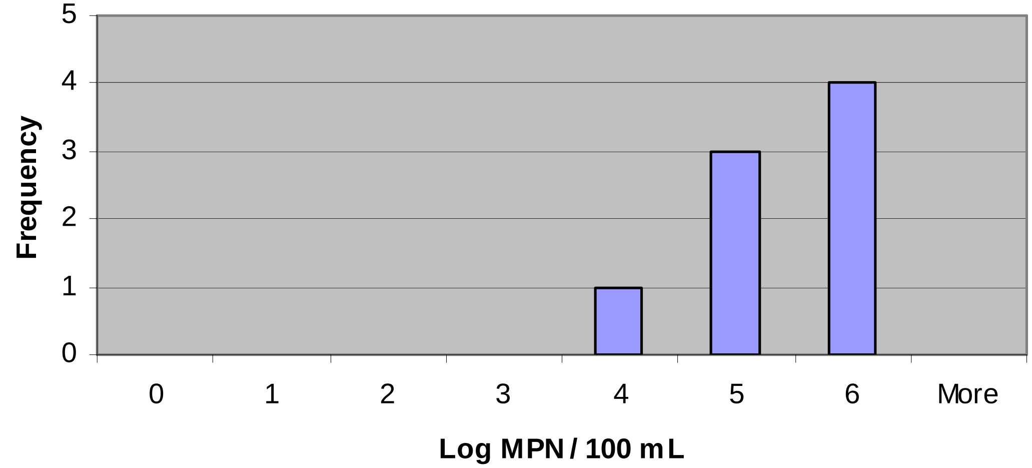
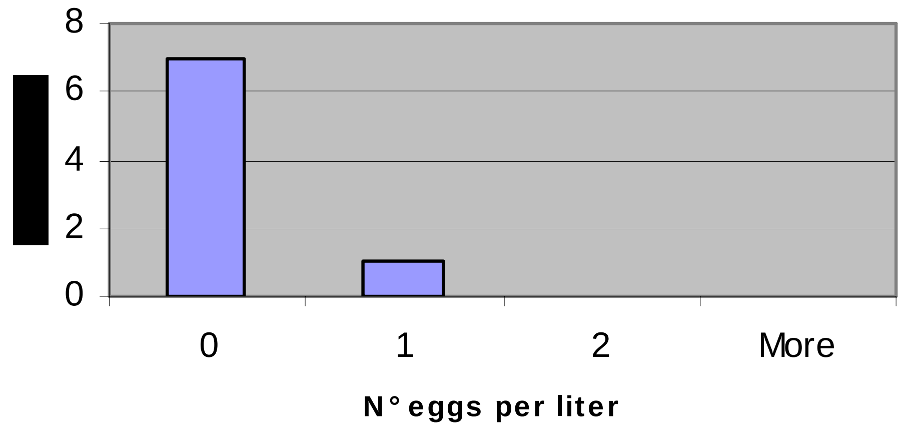
Histogram of faecal coliform concentrations



Histogram of helminth eggs concentrations



FAECAL COLIFORM CONCENTRATIONS

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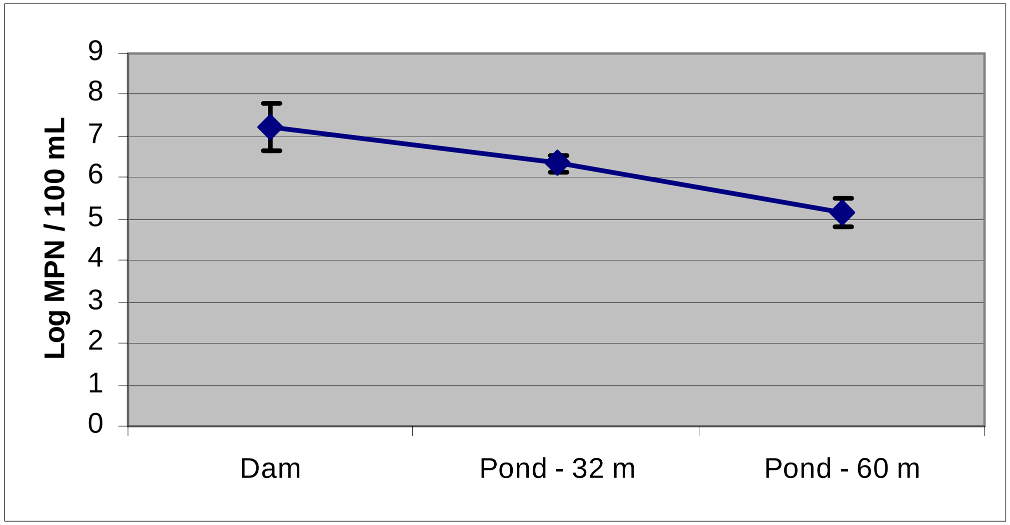

