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Perception of Water Quality in Rural/Agricultural Areas of Machakel District, North West Ethiopia

Mulugeta Temesgen Bayeh[1], Alemu Azmeraw Bekele[2*]

[1] *Amhara National Regional State, Bureau of Rural Land Administration and Youth, Ethiopia.*
[2] *Center for Rural Development and Livelihoods, College of Development Studies, Addis Ababa University, Ethiopia.*

[*] *Corresponding author E-mail: alemu.azmeraw@aau.edu.et*

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ABSTRACT

Potable water with high quality is a basic requirement for human wellbeing. However, the perceptions on the quality of potable water sources and associated factors influencing the later have not been well studied. Hence, this study aims at examining the perception of water quality in rural/agricultural areas of Machakel district, North West Ethiopia. The study used cross sectional survey design. structured interviews with 293 sample respondents, who were selected using probability sampling technique, were conducted to capture their views on water quality at the source. Descriptive statistics and ordinal logistic regression were used to identify factors affecting the perception of households on water quality in rural/agricultural areas. Most of the household heads used protected hand-dug well, protected spring and protected shallow well. Variables such as education, income, past experiences of health risks, chemicals (chlorine) and poor trust in supplier have a significant effect on perception of rural agricultural communities on water quality at the source. The study suggests education and chlorination of water sources to be promoted among the rural/agricultural communities to enhance better quality perception on potable water sources. On the other hand water quality control systems should be created to avoid health jeopardy from water born sickness. For high income groups it may be better to provide access to pipe water. User participation should be considered in the process of water source construction.

Keywords:
Machakel; perception; water quality; ordinal logistic regression

1. Introduction

Potable water with adequate quality is a basic requirement for health. Unfortunately, Sub Saharan Africa fails to achieve the Millennium development goal (MDG) target in the water sector to halve the percentage of population lacking sustainable access to potable water by the end of the MDGs (UNICEF and WHO, 2015). The problem of water quality exists both in rural and urban areas though the magnitude is higher in rural households, where large groups of communities relying on traditional ground water sources (Sharma, 2012). It is clear that providing better access to social facility (including water) can help poverty reduction in rural agricultural sector (Arsyad *et al.*, 2017).

In Ethiopia the provision of quality water is among the lowest with 57% coverage at the national level in the year 2011. Central Statistical Agency and ICF International (2012) also disintegrated the data where rural coverage is indicated to be 46%. Inadequate quality of water is a major cause of health problem in rural Ethiopia, where 60-80% of the communicable diseases are attributed to unprotected water sources (CSA, 2006).

Consumer's attitude towards their potable water will be affected to a significant level by the aspects of water quality that they are able to perceive with their personal mind. It is likely for users to consider with suspicion water that appears discolored, unpleasant taste or smell. Provision of potable water that is not only safe but also acceptable in appearance, taste and odor with high priority. Water which is aesthetically intolerable undermines the confidence of consumers and lead to complaints resulting in use of unprotected sources (WHO, 2006).

Water quality perceptions can be viewed as a reflection on the physical water conditions, the final product of processing information about water (Hu, 2011). The WHO acceptability guideline allowed assessment of water quality on human acceptability issues. The aesthetic water quality index provides assessment of public perception of water quality, rather than specific health issues, as it assesses parameters that may cause unacceptable color, taste and odor. Water that is highly turbid, highly colored or that has an objectionable taste or odor could lead the consumer to believe that the water is unsafe (UNEP, 2007).

Consumers rely principally on their senses on water quality. Chlorine concentration increases the likelihood that consumers may object to the taste, since water should ideally have no visible color (WHO, 2006). The United States Environmental Protection Agency provide standards for water in terms of its suitability, in which potable water should be clear, colorless and have no unpleasant taste or odor (Lalzad, 2007).

Hu (2011) in his dissertations of water quality perception in the United States using ordinal logistic regression model found that individual level variables: age and being male are significantly and positively related with perceptions of ground water quality. Education is also significantly and positively related with better surface water quality perception.

