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Perceived Health Hazards of Low-Quality Irrigation Water in Vegetable Production in Morogoro, Tanzania

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Abstract

This study assessed the perceptions of vegetable farmers, traders, consumers and key informants on the health hazards of using low-quality water in irrigation vegetable production in Morogoro, Tanzania. Methods used to collect data were a survey involving all farmers in Changarawe village and Fungafunga area using low-quality water for irrigation vegetable production (n=60), consumers of low-quality water irrigated vegetables (n=70) and vegetable traders selling low-quality water irrigated vegetables (n=60), focus group discussions (n=7) and key informant interviews (n=25). The study employed cross sectional research design. Descriptive statistics were used to calculate mean, frequencies and percentages while Mann-Whitney U-test and Kruskal-Wallis H-test assessed the association between social-demographic variables and respondents score on the health hazard perception scale of using low-quality water in vegetable production. Results showed skin itching, fungal diseases, bilharzias and worm infestation as among the perceived health hazards in using low-quality irrigation water. Health hazard perception differed among groups of farmers, consumers and vegetable traders (p<0.001). The mean ranks of the groups indicated that farmers perceive less health hazards in using low-quality water (mean rank = 147.98) compared to consumers (mean rank = 72.68) and vegetable traders (mean rank 69.64). More health hazards were perceived by Fungafunga farmers compared to farmers from the Changarawe village (p<0.001) while female farmers perceived less hazards in using low-quality water than male farmers (p < 0.05). Consumers with formal education perceived more health hazards than consumers with no formal education (p < 0.001) while vegetable traders from Fungafunga area perceived more health hazards in selling low-quality water irrigated vegetable than vegetable traders from the Changarawe village (p<0.001). These findings demonstrate the need to design health hazards minimization interventions for specific target group.

Keywords: agriculture, health hazard perception, low-quality water, Tanzania, vegetable production, wastewater irrigation

1. Introduction

Low-quality water, often reported as wastewater, is widely used in various developed and developing countries. Some of the countries in which the use of low-quality water has been reported include Greece, Israel and Italy (Kalavrouziotis et al., 2013), Australia (Barker, Amoah, & Drechsel, 2014), Palestine (Shaheen, 2003), Bangladesh (Mojid, Biswas, & Wyseure, 2012), Tanzania (Kihila, Mtei, & Njau, 2014) and Ghana (Keraita, Drechsel, & Konradsen, 2008a ; Owusu, Bakang, Abaidoo, & Kinane, 2011). Like many parts of the world, Tanzania is using low-quality water in irrigation to cope with climate change challenges that cause unreliable of rainfall and periodic drought (Kihila et al., 2014). Low-quality water is used for irrigated agriculture as an alternative source of water since the resource is readily available during the time needed, is free of charge and accessible (Weckenbrock et al., 2011). However, use of low-quality water in agriculture has been associated with health hazards to farmers, vegetable traders and consumers due to the presence of pathogens and toxic compounds (Jiménez et al., 2010).

Studies have identified a number of health hazards associated with the use of low-quality water. For instance, a

study by Srikanth and Naik (2004) in Eritrea on prevalence of giardiasis due to wastewater reuse for agriculture found that 45% of the 75 farmers exposed to wastewater were harboring giardia cysts in the excreta. The authors argued that the reason for the high prevalence of giardia was the consumption of raw salads produced with low-quality water. A study by Gumbo, Malaka, Odiyo and Nare (2010) in Malamulele, South Africa on health implications of wastewater use in vegetable irrigation found that improper irrigation methods such as spray irrigation used by farmers contribute to health hazards associated with the use of low-quality water. Direct contact with low-quality water exposed farmers to giardiasis and hookworm infections. Another study in Morocco on assessment of health hazards associated with wastewater reuse found Ascaris spp. and Trichuris spp. exceeding World Health Organization standards, thus implying to cause health hazards to the exposed group of farmers (Amahmid & Bouhoum, 2005). Recognition of health hazards by individuals at risk is important in taking corrective measures for managing the risk.

