Analyzing the potential of Roof Rain water harvesting Systems for water supply in Manakha town and surrounding area

تحليل إمكانية حصاد مياه الأمطار من الأسطح لتزويد مدينة مناخة والمناطق المجاورة لها بالمياه

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Sana'a University

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CONTENTS

Introduction

- **Problem statement**
- **Importance of the study**
- **Objectives of the Study**

Study Area

Methodology and results

Conclusions and recommendations

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Introduction

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Importance of the study

Exploring new sources of water

The first RTRWH study in Manakha area

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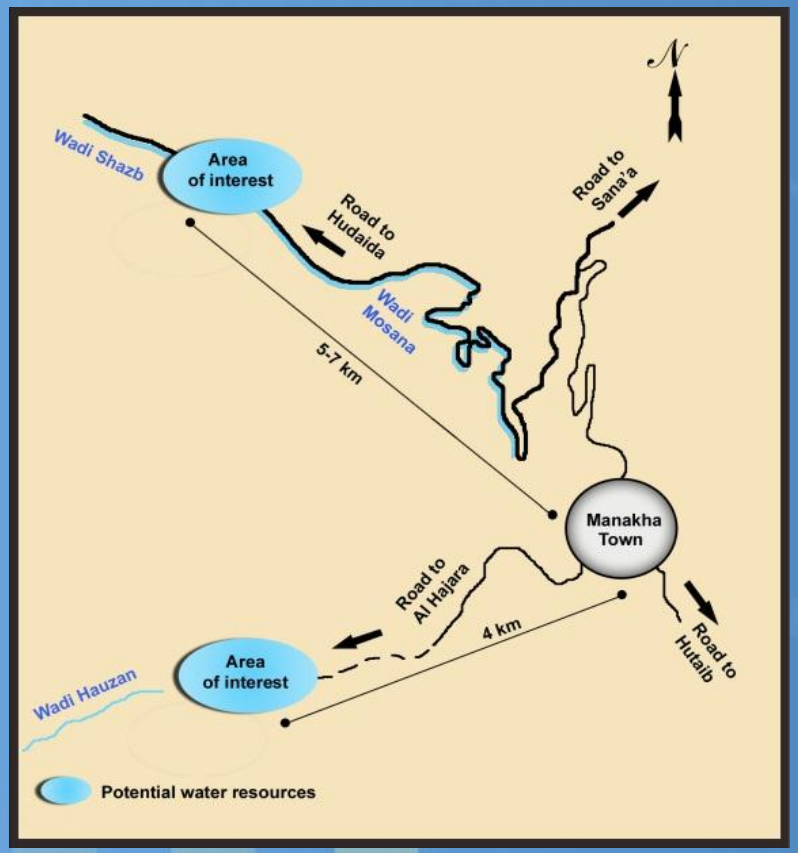
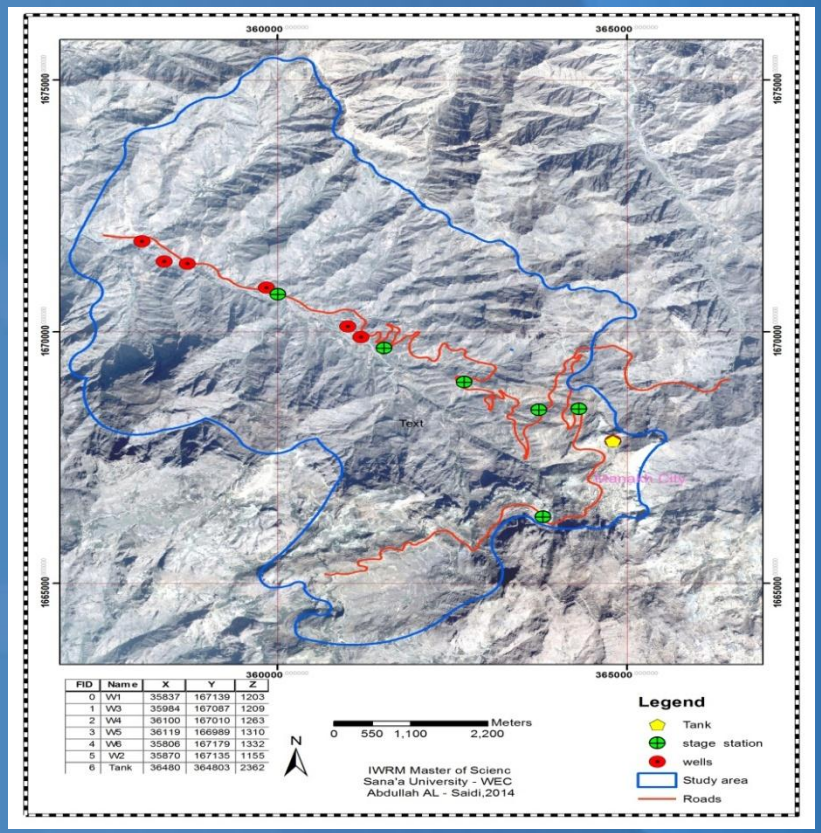
Importance of the study

Location of the water resources in study area





FID	Name	X	Y	Z
0	W1	35837	167139	1203
1	W3	35984	167087	1209
2	W4	36100	167010	1263
3	W5	36119	166989	1310
4	W6	35806	167179	1332
5	W2	35870	167135	1155
6	Tank	36480	364803	2362

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Objectives of the Study

The overall objectives of the study :

- To assess the technical, economical and social feasibility to introduce roof top rainwater harvesting systems in Manakha town to meet domestic water needs and reduce the pressure on groundwater resources and household's financial resources.

Supplementary objectives :

- To evaluate socio economic feasibility of applying RTRWH techniques in the target area.
- To calculate total harvestable water volume from the roofs and suggested bonds of Manakha .
- To identify the best techniques, including the quality aspects, that could be used for RTRWH in Manakha from the economic and equality .