Doria (2010) in his study identifies factors which have an influence on perceptions of water quality are risk perception, attitudes towards water chemicals, trust in suppliers, past problems attributed to water quality and information from mass media. Furthermore, education and income were found to be inversely related with the perception of potable water quality (Grondin *et al.* 1995; Grondin and Levallois 1999) cited by (Doria 2010).

Rojas and Megerle (2013) investigated chlorine odor is related with quality characteristics which consumers tend to transfer to chlorine treated potable water. Likewise, perception of water quality to be significantly influenced by perception of water born health risks.

Provision of potable water needs knowledge of the perception of water quality among rural agricultural communities, which would enable decision makers at different level and donors to act accordingly. Previous studies show that presence of chemicals, trust in supplier, past health risk problems, information, source, age, income and year of residence influence perception of water source quality (Doria, 2010; Hu, 2011; Rojas and Megerle, 2013). However, there are variations among empirical studies in variable selection, inconsistencies which need further investigation, and there are scarce studies concerning water quality perception in Ethiopia. Furthermore, some studies were descriptive to study the perception of water quality. These gaps initiated the need for further investigation on perception of water quality in rural agricultural areas of Machakel District, North West Ethiopia. The general objective was to investigate the perception of water quality in rural agricultural areas of Machakel District, North West Ethiopia to contribute to the limited empirical literature. Specifically, the study examines the source of potable water to households in the study areas and identifies factors affecting the perception of water quality in rural agricultural areas to give a clue to policy makers, concerned government and nongovernmental organizations.

2. Materials and Method

2.1. Research Design

This study used survey research method since it is based on households' survey as a unit of analysis. Therefore, a cross sectional survey research method was conducted to identify the household's source of potable water, to assess factors affecting household perception to water quality.

2.2. Study Population and Sampling Frame

The study area was selected purposively among 16 rural districts in East Gojjam zone because; I researcher was working there and know the area well. According to MDoFED (2015) Machakel district is divided by 24 rural administrative "*kebeles*" which has 27,105 households.

The district is characterized by three agro ecological zones (Dega, Woyna dega and Kolla). Thus, the three agro ecological zones formed the base for three different clusters of "*kebeles*." Because, except agro ecology differences, all rural *kebeles* of the district has almost similar characteristics in socio-economic and cultural practices. Out of these, one kebele from each agro-ecology cluster was selected haphazardly through lottery system, considering the time and cost limitations of the researcher. Thus, three kebeles selected randomly from each cluster with 2203 household heads formed the sample frame for this study.

2.3. Sample Size and Sampling Techniques

Probability and non-probability sampling techniques were used in this study. Using simple random sampling technique three "*kebeles*" with total of 2203 households were selected. According to Yamane (1967) a simplified formula to calculate sample sizes assuming a 95% confidence interval and p = 0.05 level.

$$n = \frac{\mathrm{N}}{1 + \mathrm{N(e)2}} = \frac{2203}{1 + 2203(0.05)2} = 338$$

Where n is the sample size, N indicates the size of population, and e is the level of accuracy. Since, the target population was less than 10,000 the desired sample size was adjusted using finite population correction formula. Because a given sample size provides proportionately more information for a small population. Thus, the sample size was adjusted as:

$$fn = \frac{n}{1+\frac{n-1}{N}} = \frac{338}{1+\frac{338-1}{2203}} = 293$$

Where: fn = The adjusted sample size, n = The sample size which was 338 and N = The target population size, which was 2203. Based on the sample size determination formula the sample size of the study was made to be 293 households. According to Bhattacherjee (2012) systematic sampling technique involves a random start and then proceeds with the selection of every k^{th} household head from that starting point onwards ($k = N/n$), where k is the ratio of sampling frame size N and the desired sample size n. Hence, every 7th household head from "*kebele*" name list in three "*kebeles*" was surveyed.

2.4. Data Source and Instruments

The study used primary and secondary data sources using different data collection instruments that enabled to achieve objectives of the study. Primary data was collected from sample household heads in the study area. Structured interview questionnaire was prepared and translated to "Amharic" the local language in the study area. This technique was used to collect cross sectional data from primary sources which were administered by university degree graduates who take research course under close supervision of the researcher. The interviewers were selected from the study area and they were well oriented by the researcher and familiarized on the interview process, purpose of the study and how to approach the respondents ethically to generate consistent data. The interview questionnaire was made to include socio-economic, demographic, water source and consumption characteristics used to collect primary quantitative data from the respondents. Secondary sources of data were the other source to collect data from published and unpublished materials. Manuals, journals, sectoral reports, previous researches, websites and regulations in relation with this study were reviewed.

