Sveriges lantbruksuniversitet
Fakulteten för naturresurser och lantbruksvetenskap
Institutionen för Vatten och Miljö

Water compositions and attitudes to a rooftop rainwater harvesting system

- A minor field study in Killarlahalli, India -

Författare Lina Jan-Ers

Självständigt arbete/Examensarbete · 15 hp · Avancerad nivå
Program/utbildning Naturresursprogrammet - biologi och mark
Uppsala Utgivningsår 2012

Titel på svenska	Attityder till regnvatten för dricksbehov och dess sammansättning *–En SIDA-finansierad fältstudie i Killarlahalli, Indien-*
Titel på engelska	Water compositions and attitudes to rooftop rainwater harvesting systems - *A minor field study in Killarlahalli, India-*

Författare	Lina Jan-Ers
Handledare:	Stephan Köhler, Sveriges Lantbruksuniversitet, Vatten och Miljö
Btr handledare:	S. Vishwanath, Rainwater Club, Bangalore, India
Examinator:	Martyn Futter, Sveriges Lantbruksuniversitet, Vatten och miljö

Omfattning: 15 hp
Nivå och fördjupning: Avancerad D
Kurstitel: Självständigt arbete i miljövetenskap
Kurskod: EX0664
Program/utbildning: Naturresursprogrammet - biologi och mark

Utgivningsort: Uppsala
Utgivningsår: 2012
Omslagsbilder och foto: Lina Jan-Ers
Elektronisk publicering: http://stud.epsilon.slu.se

Nyckelord:rainwater harvesting, rooftop, minerals, rural India, drinking, socio-cultural.

Acknowledgements

I would like to dedicate my thanks to Mr. S. Vishwanath, Rainwater Club and Mr. Ramakrischna, BIRD-K for the wonderful opportunity to contact and cooperation in the rainwater project in Killarlahalli village. Many thanks to the staff at BIRD-K office in CK. Pura for all their help before and during my interviews and specially to Suma Rao for interpretation.

I will also thank you Anna Nilsson and Hanna Carlsson for the assistance and inputs before my interviews. Great thanks to Stephan Köhler for analysis of water samples and to Nanna Håkansson for support and coaching during the work.
Enjoy!

Abbreviations

BAIF	Bharatiya Agro Industries Foundation
BIRD-K	BAIF Institute for Rural Development-Karnataka
DHAN	Development of Humane Action
FAO	Food and Agriculture Organization
IC	Inorganic carbon
JECFA	Joint FAO/WHO Expert Committee on Food Additives
MCA	Master of Computer Applications
MDG	Millennium Target Goals
MFS	Minor Field Study
NGO	Non Governmental Organization
NTU	Nephelometric turbidity unit
RRH	Roof top Rain water harvesting system
SLU	Swedish University of Agricultural Science
TOC	Total Organic Carbon
UNDP	United Nation Development Program
WHO	World Health Organization

"When it comes to clean water, the pattern in many countries is that the poor get less, pay more and bear the brunt of the human development costs associated with scarcity... the scarcity at the heart of the global water crisis is rooted in power, poverty and inequality, not in physical availability."

UNDP, Human Development Report 2006

Abstract

The ground water of about 4500 villages in the state of Karnataka is not fit for drinking purpose due to high fluoride content, iron content or brackishness. Long term consumption of fluoride contaminated water causes the disease fluorosis. In 2007 fluorosis was reported to over 20 states and more than 66 million people are at risk, indicating that endemic fluorosis has emerged as one of the most alarming problems of the country. In the rural village Killarlahalli outside Pavagada is the average fluoride content in the ground water measured to 2- 4mg/l. The WHO (World Health Organization) drinking-water guideline value for fluoride is 1.5.

The Indian Government and States have made policies to decrease the lack of drinking water by promoting organizations and the private sector to participate in the construction. The BIRD-K organization (BAIF Institute for Rural Development-Karnataka) has during a three year long pilot project, together with Rainwater club constructed rooftop rainwater harvesting systems and tanks in Killarlahalli.

During the time the project has been running the idea of possible contribution of minerals to the drinking water, to prevent malnutrition, was made. Before further investigation of the possibilities, a platform of information about the socio-cultural perspectives and the water composition was needed. The aim of this study is to investigate the social-cultural aspects to understand the culture, custom and traditions which affect the purchase of rainwater harvesting system. It is also to investigate the mineral content and total organic carbon, TOC in rainwater.

The study indicate that the tanks are sufficient used by the owner but that there are variations in pH between the tanks. Analysis of cations shows that Ca^{2+} has a very high and varied concentration in the water tanks. This indicates that Ca^{2+} is contributed from the tank or filter to the water. In an socio-cultural perspective education, experience and active participation are the key words for the information flow and work for water tanks development to become more acceptable and interesting for those who are involved.

Table of contents

List of figures

1. Introduction

In 2002 the United Nation committee declared that "water is indispensable for leading a life in human dignity".[1] 80% of the population suffering from improved water resources are living in the rural areas of India. In this context the term improved stands for desirable water condition for drinking purpose.

One of the millennium developing goals is to "by 2015, halve the proportion of the population without sustainable access to safe drinking water and basic sanitation". In order to reach this goal, the Indian Government and States have made policies to decrease the lack of drinking water. By promoting organizations and the private sector to participate in the construction of the infrastructure, this goal will be reached. This also gives the possibility for the private sector to charge or lease the drinking water facilities in the rural areas.

India is one of the most populous countries in the world with 1.2 billion inhabitants 2008[2]. More than 1/4 of the population is living under the line of poverty[3]. According to The World Bank Group 132 millions of the inhabitants were without access to improved water sources in 2006[4].

South India and in particular the state of Karnataka is a very dry region. The climate has diverse wet and dry seasons and is dominated by monsoons. Average precipitation in India is 1083mm/year.[5] Expected average of monsoon precipitation in the district is 700mm but in the latest monsoon 2010 the precipitation achieved 300mm.[6]

Meanwhile the population is increasing there is an increasing demand for drinking water and the ground water sources are getting depleted or polluted. Bore wells are silting up, running short of water or contain polluted water. Private purchase of water from tankers is unreliable in quality and is also expensive. Most of the drinking water in the rural area of Bangalore comes from a distance of 95 kilometers or more.[7]

1.2 Aim and delimitations

The aim of this study is to investigate the social-cultural aspects to understand the culture, custom and traditions which affect the purchase of rainwater harvesting system. It is also to investigate the mineral content and total organic carbon, TOC in rainwater. Further this study is to create a platform of information for future investigation of the possibility of implementing water filter to the rain water harvesting tanks.

This study is delimited to a study based on a small part of a pilot project. No other project sites by BIRD-K or any other NGO is covered or compared. The results are based on the specific pilot project for water tanks in Killarlahalli and due to time, not all households in the village have been interviewed.

---

[1] United Nation, 2002
[2] Nationalelcyklopedin
[3] The World data Bank
[4] The World data Bank
[5] FAO Water data
[6] Mr. Ramakrishna, 2011-02-22
[7] Rainwaterclub

1.3 Problem formulation

The BIRD-K organization (BAIF Institute for Rural Development-Karnataka) has together with Rainwater club constructed the RRH system and tanks in Killarlahalli. During the time the project has been running the idea of possible contribution of minerals to the drinking water, to prevent malnutrition, was made. Before further investigation of the possibilities, a platform of information about the socio-cultural perspectives and the water composition was needed. This study will focus on the following issues:

Socio-cultural perspective

- Are the water tanks being sufficiently used in the village?
- What factors affects the conclusion on purchasing a rainwater harvesting system?
- How are those factors experienced and how do those factors affect rainwater for drinking purpose?
- Would a private property of rainwater harvesting be possible in the village?

Water composition perspective

- What is the pH of the water in the tanks and is the mineral content of the water enough according to the WHO guidelines?
- Indicates the water on the existence of living organisms or decaying material?

2. Background

2.1 Studied Area

This study has been carried out in Killarlahalli, a 500 household village 11 km west of Pavagada, Tumkur district, State of Karnataka(Figure 1). As many towns in the near of Pavagada, Killarlahalli is totally dependent of groundwater. There are no rivers in the area. Uttarapinakini and Bhadrampper, the two nearest rivers are located in a distance of 20km and 100km away.[8] Geologically the areas around Bangalore consist of gneisses and closepet granites.[9] The temperature in the area has an average of minimum 15°C and a maximum of 40°C during the year.[10] The people in Killarlahalli are mostly wage laborers. The most common crops to cultivate are peanuts (Arachis hypogaea) intercropped with finger millets (Eleusine coracana Gaertn), cow peas (Vigna unguiculata) or pigeon peas (Cajanus cajan). In some irrigated land rice is also cultivated.

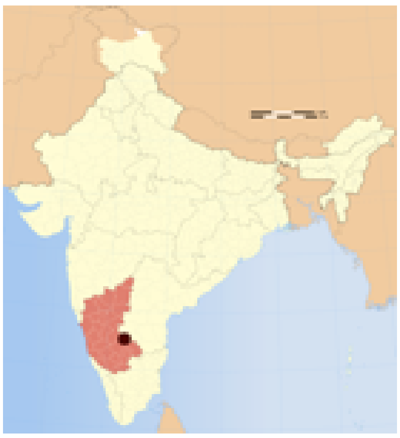


Figure 1. Map of India showing Karnataka state and location of Killarlahalli village

[8] Dr. Channakeshava, 2011-02-22
[9] India Waterportal
[10] Indian Government Climate

Killarlahalli is a poor village where the people are suffering from malnutrition. The problem of fluoride in the water was illuminated only three years ago when the BIRD-K organization came to the village and informed about the reason for the situation. According to the short time that the project has been running the knowledge is good and hopefully will increase with the increased experiences.
The investment in water tanks in the area is a co-operation between the organization BIRD-K and the Rainwater Club in Bangalore. Rainwater clubs vision is to initiate solutions that will make rural areas self supplied in healthy living in an ecologically sustainable cycle. (Such as rooftop rainwater harvesting, chair coal burner, bio filter beds etc.) Rainwater Club aims of investigate the possibility to contribute minerals to the rainwater by using mineral filters.

The village has two public taps provided by the Indian government. The people in the village are suffering from the effects of the fluoride in the drinking water. Today most of the inhabitants are aware of how widespread is and know the origin of the problem. People are willing to do something about the water problem, but most of the population are poor and are not capable to pay the costs for water tanks.[11] To provide fluoride free drinking water, 96 private tanks for rainwater harvesting were constructed during the years 2007 - 2011, partly founded by the nongovernmental organization BIRD-K. The tanks are for family purpose. The water is shared with neighbors during the rain period but is only consumed by the family during the five month dry summer season.

2.2 Fluoride

In 2010 the average fluoride content in the Killarlahalli ground water was measured to 2- 4mg/l.[12] The WHO (World Health Organization) drinking-water guideline value for fluoride is 1.5 mg/l.[13] Fluoride occur natural in groundwater. The concentrations are depending on the nature rocks and fluoride-bearing minerals. If calcium is presence it will regulate and keep the concentration of fluoride low.[14] One of the major water problems in areas of Bangalore is the availability of safe drinking water with respect to excess fluoride. Long term consumption of fluoride contaminated water causes the disease fluorosis. The most common symptom of chronic fluoride exposures is the bone disease skeletal fluorosis. In 2007 fluorosis was reported to over 20 states and more than 66 million people are at risk, indicating that endemic fluorosis has emerged as one of the most alarming problems of the country.[15]

2.3 BIRD-K, the organization

The Indian nongovernmental organization BIRD-K (BAIF Institute for Rural Development-Karnataka) was founded in 1967 by a follower of Gandhi named Manibai Desayi. It is a bottom up-organisation working to create opportunities of gaining self-employment for the rural families, ensuring sustainable livelihood, enriched environment and improved quality of life and to achieve good human values. The main projects Bird-K are acting in, are Rooftop Rainwater Harvesting (RRH), Watershed Development, Domestic Water Supply, Research/Pilot sites on water, Water Education and Groundwater management.[16]

---

[11] Mr. Ramakrishna, 2011-02-22
[12] Mr. Ramakrishna, 2011-02-22
[13] WHO 2009, Calcium and magnesium in drinking-water : public health significance
[14] Fawell, J. 2006
[15] Rural Development and Pancharat Raj
[16] BIRD-K

The organization is working in thirteen states of India and has 22 active districts in the state of Karnataka. In Pavagada taluk there are thirteen members working as employees. Today the rainwater harvesting program is active in 26 villages, including Killarlahalli. Since this was a pilot project (ended 31st March 2011) the villages were chosen according to the area size as the project needed to start with a small case. Bird-K will stay one more year to support and consult the households since they are provided another small program in the same area. According to Mr. Ramakrishna, Taluk project leader, this will make the households with rainwater tanks more secure and stabile in managing the tanks for the future.[17]

2.3.1 Profound

Fourteen percent of the Rooftop rainwater Harvesting (RRH) program is financed by the state government and the remaining costs are covered by the Indian government. This is due to the government itself having no technical and practical capacity to implement the RRH programs in the villages.[18] If the tank satisfies the technical qualification after it has been built, parts of the invested money will be refunded to the household. Depending on the status of the household, there are three different categories defining the financial payback to the household. The poverty line is set to Rs.420 per capita and month[19]. *Above poverty families* have to contribute with 30 % of the invested money, *Below Poverty Line Families* with 20 % and *Disabled Families* with 10%. The self investment has to be covered by all families, no matter what category they belong to. In case the Households have no financial possibilities to do the investment, in some cases Bird-K can give the opportunity to loan money for the water tank.

2.3.2 Spreading information

The idea and value of rainwater harvesting program was promoted in the village by informative street plays about the fluoride contaminated groundwater and its effects on the human body. Interested people could then learn more about rooftop rainwater harvesting system by reading information materials in the local language kannada, talking to the informant that visited the village once a week or visiting the head office in the neighbor village C.K. Pura or take part in the arranged study visits to a training campus in Tiptur.

2.3.3 Co-operations

Bird-K is taking technical advice from the Rainwater club in Bangalore since 10 years back in time. Rainwater club is a private business running by Mr. S. Wishwanath, which focuses on drinking water and grey water solutions for private households. Bird-K gets technical support and is exchanging knowledge and experiences with Rainwater Club, mainly in the RRH program.

Bird-K is the only NGO working with water solutions in the area. According to Mr. Ramakrishna there is another NGO working with rural development in the same area, DHAN foundations, (Development of Humane Action). They are not providing any drinking water solutions, but other micro finance programs.[20]

[17] Mr. Ramakrishna, 2011-02-22
[18] Mr. Ramakrishna, 2011-02-22
[19] BIRD-K
[20] DHAN

2.4 Rooftop Rainwater harvesting system

Rooftop rainwater harvesting system is an old way of collecting water. Already during the Roman Empire the technology was used. Rooftop rainwater harvesting systems are used all over the world. In Bangalore it is used both in the city of Bangalore and now it is also becoming a possible option for rural areas.

2.4.1 Construction

There are many ways of constructing a rainwater harvesting system. A simple rain harvesting system leads the water that hits the roof threw gutters and pipes to a storage tank with an outlet tap. 85% of the rainfall that hits the roof in tropical climate can be collected by using rooftop rainwater harvesting system (RRH). (15% are lost in evaporation and splashing)[21] A roof area of 20 square meters and a yearly rainfall of 500mm can give 8.5 cubic meters of improved drinking water, which would be enough drinking and cooking water for a five member household during seven months.