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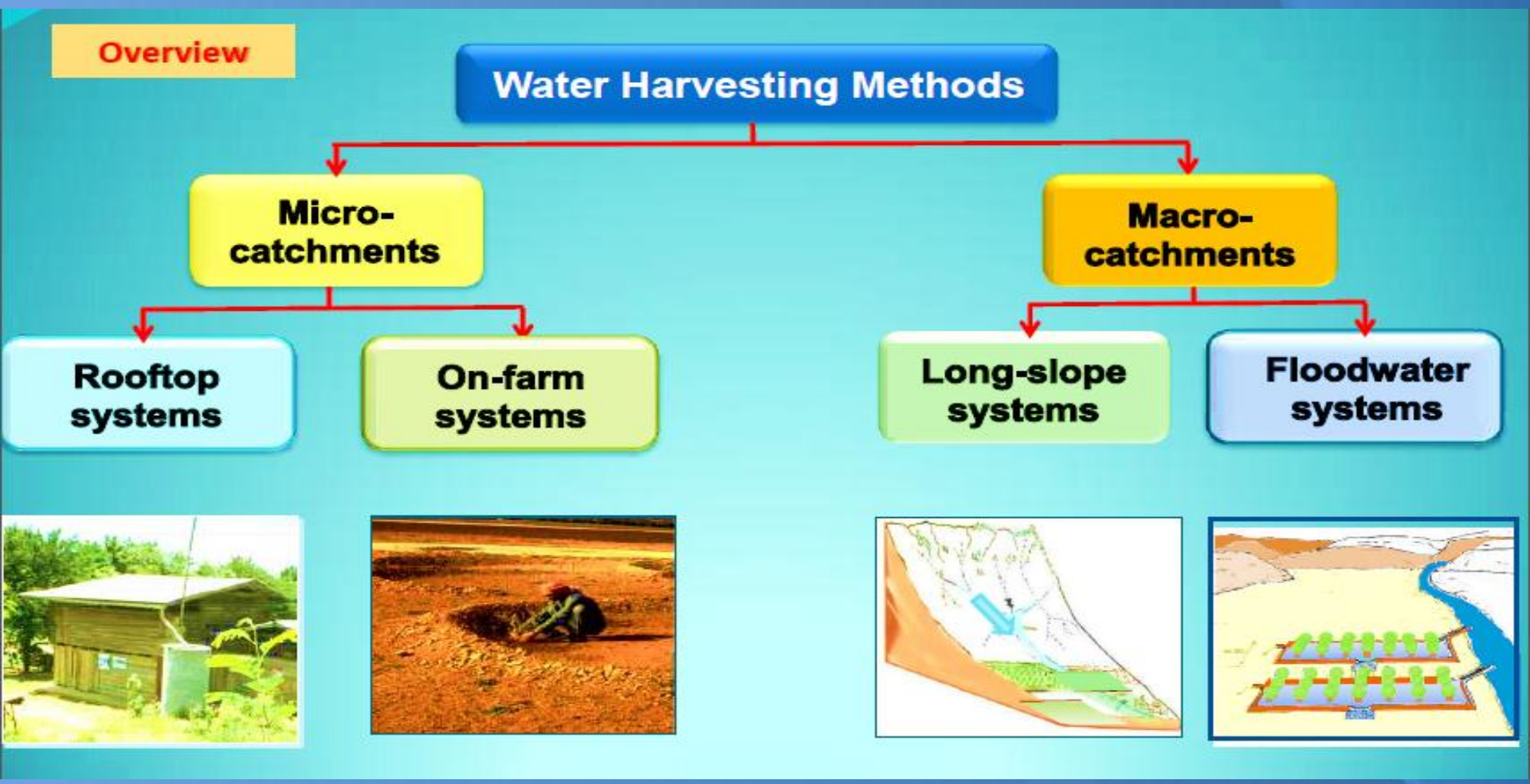
The Methods of Water Harvesting

Overview



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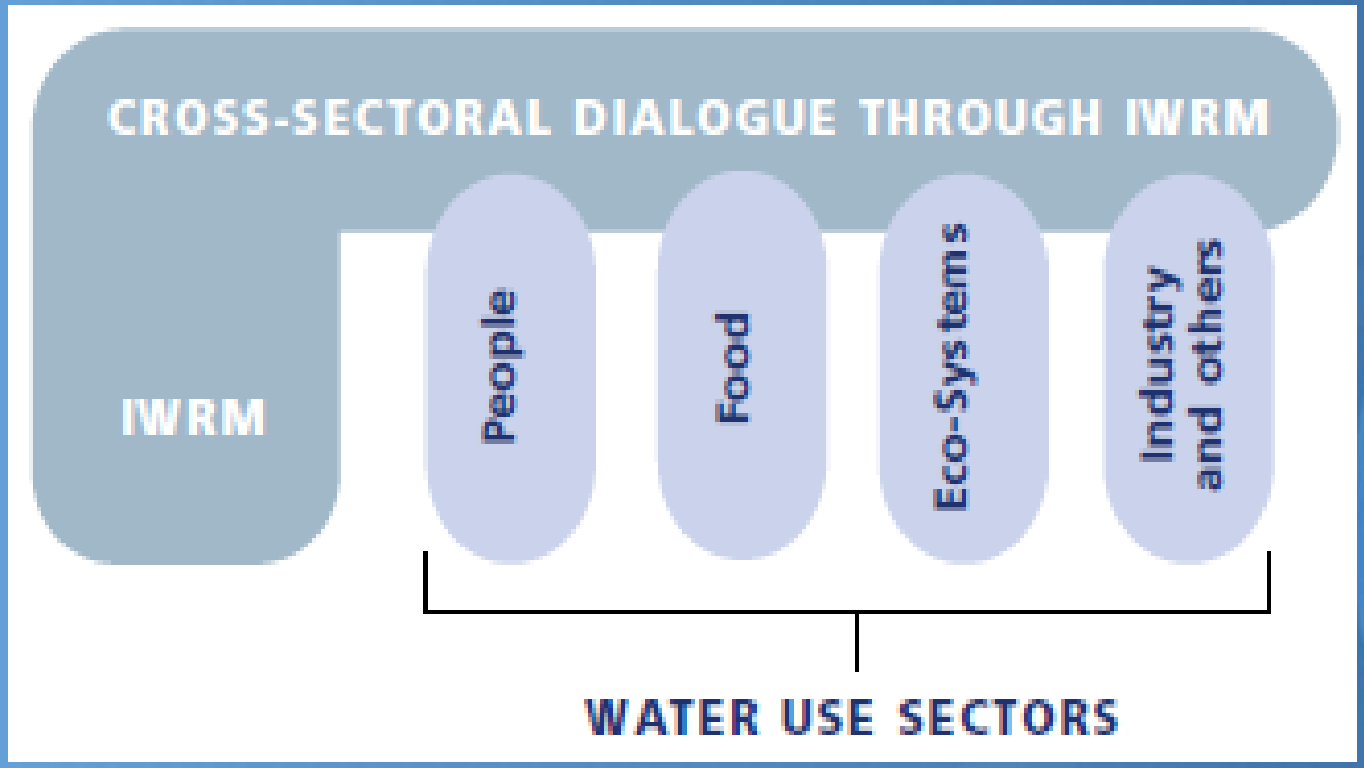
Installation Planning for a Rain Water Harvesting System