2.5. Methods of Data Analysis

The collected data was analyzed using qualitative and quantitative methods. The qualitative analysis was used to present results from questionnaires asking about reasons and justifications. In was presented in the form of narrations and statements to support different findings of the study. On the other hand, the statistical analysis took a form of descriptive and inferential statistics. The descriptive statistics is presented as frequency, percentage, tables, mean and standard deviation to describe the socio-economic characteristics, sources of potable water and perception of respondents.

Inferential statistics was used to understand factors that affect the perception of water quality in rural agricultural areas. Ordered logistic regression was employed to estimate the level of determination of demographic and socio-economic variables on the dependent variable. Then the collected data was entered, cleaned and analyzed using STATA Version 13.

2.6. Model Specification

The dependent variable was measured using household perception of water quality at the source. Hence, the study used model to identify factors affecting the likelihood of water quality perception at the source. It was computed as the average value of color, odor and taste perceptions of the respondent household heads and each average value is given a category based on the value it takes. Taking into account the observed perception of household heads on their water quality is categorical ordinal variable; although the real distance between categories is unknown the categories follow a certain natural ordering, ranging from (1 to 4), where 1 = very poor, 2 = poor, 3 = good and 4 = very good. Thus, ordinal logistic regression model was applied using maximum likelihood estimation. According to Liu X. (2009) and Gujarati D. (2004) in ordered logistic regression, the underlying score is estimated as a linear function of the predictor variables and a set of cut points. The probability of observing the outcome variable corresponds to the estimated linear function of age, education, income, past experience, type of water source, trust in supplier, information source, length of residence and presence of chemicals, plus random error, is within the range of the cut points estimated for the outcome:

$$Pr(outcome_j = i) = Pr(\kappa_{i-1} < \beta_1 x_{1j} + \beta_2 x_{2j} + \cdots + \beta_k x_{kj} + u_j \leq \kappa_i)$$

u_j is assumed to be logistically distributed in ordered logit. In either case, we estimate the coefficients $\beta_1, \beta_2, \ldots, \beta_k$ together with the cut points $\kappa_1, \kappa_2, \ldots, \kappa_{k-1}$, where k is the number of possible outcomes. κ_0 is taken as $-\infty$, and κ_k is taken as $+\infty$. Independent variables in this study are identified based on empirical literatures and actual conditions in the study area which are useful to explain the dependent variable.

Table 1. Socio-economic and demographic variables and expected signs

Variables	Definition of variables	Measurement	Expe sign
Dependent variable			
Perception of water quality	Household's perception of water source quality	Categorical	
Predictor Variables			
Age	Age of the household head in years	Continuous	+
Sex	Sex of the household head, 0=male 1=female	Categorical	+
Education level	Year of schooling	Categorical	+
Occupation	Occupational status of the household head	Categorical	-
Income	Per capita income per month in ETB	Continuous	+
Type of water source	Primary source of water for household consumption	Categorical	+
Reliability	Year round reliability of the water source	Categorical	+
Chlorine	Dummy 1 if chlorine is added, 0 otherwise	Categorical	+
Past experience	Past experience of health risk in the family, 1 if yes, 0 = otherwise	Categorical	-
Trust in supplier	Level of trust on the water source supplier	Categorical	+
Information	Primary source of information on water quality	Categorical	+

Source: Derived from literature review, 2016

3. Results and Discussion

3.1. Descriptive Statistics

3.1.1. Demographic and Scio-economic Characteristics

The study surveyed a total of 293 sample household heads through interview questionnaires which makes the response rate for the study to be 100% without any default from the expected sample size. Looking first in the demographic and socio-economic characteristics of the respondents, as presented in table 2 most of the respondents were male household heads contributing about 88.4%, while the rest of the proportion belongs to female respondents.