To filter leaf, mud, debris and bird droppings a first flush system should be used. The first flush method is basically a way of roof washing. First flush is the initial rain that falls on a catchment area. It reduces organic loads and bacterial inflow. [22] Rainfall intensity, frequency and volume have all an influence on the roof area in terms of cleaning. The volume of the desired first flush is depending on turbidity and the intended water use. Turbidity gives a value of the water quality and has the unit NTU (nephelometric turbidity unit). According to WHOs guidelines 5 NTU is acceptable to consume for small water supplies with limited resources and treatments.[23] Calculations by Brett Martinson et.al 2009 shows that 7.5 -8.5 mm of the first flush is needed to reach the standard of 5 NTU if the site is close to a dirty road and/or after a long dry period (based on dirty water of 900-1000 NTU).[24] Figure 2 shows two first flush pipe systems where the flush water is stored in a vertical pipe designed for the size of the roofs first flush. After the vertical pipe is filled, the coming rainwater is led into the tank. (Figure 2)

Figure 2. Vertical pipes for first flush. The initial rainwater and debris goes into the pipes. When the pipes are filled the clean rainwater is led to the tank. (Own picture.)

Many tanks are also constructed with a filter before the water reaches the tank. A study of pH and the total bacteria content, in four different tank collection designs by Fujioka et. al. (1994) shows that tanks with gutter covered by net and sand/gravel/charcoal filter differ significantly in fecal coliform bacteria levels compared to tanks with gutter net and first flush. Even though the

[21] Thomas, T.H et.al. 2007
[22] Kinkade-Levario, H. 2007
[23] WHO 2011, p229
[24] Brett Martinson et.al. 2009, pp. 6-7

filter reduced coliform bacteria, it had a bacterial peak shortly after filter installation and the pH was significantly higher after a filter was installed.[25]

In Killarlahalli there are two tank constructing methods. One method of implementing the RRH in a household is to build above the ground surface, and the second method is to build an underground tank. The underground tank is estimated to cost about 20 200 RS, and the surface tank about 35 000 RS. (1 USD is 43 Rs.)[26] The price difference is due to the materials and amount of walls that are used for the construction. Households that are investing in the RRH system have tanks that are built with a structure based on the Bird-K technical guidelines and supervision monitoring.[27] Other aspects that affect the bacteria level is the roof material. A brick tile roof for example gives higher bacteria count than plastic or metal roof and that the decay rate of E.coli and Streptococcus increases with presence of nutrition.[28]

2.4.2 Vasto architecture

Cultures religion and different traditions play a big role in the problematic water situation and are sometimes even creating problems. Vasto is a religious view in architecture that says bad karma will come to you if there is something built in a certain spot of the house that can bring bad karma, for example the south east corner of the house. If a house has not been constructed after the Vasto architecture, it may affect the health in the family; give bad luck or less money etc. Sometimes this creates problems in the project.[29]

2.5 Water management in India and Karnataka

According to the WHO (2008), 89% of the population in India is using improved drinking water sources. Only 23% is piped water on premises, where the water pipe is connected inside the household yard or plot. 64% is other improved drinking water sources such as public tap, stand pipes, tube wells, bore holes, protected dug wells, springs or rainwater collection. More than seven out of ten people are living in the rural areas; here 16% of the rural population (135 million people) is using unimproved water resources. In urban areas the use of untreated water resources is 4%.[30]

2.5.1 Water policies of the Indian Government

India's national water policy 2002 recognizes "water as a part of a larger ecological system, realizing the importance and scarcity attached to the fresh water, it has to be treated as an essential environment for sustaining all life forms". The standard water purpose adopted by the Government of India is 40 liters per person and day in rural areas[31].

2.5.2 Water issues in the state of Karnataka

Because of high fluoride, iron content or brackishness, the ground water of about 4500 villages in the state of Karnataka is not fit for drinking purpose.[32] According to the World Health Organization the daily consumption requirement of drinking water is approximately two liters for

[25] Fujioka R.S. & Faisst E.W. 1994, pp. 399-406
[26] Forex 2011-09-12
[27] Mr. Ramakrishna
[28] Vasudevan et. al, 2001
[29] Mr. Ramakrishna
[30] WHO and Unicef, 2010
[31] Vishwanath, S.
[32] Government of Karnataka, 2002

adults. To cover the need for both drinking and cooking purpose a minimum of 7.5 liters per person and day are provided.[33]

2.5.3 The Millennium Development Goals

One target of the Millennium Development Goals (MDG) is to "Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation". Both globally and in Bangalore a huge gap exists between urban and rural areas, 80% of the people that are suffering from unimproved water resources are living in rural areas.[34] The ability to reach the MDG target is highly depending of the performance of India and China. Together 42% of the population in these two countries lack improved water resources.[35]

2.6 Minerals in drinking water

In this study the water composition in terms of cations, is investigated. The health based guidelines for (cation) minerals in drinking water are listed below. All information is taken from the WHO guideline for drinking water 2011 unless otherwise is stated in the text.

2.6.1 Calcium, (Ca^{2+}) & Magnesium, (Mg^{2+})

The mineral contents of water from most Asian drinking-water supplies is generally in the range of 2–80 mg/l for calcium (Ca^{2+}) and below 20 mg/l for magnesium (Mg^{2+}) [36]. A study by Yang *et al.* (2002b) highlights that calcium in drinking water is protecting against giving birth to a low weight baby (birth weight under 1500g). Yang *et al.* (2002a) shows that there is a relationship between low intake of magnesium from drinking water and delivering a baby with low birth weight (under 1500g).

2.6.2 Iron, (Fe)

There is usually no taste effect of iron at concentrations below 0,3mg/l and WHO has no health-based guideline value proposed for iron.

2.6.3 Silicon, (Si)

Silicon occurs in clay and sand, and is also a component in cement. WHO has no health-based guideline value proposed for Silicon.

2.6.4 Aluminum, (Al)

In 1998 WHO concluded that there may be a positive relationship between Alzheimer decease and aluminum in drinking water. A health based guide line cannot be made according to the limitation of data.[37] Aluminium salts are used in water treatments to coagulate and reduce color, turbidity, organic matters and microorganisms. Further WHO refers to the JECFA (Joint FAO/WHO Expert Committee on Food Additives) which has determined that the provisional tolerable weekly intake of aluminum in drinking water would be 0.9 mg / l, (based on an adult (60kg) drinking two liters of water per day)[38].

---

[33] WHO, 2008
[34] United Nation, 2010
[35] WHO and Unicef, 2010
[36] WHO 2009
[37] WHO 1998
[38] WHO 2011

2.6.5 Manganese, (Mn)
The levels of manganese exceeding 0,1mg/l cause an unpleasant taste. Usual acceptance by consumers are 0,1 mg/l, even though the health based value is 0,4 mg/l.

2.6.6 Strontium, (Sr)
Sr is not mentioned in the WHO guidelines.

2.6.7 Sodium, (Na)
No health based guidelines is given in WHO guidelines for drinking water as the intake from drinking water is rather small.

2.6.8 Potassium, (K)
Recommended daily intake is 3000mg, it occurs in drinking water at levels far below the health hazardous levels.

2.6.9 Cement
Cement is a mixture of calcium-silicates, aluminates, and some free lime. Prolonged exposure to aggressive water such as chloride or sulfate can deteriorate cement due to dissolution of limestone or other chemical components. A newly installed tank will leak lime, potassium, silica and display high pH values. Cement may contain a wide variety of metals which are liable to dissolve and leach out into drinking water. WHO has established an "aggression index" to assess the dissolution potential of cement. The recommendation is to investigate possible cement corrosion if the pH exceeds 8.5.[39]

3. Method

A field study was made in the village of Killarlahalli. To investigate the issues in a socio-cultural perspective interviews were undertaken. The plan of respondents in the interviews, water sampling and analysis is presented below.

- Ten individual interviews with respondents that have a rainwater harvesting tank
- Ten individual interviews with respondents that do not have a rainwater harvesting tank
- Two focus group interviews with respondents that have/ don't have a rainwater harvesting tank
- Two interviews with key persons, one from the organization and one from Pavagada hospital
- Analysis of the results from the interview
- Sampling of water and measurement of pH in field
-Analysis of the chemical results and measurement of pH in laboratory

In order to give the stakeholders more influence of the interview the PRA-method (Participatory Rural Appraisal/Participatory Reflection and Action) was used. In the PRA-method the stakeholders analyze their own conditions and needs and have the role as lecturer and main actors.[40] This increases the awareness of local priorities and provides insight into the culture and customs, which also increases the possibility that in the future they are able to implement sustainable and functional solutions. By mapping their version of the society and environment is a way of making the stakeholders "expresses their knowledge within their own conceptual

[39] WHO 2011
[40] Pretty, J.N. 1995

frameworks"[41]. To make the stakeholders to prioritize their needs (in this case) for water, a scoring method was used. Tankwater was sampled from the tanks into a cup. pH was measured in field with pH paper indicators.

3.1 Field study

The field study started with a transect walk. The aim was to observe the life and behavior in the village and to note reflections that would not be alerted after a few visits. A gender and age mixed group of volunteering participants in Killarlahalli were testing the interview questions, season map and village map. After this visit the method was adapted to better meet the respondents. Some of the phrasing and question in the interviews were changed during this process to ensure that all the questions were understandable.

Furthermore, continuing field work with focus groups: One of respondents with a rain water tank and one group without. Interviews with BIRD-K organization and Dr. Channakeshava, taluk health officer in Pavagada was held to get a wider and deep understanding of the risks, consequences and local situation of the fluoride contaminated water. Semi structured interviews were conducted with household in the village. Observations in the village and spontaneously discussions with inhabitants were conducted during the stay and visits in Killarlahalli. All interviews were held with volunteering participants. Focus groups and semi interviews were recorded. The questions are shown in Appendix 1. Transcripts are available on request. Water samples were taken in connection to the semi structured interviews. In some cases where the tank was empty water sample was collected at household that had chosen to refrain from the interview. pH was measured in the field with pH indicator sticks and in laboratory with pH meter. Major cation analysis was made at SLU accredited laboratory in Uppsala. The methods are explained below.

3.1.1 Respondents

The visits in the village was always accompanied by a, locally, known member of the BIRD-K organization. Respondents were randomly asked for an interview during walks in the village. Both passing persons and households were asked. No consideration or planning was taken to the spatial structure.

3.1.2 Focus groups

Focus groups give the respondents the possibility to tell their story in interaction[42] but also to raise different opinions[43] within the same topic. This gave a wider perspective of the situation. All focus groups were of mixed gender and age. The focus groups had 4-12 participants. An initial focus group was asked at early stage to test how the questions were perceived, and to get a sense of relevance and time as Gillham (2008) suggest.[44] Later two different focus groups were held in the village, one with RRH tanks and one group without RRH tanks to get an overall view of the situation in Killarlahalli village.

The groups both made the semi structured interviews and two map drawings. In the first mapping exercise the group was asked to draw a seasonal calendar including start of the year, the seasons, rain intensity, growing crops in the village, water consumption by crops, livestock, festivals and rituals. The second mapping, village mapping, included households, streets and fields, important buildings, water sources, bore wells, RRH tanks and water taps provided by the

---

[41] Cornwall, A et. al. 1995
[42] Thomsson, H. 2010
[43] Kvale S. et al 2009
[44] Gillham B. 2008

government. The aim of this mapping session was to give a wider picture of the situation and functions of the village (Appendix 5). It also contributed to the possibility to triangulate and validates data from interviews. Snacks were served during the group interviews to create a more relaxed atmosphere as recommended by Stewart et al. (1990).[45]

3.1.3 Key informants

The key informants are persons that are willing to share their deep knowledge[46] and are "usually chosen on their formal role in an organization"[47]. The key informants in this study are Mr. Ramakrishna and Dr. Channakeshava. Mr. Ramakrishna, taluk manager of BIRD-K organization in C.K Pura, Pavagada, chosen for his knowledge the organization and participating in the 4-year project of rooftop rainwater harvesting system. Dr. Channakeshava, taluk helath officer, Pavagada Hospital, Pavagada are working with fluorosis patients since 13 years at Pavagada hospital.

3.1.4 Semi structured interviews

A semi structured interview consists of written questions and/or topics that need to be covered during the interview. If the structure is followed the data will be both reliable and comparable qualitative data[48] as same questions are asked in all the interviews[49]. An interview guide was developed and corrected during the test interview. During the semi structured interviews the guide remained the same.

The interviews were used to collect data regarding the water consumption behavior (historical, present and in the future). The respondents came from different households. To investigate and compare the interest for rainwater harvesting 10 household without RRH tank and 10 household with RRH tank were participating in the semi structured interviews. Due to time and the desire of respondents the answers for the mapping questions were given orally. The interview started with open questions such as "*Can you describe an ordinary day in the village?*" and proceeded with more precise questions as recommended by Kylén (2004) and Gillham (2008)[50]. See *Appendix 2* for full list of respondents.

3.1.5 Observation and spontaneous discussions

The observations took part during the whole field visit and also during the interviews. The observations were to reflect about and understand human behavior and factors in a certain environment, which also is a source of information.[51] The observations gives also an insight of how the technology, in this case RRH, is used and applied or how eventually problems are solved. It shows new dimensions for understanding the context of using the RRH system.[52] The spontaneous discussions were of a more participating observation as the inhabitants were inviting the interviewer in the talking to each other in the daily life, at the bus stop, market place or street. An example could be a group of people standing around a small petroleum generator and talking about how the lack public tap water is a fact as the power goes off.

---

[45] Stewart David W. et al. 1990

[46] Russel Bernard, H. 2006

[47] Kumar N. et al. 1993

[48] Russel Bernard, H. 2006

[49] Gillham B. 2008, pp 103-109

[50] Kylén, J-A. 2008. & Gillham B. 2008, p 103

[51] Yin Robert K. 2007& Gillham B. 2008, pp 65-70

[52] Yin Robert K. 2007, p 120

3.1.6 Interpreter

An interpreter talking the local accent of the Kannada language was necessary. To minimize the risk of being partial in the questions about the RRH systems and the risk of respondents answering what they thought that BIRD-K wanted them to answer, an outside translator was contacted. There was no professional interpreters in the Pavagada area, so the "translators" were found by contacting the local schools. In order to get an objective translator that would understand the questions and also understand the meaning of translation and interpretation in the context of the study, 3 translators were contacted. Two of them were teachers (Maths and English) at the local schools. One of them was a master degree student in MCA (Master of Computer Applications), Bangalore, also teaching in Degree College. Even if the "translator" is known by the respondents there will always be a distance between the interviewer and the respondents as a third part are participating.[53]

3.1.7 Triangulation

Triangulation is a tool to compare different methods and kinds of data to see if the given information is reliable.[54] It can also be used to see if a situation/factor is perceived in the same way of all the different parts, in the same time as it minimize the foregone conclusion of the interviewer.[55] Triangulation shows a strength to the study as it gives coherence.[56]

The triangulation tool was used both as an overall view but also as triangulation in different levels such as in the group interviews, (to see if the understanding about RRH and Fluoride differed between the groups that had a RRH system and those who had not), interviews of the key informants and between the semi structured interviews and also the observations and spontaneous discussions.