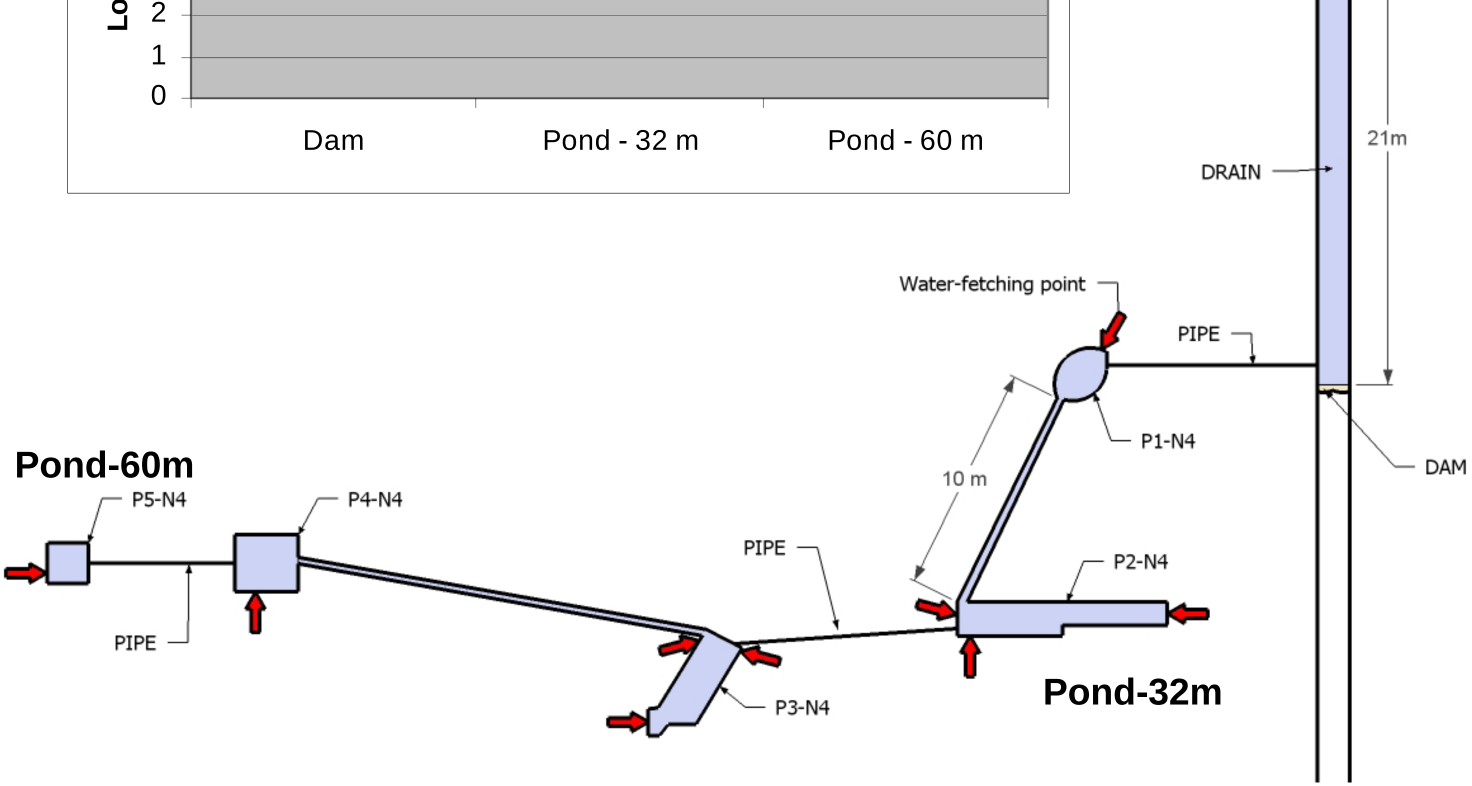

INDIVIDUAL PONDS: EXTENT OF CONTAMINATION

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