IWRM and water management through sub-sect oral to cross-sect oral



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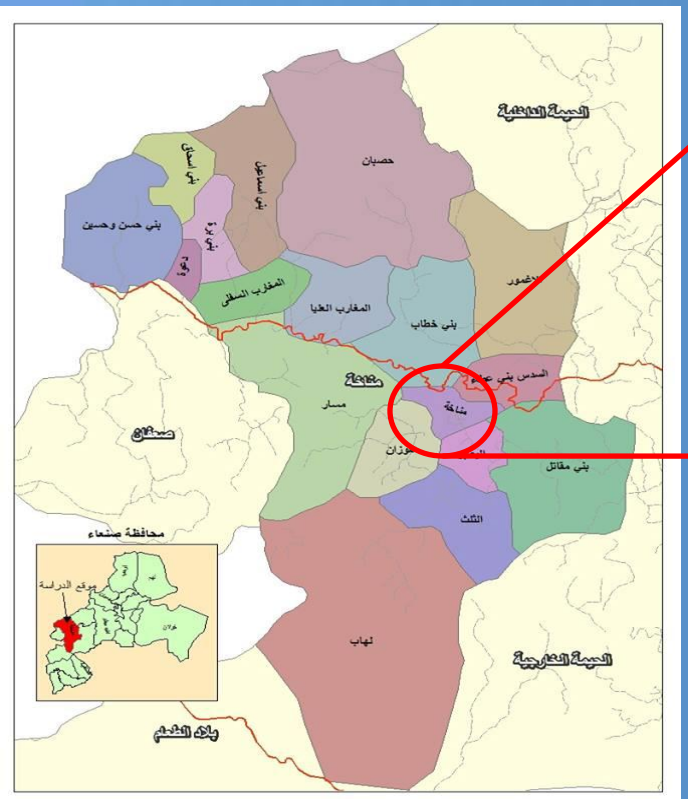
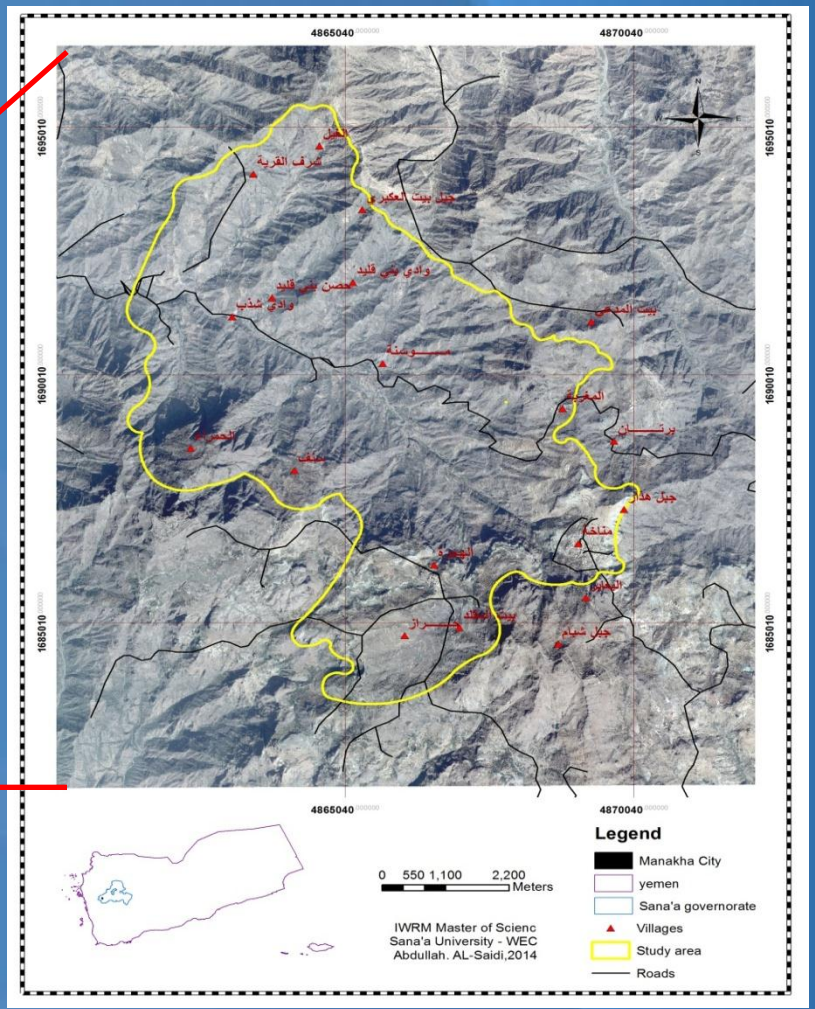
Study area Location





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Research Methodology

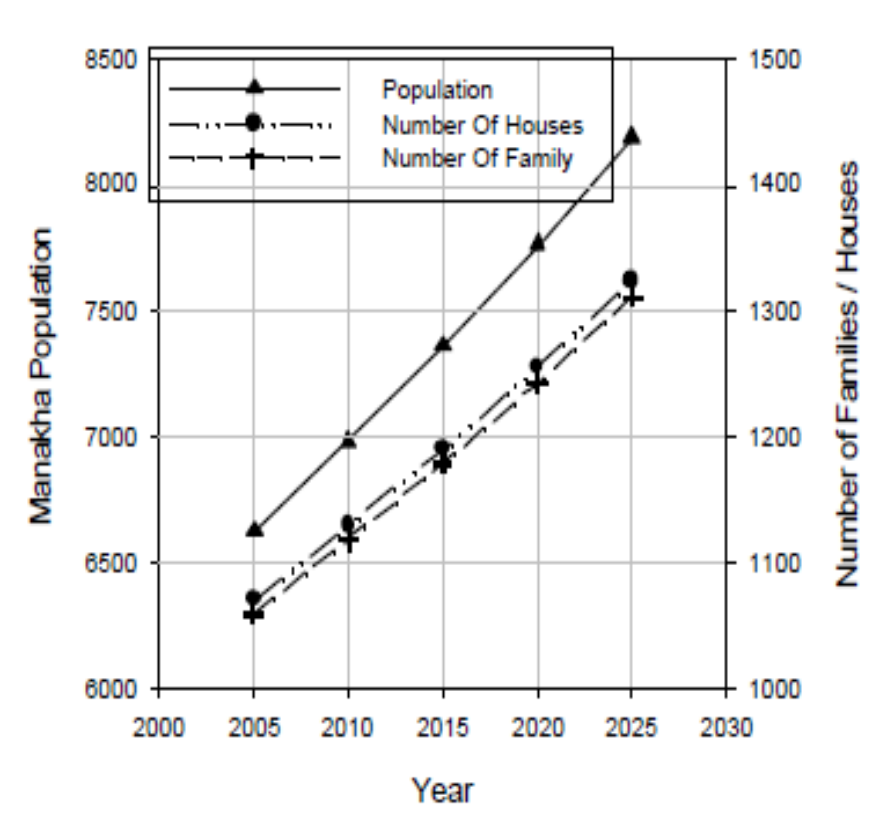
Socioeconomic survey methodology:

- Key informant interviews
- Interviews
- Households
- Existing RTRWH
- Public building

Potential Rainwater harvested quantity …methodology

- Digitizing
- Satellite image
- isohyets map
- ArcGIS
- Zoning
- Roof areas
- Water quantity (isohyetal method)

Manakha Population up to 2025



Manakha	2004	2010	2015	2020	2025
Population	6,553	6,983	7,363	7,764	8,187
Families	1060	1119	1179	1243	1311
Houses	1,071	1,130	1,191	1,256	1,324

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Shows a summary for the metrological data for Manakha area

Parameter /Month	Jan-Mar	Apr-June	July-Sept	Oct-Dec	Average
Temperature, ºC	25.6 - 6.7	28.9 - 12.1	33.2 - 15.2	31.9 - 7.0	29.9 - 10.3
Wind speed, m/s direction	3.0 Southwest	3.9 southwest	4.3 Southwest	3.5 Southwest	3.7 South
Relative Humidity	49%	47%	42%	41%	45 %
Evaporation / transpiration					1,800 mm/ Year