3.2 Water use and water sampling

The average tank size in this study is 6175 liters and the average household consists of 5.5 persons. The general use of rainwater is six liter per day and person. With this consumption rate the existing tank water will cover the household need for six months. Conversely, if the current consumption of rainwater was used by the whole village, the 96 existing tanks would cover 1/4 of the water demand over a five month period.

Samples from 15 different water tanks were collected. The tank water was collected in a cup and stored in three different containers. Fourteen ml of the water was filtered using a 0.45 um syringe coupled to a cellulose acetate filter and stored in a 15ml plastic test tube, 1ml was kept, unfiltered in a 1ml test tube and 30ml unfiltered water was kept in a 40 ml PE plastic container. All samples from the same tank were marked with a "tank number" (2-16) and GPS coordinates of the tank were noted by using a Etrex® 12 channel GPS version 3.30.
All samples were stored in a fridge. pH was measured in field with single use pH indicator sticks.

[53] Thomsson, H. 2010, p 96
[54] Silverman D. 2001
[55] Gillham B. 2008, pp 217-218
[56] Yin Robert K. 2007, pp 125-126

4. Analysis of the data

After all data was collected they were evaluated according to the literature given above. The water samples were analyzed in laboratory and a discussion and conclusion are based upon the results.

4.1 Interview analyzing

Important expressions and relevant information were coded and categorized as recommended by Gillham (2008), Trost (2010) and Kvale (2009). As translators were used in the study some of the expressions and raw material got lost during the translation. Triangulation and observation during the interview, such as the existential circumstances there and then, and body language was taking into account in validating the data. For example if the respondent told that the family only drank the rainwater and felt so much less body pain, but the pump to the water tank was broken, that could indicate both that they did not see the importance to drink the rain water instead of tap water, or that they told the story they assumed that the interviewer or BIRK-K member wanted to hear.

Coded data was elaborated and categorized. The result of the complex situation was assembled by three methods to show how the socio-cultural aspects influencing the use of RRH system. Trost (2010) writes that a qualitative content analyze of the raw material only can be human made.[57] In other words there is no objective or absolutely correct way of making the identifying and categorizing of the respondents expressions. It has been taken to account that the identifying and coding are made by the interviewer and the analysis is based on those categories.

Three different ways in presenting the results from the interview analysis were made and described below.

- An overview of the existing factors that affect the use of RRH was made inspired by Ishikawas method "fishbone diagram" that originally is used to identify the causes and its hierarchy impact on a problem.[58] In this study is the fishbone diagram showing the existing factors categorized in an easy and comprehensible format.

- A rich picture was made to show how the existing factors are perceived by the inhabitants in Killarlahalli. A rich picture is a try to bring together all information that might be relevant for a specific complex situation.[59] It should cover every points of view and prejudices, spiritual and human natural parts.

- A force field diagram was made to show which factors and main arguments that are acting for or against rainwater harvesting for drinking purpose. The factors/main arguments are visually shown at different sides of the RRH for drinking purpose. Each argument is shown as an arrow. According to Straker D, (1995) is the lengths of the arrows are depending on the power of the argument[60].

To create the force field diagram the driving forces (which favors RRH) was brainstormed and listed on the left side. Then the restraining forces were brainstormed and listed on the right side. The forces have been valued by the interviewer based on the comprehension of how the respondents perceive the strength of the factors.

---

[57] Trost, J. 2010, pp 182-194
[58] Ishikawa, K. 1984
[59] Checkland. P et. al. 1986
[60] Straker, D. 1995

4.2 Water analysis
On arrival at the laboratory in Sweden 100 µl distilled 65% HNO_3 was added to the filered water in the 15ml test tube and sent to analysis of cations at SLU accredited laboratory in Uppsala. The 1ml test tube were supposed to use in analyzing anions but due to the high cost of analysis in relation to the given budget they were stored in the fridge for the future. Readings of potential (mV) in the sample cups were measured with a pH meter during 2 minutes and noted in excel. Subsets of samples were then sent to TOC analysis at Uppsala University. A piper diagram was used to plot the cations[61].

4.3 Sources of errors in interviews
Sources of errors are identified, discussed and addressed below.

When using a translator it is impossible to translate the respondents' words exactly as languages do not have words that express the same thing. Even if the language had been understood by the interviewer, the cultural differences between the interviewer and the respondent had occurred in that some of the information and expressions would get lost. The difference between translating and interpretation could also result in that some of the raw data was lost during the interview.

Even if the translators were grown up in the area and known by the people it was sometimes different when using a male or a female translator. One problem that occurred as the male translators was working, was that they both tended to answer the questions themselves, instead of asking a group of women since they already knew the right answer. This could both be due to quality deficient or different cultural genus perspectives.

The presence of a BIRD-K member could make the respondents answer what they though the organization would like to hear. The BIRD-K member presented the interviewer before asking for an interview and staid in the nearby area during the interview. None of the questions regarded the work of BIRD-K. In any case of hesitation of the truth in the answer has observations and questioning been compared.

Further, interview questions in a retro perspective has been compared, such as "*In what conditions was the water resources ten years ago and how did you use it?*" This question could either be answered in *how it was then* in that specific time the question was about or how the respondent *now look at that time*. To avoid this the respondent was encouraged to give a significant occasion in combination with the answer, as suggested by Trost (2010)[62], but in some cases there was no specific occasion given, or lost during the translation. This has been taken in consideration during the analysis.

[61] Appelo et. al. 2005
[62] Trost, J. 2010

5. Results and analysis

5.1 Water sampling sites

That water sampling sites was unevenly scattered throughout the village map. This was depending on the availability of respondents, level of rainwater in the tank and access to the water tanks. In the map of Killarlahalli below are the sampling sites for rainwater marked with red and numbered. The two public taps in the village are marked in blue (Pt).The fact that households were unevenly scattered throughout the village was depending on the availability of respondents. Many of the households worked in the field during daytime and a more structural choice of participating households' areas could therefore not be undertaken

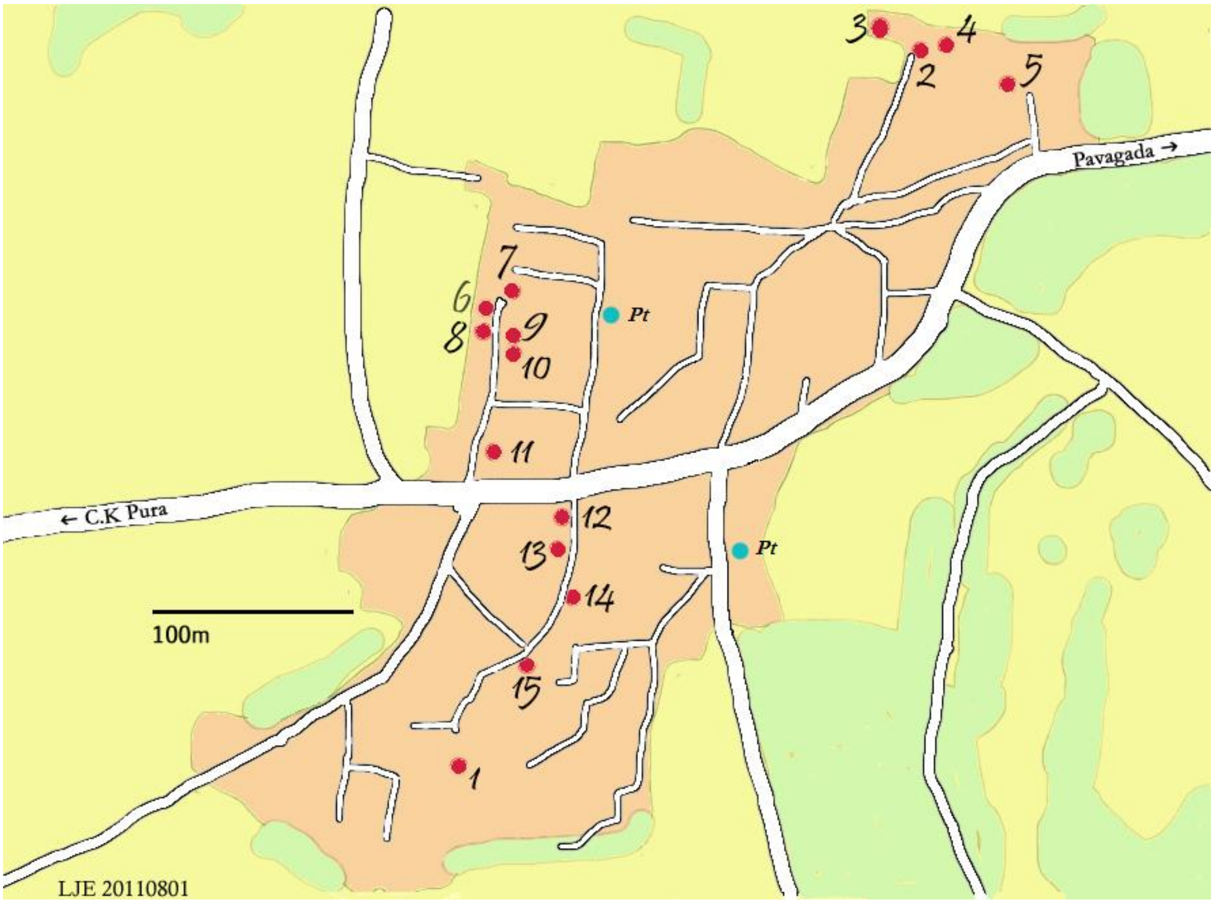


Figure 3. Map of Killarlahalli. Sampling sites for rainwater tanks are marked in red and numbered (1-15). Public taps with groundwater are marked in blue (Pt). Own illustration.

5.2 Calculations and scoring of water

The following calculations for the tanks in the village are based on an adult´s water needs per day: According to the WHO´s recommendations with a drinking need of two liters per day would one tank cover an 19 month water demand per household or be equal to 3/4 of the village´s drinking needs over a five month period. Furthermore, would the tank cover a households needs just less than five months if the outtake followed the WHO´s estimations of water demand for drinking and cooking (7.5 liters/day). The existing tanks would then cover 1/5 of the villagers water needs.

The scoring method gave the same results in both the group that had a tank and in the group that only used the public tap. 100% answered that the most important use of water was for drinking purpose, in the second place nine out of ten said cooking and in the third place almost nine out of ten answered sanitation use such as washing, cleaning and bathing was mentioned.

5.2.1 Filter and cleaning

A simple filter system for removal of unwanted substances is in use. All tanks had a filter composed of the following layers: very fine gravels/net/very fine gravels/net/coarse sand/net/charcoal/medium sand/fine sand (Figure 4). The filter is changed annually or every second year. New sand is delivered with tractor to the village and is rinsed carefully before use. The tank is cleaned inside once a year. After emptying the tank, one person is entering into the tank with a small brush like tool to clean the walls and floor. One respondent also said that he washed the tank with chlorine. In eight out of ten cases the men in the house manages the filter while in nine of ten cases the women in the household are responsible for the water collection.

Figure 4. A house with rooftop rainwater harvesting system and underground tank. The filter is the box in the front of the house (bottom right in the picture). Own picture.

A short time before the rain period starts the roof and pipes are cleaned and checked. All tank owners said that they are using the method of "first flush". When it starts to rain the water is led outside the tank for ten minutes up to one day. In some cases a small first flush stand pipe was observed at the house wall. Those stand pipes had a volume of two to fifteen liters. The duration of the first flush is dependent on roof size. The pipe volume is enough for a roof area of two and a half to eighteen square meters according to Brett Martinson et.al 2009.

The users themselves don't use any treatment against bacteria besides the filter described earlier. "*The tank is closed, no bacteria can come inside*" or "*Sand and no air makes it impossible for bacteria to enter*" was always given as the answer. The BAIF members are making weekly-monthly quality tests. "*First they drank it, and then they told me that it was very good. They were also carrying away water in bottles and when they came back they told me this water was fine.*" 20% say that BAIF sometimes add chlorine to the water "*which makes it pure* . BIRD-K members investigate the bacteriological quality of the water using the H_2S test (this is when they carrying away bottles). The test is based on the sulphur reducing bacteria production of H_2S. Those bacteria are usually present in faeces and can survive longer in water than coliform bacteria.

More than half of the interviewees are using a thin cloth to filter the water before drinking it. In one case the tank owner used filter stones "just in case" to be sure that the water was clean (Figure 5). The filter stones had never shown that the water was contaminated with dust.

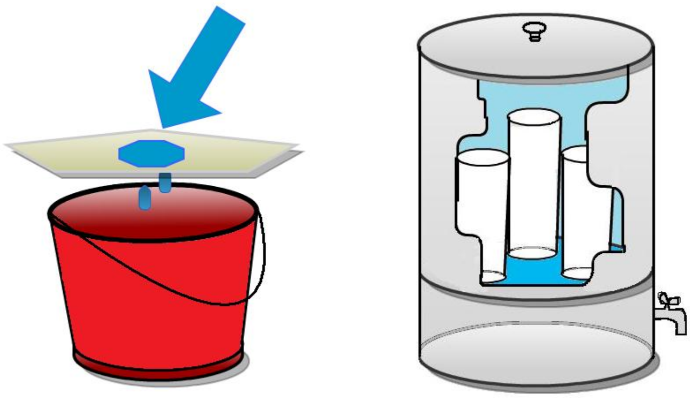


Figure 5. Filtering equipment for dust removal, used before drinking the tank water. Left: a thin cloth is filtering the water. Right: filterstones for filtration. (Own illustration.)

5.2.2 Water level

A few users have a checking pipe to see how much water is left in the tank (Figure 6). This pipe is not used often, as it is said that it makes a risk for bacteria to enter the tank. Usually the tap force tells how much water there is left in the tank. One interviewee told that he could feel the temperature on the wall to the surface tank; between hot and cold, there was the water level.

Figure 6. Lady sitting on the underground water tank, next to a dismantled water pump. The checking pipe is seen as a short blue pipe in the front of the picture.

5.3 Socio-cultural aspects

5.3.1 Fishbone diagram

The identified factors influencing the RRH system were categorized into the main groups, Environment, Access/Participation, Usage, Politics/Organization, Education, Experiences and Future as shown below in Figure 7. Each groups contains factors that all or partly affect the reflection on RRH. The individual households are not significantly affected by all the categories within each main group. (As mentioned earlier, the coding of those factors is made by the interviewer and there is no objective or absolutely correct way of making the groups of factors that the analysis is based on.). These factors are the basis for the analysis and discussions that follows. Each factor is shortly explained below.