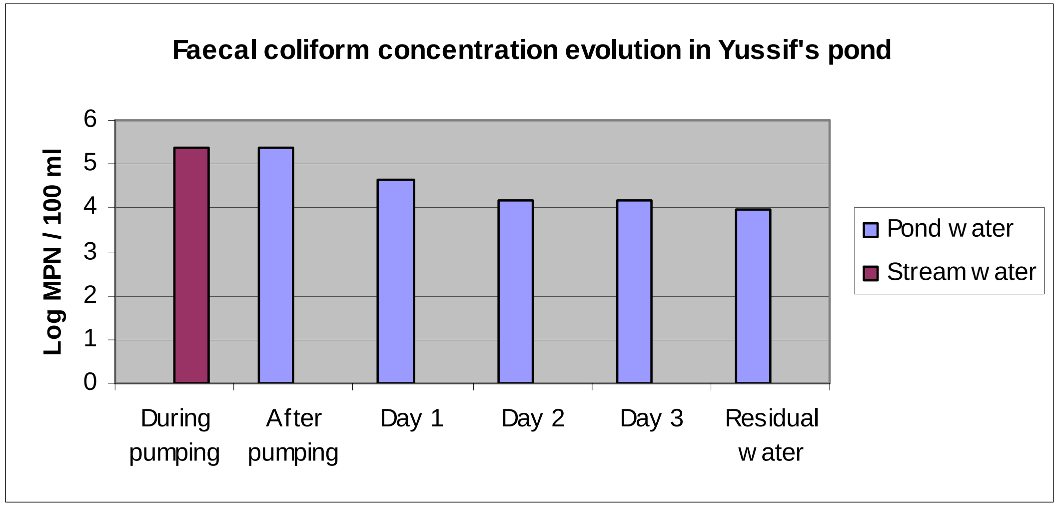
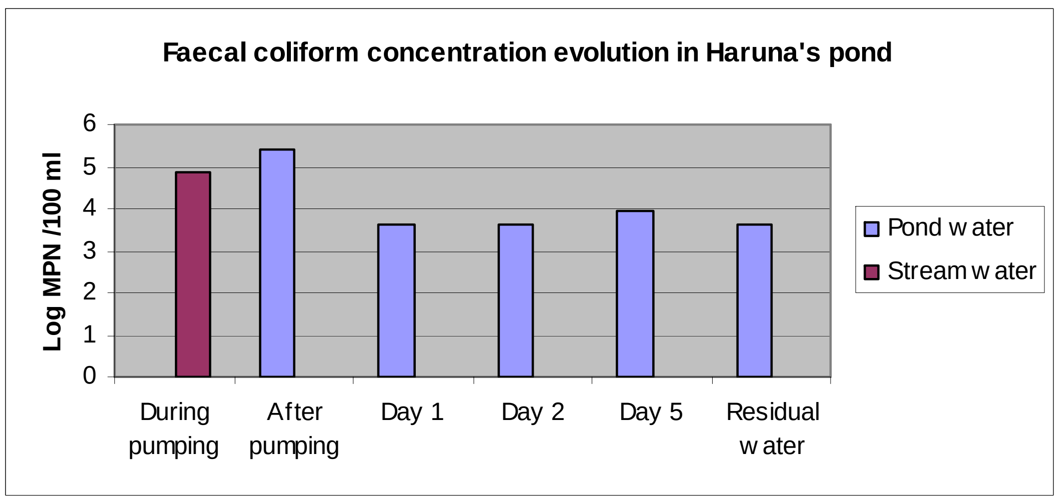
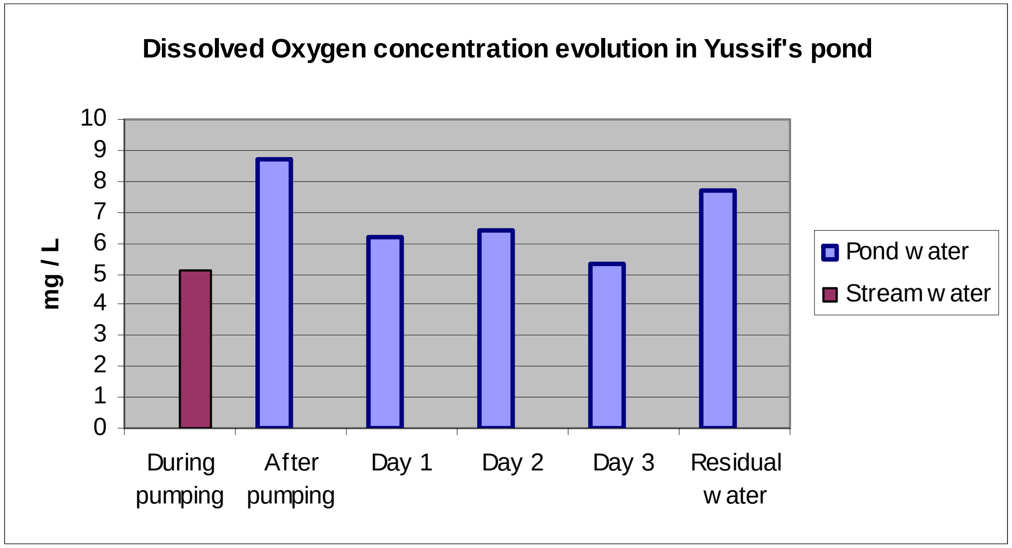
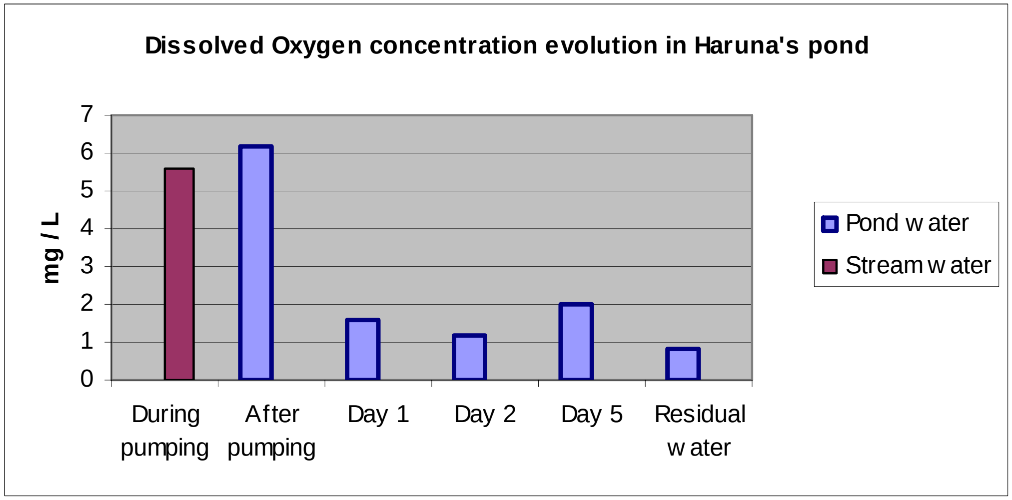