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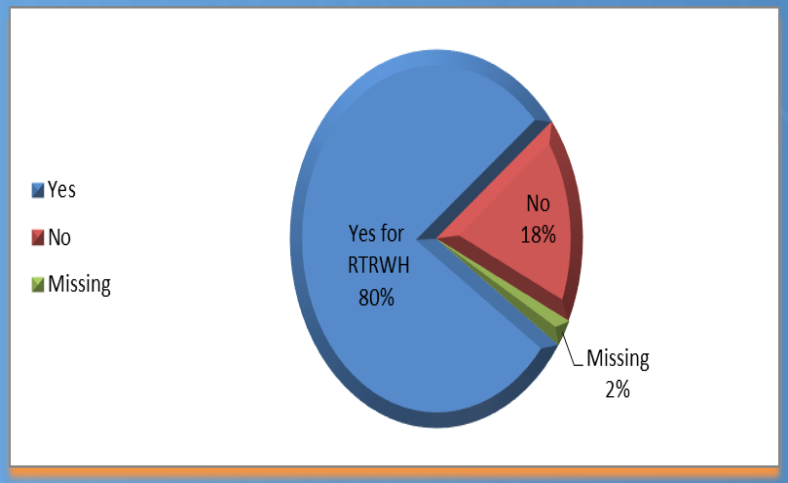
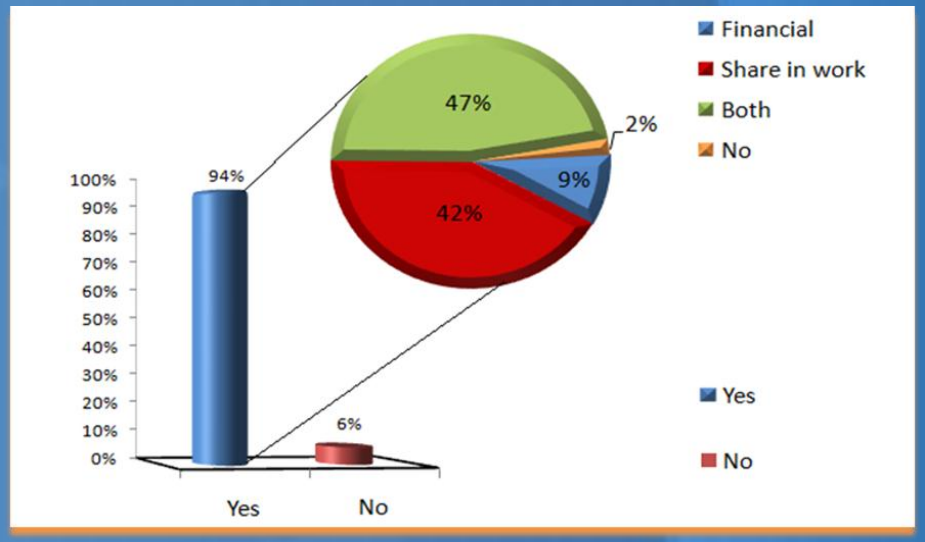
Social survey…results

Acceptance



The agreement and encouraging RTRWH

Willingness



Willingness and ability to participate in RTRWH project (Kinds of participate)

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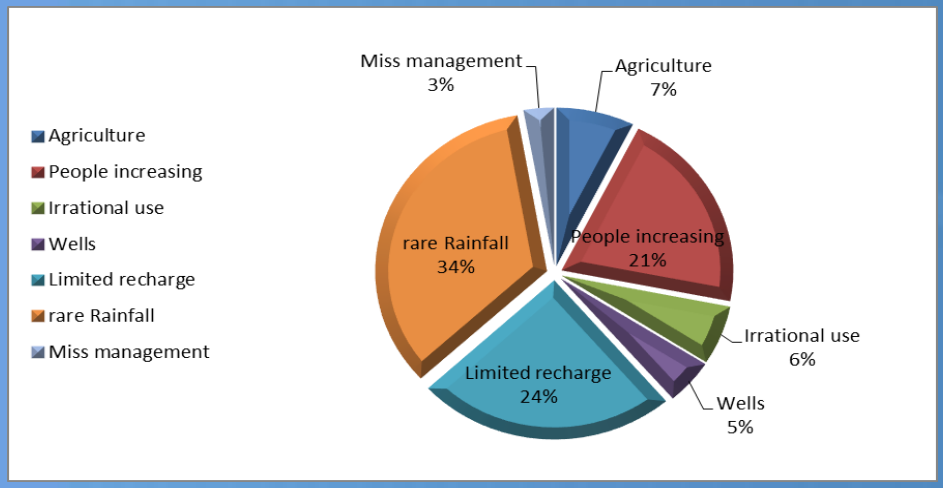
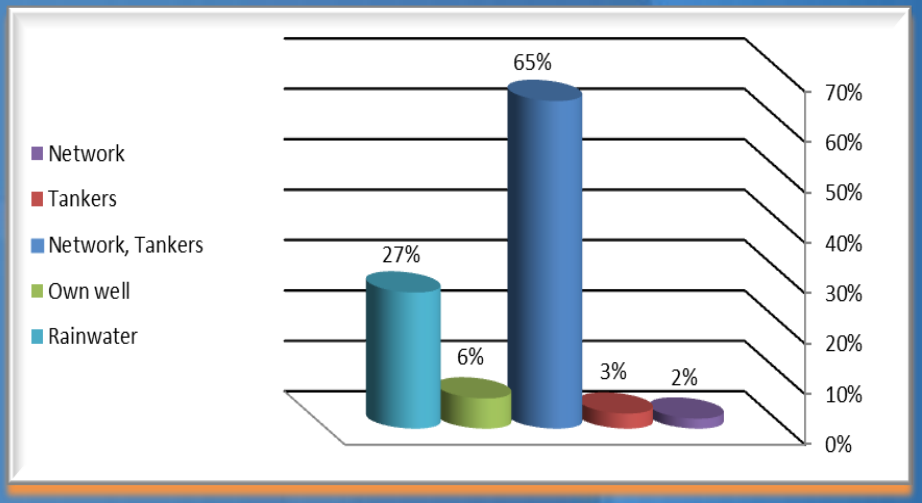
Social survey…results

Awareness



The reasons of water shortage in Manakha area

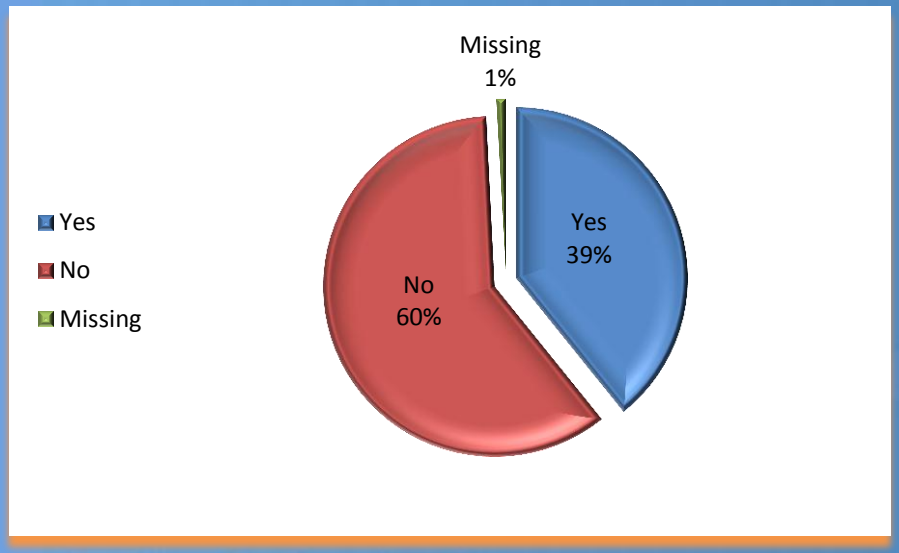
water resources



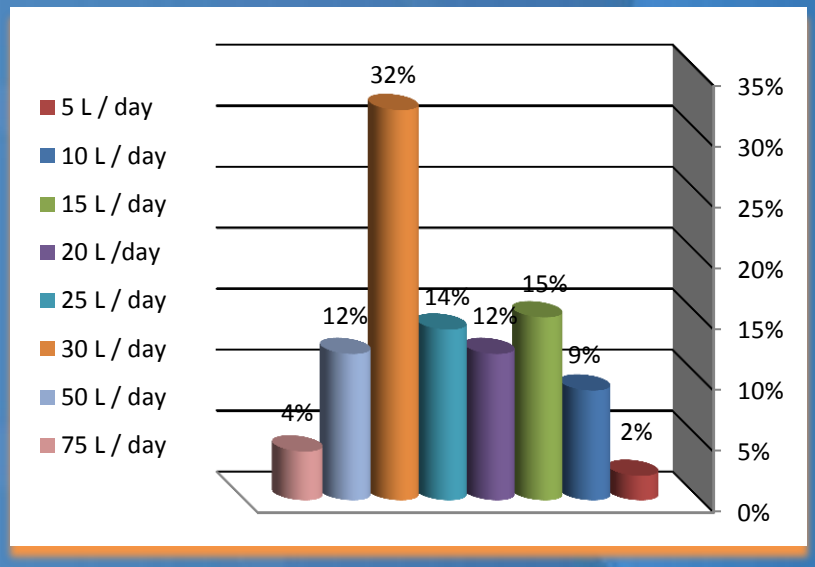
The main water resources for domestic uses