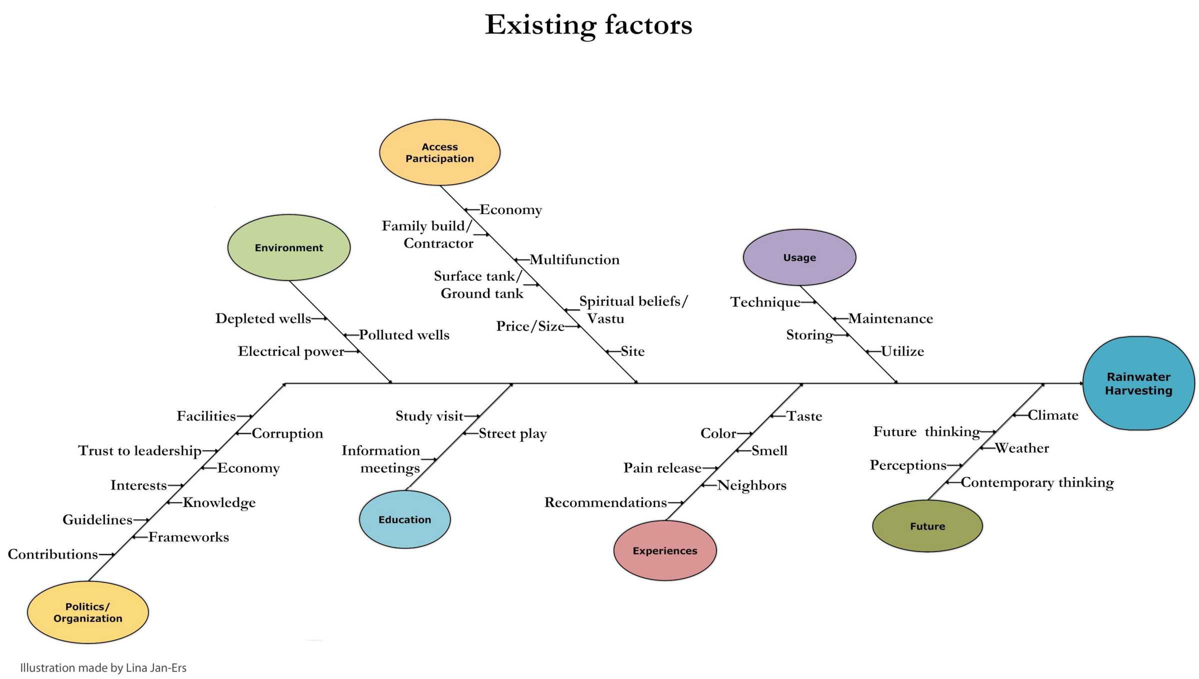


Figure 7. Fishbone diagram showing the identified factors influencing rainwater harvesting system, categorized into seven main groups. A large version of this figure can be found in the Appendix 3

During the interviews, many of the environmental situations were discussed and caused by the depleted wells, water pollution and power outages, resulting in difficulty of access to drinking water. **Education** in the water issue through study visits, street plays and information meetings have led to a greater understanding and an interest in alternative water sources.

Most of the respondents mentioned trust, corruption and contributions during the interviews and reveals that there are many factors in the **organization and politics** that are affecting the choice of investing in a rainwater tank. The trust in politics is generally low, while the trust in the organization BIRD-K is large. This section also addresses the supporting instructions during construction and maintenances contributed by BIRD-K.

Another important factor is the **Access and participation.** A possible investment in a tank is depending on the household's economical, functional and spiritual needs. Under this section the following may be included: the building of the tank, the option of choosing surface or underground tank and its location headed. Furthermore, several of the respondents told about the **experience** of the existing tank and/or other peoples experiences of consuming rainwater. Many users recommend the idea warmly and are pointing at pain release, that color, taste and smell differs compared to spring water or public taps. When it comes to the **use** of rainwater, the tanks are maintained in the same ways when it comes to cleaning and use. Some tank owners have developed their own techniques to ensure the water level in the tank. The **Future** includes perceptions of climate, weather, future- and contemporary thinking.

5.3.2 Rich picture

The identified socio-cultural aspects includes the main categories of the fishbone diagram (Education, Politics/Organization, Access and participation, Usage, Environment, Future and Experience) (see *Figure 7*), and also Spiritual beliefs as those aspects influence the position to rainwater harvesting in different ways. (Figure 8.)

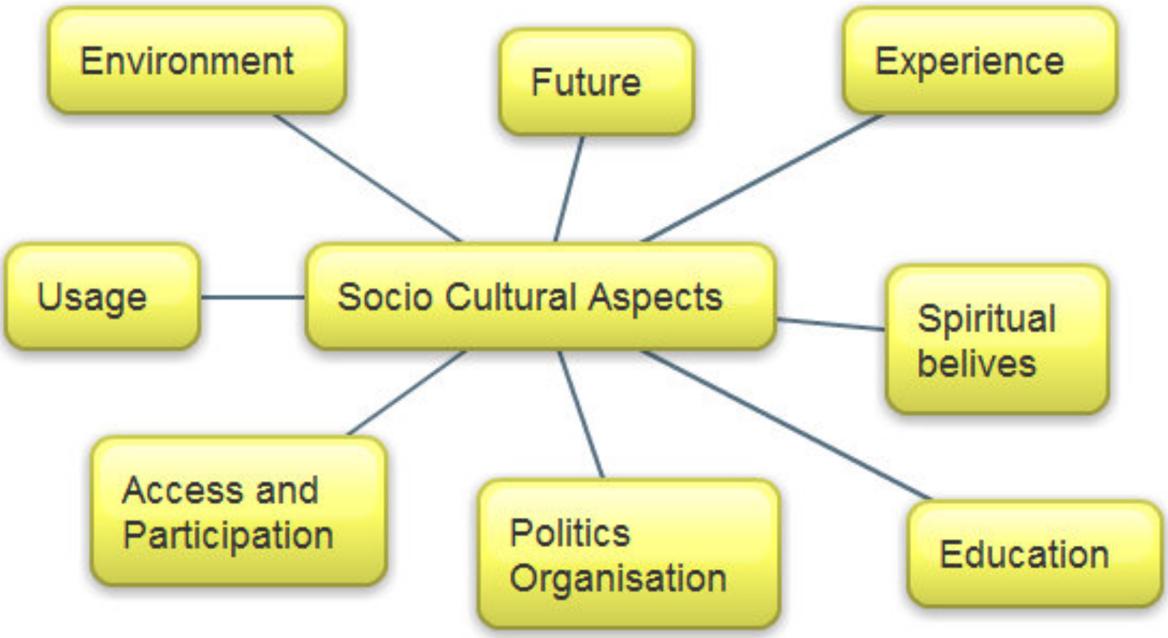


Figure 8. Rich picture showing the socio-cultural aspects that influencing the position adopted for rainwater harvesting.

An in-depth view of the categories, with citations from the respondents, is presented below**.** Each box contains the character/s X and/or ϴ to indicate if the aspect is made by someone with or without a rain harvesting system. Where X represent respondents without rain water tank and ϴ is representing respondents with a rain water tank. One aspect may be expressed by both X and ϴ. Furthermore, the numbers at the lines of the boxes shows how many times the aspect has been mentioned. The numbers are left out where the aspect has been mentioned once. Color of the boxes indicate if the aspect is facing rainwater harvesting in an positive (green) or negative (blue) way. (For fullscale picture see appendix 4.)

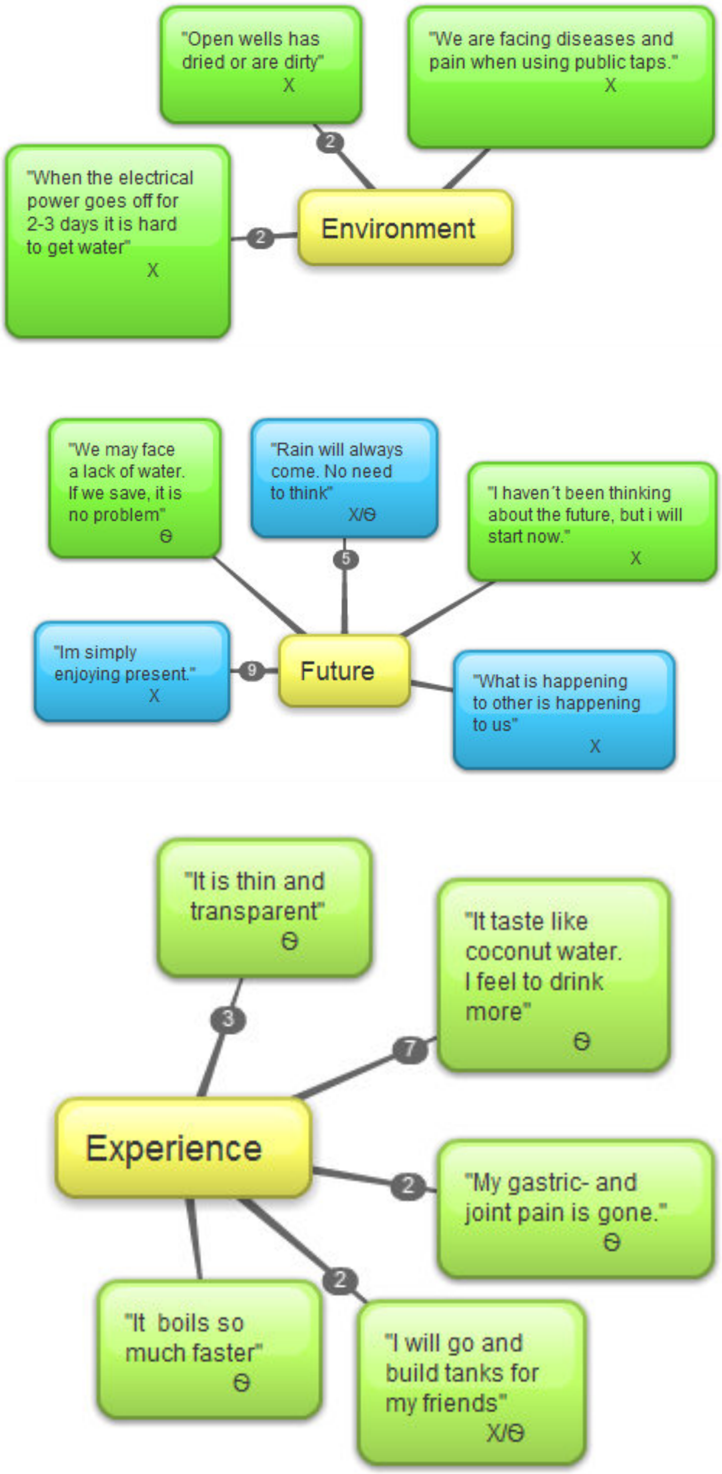


Figure 9. Citations from the respondents according to the environmental prospects, future prospects and experience.

The environmental and future prospects (Figure 9) were discussed in all the interviews and reveal that the majority of the interviewer "live in and enjoying present". Although many of the respondents talked about the conditions of depleted wells they did not had an opinion about the future water issue. Many of the respondents told that rain has always and will always come, so there is no need to think about the future.

The experience of RRH water tanks indicate only in positive reactions. Many of the respondents explore a better health, with no or less body pain when drinking the rain water. Almost all of the interviewed told that they wanted to drink more water now, as it is "clear to the color and taste like coconut water" and boils much faster.

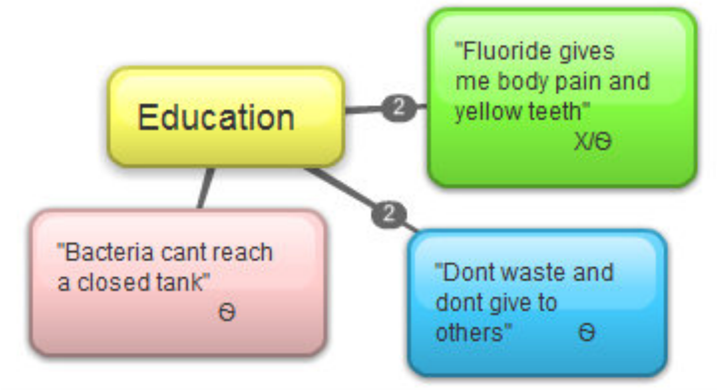


Figure 10. Citations from the respondents according to the education category.

In the early stage of introducing the water tanks the villagers were informed about the benefits of rainwater through street plays and general information on the village mail square. This initial information has crucial relevance for the villagers understanding of why they experience pain in the body when drinking the ground water. All the interviewed had the same knowledge about the issue and all of them could point out the street plays as the source of knowledge. The left box has a pink color. This aspect is both and neither positive (green) or negative (blue). It is positive that the tank safety is trusted, but negative as bacteria do may reach the tank. (Figure 10).

Figure 11. Citations from the respondents according to the category "Access and Participation".

Many of the interviewers without a water tank faces the problem of access to water as the power runs out in the village. A majority of the respondents express the open wells as bad quality water compared to the public taps which also holds a higher comfort compared to going far to a water source. The positive experience by others shows that several of those respondents who had no water tank were now ready to get one. The only problem was that they did not have the financial means and as the project is over and no further grants are awarded. The central blue box in the bottom "We wanted a surface tank so we could sundry grains and tamarind" indicate an aspect in lack of participation as the statement is made by a tank owner who wanted a surface tank but received an underground tank (Figure11).

Figure 12. Citations from the respondents according to the category "Politics, Organisation".

The corruption is a daily event. Several of the respondents and also employees within the BIRD-K organization tell how contributions to the water tanks never reach the villagers although they were promised. A lot of the investments "stay in the pocket of important persons" within the panchayat. One of the boxes connected to Politics and Organization has a blue-green tone (central, bottom of figure 12). This box has not been identified as either a positive or negative aspect. "The panchayat gave us public tap. that's why we don't walk far to open wells" – Due to the public tap it can be considered as the rainwater harvesting is an unnecessary investment as it will go to get water easily any way. The public tap also has a poor water quality which means that many may look for another solution. In other words, there is both a positive and a negative aspect of this statement (Figure 12).
'

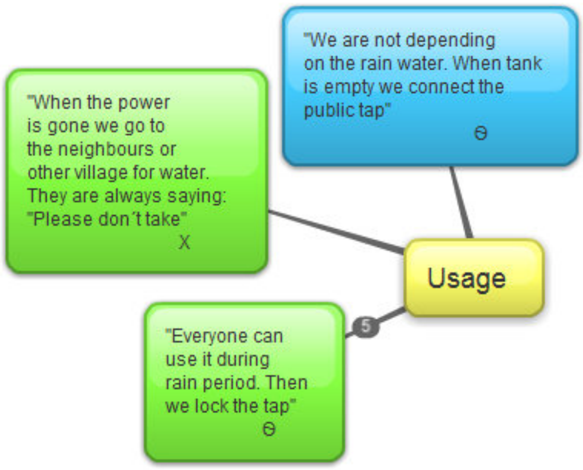


Figure 13. Citations from the respondents according to the categories "Usage and Spiritual believes".

In many cases the tank owners have been told to not give to someone else but instead recommend that these persons also should purchase a water tank. However, the majority of the owners give one or a couple of koda (water storing object equivalent to about 15 liters) to the neighbors and villagers when there is a power failure in the village for a long time. The spiritual believes has a big influence of tank location. In some cases the household had economy for a water tank, but not a good space (Figure 13).

5.3.3 Force field diagram

Figure 14 shows a force field diagram over the driving and restraining forces due to the equilibrium of rainwater harvesting for drinking purpose. The forces have been evaluated and valued by the interviewer based on the comprehension of how the respondents perceive the strength of the factors. Each factor has been given a value between 1 to 5, where 1 has a weak driving force and 5 has a strong driving force. The longer the arrow is the stronger is the power to influence for or against rain water harvesting. Please note that the arrows are not opposite each other in pairs, but the sides of driving forces and restraining forces are opposite each other. Some of the arrows may interact directly. A change in one of the arrows can also result to changes in several other arrows. The categories were selected as they represent specific areas that may be affected and lead to an alerted state.