DISSOLVED OXYGEN CONCENTRATIONS





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- Permanent **need of water**
- **Variability of water needs** and watering schedule
- **Difficulty to dig** deep ponds
- Energy needed to **carry water**
- Lack of **space**
- Limited **financial resources**
-

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MOTIVATIONS:

- Increase the **volume of available water**
- Increase the **comfort** at the **water fetching** points.

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- Increase the **volume of ponds and trenches**
- Avoid **short-circuiting** and hydraulic dead zones
- **Favor plug flow at the entry point** of the networks
- **Upstream** action
- Avoid **resiltation**
- Avoid **runoff** into the ponds

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- No lost of arable land
- **Low cost**
- Cheap and available materials
- **Same water fetching points**
- No impact on watering practices

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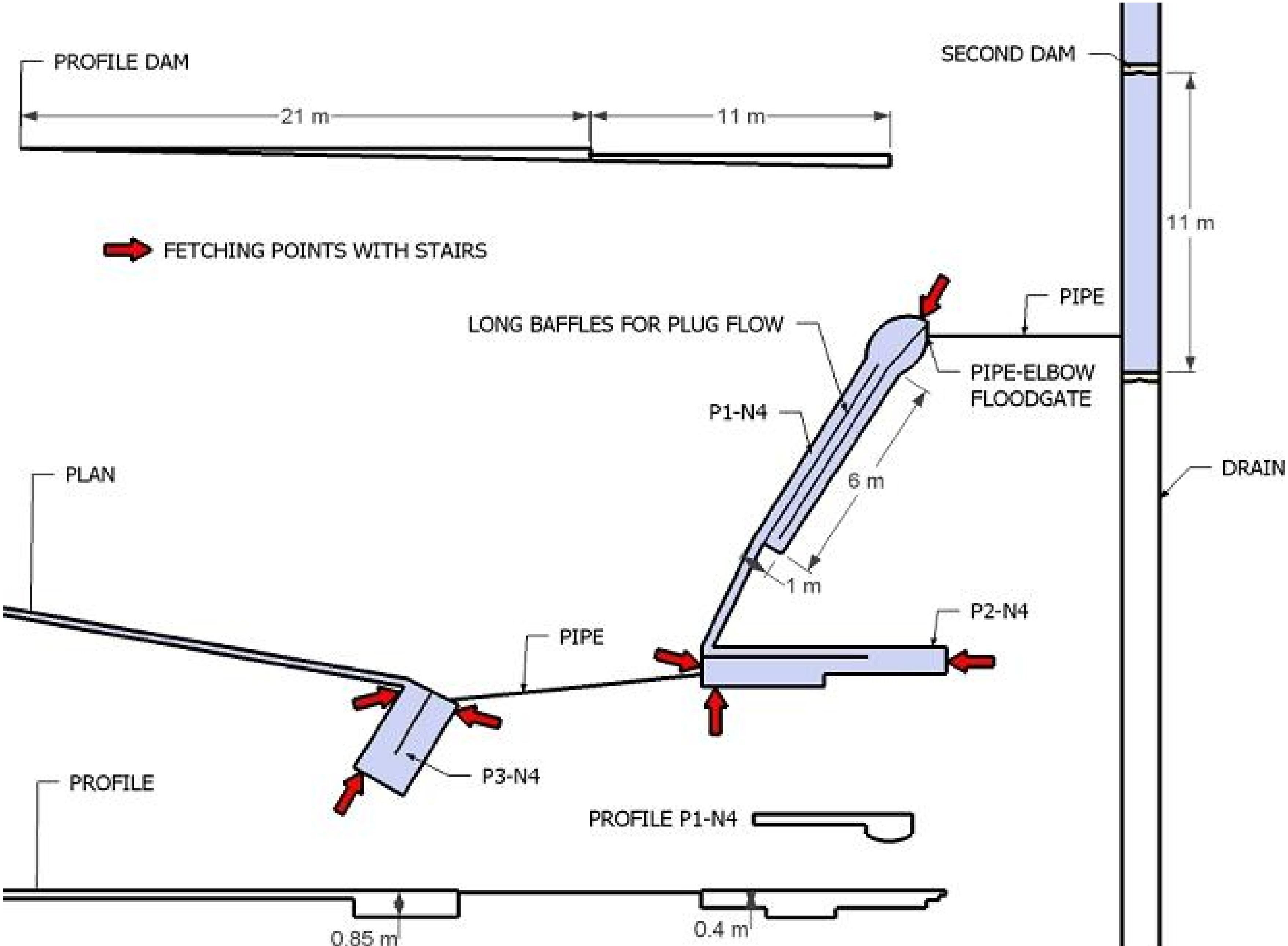
- Deepening of networks
- Improvement of water fetching points
- New retention ponds
- Baffles
- Temporary separation of source and network
- Doubling of individual ponds