Social survey…results

Household's water sufficiency

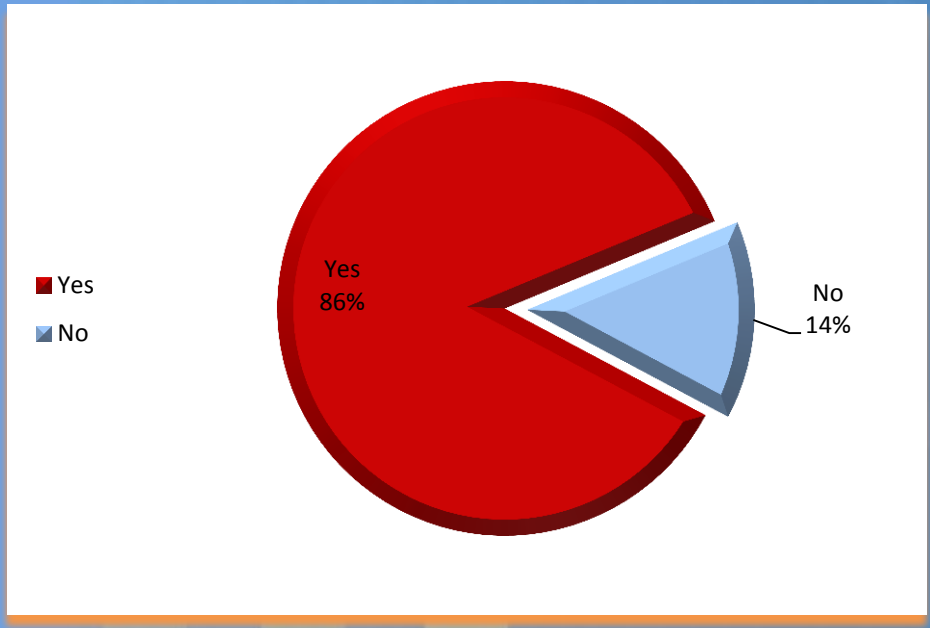


Water consumption (L / day) per capital

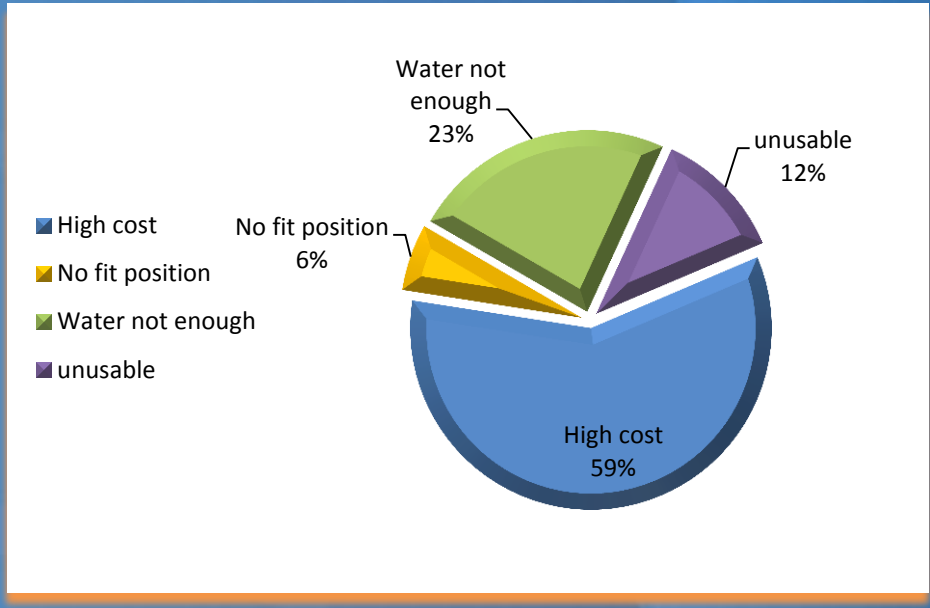


Social survey…results

Interviewees' willingness to donate their land for building general reservoirs

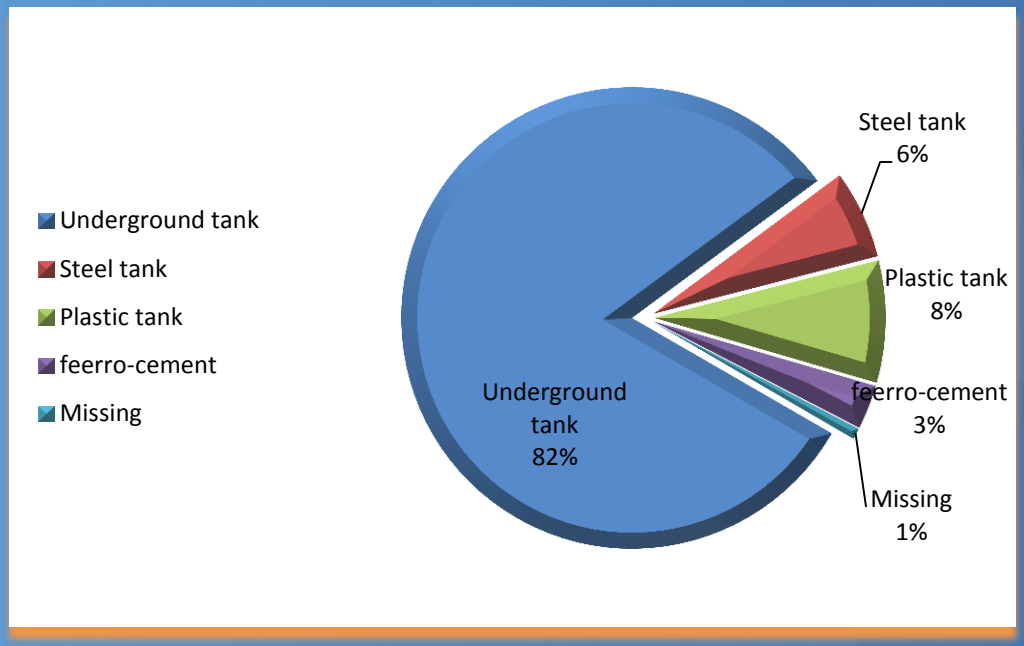


People reasons of not encouraging, sharing RRWH



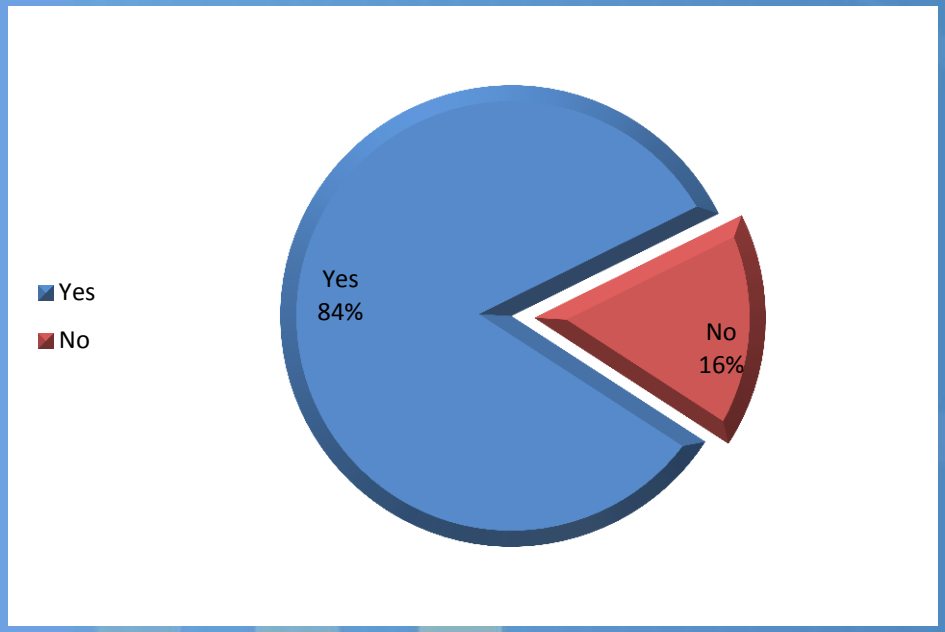
Social survey…results

Interviewees' tank preferences for RTRWH

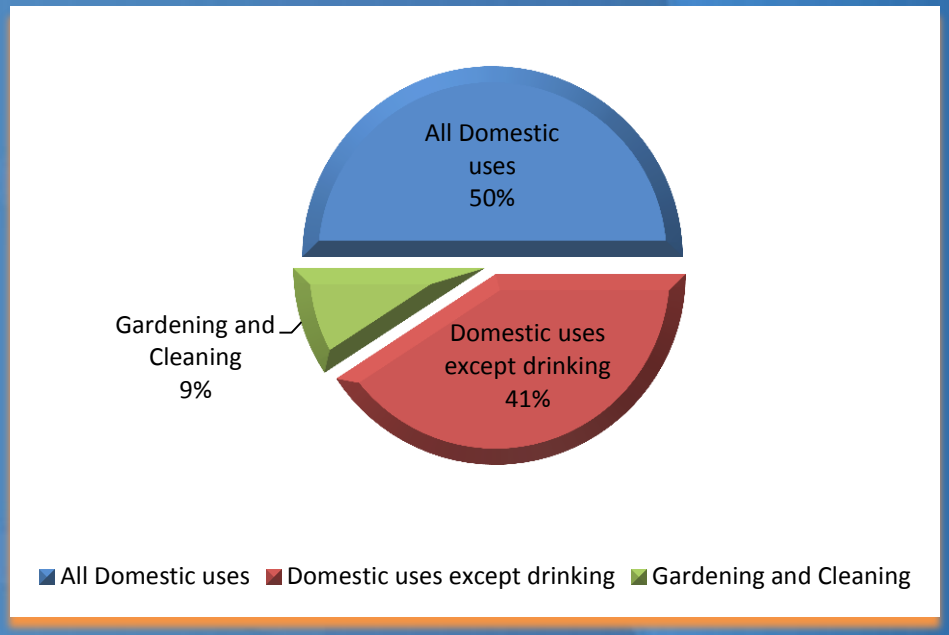


Social survey…results

Public RTRWH System & NWSA administration



Different uses of rainwater when applying RTRWH projects



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Potential Rainwater harvested quantity… methodology

- Digitizing
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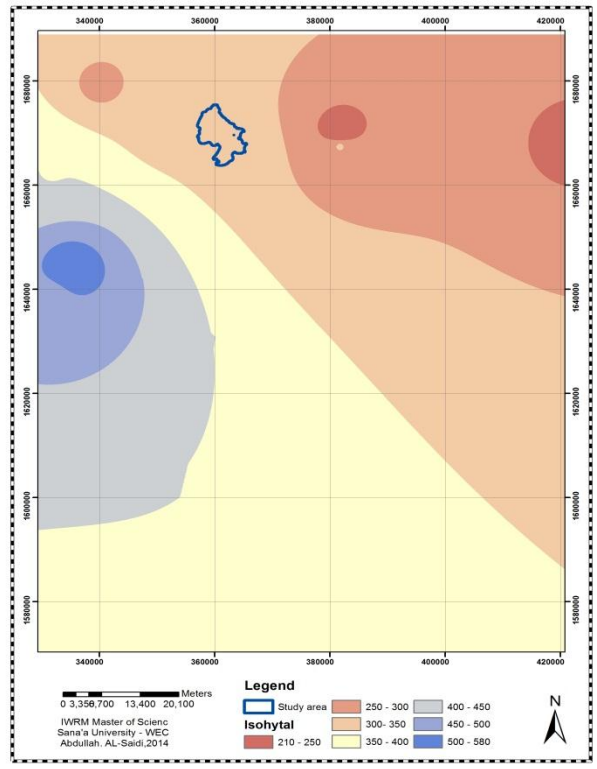
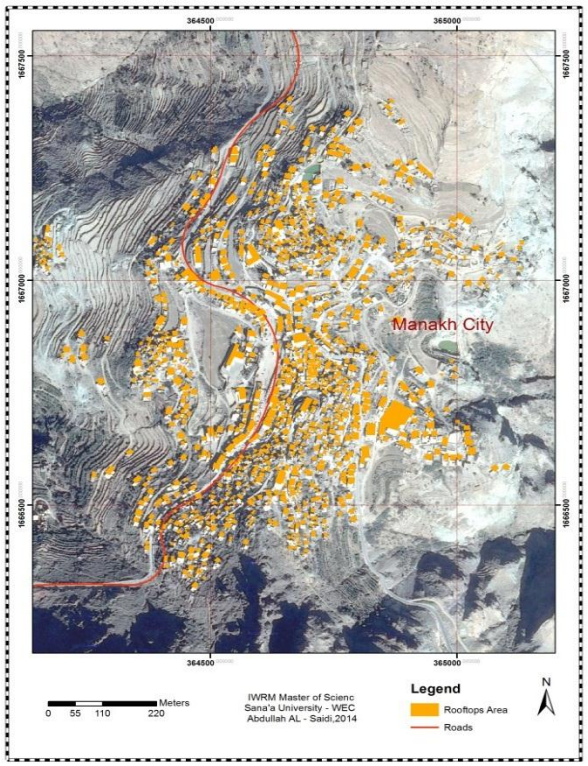