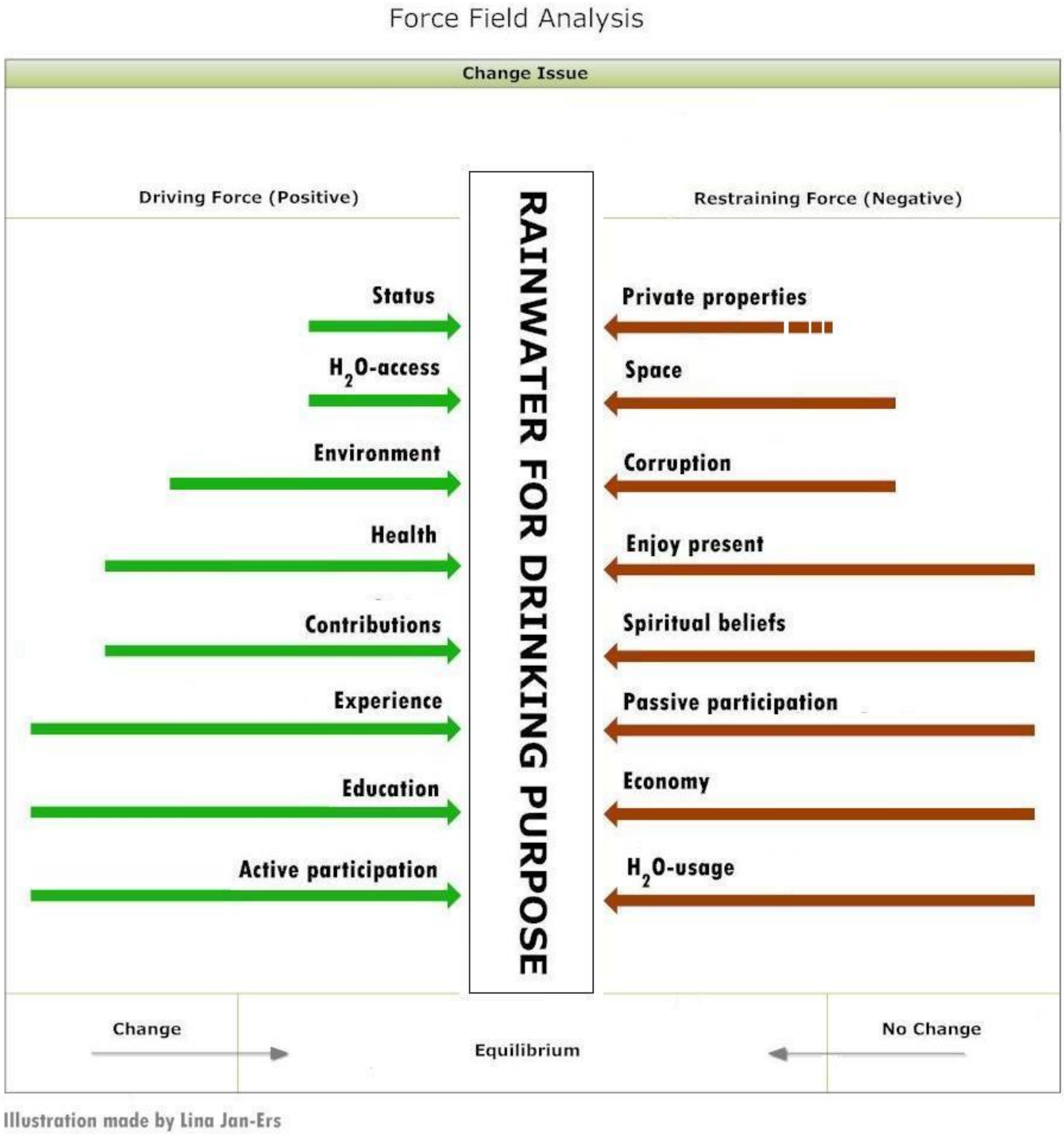


Figure 14. A force field diagram showing the driving (left side) and restraining (right side) forces due to the equilibrium of rain water for drinking purpose.

The driving forces in the figure are the one that causes people to see an attractive change while the restraining forces heading towards a condition to be just as it is. To achieve a complete change to the desired state the total sum of the driving forces must be stronger than the opposite side. The greater the difference is the faster the state will be achieved. By strengthening the driving forces, tern or diminish the restraining forces a successful change can happen. The figure provides a better understanding of the groups values and experiences. By analyzing the counterforce engines, the information can flow and work for water tanks develop to become more acceptable and interesting for those who are involved. Each arrow is explained below.

➔**Status:** Although there is a certain cachet in having a rainwater tank, there is little interest in enhancing ones status by obtaining a tank. The status is more for a way of being self supplied as there is no power in the village.

➔**H_2O-access**: The lack of water doesn't seem to make the rainwater tank more attractive. Most of the respondents say that they usually have access to water through the public tap or open wells. And those who do not have a tank also mean that they get water from others when there is a power failure. However, several of the respondents fill their tank with water from the public tap, when the tank is empty, to have constant access to water even during power failures.

➔**Environment:** This arrow is a combination of experience and education, yet it has such an important role that it appears as an independent arrow. The water from the open wells has a bad taste and the wells are often depleted or located far away from the village. The risk that the flouride content will increase in the groundwater influences to a change.

➔**Health:** All tank users are experiencing reduced body pain and good tasting water. They all feel better and want to drink more water now than before. This is a serious reason and a huge driving force, but it is also related to education and experience.

➔**Contributions:** Those who had received financial support for the tank construction have simply had a greater opportunity to build the water tank. On the other side, there are still many that cannot afford to build a water tank due to their economical situation and or because the project is over.

➔**Experience/Education:** All respondents with a rainwater tank are showing that they understand the problem of fluoride in groundwater and can relate it to their previous lives. Here, education and experience have shown great positive sides. Many of the respondents have built tanks after training sessions or visits to the test location. Individuals who currently have no tank can also see the benefits of their neighbor experiences.

➔**Active participation/ 🡐Passive participation:** This arrow shows the consequences of participation. There is a connection between active participation and maintaining techniques. The tank owners who have participated active in the construction and location of their rainwater tank were also using various techniques to ensure the water level in the tank. No one of the passive tank owners used those kinds of techniques. In an active participation the owner could also choose construction to use for drying tamarinds.

🡐**Private properties:** The idea of rainwater tanks to be a private ownership has on one hand a possibility for the owner to be self supplied as there is no power in the village, but on the other hand there could be a restraining influence with private ownership. For the individual household with a tank the restraining force is limited or nonexistent. A household without a tank sees a large restraining force of not having access to rainwater for drinking purpose. From a village perspective, in terms of availability of tank-rainwater, there is a quite strong restraining force as there are relatively few households in the village who have a rainwater tank; the prosperity of the village is not significantly increased.

🡐**Space:** The shortage of space for a rainwater tank has a large power. One of the respondents says that they would have a tank but as they are living on a flat rock a subsurface tank is impossible. This household of 15 members has not room for a surface tank on the land belonging to their house.

🡐**Corruption:** All participants who have received grants or were promised but never received a contribution indicate a powerless feeling according to the prevailing corruption. One woman says that the political members has 100% discount on rainwater harvesting tanks, she is smiling, and telling that she cannot influence the situation.

🡐**Enjoy present:** More or less all of the respondents have no vision for their water supply for the next 5-10 years to come. They live in the moment with thoughts that "no one knows what will happen" or "what happens to others is happening to us". Only one of the respondents says that she has never thought about it, but she will do from now (this statement is shown in figure 4).

🡐**Spiritual believes:** In many cases has the spiritual believes had a decisive influence. Economy, education and experiences indicate that a rainwater tank is a possible investment, but how things will turn out for the family if the purchase a water tank is ruled by Vasto.

🡐**Economy:** Many of the respondents say that they don't have the economy to build a tank or to take a loan as the rent is very high and gives them too much economical pressure. Since the water tank project is over, there is no grand for building a tank and even if there are families that are ready to build a rainwater tank, there is no money to fulfill or maintaining the construction. One man told that he build a tank but partly of the construction was standing on the road. The tank was in use for 1 month before it was taken down. This family lost both their rainwater supply and the invested money. Some of the respondents built a tank but could not afford to change their thatched roof to plastic or metal the same year.

🡐**H_2O-usage:** There is an over consumption of the current rainwater. The tanks are not always large enough to cover the water demand according to WHOs recommendations and the need increases with increasing comfort. Easier access to drinking water (closer distances) makes the water more accessible and used.

5.4 Water composition

5.4.1. pH and mineral contents in the tanks

Comparing of the field pH and laboratory pH measurements are shown in figure 15 below. The field pH has a generally lower value than the pH measured in laboratory.

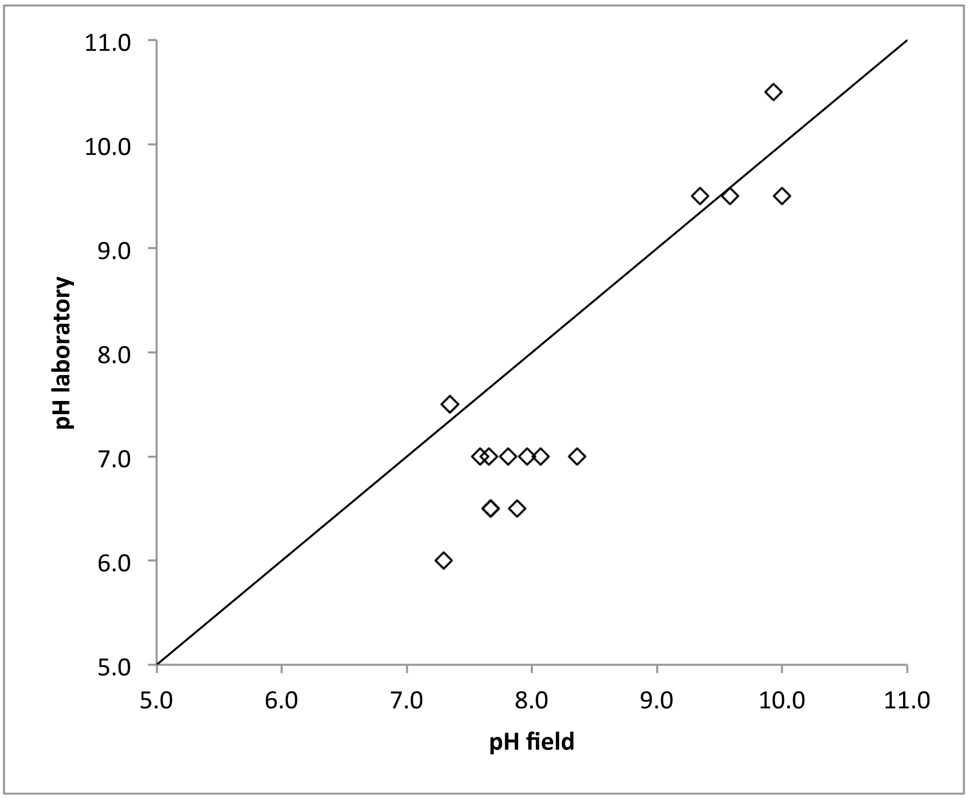


Figure 15. Comparison of field measurements of pH, in the RRH-tanks, with pH measurement in laboratory.

Field pH and laboratory pH and evaluated cations are presented in *Table 1* below. The field pH varied between 6-10,5 and the laboratory pH was measured to 7,3-10,0. According to WHO guidelines for drinking purpose, there is no health based guideline value purposed but a desirable value for pH is 6,5-8,5. No specific pattern between years since establishment of tank and pH could be seen. None of the chemicals in the *Table 1* exceed the WHO (2011) recommended health- based guidelines.

The tank water data is compared with Siva Soumya et. al (2009) rain water data from Kodaikanal 250km south of Killarlahalli. As seen there is a big difference in Ca^{2+} content. According to WHO (2011) a new installed concrete tank may leach Ca^{2+} with elevated pH. In this study there is no significant relationship between high Ca^{2+} content and high pH ($p>0,05$).

Table 1: The range of water compositions in the rainwater tanks are listed below. (concentrations in mg/L). Please note that sample 1 is missing in the table due to missing analysis. Mule Hole is rain data (mean concentration) collected by Soumya et.al (2009) in Kodaikanal 250km south of Killarlahalli.

Sample	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Mule Hole**
pH field	6	9,5	7	7	6,5	7	7	-
pH lab	7,3	9,3	8,4	8	7,9	7,8	7,6	6,76
Ca^{2+}	15,5	100,3	10,2	76,0	92,6	41,2	21,0	0,376
Fe	0,01	<0,01	<0,01	<0,01	<0,01	<0,01	0,047	-
Mg^{2+}	1,23	0,12	8,87	27,9	10,3	8,11	0,54	1,159
Si	2,3	3,0	1,9	0,0	7,6	5,0	2,9	-
Al	0,03	0,16	0,05	0,02	0,03	0,01	0,04	-
Mn	$9x10^{-4}$	$6x10^{-5}$	$1x10^{-4}$	$8x10^{-4}$	$1x10^{-4}$	$3x10^{-4}$	$5x10^{-3}$	-
Sr^{2+}	10^{-1}	$8x10^{-2}$	10^{-1}	10^{-5}	10^{-5}	10^{-5}	$6x10^{-2}$	-
Na^+	4	32	15	166	63	68	2	0,695
K^+	4	2	2	4	12	5	4	1,009
Sample	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Mule Hole**
pH field	7	6,5	7	6,5	7,5	9,5	10,5	-
pH lab	8,1	7,7	7,7	7,7	7,3	10	9,9	6,76
Ca^{2+}	26,8	21,1	19,2	15,6	15,7	21,7	40,7	0,376
Fe	<0,01	0,022	0,011	<0,01	0,011	<0,01	<0,01	-
Mg^{2+}	2,13	1,43	0,54	1,07	1,01	0,27	0,13	1,159
Si	5,2	3,2	1,8	3,8	2,4	1,5	5,6	-
Al	0,05	0,02	0,07	0,02	0,11	0,10	0,68	-
Mn	$8x10^{-4}$	$9x10^{-4}$	$8x10^{-4}$	$5x10^{-4}$	$2x10^{-3}$	$6x10^{-4}$	$6x10^{-5}$	-
Sr^{2+}	10^{-1}	10^{-1}	$5x10^{-2}$	10^{-1}	$9x10^{-2}$	$9x10^{-2}$	10^{-1}	-
Na^+	17	17	2	24	5	4	3	0,695
K^+	3	6	4	3	2	2	6	1,009

The Mg^{2+}within the tanks differs from 0,125-27,9 mg/L. The calculated residence time of the tank water in this study varies from 0 to 150 days while the residence in the filter where some of the mineral/water interaction occurs is unknown. Comparing the rainwater data result from Siva Soumya et. al (2009) some of the tanks have a much higher Mg^{2+} content than the expected rainwater.

5.4.2 Total organic carbon (TOC)

The mean TOC for each tank is represented in *Table 2* below. The low concentration in all of the tanks indicates that there is no contamination of organic substances. The mean concentration TOC in Swedish surface water is around 8000 ppb.[63] These results provide no clear picture of TOC in the tanks, but it gives a hint of the generally low contamination by organic substances.

The low contents of inorganic carbon (IC) indicate that there is no bicarbonate in the samples. Likely anions in the water should therefore be sulfate, chloride and nitrate.

Table 2. Total organic carbon (TOC) and inorganic carbon (IC) for the tank water samples.