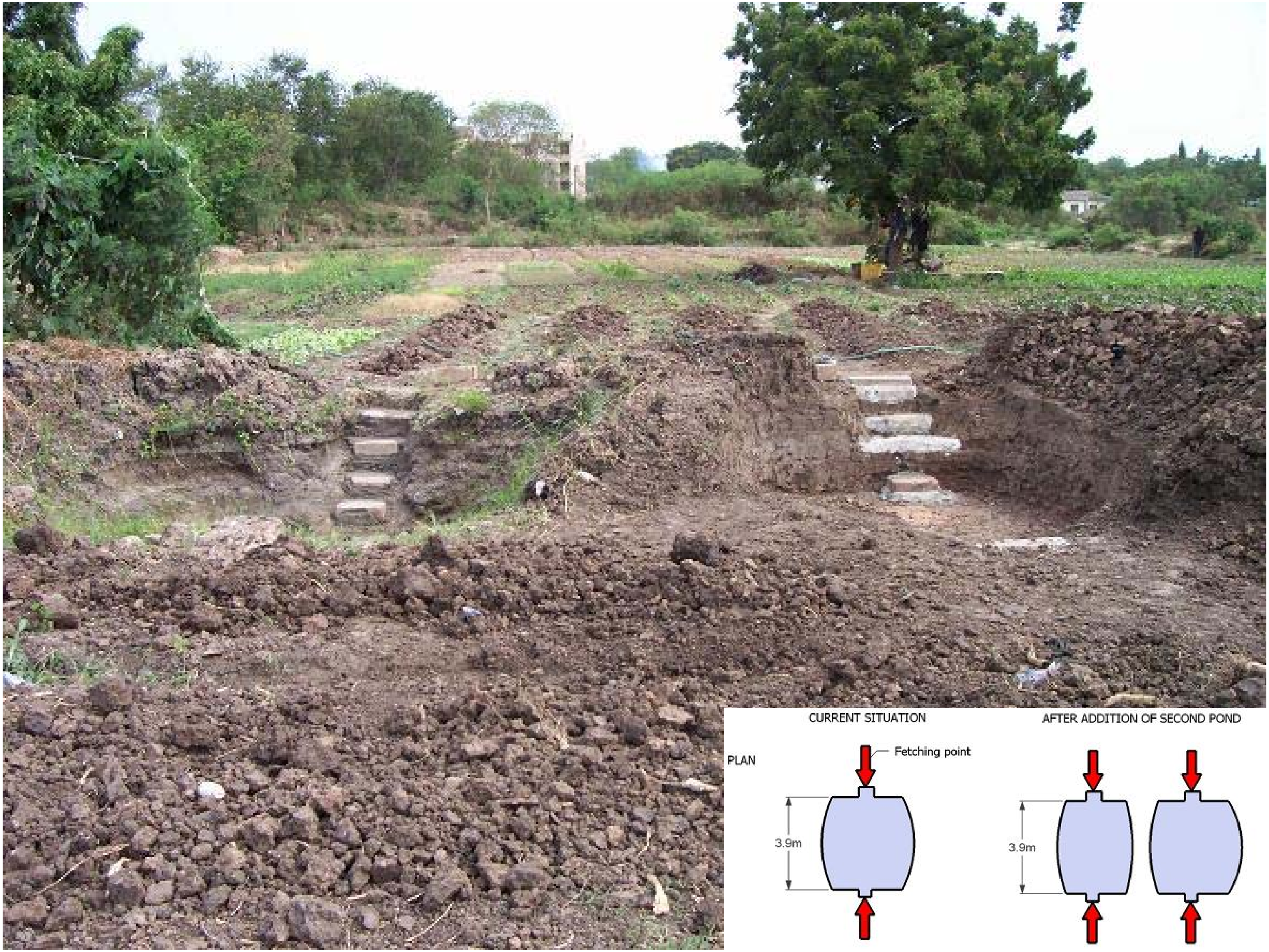


Sketch of the main modification in Network 4

IMPROVEMENT OF FETCHING POINTS

BEFORE

AFTER


CURRENT SITUATION
AFTER ADDITION OF SECOND POND
PLAN
Fetching point
3.9m
3.9m

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- Natural faecal coliform removal of about **2 log units** from the wastewater source to the last pond

- Helminths are **NOT** in the water.