With regard to the educational background of the respondents 34.13% of the study samples were illiterates, 31.4% of respondents able to read and write with no formal education. Only 7.51% and 1.02% of respondents completed first cycle secondary school and preparatory school respectively. The resulting distribution indicates that there is a clear manifestation that most of the respondents were illiterate. This is partly because of the rural setting of the study area where most of the household heads have less probability of getting into formal education. Even though, majority of the respondents have no formal education. They will have their own way of perception to understand the quality of their water source.

Table 2. Household head gender and educational status characteristics

Variables	N	Valid %
Gender		
Male	259	88.4%
Female	34	11.6%
Total	293	100.0%
Educational Status		
Illiterate	100	34.13%
Read and Write	92	31.4%
Grade 1-4	43	14.68%
Grade 5-8	33	11.26%
Grade 9-10	22	7.51%
≥Grade 11	3	1.02%
Total	293	100.0%
Total	**293**	**100.0%**

Source: Field Survey, 2016

The average age of respondents was 41.53 years with standard deviation of 10.64 from the mean age of the respondents. The result indicated that most of the respondents of the study were adults given the mean value of age with its average variation. When the age variation is considered the respondents have a huge difference in their age where the minimum age was 22 years while the maximum respondent is aged 68. The wide gap in age between sampled respondents enables to better understand the household's water consumption and perception of water quality at the source.

Table 3. The respondents age and income characteristics

Variables	N	Mean	Std. Dev	Minimum	Maximum
Age	293	41.53	10.64	22	68
Income	293	506.56	214.49	106.25	1285.55

Source: Field survey, 2016

Most of the sample household heads generate their income from agriculture. The average calculated crop production value for all respondents was 25,586.16ETB per annum with standard deviation of 10070.04. Likewise, average livestock sales earning was 3344.76 ETB per annum with standard deviation of 5133.09 and the average nonagricultural earning was 245.73 ETB per annum with standard deviation of 1475.16.

The average per capita income of members of the household was 506.56 ETB per month with standard deviation of 214.49 from the mean income. The minimum per capita income was 106.25 ETB per month and the maximum per capita income 1285.55 ETB per month.

3.1.2. Household Water Source

This study shows that most of the respondents have access to potable water from protected sources of water. In which (47.44%) of the respondents used protected hand dug well; (29.01%) of the respondents used protected springs and (13.31%) of the respondents used protected shallow wells as a primary source of potable water. However, (10.24%) of the respondents were using water from unprotected springs, wells and surface water sources.

Most of the respondents reported that their water sources were reliable throughout the year with no interruption (88.4%). The rest (10.58%) of the samples respond that their water sources were available throughout the year with some interruption (volume decline). But, 1.02% of the respondent's water sources were available only in rainy seasons.

Table 4. Household water source characteristics

Primary source	N	Valid Percent
Protected spring	85	29.01%
Protected hand dug well	139	47.44%
Protected shallow well	39	13.31%
Un Protected sources	30	10.24%
Total	293	100.0%
Reliability		
Reliable year round	259	88.4%
Reliable year round with interruption	31	10.58%
Reliable only in rainy season	3	1.02%
Total	293	100.0%
Total	**293**	**100.0**

Source: Field survey, 2016

The result show that, women were more responsible to fetch water for the family every day (89.42%) followed by daughters (9.56%). Only 0.34% of husbands and 0.34% of sons were responsible to fetch water.

3.1.3. Household Perception on Water Quality

The respondent's average year of residence in the village was 38.37 years with a standard deviation of 13.47. The minimum year of residence was one year and the maximum year of residence was 64 years in the respondent's village.

Table 5. Respondents year of residence in the village

Variable	N	Mean	Std. Deviation	Minimum	Maximum
Years of residence	293	38.37	13.47	1	64

Source: The researcher's computation, 2016

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Most of the water sources were supplied by non-government organizations (56.66%). The rest (43.34%) were supplied by government. Moreover, the result shows that most of the respondents (57.34%) have a very good trust on the supplier of their water source followed by good trust (36.18%). In other words (4.78%) of the respondents had a very poor trust on their water source supplier. This category enables the researcher to examine the respondents trust on the supplier of their water source and its effect on the perception of household heads.