Tank no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
TOC (ppb)	2153	501	1167	473	622	1007	1987	622	827	626	1000	365	626	567	813
IC (ppb)	7,32	6,60	7,44	6,22	17,67	9,78	11,99	8,63	8,42	6,57	5,99	7,84	6,54	6,25	5,48

5.4.3 Comparison of cations

The chemical composition of the Piper diagram is independent of ionic strength, and is calculated on the ionic charge. This relative comparison is an ideal way to compare samples from different regions or in this case different tanks. Figure 16 shows that the Ca^{2+} composition within the water tanks varies widely. The black point in the triangle is the rainfall data from Mule hole for comparing precipitation water with tank water. As mentioned above the Mule hole data is not totally compatible with the Killarlahalli region, but it is a guide to see how the tank water differ from the precipitation.

Since the precipitation water in the tanks come from a geographically small region should the variation of Ca^{2+} not exist. The Piper diagram indicates that Ca^{a+} is contributed to the water by the tanks, as there is no cluster of Ca^{2+} shown in the diagram.

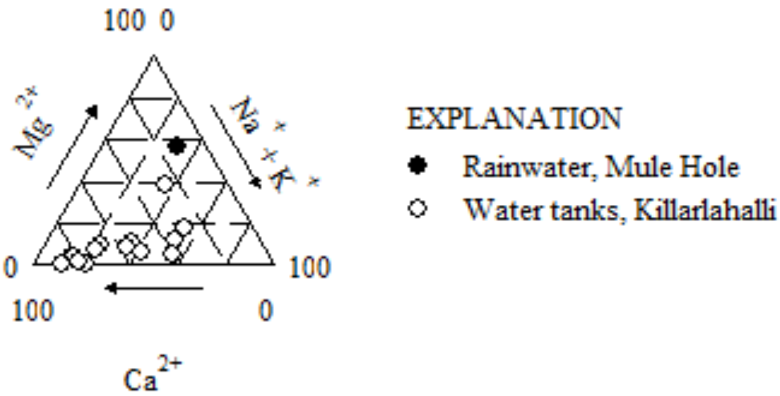


Figure 16. Part of a piper diagram (mg/L). The figure indicate wether the tank water is different from each other in relation to a potential evaporation.

[63] SLU, Databank för vattenkemi

6. Discussion

6.1 Socio-cultural perspectives
The interviews indicate that most of the people are aware of the concept of roof rain water harvesting (RRH). As this is a small study it is impossible to say how many people that are aware of the concept of roof top rainwater harvesting systems in the village.

6.1.1 Tank use and management
All the tanks in the study are more or less sufficiently used. Some tanks are at sometimes filled with water from the public tap. On the one hand, this shows for an active participation and ideas for comfortable life. On the other hand it shows a lack of understanding of the complications that the groundwater provides. This applies mainly when rain water is mixed with groundwater. When the tanks are empty and there are weeks remaining until the next rainy season, it is a certainty to fill the tank with public tap water to be protected from a power failure. It also avoids daily trips to the public tap for water. This allows the individual need for water control the consumption rather than that the ability of water controls the need.

The use of a RRH system is increasing the understanding for the current water situation and the value of clean water. But a nearby water source may also increase the consumption as it is easy and convenient to increase the water extraction. It is important to bear in mind that the daily demand of drinking water is generally the same for all people, but that the water supply varies depending on how developed the infrastructure is. On the other hand, the value of water is also increased in the active participation. The tank can be formed and used by the family's individual needs for limited space and instance storage of dried tamarinds and thus appreciated for both the physical tank and its water. The interviews indicates that those who actively participated in the design features of their tanks also have developed a greater wealth of ideas to find solutions i.e. finding the water level or use the space on the tank for their everyday tasks.

6.1.2 Affecting factors for RRH
The interviews indicate that the main affecting factor for purchasing a RRH system is simply for health reasons. Purchasing a tank will reduce body pain and ensure ability to drinking water even during electrical power breakdown. But also economy, vastu and space play a major role for purchasing a rainwater harvesting tank. It is a large cost to both build a tank and to change the thatched roof to metal, tiles or plastic. Families with low income and/or lack of space and householders that are tenant are not able to purchase a rainwater harvesting tank.

In some cases where there is an economical possibility to invest in a RRH system the respondents has explored that it was impossible to have a water tank because of vastu. When there is no possible space or corner that would be a suitable place, it is safer to refuse. In those cases Bird-K is trying to perform alternatives by placing water tanks adjacent to the houses. An underground tank might also be a better option, but still not optimal. A couple of times, new built tanks have been closed or removed the same day because of the location. The invested money is lost as the tank is then unusable.

In future water issues almost all respondents agree on that rain has always occured and that there is therefore no need to think about it. This way of arguing indicates that rainwater harvesting is a reliable source, but it can also be seen as an obstacle in the development of access to pure drinking water as it also speaks for that the groundwater and open wells will be attending. Many of the inhabitants in whole or in part don’t have an interest in actively pursuing the water issue. It is a difficult dilemma in which multiple factors are crucial. To change this behavior education and experiences are required. As the rain always has come in different amounts every year it is impossible for someone who has no training on the issue to understand the chemical reason why bodily pain occurs during chronic use of the ground water. It needs to be experienced by someone who has a tank and is pleased with the idea and also inspires the people that this is a good investment.

Active participation and wealth of ideas increases experience, which in turn is a resource of knowledge. Knowledge in combination with education and experience may also indirect increase the active participation. Although the current knowledge about the water problem is in general widespread in the village, there is still a lack of knowledge.

There is a great advantage with an Indian organization as BIRD-K in the Killarlahalli area. Often there are western water companies with high technology that are supporting the projects in India. There is a risk for local and traditional solutions to be overridden by the modern technology. In those cases the future maintenance may not be economically functional in the rural areas when it will be managed by the local committees. Local knowledge and traditions must be upheld to promote and enhance both the democracy and the ecology. Since the BIRD-K is the only organization working on water issues in the area is also the only option of alternative water resources and there is no possibility to compare eventually other rainwater harvesting products. All information about the water issue comes from the same source.

The critical thinking about the water condition is somewhat poor. Many of the tank owners insist that their tank is sealed from all possible bacteria intrusion. Even though they know that the organization sometimes pours chlorine into the tank after quality check "to make the water even cleaner". There is a missing link between bacteria and chlorine. This could both be due to not worry the tank owner, so the families will continue use the rainwater and to not make the families questioning the system security. "Bacteria cannot reach a closed tank" is indicative of how the respondents see the hygienic safety as a major positive force, but the ignorance in this statement denies any aspect of possible microbial growth. Due to this reason one of the boxes in figure 10 has a pink color. It has both a positive and a negative force.

6.1.3 Village private property

Besides economical problems the lack of space is a problem that many states to why they do not have a water tank. If we are playing with the idea that the village's tanks should belong to everyone, a village common property would reduce the problem of limited space and also affect the collective status. Entire village cohesion could increase by being strong together. However, it can also lead to conflicts over who is entitled to more water than any other. Access to clean water is a multifaceted problem. Overall, all living beings have the right of access to clean drinking water. On a smaller scale where the economy, property rights and individual needs are determining the issue seems not so clear.

The water has to be a common property, i.e. no one owns the water, but in the same time the risk of "tragedy of the common" must be avoid. So there is a point privatizing (in a village perspective) the water facilities to avoid that the property will be overused. A village privatization would reduce the private property-arrow in Figure 13 slightly, but not entirely. The water in the tanks do not completely cover the villager's drinking needs. In a village common property this could lead to problems. The ability to the water would be reduced for a household that owns a tank today, while water ability would increase for those without a tank. Questions about who gets to take out what, how much water may be used and how much water the households actually consume will vary among households and can therefore also lead to disputes and injustices.

The best way is to start a village common property project is in the startup with a new project. However, the solution is not so simple that if everyone pays the same amount they all get the same amount of water. Here is a problem, not everyone can afford to pay as much as needed. And in order to not overuse the water; the price can rise so high that many of the people that *could* afford it cannot use the facilities anyway. The technological investment will then be meaningless from a perspective of human rights and survival. The economically water issue is difficult and complex when one owns the water, but the technologies to deliver it. By earmarking governmental money the benefits for the villagers will increase and might help to avoid corruption

6.1.4 Confidence of the respondents

From a western perspective, the inhabitants have little confidence to what they know about the current situation and their ability to influence their situation. This is something that has been raised with increased knowledge about the problem. Cultural issues and thoughts about the future are very different from a western perspective. Many of the respondents indicate that they have not thought of future water resources or opportunities. In this culture, the caste system plays still a major role. Some of respondents expressed themselves, that they live the life they were born to and may do their best to get a better life in his next. This is very important to take in to account in future studies and development programs.

This way of life view made it sometimes difficult to use the PRA method during the interview as the elderly in the village did not regard themselves as consultants or colleges with me. When the questions was reformulated so they could talk about historical water use and the current water issues they could act as actors without putting pressure on themselves. This could also be a generational issue. School children seemed to have less or no such class differences. A clear example is when the children took part in the focus groups. The village mapping worked out best in the groups where curious school children started to draw. Many of the adults did not want to draw any picture, as they did not believe in their drawing skills. Instead it became teamwork with the adults explaining as the school children were drawing.

6.2 Water composition

6.2.1 pH

According to WHO a desirable pH value for drinking water is 6.5-8.5. The pH in this study varied between 6-10.5 (field) and 7.3-10.0 (laboratory). In some of the tanks pH is also rather high comparing to the rain data from Mule Hole (6.76). The high levels of pH may be correlated to the use of filter as Fujioka et. al. (1994) indicates in their study. High values of pH could also point at interactions with Zn from eventually roof material, contributions from the filter or the concrete walls within the tanks. Four of the samples in Figure 14, have a pH that is significantly higher compared to the other samples. A possible reason could be an interaction with Zn from eventually metal roofs or gutters. This cannot be determined in this study but should be developed further in a future study. A pH over 8.5 could also indicate cement corrosion. Some of the tanks in this study may therefore also be further investigated according to risk of cement corrosion.

Although a high pH slow down bacterial growth, is WHO recommendation to keep a pH below eight for effective disinfection with chlorine. In this study it is unknown how many of the tanks that had a chloride contribution or what the pH was prior to adding chloride. In those cases when pH was high and the controller from BAIF had added chlorine, no one of the respondents knew why the chlorine was added. This could be a lack of involvement and may lead to less commitment and development as mentioned above. BIRD-K is though good in involving the stakeholders in the plans and construction of the tank as the owner are building their tanks themselves.

A small variation is seen comparing the field measured pH results with laboratory measured pH results. This may be due to uncertain measurement in fields where the color scale on the strip varies with the specified values of integers. Increased TOC also produces a decrease in pH. Laboratory measurements were made on filtered water which could have result in a removal of carbon and thus a slight increase in pH. The pH paper indicators used in the field corresponded anyway sufficiently well with the laboratory results and may therefore be used to assess the water quality in terms of pH.

Comparing the Indian drinking water in this study with the Swedish limitation values for pH may seems irrelevant considering the high quality of Swedish drinking water. The comparing is rather to give the reader a reference of the general perspective than to compare the pH values.

6.2.2 Mineral content
No one of the cations in the water composition reach the levels above the WHOs guidelines for drinking water. However it is difficult in such a small study to define the overall mineral content and to detect peaks of chemical substances.

The Mg^{2+} content differed between the tanks. There is no obvious explanation for the large differences in Mg^{2+} content, but the residence time in the tank may have some impact on the results. The tank has no clear induction for water level and the water use varies with feasts and daily needs, there are therefore no data on the residence time in an individual tank. Comparing the rainwater data result from Siva Soumya et. al (2009) some of the tanks have a much higher Mg^{2+} content than the expected rainwater. Here it could be worth questioning the methodology used for constructing the tanks.

Also the Ca^{2+} content varied within the tanks and compared to the pure rainwater data. It may be possible that the rainfall contains a higher value Ca^{2+} in Killarlahalli region. The most possible reason to the huge differences is rather that the Ca^{2+}compounds in the concrete tank walls is dissolved and leached out into drinking water.

Killarlahalli is a small village so the rainwater in the tanks is collected in a, geographically, small area. Therefore it is expected that the rain water quality does not vary considerable within the tanks. However, the method of constructing and using tanks may vary as several of the tanks deliver drinking water with different water chemistry.

The rainwater data used in this study comes from an area 300km south west of the study site. It should be kept in mind that this data not totally correspond to the study site as the landscape in Killarlahalli (inland, open area) is different from the rainfall measurement location (forestland, close to the coast). For a better reference should a rain sampling site be rigged in the Killarlahalli area in a further study.

The low contents of inorganic carbon (IC) indicate that there is no bicarbonate in the samples. Likely anions in the water should therefore be sulfate, chloride and nitrate. Since sulfate is a product of the reaction between water and concrete walls, it could be a reasonable explanation for the high concentration Ca^{2+} in the water tanks. The suspected chloride present in the water may come from the precipitation, concrete walls and the addition of chlorine when cleaning. As nitrate is an unstable substance it should be measured directly in connection to the water sampling to enhance a true determination of the mineral composition.

6.2.3 Existence of living organisms

The results from the TOC indicate that there is a low contamination of organic substances in the water. This means that there is no indication of living organisms or decaying material in the water tanks. According to the Swedish National Food Administration (2006) TOC limits are established individually according to the relationship between TOC and oxidiability, measured during at least two years in the current drinking water. The TOC should therefore be measured regularly at the study site to detect unwelcome bacterial growth. As oxidation was not measured in this study, the TOC results will not indicate a limitation value but rather give an idea of contamination of organic substances in the water.

The low TOC in this study be made of two reasons; it could indicate an effective first flush system and that the high pH in the tanks is unfavorable for bacterial growth. To maximize the function of a first flush system and to minimize the risk of a too short first flush, each household could use a rain gauge to see when a proper amount of first flush has passed the system (if not a first flush vertical pipe is used).

In a further study the coliform bacteria should be measured in directly contact with the water outtake to detect eventually colioform bacterial growth in the water tanks.

7. Conclusions

The tanks are sufficiently used in the village. Health and environmental issues, education and economy affect the conclusion on purchasing a rainwater harvesting system. Vastu and active participation has a major role in RRH system. The study indicates that an active participation in constructing the tank increase tank management and develop the way of using the tank.

A village private property is difficult to apply in an ongoing project. If it is possible to maintain justice and unity a village private property should be started up in the beginning of a small scale project.

No one of the water compositions indicates that the water may not be consumed according to the WHOs guidelines for drinking water. However it is difficult in such a small study to define overall the mineral content and to detect peaks of chemical substances. The pH paper indicators unused in the field corresponded sufficiently well with the laboratory results that they may be used to assess the water quality in terms of the pH.

According to the high content of Ca^{2+} in the rainwater tanks there should not only be guidelines for how to build the tank. Guidelines in material quality and maintenance should also be provided.

The low TOC in this study be made of two reasons; It could indicate an effective first flush system and/or that the high pH in the tanks is unfavorable for bacterial growth. To maximize the first flush system and to minimize the risk of a too short first flush, each household could use a rain gauge to see when a proper amount of first flush has passed the system (if not a first flush vertical pipe is used).

8. Futurer studies

Proposal for further studies are presented below.