- **Constraints for design modifications** are described.

- Design modifications currently being **assessed**

- **Costs** for materials and design modifications are not high

- On the field, farmers have seen **concrete action**.

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- **Validation** of design modifications' impact on water quality
- Quantify **pathogen flows** (water, soil, manure)
- Find out if and where **helminth sedimentation** takes place.
- Organization of **upstream action**
- **GUIDELINES** for use in urban agriculture

Improving on-farm ponds for wastewater treatment in Accra, Ghana

SWITCH

Site description: A vegetable farming site of 500 farmers using polluted water of varying quality. Individual ponds and networks of interconnected ponds are a common feature (Fig 1). Pond systems are managed by two or more farmers depending on their size. This project upgrades an existing 5-pond network for enhanced risk control. Farmers participated in construction and maintenance. The design doubled the water volume and reduced “short-circuiting” (rapid flow), increasing the overall water retention time from one to two days.

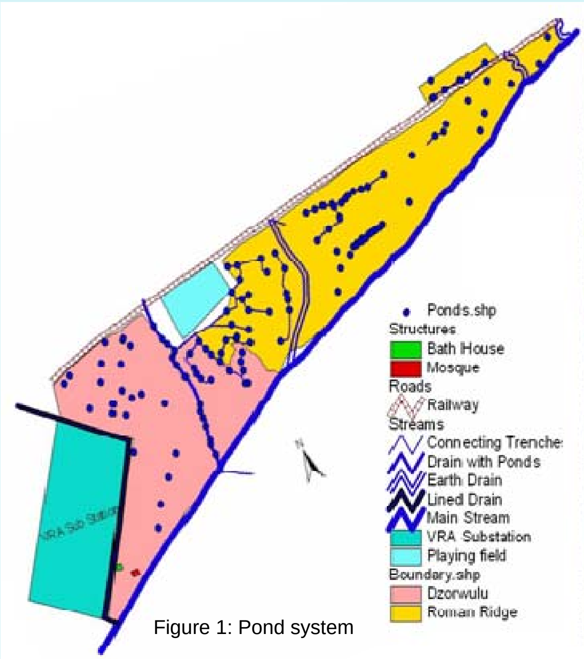

Figure 1: Pond system

The Demo site in Accra, Ghana, drawing water via pumps from polluted streams and wastewater drains

Technology Description:

Trenches were slightly widened and ponds were deepened and their shape regularized. Steps were built to facilitate entry into ponds and avoid sediment re-suspension. Simple baffles were placed to increase the water retention time (see figure 2)

Required inputs: Mostly labor for construction (two man-days) and USD 50 per farmer for construction materials.

Figure 2**:** Interconnected pond with hardwood baffles.

Pathogen removal

The systems enhance fecal coliform removal from 10^6-10^7 MPN/100ml by at least 2 log units from the first to the last pond. Individual ponds showed a removal of 1-1.5 log units over two days. Helminth eggs were not frequently found in the source water (up to two eggs/litre) but when present, dropped below one egg/litre in the first pond.

TIP: the retention trenches account for a quite stable permanent improvement and a barrier (raising the height of the inflow pipe above the diversion weir) stopped the continuous inflow of pathogen-rich water from the main stream during the watering period, preventing re-contamination.

Adoption and out-scaling potential:

Whilst this case does not illustrate a perfect solution, it shows that farmer initiatives can contribute to pathogen reduction and also offer opportunities for improvements through participatory research. Important site criteria were sufficient tenure security, space, and an adequate slope to allow flow by gravity for interconnected systems. Given the load of two 15 l watering cans to carry each time, farmers cooperate if modifications can reduce transport time. The system is not suitable in flood-prone areas.

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IWMI International Water Management Institute

Urine in Urban Agriculture in Accra, Ghana

Assumption

Urine if properly harvested and managed, can replace fertiliser as nitrogen source and improve environmental sanitation in cities.

Constraints

Societal perception and logistic requirement.