- Zoning
- Roof areas
- Water quantity (isohyetal method)





Potential Demand Quantity

Water demand in Manakha

Parameter	year	Population	demand L/c/d	Q m3/year	product ratio %(service coverage)
Water production $m^3\ yr^{-1}$	2010	6,983	15.30	83757	**100%**
max demand $m^3\ yr^{-1}$	2010	6,983	50.00	273750	**31%**
avg. demand $m^3\ yr^{-1}$	2010	6,983	26.67	146000	**57%**

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حساب معدل الانتاج للمياه ومعدل المباع والفاقد من خلال الكشوفات المعدة من قبل فرع المؤسسة العامة للمياه والصرف الصحي (فرع مناخة) محافظة صنعاء ، وذلك للعام ٢٠١٠م

كمية المياه المنتجة الكلية ($م^3$)	كمية المياه المنتجة والمباعة ($م^3$)	كمية فاقد المياه ($م^3$)	المشترك المستفيد من المياه المنتجة	عدد المستفيدين (مشترك)
٨٣٧٥٧	٥٣٥٦١	٣٠١٩٦	كلي (منزلي ، حكومي ، تجاري)	١٤٣٠
------	٥٢٣٥٧	------	جزئي (منزلي)	١٣٧٤
------	٦٠٧	------	جزئي (حكومي)	٢٦
------	٥٩٧	------	جزئي (تجاري)	٣٠