- Participation and maintenance

  Develop the study of the link between active participation and good maintenance of the tanks.
- Sampling of pure rainwater

  Pure rainwater should be sampled and measured in the Killarlahalli area to determine the amount of chemicals in the precipitation water. This will make it easier to identify how the tanks are affecting the water quality.
- Measure an concrete absent element

  It would be good to measure an element that occurs in rain water but not in cement, for example chloride. Even if chloride is contributed to the tanks by chlorine when cleaning the tanks, it should cause significant changes.
- Colioform bacteria

  H_2s bacterial test in field could be used to detect colioform bacteria.
- Turbidity and first flush

  Measure the turbidity to see how much first flush is needed.
- Zn and roof material should be investigated to evaluate the high levels of pH.

  Roof material could be examined to see if there is a possible relationship between sunheated metal roof and the total bacterical level.
- Fluoride and calcium

  Could it be possible to regulate the fluoride concentration in the ground water? As the concentration of fluoride is regulated by the presence of calcium and Ca^{2+} compounds in the concrete tank walls probably are dissolved and leached out, perhaps it could be possible to regulate the high content of fluoride in the groundwater by using calcium. A future study should therefore investigate the possibilities to regulate the fluoride concentration in water tanks or village pools or ponds.

Bibliography

Literature and publications

Appelo C.A.J & Postma D. 2005. Geochemistry, groundwater and pollution 2nd edition A:A Balkema publishers, Leiden, The Netherlands. pp.7-16 (ISBN 0415364280)

Brett Martinson et.al. 2009. Quantifying the first flush phenomen pp. 6-7 Development technology unit. School of engineering, University of Warwick, UK.

Checkland. P 1986 *Systems thinkings, systems practice.* John Wiley & Sons Ltd., Great Britain.(ISBN: 0-471-92768-6) p 317.

Cornwall, A & Jewkes, R. 1995. *What is participatory research?* Social Science and Medicine, Volume 41, Number 12, 1995 , pp. 1667-1676(10)

Fawell, J. 2006. World Health Organization. *Fluoride in Drinking-water.* Albany, NY, USA: World Health Organization, p 6

Fujioka R.S. & Faisst E.W. 1994, *Assessment of four rainwater catchment designs on cistern water quality.* University of Hawaii, USA p. Proceedings of the sixth international conference on rainwater catchment systems, Nairobi, Kenya. pp. 399-406

Gillham B. 2008. *Forskningsintervjun, Tekniker och genomförande* Bill Gillham och Studentlitteratur, Malmö. pp. 44-46, 65-70, 103-109, 217-218 (ISBN 978-91-44-04012-7)

Government of Karnataka, 2002. *State Water Policy 2002, Water Resources Department.* www.ielrc.org/content/e0205.pdf

Ishikawa, K. 1986. *Guide to quality control* Asian productivity organization. Tokyo. (ISBN 92-833-1036-5) pp.148-157

Kinkade-Levario, H. 2007. *Design for water, Rainwater harvesting, Stormwater catchment and alternate water reuse.* New society publisher, Cannada. (ISBN 978-0-86571-580-6) pp. 7-224

Kumar N., Stern W. L & Andersson J. C. 1993. *Conducting Interorganizational Research Using Key Informants.* The Academy of Management Journal, Vol. 36, No. 6. p1635

Kvale S. et al 2009. *Den kvalitativa forskningsintervjun* Studentlitteratur AB. Lund. p. 160 (ISBN 978-91-44-05598-5)

Kylén, J-A. 2008. *Att få svar. Intervju, enkät, observation* Jan-Axel Kylén & Bonnier Utbildning AB, Stockholm. pp 31-40 (ISBN 91-622-6577-6)

Livsmedelsverket. 2006 *Information om kemiska parametrar i Livsmedelsverkets föreskrifter (2001:30) om dricksvatten, bilaga 2, i bokstavsordning.*

Pretty, Julens N. 1995. *Participatory Learning For Sustainable Agriculture.* World Development, Vol. 23, No. 8. pp. 1247-1263

Rural Development and Pancharat Raj. 2010. *Baseline Report of Sachetana Drinking Water Project.* Bangalore http://www.indiawaterportal.org/sites/indiawaterportal.org/files/sachetana_complete.pdf

Russell Bernard, H. 2006. *Research methods in anthropology qualitative and quantitative approaches, 4th edition.* AltaMira Press.Oxford p. 212 (ISBN 0-7591-0868-4)

Silverman D. 20011 *Interpreting Qualitative Data. Methods for Analysing Talk, Text and Interactions.* SAGE publications. Great Britain. (ISBN 0-7619-6864-4) pp. 233-235

Siva Soumya B. M. Sekhar, J. Riotte & Jean-Jacques Braun 2009. *Non-linear regression model for spatial variation in precipitation chemistry for South India.* Atmospheric Environment 43 (2009) 1147–1152

Stewart David W. & Shamdasani Prem N.. 1990. *FOCUS GROUPS Theory and Practice* SAGE publications. USA. (ISBN 0-8039-3390-8) p 55

Straker, D. 1995. *A Toolbook for Quality Improvement and Problem Solving* Prentice hall.UK. (ISBN 0-13-746892-X) pp. 217-224

SWARAJ, 2009. The Society for Voluntary Action Revitalization and Justice. *The state of Water, Sanitation and Solid waste management*, p26ff. http://www.indiawaterportal.org/sites/indiawaterportal.org/files/The%20State%20of%20Water%20Sanitation%20and%20Solid%20Waste%20Management%20in%20Doddballapur%20town_SVARAJ_2009_res-25011003.pdf

Vasudevan P., Tandon M., Krishnan C. & Thomas T. 2001. *Bacteriological Quality of Water in DRWH.* RWH Conference, IITD, New Delhi April 2001.

Thomas, T.H and Martinson, D.B, 2007. *Roofwater Harvesting, -a handbook for practitioners.* Technical Paper Series 49. ICR International Water and Sanitation Centre. Delft, The Netherlands.

Thomsson, H. 2010. *Reflexiva intervjuer.* Studentlitteratur AB, Lund. p. 69, 96 (ISBN 978-91-44-06828-2)

Trost, J. 2010. Kvalitativa Intervjuer Studentlitteratur AB, (ISBN 978-91-44-06216-7) pp. 99-102, 182-194

United Nation, 2002, *Economic and Social Council, General Comment No. 15*, Geneva, p.1. http://www2.ohchr.org/english/issues/water/docs/CESCR_GC_15.pdf

United Nation, 2010. *the Millennium development goals report 2010* http://www.un.org/millenniumgoals/pdf/MDG%20Report%202010%20En%20r15%20-low%20res%2020100615%20-.pdf#page=60

UNDP, Human Development Report 2006. New York 2006 http://hdr.undp.org/en/media/HDR06-complete.pdf

Vishwanath, S. *Rooftop rainwater harvesting for tackling fluoride contaminated ground water.* Bangalore p.17ff. http://www.rainwaterclub.org/docs/tackling_flouride_contaminated_ground%20water.pdf

WHO, 1998:1. *Aluminium in Drinking-water Background document*

WHO 1998:2. *Guidelines for Drinking-water Quality, Geneva 1998*

WHO, 2008. *Guidelines for Drinking-Water Quality 3rd edition, incorporation the first and second agenda. Volume 1 recommendations.* Geneva
http://www.who.int/water_sanitation_health/dwq/fulltext.pdf

WHO 2009. *Calcium and magnesium in drinking-water : public health significance.*
ISBN 978 92 4 156355 0

WHO and Unicef, 2010. *Progress on Sanitation and Drinking Water, update 2010*
http://whqlibdoc.who.int/publications/2010/9789241563956_eng_full_text.pdf

WHO, 2011. *Guidelines for Drinking-Water Quality, 4th edition.*
ISBN: 978 92 4 154815 1
http://whqlibdoc.who.int/publications/2011/9789241548151_eng.pdf

Yang, C.Y., Chiu, H.F., Tsai, S.S., Chang, C.C. and Sung, F.C (2002a) *Magnesium in drinking water and the risk of delivering a child of very low birth weight.* Magnes. Res. **15**, 207–213.

Yang, C.Y., Chiu, H.F., Chang, C.C., Wu, T.N. and Sung, F.C (2002b) *Association of very low birth weight with calcium levels in drinking water.* Environ. Res. **89**, 189–194.

Yin Robert K. 2007. *Fallstudier: design och genomförande*
Liber AB. Slovenia. pp120-123, 125-126 (ISBN 0-7619-2553-8)

Internet

Bird-K

1. Bird-K, 2011-04-03
http://www.birdk.org.in/index.php

DHAN

1. DHAN Foundation, 2011-05-03
http://www.dhan.org/

FAO

1. Aqua Stat, 2011-06-10 (Water balance ->India)
http://www.fao.org/nr/water/aquastat/data/wbsheets/aquastat_water_balance_shees_ind_en.pdf

Forex

1. Valutaomvandlare, 2011-06-17
   http://www.forex.se/sv/Valuta/Omvandlaren/

Indian Government Climate

1. BENGALURU, 2011-06-07
   http://www.imd.gov.in/section/climate/bangaluru2.htm

India Waterportal

1. Groundwater Quality Scenario in Karnataka State - District-wise reports (single file) (2004) -> Bangalore (R) District, p66. 2011-06-27
   http://www.indiawaterportal.org/node/8124

Nationalencyklopedin, http://www.ne.se ,

1. Indien 2010-05-22
   http://www.ne.se/indien

Rainwater Club, India http://www.rainwaterclub.org

1. Why rainwater harvesting? 2011-06-17
   http://www.rainwaterclub.org/why.htm

2. Why rainwater harvesting? 2011-06-17
   http://www.rainwaterclub.org/why.htm

Swedish agricultural University

1. Instutitionen för vatten och miljö, Databank för vattenkemi, 2012-03-22
   http://info1.ma.slu.se/ma/www_ma.acgi$Project?ID=Intro

The World databank

1. Line of poverty, 2010-02-18
   http://ddpext.worldbank.org/ext/DDPQQ/member.do?method=getMembers

2. Improved water sources, 2010-02-20
   http://ddp-ext.worldbank.org/ext/DDPQQ/report.do?method=showReport

Personal messages

Dr. Channakeshava
Taluk health officer, Pavagada
Personal meeting 2011-02-22

Mr. Ramakrishna
Organizer for BIRD-K in Pavagada Taluk.
Personal meeting 2011-02-22

Appendix

Appendix 1. List of questions

- Can you describe an ordinary day?
- What is your occupation?
- Which water sources are you using during the year?
- For what purpose are the sources used?

--- Questions for tank owners:

- Who is responsible for collecting water, washing and cooking?
- Who is responsible for the filter and the tank?
- How do you use the (tank) water?
- How many times a day is the tank used?
- How much is the outtake?
- Is any other source used more intensive during certain periods?
- Is there anyone else that are using this households rain water?
- How do you maintenance the roof and pipes?
- Are you aware for first flush?
- Do you know how much is left in the tank?
- Are you making any quality tests?
- Are you using UV light to decrease the bacterial growth?

--- Question for household without a tank:

- Do you use rainwater from other households?

--- Questions for both parts:

- Why/why not are you having this rain harvesting solution?
- How came the idea?
- Did you participate?
- Did you calculate the costs? / How much did it cost?
- Are you/ Would owner or renting (be interesting)
- Did you have any education according to the construction?
- Do you have to pay for access?
- Is there any premiums or compensations?
- Where you aware about the rainwater harvesting concept?
- How was the water quality as you/your parents where young?
- Are same sources used now?
- What do you think about the water situation in five years?
- What does the rainwater taste like?

--- Have you explored any change in:

- Health?
- Sort of cultivated crop?
- Crop growth result?
- Forests, trees or landscape?

Appendix 2

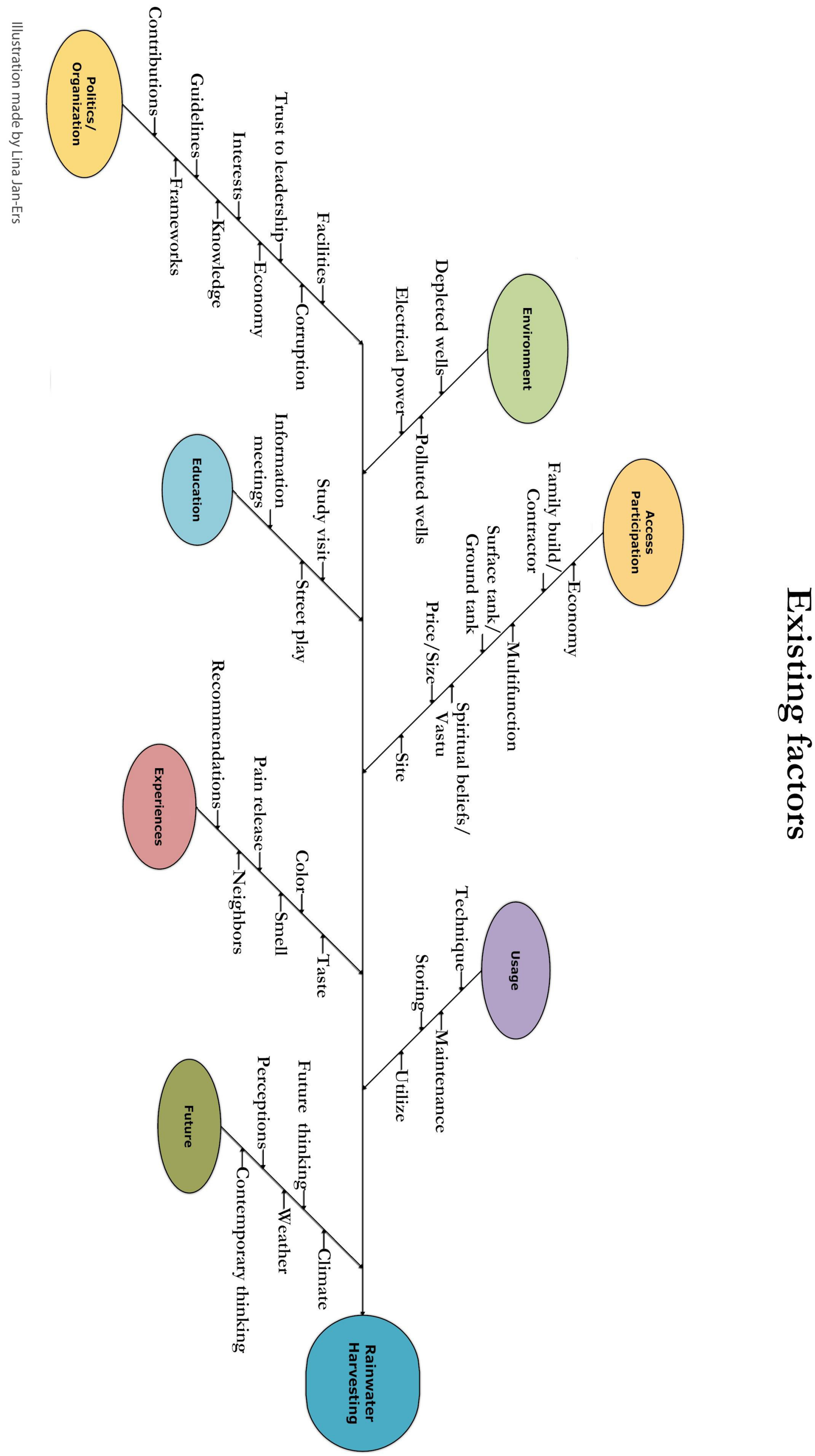
Respondent focus groups

Interview id	Date	Gender	Age	Water tank
1	2011-01-28	3 women 2 men, 4 boys, 3 girls	6-45	Yes/No
2	2011-02-15	3 women 4 men	30,32,32,33,38,40,50	Yes
3	2011-02-15	3 women 1 man	22,26,30,30	No