Research/Demonstration

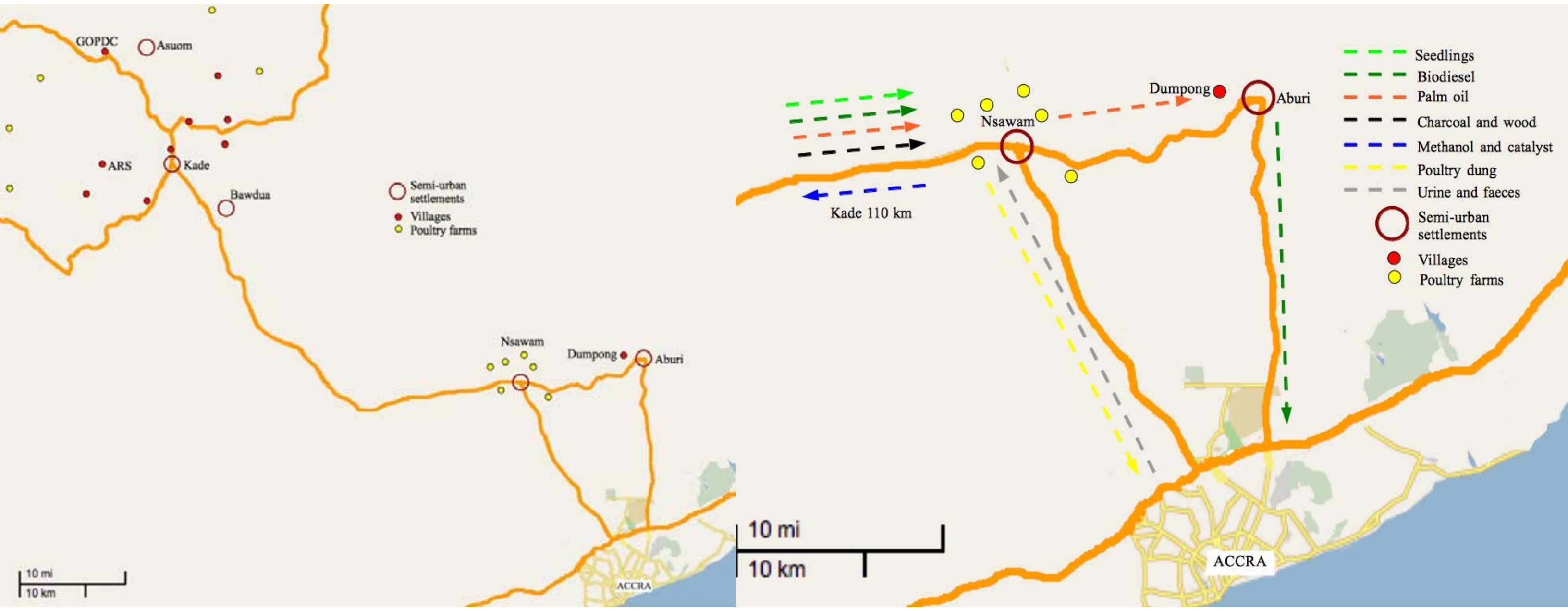
To pilot test the potential for using urine for crop production in Accra Metropolitan Area and provide recommendations for scaling up its use.

perception vs **willingness to buy**
demand vs **supply**

technical vs **financial feasibility**

Findings

- positive perception and willingness to use by farmers
- 50% of marketers are willing to buy
- urine grown crops compared favourably with crops grown with fertilizer
- 77% of marketers are not willing to buy at higher price
- for profitable business, the user fee has to increase by 50%
- scaling up will require a different supply chain



Linking urban and peri urban Accra: alternative supply chain for urine ,Accra-Nsawam-Dumpong .Source: Martinez, 2009)

Outputs

Guidelines
Training manual
MSc theses

International Water Management Institute | RUAF Foundation | SWITCH | SAFISANA LTD

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Table 3: financial analysis of the investment into urine-based fertiliser production system - Private ownership

Investment cost	78502.60
Total operating cost	1062106.04
Total benefit	885433.00
NPV (25%)	GH¢ -89372.15
BCR (25%)	0.59:1
IRR	-

Source: Survey results, May 2010

Table 4: financial analysis of the investment into urine-based fertiliser production system - Public ownership

Investment cost	GH¢ 78,502.60
Total operating cost	GH¢ 793,820.04
Total benefit	GH¢ 885,433.00
NPV (25%)	GH¢ -50699.01
BCR (25%)	0.71:1
IRR	1.37%

Source: Survey results, May, 2010

- The results of the sensitivity analysis showed that the investment can be ***financially profitable***;

- for a profit-oriented entrepreneur and AMA only if the discount rate is 20% and lower with a urine user fee of GH¢ 0.10 or higher per visit and sale of urine to farmers at GH¢0.30 per jerry-can (20 litres).

- As it gave NPVs, BCRs and IRRs (GH¢ 8,147.79, 1.03 and 22.65%) and (GH¢ 104901.34, 1.49 and 51.45%),

- with payback periods of 5.44years and 2.91 years respectively.