The descriptive statistics show that (68.6%) of the respondents primary source of information on water quality were from health education. The other (27.3%) of respondent's primary source of information was from interpersonal communication. The rest of (4.1%) were used radio as a primary source of information. Only 15.36% of the respondents confirm that, they were faced with health risk from water born disease among their family members.

Table 6. Household trust on water source supplier, primary source of information on water quality, health risk and chlorination of water source

Variable	Frequency	Valid percent
Supplier of the potable water source		
NGOs	166	56.66
Government	127	43.34
Trust on supplier		
Very poor	14	4.78
Poor	5	1.71
Good	106	36.18
Very good	168	57.34
Total	293	100
Primary source of information on water quality		
Interpersonal communication	80	27.3
Radio	12	4.1
Health education	201	68.6
Total	293	100
Health Risk from water born disease		
No	248	84.64
Yes	45	15.36
Total	293	100
Chlorination of the water source		
No	72	24.57
Yes	221	75.43
Total	293	100
Perception on potable water quality		
Very poor	1	0.34
Poor	20	6.83
Good	201	68.6
Very good	71	24.23
Total	293	100.0

Source: Field survey, 2016

Most of the water sources (75.43%) were added with chlorine as a refining chemical. Likewise, most of the respondents (58.7%) were strongly agree and (38.57%) agree with chlorination of their water source. Only (0.68%) of respondents strongly disagree with chlorination of their water source.

The result of this study indicates that (24.23%) of the respondents perceive that their water quality is very good, and (68.6%) of the respondents perceives that their water quality is good. The rest of 6.83% and 0.34% of the respondents perceive that their water quality is poor and very poor respectively.

3.2. Results of Inferential Statistics

3.2.1. Goodness of Fit

Ordinal logistic regression was applied to examine the perception of water quality in rural agricultural areas. The fitness of the model for the dataset was tested. The resulting likelihood ratio of chi square test statistics was 77.38 with a P-value of 0.0000. This indicates the rejection of the null hypothesis that states the predictors of the model do not possess the ability to predict the outcome variable. The predictors in this model jointly have the ability to predict the outcome variable perception of the households on water quality and their coefficient is significantly different from zero.

The o-parallel test for post estimation of the parallel regression assumption was used for this ordered logistic regression model. The result show that the likelihood ratio test for proportionality of odds across response categories was chi squire (33) = 40.43 with a prob > chi squire 0.1750. The insignificant test provides evidence that, the parallel regression assumption was not violated.

Therefore, this study used an ordinal regression model to estimate the parameters of the factors affecting households' perception of water quality. The estimated model coefficients cannot be interpreted directly but they tell us much about the direction and significance of the predictors. Hence, the factors are identified by using the coefficients, while the magnitude of influence is expressed using the odds ratio. The odds ratio was computed to be used in order to show the magnitude of influence of independent variables on the dependent variable household perception of water quality.

3.2.2. Determinants of water quality perception

For education, when it is going from illiteracy to grade 5-8, the odds of very good perception versus the combined good, poor and very poor categories are 2.96 greater, being other variables in the model are constant. Likewise, the odds of the combined very good and good versus combined poor and very poor perception is 2.96 times greater, given all other variables in the model are constant. Furthermore, the odds of the combined very good, good and poor perception versus very poor perception is 2.96 times greater, given that all other variables in a model are constant.

In addition, when educational status of the respondents going from illiteracy to grade 9-10, the odds of very good perception versus the combined good, poor and very poor categories are 5.07 greater given another variables in the model are held constant. The odds of the combined very good and good categories versus poor and very poor perception is 5.07 times greater, given that all other variables in a model are constant. Likewise, the odds of the combined very good, good and poor categories versus very poor perception is 5.07 times greater, given that all other variables in a model are constant. This result is in line with the findings of (Hu, 2011). He argues that those household heads with formal education has significant positive effect on the perception of their water quality.