Semi structured Interview

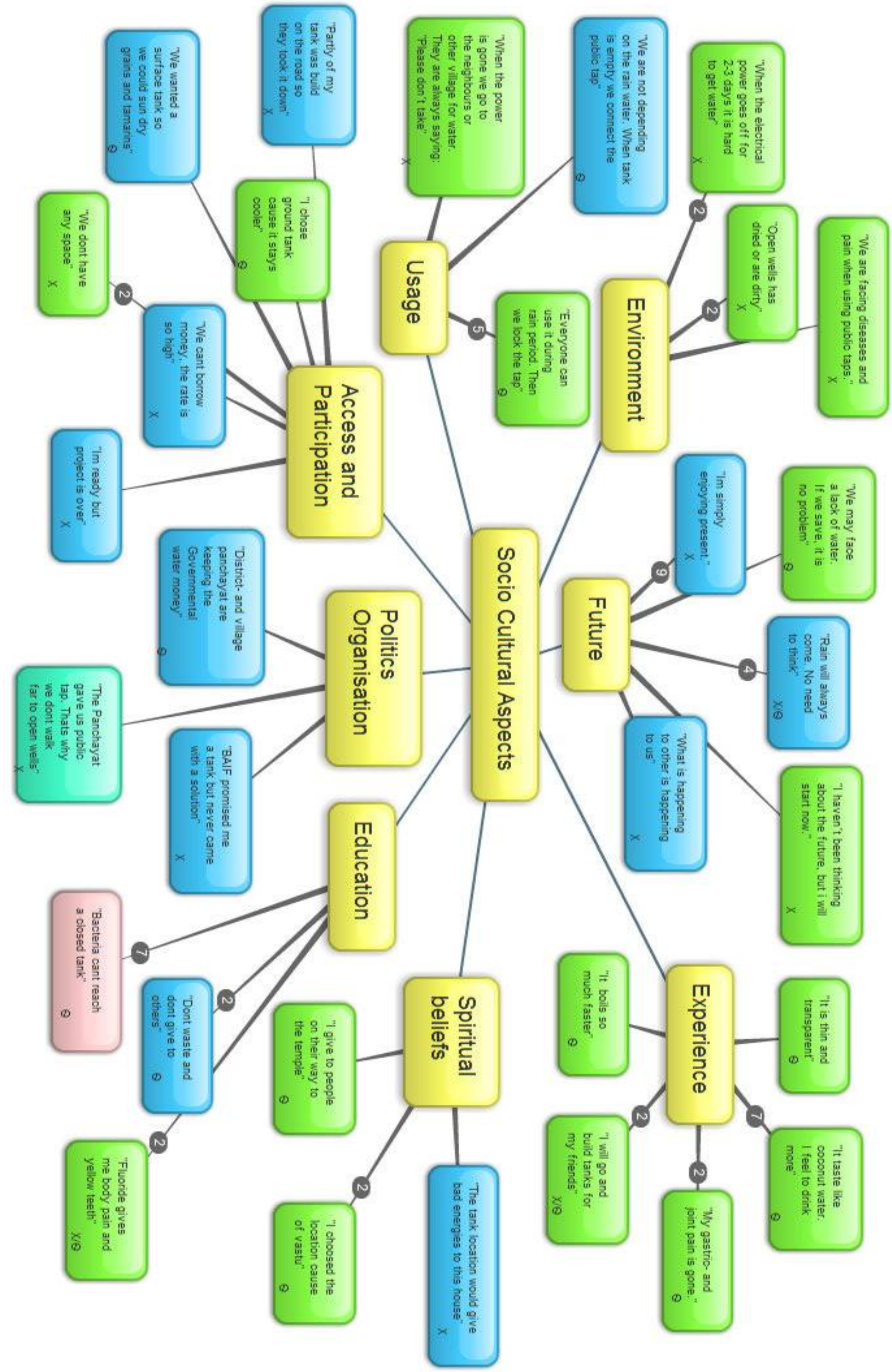
Interview id	Date	Name	Age	Water tank	Member in HH
4	2011-02-16	Ms. Raajamma	24	No	7
5	2011-02-16	Mr. Hanumantharanyappa	60	No	6
6	2011-02-16	Ms. Bhagyalakshmi	23	No	15
7	2011-02-16	Mr. Hanumanthappa	28	No	6
8	2011-02-16	Ms. Gowramma	55	No	2
9	2011-02-16	Ms. Srilakshmi	26	No	4
10	2011-02-16	Ms. Suvarna	40	No	5
11	2011-02-16	Ms. Thimmakka	60	No	7
12	2011-02-16	Ms. Lokamma	35	No	4
13	2011-02-16	Ms. Susheelamma	45	No	4
14	2011-02-21	Ms. Thepamma	50	Yes	5
15	2011-02-21	Mr. Nagaraj	42	Yes	5
16	2011-02-21	Ms. Sriranyamma	25	Yes	5
17	2011-02-21	Ms. Sakamma	50	Yes	6
18	2011-02-21	Ms. Lakshmamma	42	Yes	3
19	2011-02-22	Ms. Rathhnamma	36	Yes	5
20	2011-02-22	Ms. Jayindramma	35	Yes	4
21	2011-02-22	Ms. Sakamma	45	Yes	3
22	2011-02-22	Ms. Lakshmiadevamma	30	Yes	5
23	2011-02-22	Ms. Nagappa	59	Yes	8

Appendix 3

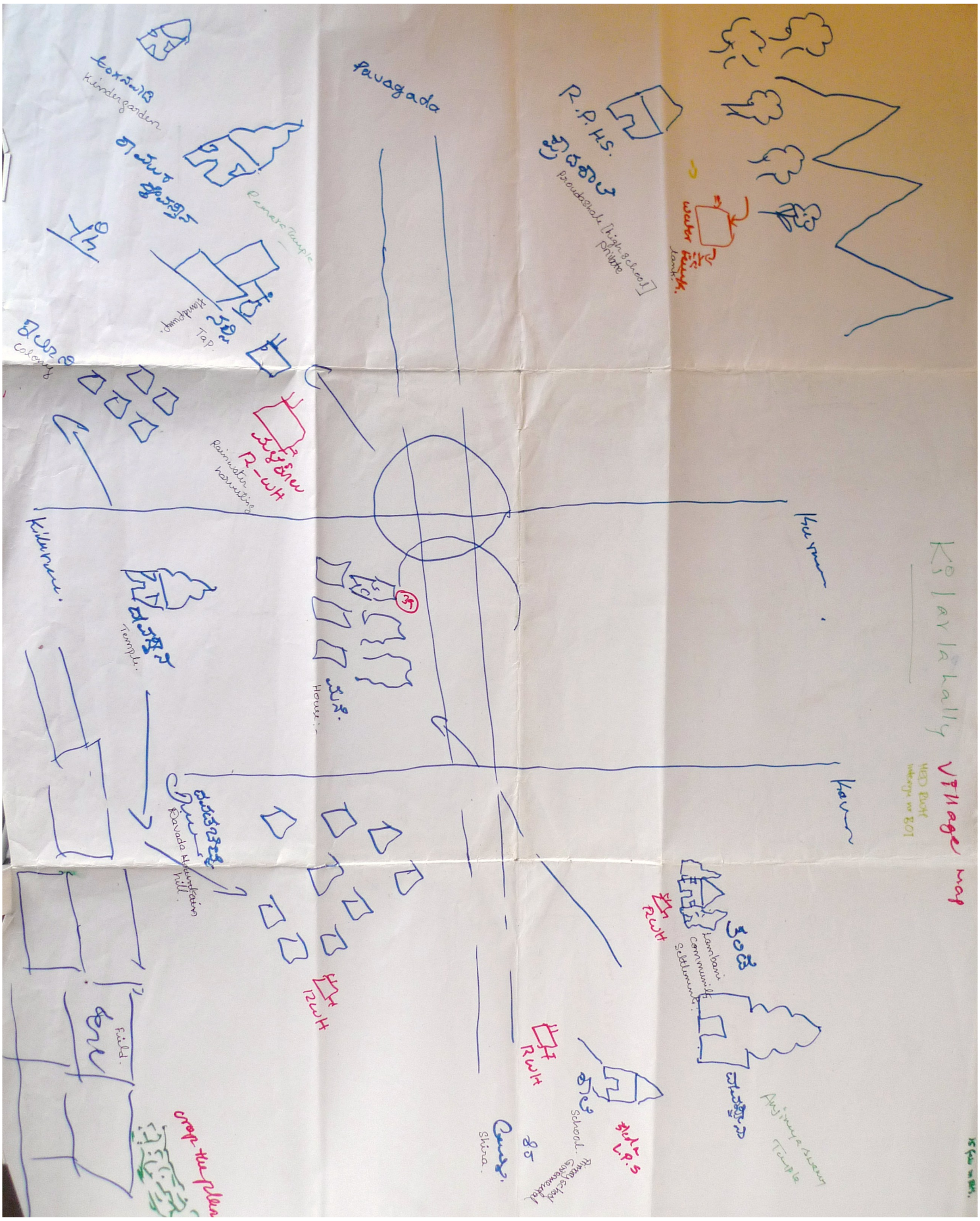


Existing factors
Politics/ Organization
Contributions
Frameworks
Guidelines
Knowledge
Interests
Economy
Trust to leadership
Facilities
Corruption
Environment
Depleted wells
Electrical power
Polluted wells
Education
Information meetings
Study visit
Street play
Access Participation
Family build/ Contractor
Economy
Surface tank/ Ground tank
Multifunction
Price/Size
Spiritual beliefs/ Vastu
Site
Experiences
Recommendations
Pain release
Neighbors
Color
Smell
Taste
Usage
Technique
Storing
Maintenance
Utilize
Future
Perceptions
Future thinking
Contemporary thinking
Weather
Climate
Rainwater Harvesting
Illustration made by Lina Jan-Ers

Appendix 4 Rich Picture

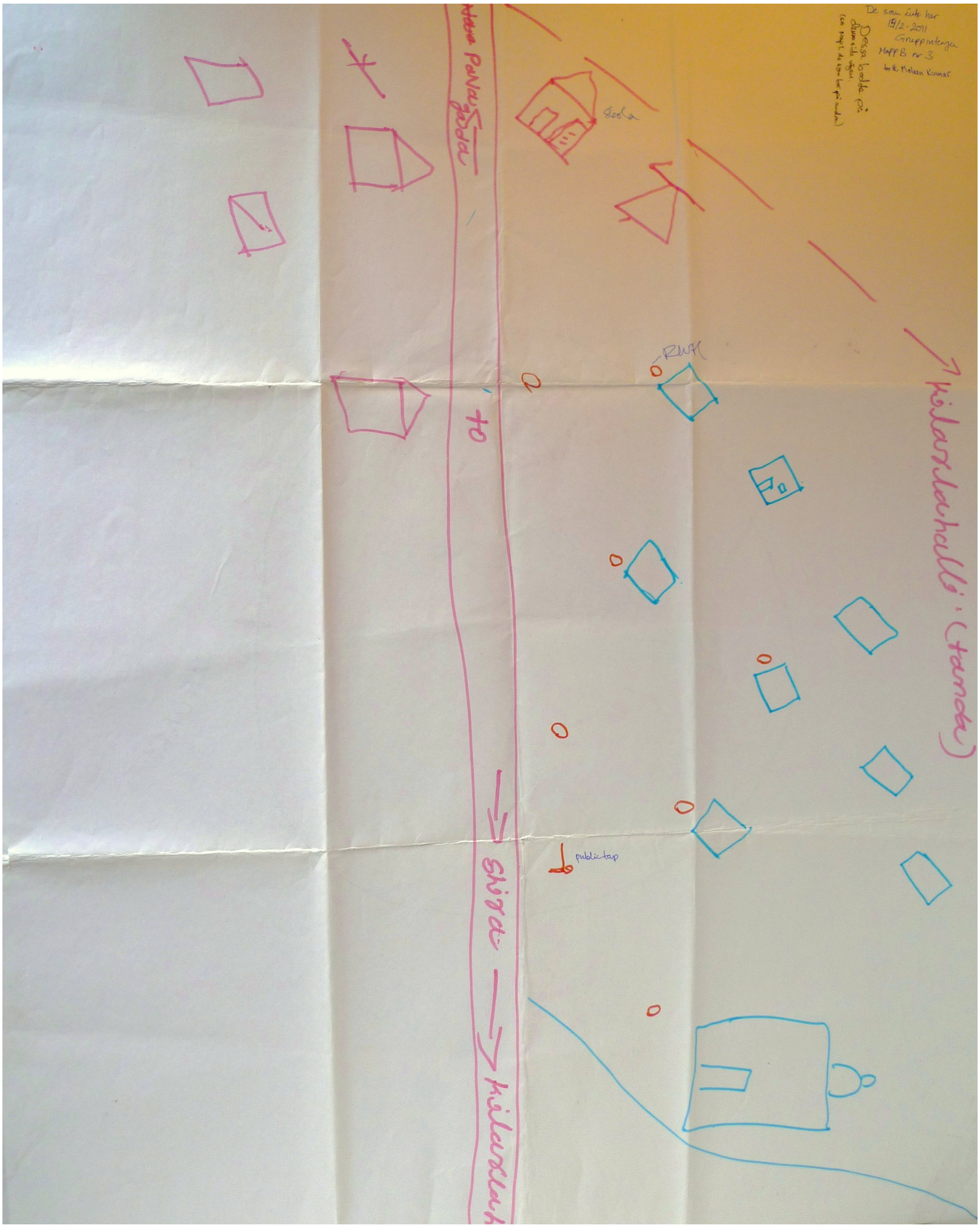


An in-depth view of the categories, with citations from the respondents. Each box contains the character/s X and/or Θ to indicate if the aspect is made by someone with or without a rain harvesting system. Where X represent respondents without rain water tank and Θ is representing respondents with a rain water tank. One aspect may be expressed by both X and Θ. Furthermore, the numbers at the lines of the boxes shows how many times the aspect has been mentioned. The numbers are left out where the aspect has been mentioned once. Color of the boxes indicate if the aspect is facing rainwater harvesting in an positive (green) or negative (blue) way.



Village map drawn at the group interview with the tank owners. Houses are marked as blue squares. RRW tanks are marked in red. The central circle is the bus stop. Schools are marked out as houses with triangular roof. Temples are marked out with cupola roofs. Fields are drawn in the left down corner. Public tap is marked out in blue squares on top of each other and a koda standing under a tap, top left of the picture. Top of map is the east direction.

Appendix 5 Village map 2



Village map from the group interview with respondents without a RWH tank. Houses are marked as blue squares. RWH tanks are marked in orange. Schools are marked out as houses with triangular roof and door. Temple are marked out with a cupola roof. Bus stop is marked out on the road (a pink,small circle with a connected cross) Public tap are marked out in orange as an upside-down "T". Top of map is the east direction (to Pavagada).