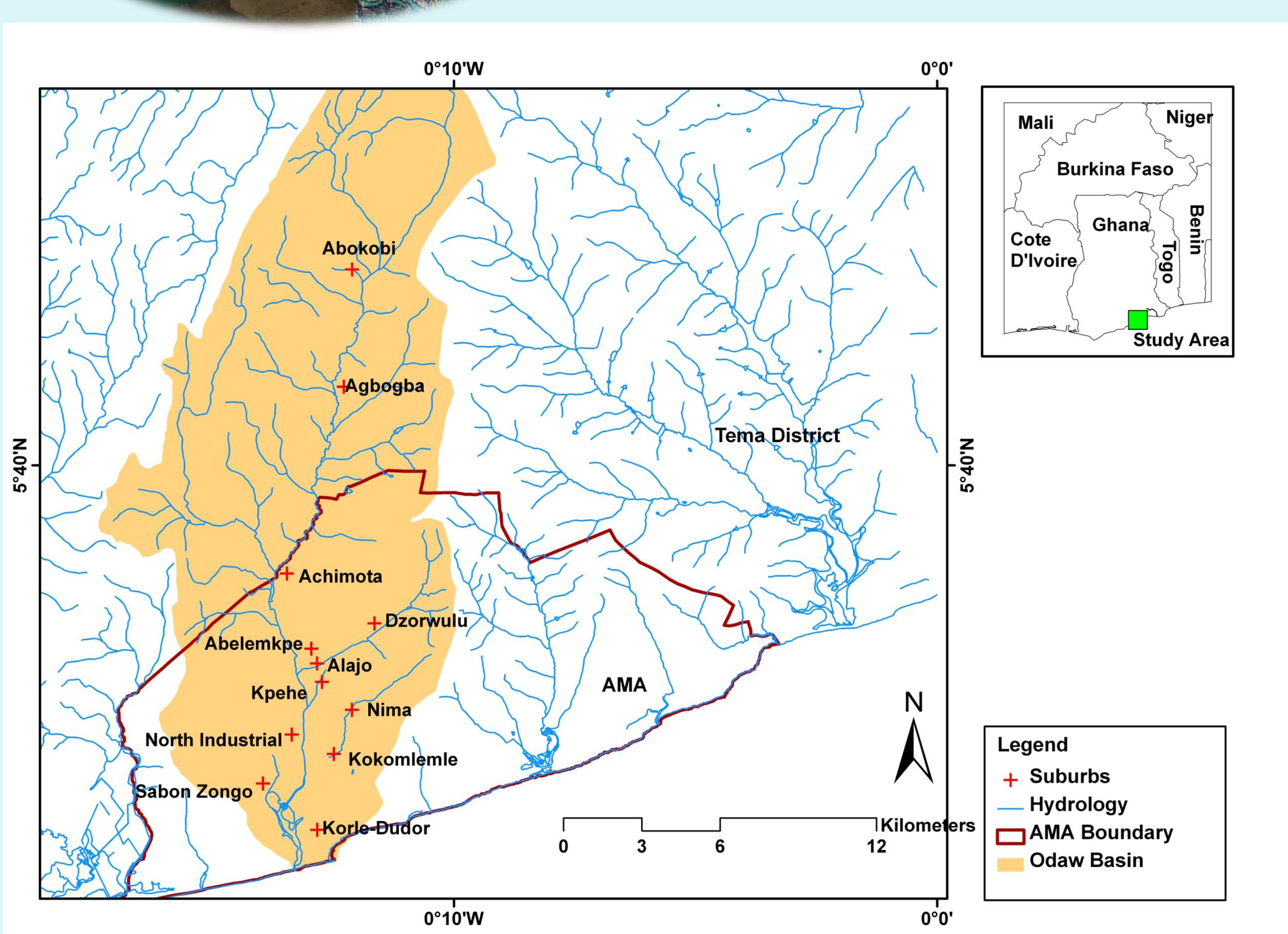
Improving Urban Water Quality for Livelihoods Enhancement in the Odaw-Korle River Catchment of Accra, Ghana

Background and Objectives

The research sought to understand the interrelationship between water for livelihoods, and attitudes to water and the environment, which constrain the use of surface water for various purposes in the urban context.

Methodology and Research Activities

- Ten selected communities reflecting different urban contexts - peri-urban; high income; middle income; and low income categories
- Focus group discussions; 443 households questionnaires; interviews .
- Water samples from five locations analyzed over a period of time.



Map of Odaw-Korle River Catchment showing study communities

Findings

- **Varied access to water across communities**: less than 30% of households in peri-urban communities had tap water supply but this was over 70% for high income communities. Middle and low income communities were in between.
- **Contribution to household income**: 43% of households engaged in water-dependent occupations but less than 10% of households derived 90% of income from such use. About 17% derived at least 50% of their income from water.
- **Varied attitudes to pollution across income classes**: Environmental pollution was low in peri-urban and high income areas but high in middle and low income communities.

Recommendations

- Improve access to water in the worst served areas ie peri-urban, middle and low income communities, and support water dependent livelihoods
- Change in attitudes towards water and environmental pollution, is possible through organized efforts within communities.
- A user friendly approach to regulation and fee payment by Accra Metropolitan Assembly (AMA) will help poor households comply, and avoid widespread pollution by solid waste.

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