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حساب معدل الإستهلاك للمياه من خلال الكشوفات المعدة من قبل فرع المؤسسة العامة للمياه والصرف الصحي (فرع مناخة) محافظة صنعاء ، وذلك للعام ٢٠١٠م

المشترك المستفيد من المياه المنتجة	معدل الاستهلاك للمياه							
	سنوي لكل مشترك		شهري لكل مشترك		يومي لكل مشترك		يومي لكل فرد (بمعدل ٧أفراد)	
	(م³/سنة)	(ل/سنة)	(م³/شهر)	(ل/شهر)	(م³/يوم)	(ل/يوم)	(م³/يوم)	(ل/يوم)
كلي (منزلي ، حكومي ، تجاري)	٣٧,٤٦	٣٧٤٥٥,٢٤٤٧٦	٣,١٢	٣١٢١,٣	٠,١٠٤	١٠٤,٠٤	٠,٠١٥	١٤,٨٦
جزئي (منزلي)	٣٨,١١	٣٨١٠٥,٥٣١٣	٣,١٨	٣١٧٥,٥	٠,١٠٦	١٠٥,٨٥	٠,٠١٥	١٥,١٢
جزئي (حكومي)	٢٣,٣٥	٢٣٣٤٦,١٥٣٨٥	١,٩٥	١٩٤٥,٥	٠,٠٦٥	٦٤,٨٥		
جزئي (تجاري)	١٩,٩٠	١٩٩٠٠	١,٦٦	١٦٥٨,٣	٠,٠٥٥	٥٥,٢٨		

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حساب معدل الكلفة التشغيلية من خلال الكشوفات المعدة من قبل فرع المؤسسة العامة للمياه والصرف الصحي (فرع مناخة) محافظة صنعاء ، وذلك للعام ٢٠١٠م

النفقات التشغيلية (المبالغ بالآلاف)								إجمالي النفقات التشغيلية	كلفة انتاج وحدة المياه الكلية (ريال/م³)	كلفة انتاج وحدة المياه المباعة (ريال/م³)
المرتبات والأجور							نفقات أخرى			
المرتبات الأساسية	البدلات الشهرية الثابتة	الأعمال الإضافية	المكافأت	أخرى	إجمالي	المستلزمات السلعية	المستلزمات الخدمية			
١٢،٤٦٧	٢،٠١٧	٩٨٢	١،٢٣٥	٧٨٤	١٧،٤٨٥	٢٠،٨٤٣	١،٥٥٤	٤٦٩	٤٠،٣٥١	٤٨١,٧٦	٧٥٣

Potential of harvested water quantity - results

Area Name	Annual Rainfall (mm/year)	Rooftops Area (km2)	Harvested Water (CM/year)
Manakha	300-350	0.138	31092.67
Total Harvested Water			31092.67

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Potential water supply quantity…results

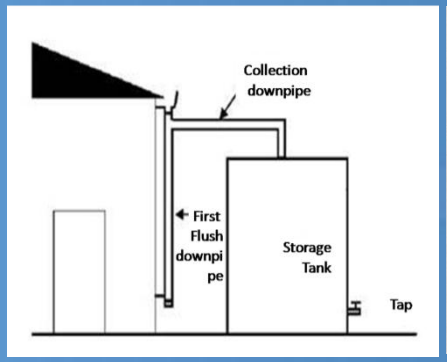
• Per capita consumption	28-30 liters/day
• Volume of water losses by public network (m3/year)	30,196
• Average per capita water consumption / day from NWSA wells	15.30 L /day
• Cost of public water unit (tarfa)(by NWSA)	400YR/M3
• Cost of public water unit(without subsidence)	1225YR/M3

Potential RTRWH components systems

Component
- Rooftops
- Gutters
- Down pipes and first flush pipe
- Filter Unit
- Storage tank

Technical for better quality
- Leaf screen (1)
- First flush pipe (2)
- Top tank filter (3)
- Filter before drinking (4)

(1)



(2)

Top tank filter

(3)

(4)

Cost estimation of RTRWH system

This study provides some information on cost ranges for standard components of rainwater harvesting systems for both potable use and domestic use .

The range of cost estimation for an ideal system	**614100 YR (2856 $)**
Cost of rainwater unit(m3/month)	**186 YR/M3**
The capacity tanks required for rain water storage	**37m3**

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Appropriate tanks … types and cost estimation in Manakha

Tanks	Capacity (m3)	Cost $/ m3	Source	Comments
Concrete	< 100	110 – 180	SFD	Risks of cracks and leaks but this are easily repaired
Block tank	< 20	75-100	SFD	
Brick cement	1– 30	10 – 40	Calculation	
Ferrocement	50 – 100	47 – 65	SFD	Risks of cracks and leaks but this are easily repaired
Masonry	850-1700	16- 50	Calculation	Risks of cracks and leaks but this are easily repaired;
Steel	5	42	Invoice	
Sentik(plastic)	5	120	Invoice	

Pipes types and costs estimation in Yemen

Pipe type	Cost (YR/m)	Pipe diameter (mm)	Comments
Plastic PVC*	280 - 500	50 – 100 (2inc – 4inch)	Leaking, warping and breaking are common problems; used to divert flows to tanks
Galvanized steel **	3800-4600	75 – 100 (3inch – 4 inch)	Mixture of aluminum and galvanized steel; must be professionally installed; used to supply from tanks
Galvanized steel **	560	25 (1 inch)	Mixture of aluminum and galvanized steel; must be professionally installed; used to supply from tanks

** Drainage pipe from roof to tanks*

*** Water supply from tank to consumption place*

- The range for pump costs runs from 12000YR to 25000YR for buildings of 2-6 stories.

Tank size and control

Tank size

- There are several computer-based programs for calculating tank size that connected to more than one source (RTPC)

Tank control

- Besides float valve, control valve is required
- Overflow pipe

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Rainwater sampling methodology

- Three samples
  - ✓ Tow from gutters
  - ✓ One from tank

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Rainwater quality…results

Physical, chemical and biological parameters analysis results for RTRWH .

Parameter	Unit	Sample 1	Sample 2	Sample 3	NWRA Guide line Value	WHO Guide line Value	Remarks
Electrical Conductivity at 25 C [EC]	µS/ cm	144	166	56.2	2500		
pH at28.2C		7.56	7.53	9.34	6.5-9	6.5-8.5	
Total Dissolved Solid (EC x 0.65)[TDS]	mg/L	93.7	108	37	1500	1000	
Total Alkalinity as[CaCO3]	mg/L	39	40	79			
Carbonate [CO3]	mg/L	47	48	8			
Bicarbonate [HCO3]	mg/L	Nil	Nil	Nil	500		
Hydroxide	mg/L			1			
Total Hardness as[CaCO3]	mg/L	45	68	9	500	500	
Calcium [Ca]	mg/L	18	26	6	200	200	
Magnesium [Mg]	mg/L	Nil	0.7	1	150		
Chloride [CI]	mg/L	7	8	4	600	250	
Sulphate [So3]	mg/L	23	27	2	400	400	
Nitrate [NO3]	mg/L	30	30	0.8	50	50	
Sodium [Na]	mg/L	5	2.45	6	400	200	
Potassium [k]	mg/L	2.72	5	1	12		
Iron total[Fe]	mg/L	0.347	0.876	0.293	1	0.3	
Fluoride [F]	mg/L	0.47	0.48	0.06	1.5	1.5	
Total coli forms	Col/100ml	T.N.T.C	T.N.T.C	T.N.T.C	0	0	
Fecal coli forms	Col/100ml	T.N.T.C	T.N.T.C	T.N.T.C	0	0	

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Women and …….Water management

- Women and men involved in water management in different ways.
- Women and girls use water for domestic purposes,
- Men and boys may compete for water from the same sources for farming and livestock.
- Adopting a gender sensitive approach means that the different needs of both women and men are taken into account in the design an management of projects.
- Gender relations need to be understood in the local context and efforts need to be made to ensure the fullest possible participation of both women and men in all stages of projects.