A unit increase in income the odds of very good perception versus the combined good, poor and very poor perception are 0.99 times lower than the poor households, given all variables in the model keep constant. The odds of the combined categories of very good and good perception versus poor and very poor perception is 0.99 times lower for wealthy households compared to poor households, given all the other variables held constant in the model. Similarly, the odds of the combined categories of very good, good and poor perception versus very poor perception is 0.99 times lower for wealthy households compared to poor households, given all other variables are held constant in the model. This result is in line with the findings of (Grondin *et al.* 1995; Grondin and Levallois 1999) cited by (Doria 2010).

Table 7. Odds ratio result for ordered logistic regression model

	Number of obs	**=**	**293**
	Wald chi2(18)	=	77.38
	Prob > chi2	=	0.0000
Log pseudolikelihood = -198.00259	Pseudo R2	=	0.1602

Perception	**Odds Ratio**	**Std. Err.**	**P>z**
Age	1.036	0.018	0.053
Read_Writedummy	0.967	0.335	0.924
Grade1_4dummy	2.585	1.268	0.053
Grade5_8dummy	2.963	1.363	0.018**
Grade9_10dummy	5.074	3.125	0.008*
G11_abovedummy	0.226	0.266	0.207
Income	0.997	0.000	0.004*
Residyr	0.986	0.013	0.310
HealthRisk	0.239	0.112	0.002*
Chlorine	4.824	1.937	0.000*
PSdummy	1.472	0.954	0.551
PHDdummy	2.164	1.382	0.227
PSWdummy	2.257	1.529	0.229
Poordummy	0.064	0.076	0.022**
Gooddummy	0.859	0.707	0.854
VGdummy	0.631	0.509	0.569
Radiodummy	1.358	0.914	0.649
HealthedDummy	1.134	0.422	0.735
/cut1	-5.43977	1.998152	
/cut2	-1.77918	1.437533	
/cut3	2.984594	1.496958	

Source: The researcher's computation, 2016

As the households experience health risk from water born disease, the odds of very good perception versus the combined good, poor and very poor perception are 0.23 times lower than households with no past health risk experience, given the other variables in the model are held constant. The odds of the combined categories of very good and good perception versus poor and very poor perception are 0.23 times lower for health risk experienced households compared to households with no past health risk experience, given the other variables are held constant in the model. More over the odds of the categories of very good, good and poor perception versus very poor perception are 0.23 times lower for health risk experienced households compared to households with no past health risk experience, given the other variables are held constant in the model. This result is in line with the findings of (Rojas and Megerle, 2013 and Doria, 2010).

When the household's source of water becomes chlorinated, the odds of very good perception versus the combined good, poor and very poor categories are 4.82 higher, given all another variables in the model are keep invariable. Also, the odds of the combined very good and good categories versus poor and very poor perception is 4.82 times greater, given that all other variables in a model are constant. The odds of the combined very good, good and poor categories versus very poor perception is 4.82 times greater, given that all other variables in a model are constant. This result is in line with the findings of (Rojas and Megerle, 2013; Doria, 2010; WHO, 2006).

As the households has poor trust on their water source suppliers, the odds of very good perception versus the combined good, poor and very poor perception are 0.06 times lower than the poor households, given other variables are constant. The odds of the combined categories of very good and good perceptions versus poor and very poor perceptions is 0.06 times lower for households with poor trust compared to households with very poor trust, given other variables held constant in the model. Also, the odds of the combined categories of very good, good and poor perceptions versus very poor perception is 0.06 times lower for households with poor trust compared to households with very poor trust, given all variables are held constant in the model. This result is in line with the findings of (Doria, 2010).

4. Conclusion

This study was undertaken to better understand the perception of water quality in rural agricultural areas. Most of the respondents have access to potable water sources. It is possible to conclude that educational status of the household head and chlorination of the water source affects the perception of water quality in a positive direction. In other words the increase in these variables results in increases the likelihood of households to be in a very good perception category. Variables such as income, poor trust on supplier and past health risk experience resulting from waterborne diseases affect the household perception of water quality in a negative direction. The increase in these independent variables underestimated the likelihood of households to be in very good perception category. Based on the results of odds ratio, the increase in these independent variables, and the likelihood of households to be in a very poor perception increases on the other hand the likelihood of them to be in a very good perception category decreases.

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