Traditional gender roles and gender imbalance in study area

Traditional gender roles, allotted few rights to women:

- Women rarely took part in activities outside the home:
  - **Fully Pasay collecting water,**
  - **looking after their children,**
  - **performing other household tasks.**
- Women unable to participate in external social roles and most are illiterate and using legal obstacles to prevent women's participation in community life.
- Many lack proper identification, since as women, it has not been important opinion for their activities to be registered.

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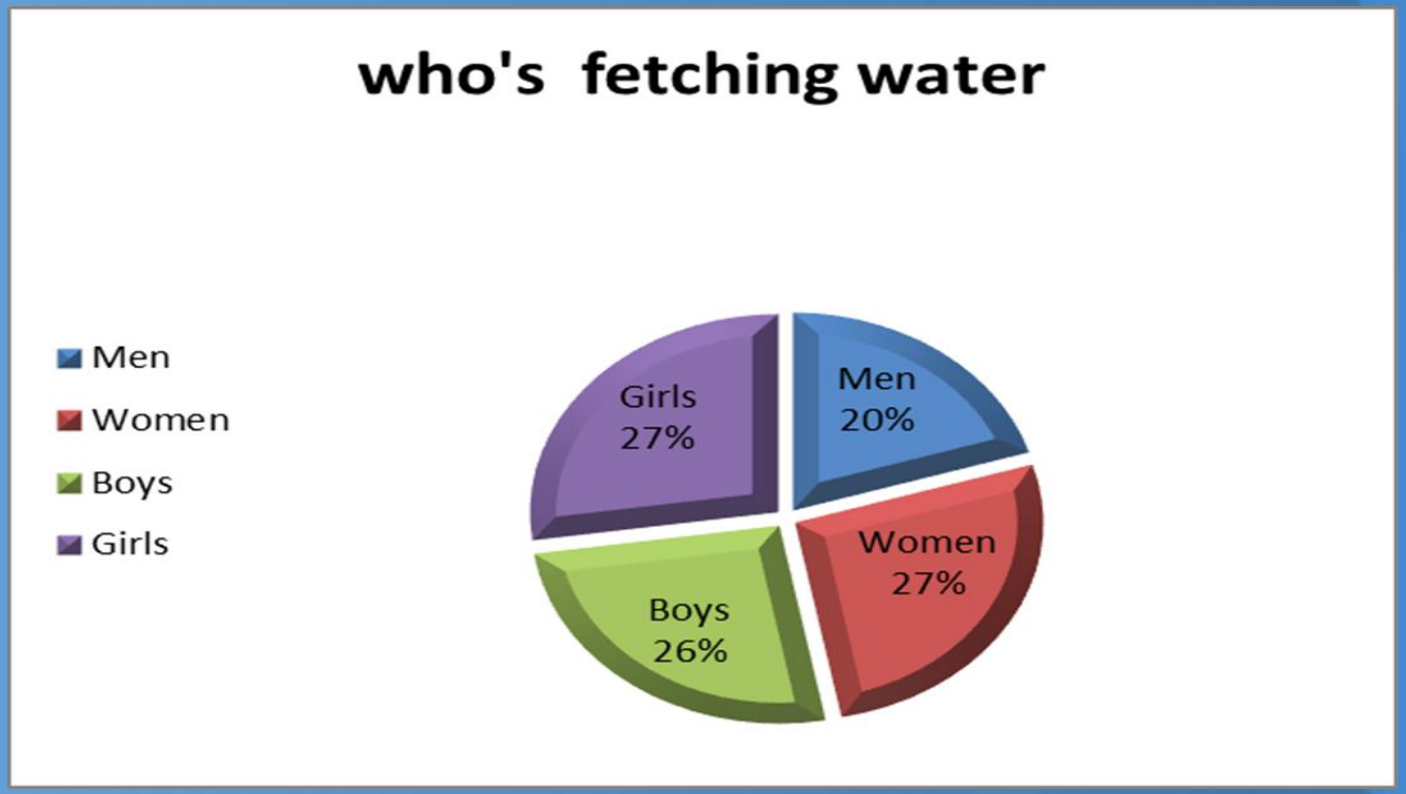
Women and …….Water management



Women and …….Water management

Means, frequency and time spent fetching water from the source

2	How much times spend to fetch drinking water from the source (springs)?	Number	Percentage
	1/2 hour	21	21%
	One hour	42	43%
	2 hours	21	21%
	3 hours	11	11%
	More than 3 hours	4	4 %

Women and …….Water management

Means, frequency and time spent fetching water from the source

3	**How much time spend to fetch water for domestic and other uses?**	Number	Percentage
	1/2 hour	32	31%
	One hour	41	40%
	2 hours	19	19%
	3 hours	7	7%
	More than 3 hours	3	3%

Women and …….Water management

Means, frequency and time spent fetching water from the source

4	**How many times in a day, do you go fetching drinking water?**	Number	Percentage
	Once	22	22%
	Twice	24	25%
	Three times	28	29%
	More than three	23	24 %

Women and …….Water management

Means, frequency and time spent fetching water from the source

5	**How many times in a day, do you go fetching water for domestic and other uses?**	Number	Percentage
	Once a day	19	19%
	Twice a day	25	25%
	Three times a day	30	29%
	More than three times a day	26	25%
	Once a week	2	2%

Women and …….Water management

Means, frequency and time spent fetching water from the source

6	**How much (amount) of water do you carried in once time for drinking?**	Number	Percentage
	10L	17	18%
	20L	35	36%
	40L	17	18%
	More than 40 L	27	28%

Women and …….Water management

Means, frequency and time spent fetching water from the source

7	**How much (amount) of water do you carried in once time for domestic and other uses?**	Number	Percentage
	10L	12	12%
	20L	38	37%
	40L	20	20%
	More than 40 L	31	31%

Conclusion and Recommendations

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Conclusion

- Public water network are insufficient supply by NWSA
- Rain water harvesting currently being used by 27% of the households
- RTRWH contribute in Relieve the pressure on ground water
- Harvested rainwater can be used for all uses (filtering before drinking)
- RTRWH is applicable, feasible and more reliable than water from other unknown and infrequently tested sources
- General tanks for water harvesting and shared with water project within the system(NWSA) for the purpose of operation, maintenance and sustainability, thus relieve the pressure on groundwater

Recommendations

- Raising awareness among the people in the region through the media, workshops, as a first step to define the importance and use of RWH
- RWH should be defined as a necessity, not an option
- Encourage and enhance Gender to participation and integration in water management projects
- Coordination and cooperation between the relevant government institutions, private sector and urban, ruler households is required for access to Better water management

Recommendations

- Strategies and policies should be paid for rainwater harvesting management
- Recommend using silver filters ,etc.. in household for drinking RTRWH
- Trend government, NGOs to implementation RTRWH system as first step in the region to encourage all people, stakeholders relevant agencies
- Required RTRWH systems on building degasing
- Recommend using silver filters ,etc.. in household for drinking RTRWH

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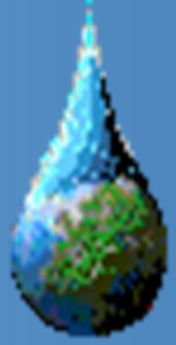

Rainwater Harvesting

THANK YOU