In Tanzania, information on the perception of health hazards associated with the use of low- quality water in irrigating vegetables among farmers, traders and consumers is limited. A recent study by Kihila et al. (2014) in Moshi, Tanzania on wastewater treatment for reuse in urban agriculture looked at the perception of farmers on the quality of wastewater as well as their acceptance of the crop grown using such water, but did not look at the farmers' perceptions of the health hazards of using low-quality water. Furthermore, most studies in the field of low-quality water use in irrigated agriculture identified the health hazards of low-quality water based on laboratory test results of stool samples of the exposed group. In laboratory studies, it may be difficult to assess the health hazard and may overestimate or underestimate the actual health hazards. Studies by Keraita et al. (2008) in West Africa and Gumbo et al. (2010) in South Africa are examples of studies where farmers express their perception on the health hazards experienced from using low-quality water for vegetable production. In these studies, perceived health hazards mentioned included skin infections, nail problem commonly known as koilonychias, perceived health risk resulting from bad odor, bilharzias, diarrhea and cholera. Evidence shows that respondents' perception of health hazards has an impact on how the hazard is managed (Keraita, 2008). Hence, this study aimed to (i) examine perceived health hazards of using low-quality water for irrigation vegetable production among vegetable farmers, traders, consumers and key informants living in Morogoro, Tanzania and (ii) assess the influence of age, sex, marital status, district where respondents belong and education level on the perception scale of the health hazards of using low-quality water in irrigated vegetable farming among vegetable farmers, traders and consumers.

2. Methodology

2.1 The Framework of Social Amplification of Risk

The current study draws upon the framework of social amplification of risk which explains how hazards are perceived in society. The framework asserts that individual perception of health hazards is determined by psychological, cultural and social-economic factors (Renn, Burns, Kasperson R, Kasperson E, & Slovic, 1992). In this study, the framework is used to analyse farmers', consumers' and vegetable traders' perception of health hazards in using irrigation low-quality water for vegetable production and factors influencing their perceptions. Perception studies provide the useful insight on how risk is perceived by different categories of people and factors influencing their perceptions (Slovic, 1987).

2.2 Study Site

This study was carried out in urban and peri-urban areas of Morogoro Municipality, Tanzania. Morogoro region of Tanzania was selected as the study region because of variations of climatic conditions and dependency of rain fed agriculture making the region vulnerable to drought (Paavola, 2008). The total average annual rainfall ranges between 821mm and 1,505mm. Long rains occur between March and May and short rains occur between October and December. Within the Morogoro region, Kichangani Ward of Morogoro Municipal Council and Mzumbe Ward in Mvomero district were chosen due to their vegetable production potentials using either irrigation wastewater or polluted river water. As of 2003, Morogoro Municipal Council had a population of 315,866 persons while Mvomero district had a population of 312,109 persons (Tanzania National Bureau of Statistics, 2013). The corresponding populations for Mzumbe and Kichangani Ward were about 19,166 and 19,056 persons respectively (Tanzania National Bureau of Statistics, 2013). Specifically, the study was conducted in a Changarawe village in Mzumbe Ward and Fungafunga area of Kichangani Ward.

Changarawe village is affected by water scarcity causing farmers in village to rely on effluents from wastewater stabilization ponds that serves Mzumbe University for irrigation vegetable farming. Vegetables produced in the village include *amaranths*, sweat potato leaves, spinach, chinese cabbage, okra, african eggplant, green pepper and pumpkin leaves. Farmers in Changarawe village use surface irrigation method where by water from

wastewater stabilization ponds is collected from one point and poured onto the vegetable fields using a bowl or bucket. At maturity, vegetables are harvested by the farmers and sold to vegetable traders and consumers directly from the field. Fungafunga area is also potential for vegetable production in Morogoro Municipal Council. It is located along Morogoro river where farmers irrigate their vegetables using the polluted water from Morogoro river. Pollution is caused by human activities such as bathing, washing and swimming. A study by Shayo, Chove, Gidamis and Ngoma (2007) noted contamination of Morogoro ground water sources by feacal coliform and toxic minerals such as copper and lead. At Fungafunga, vegetables were irrigated using water pumps. Vegetables produced include *amaranth*, chinese cabbage, spinach, nightshade, sweet potato leaves and radish. At maturity, vegetables are harvested by the farmers and washed using the same polluted river water before being sold to vegetable traders or consumers. Figure 1 presents map of the study site.

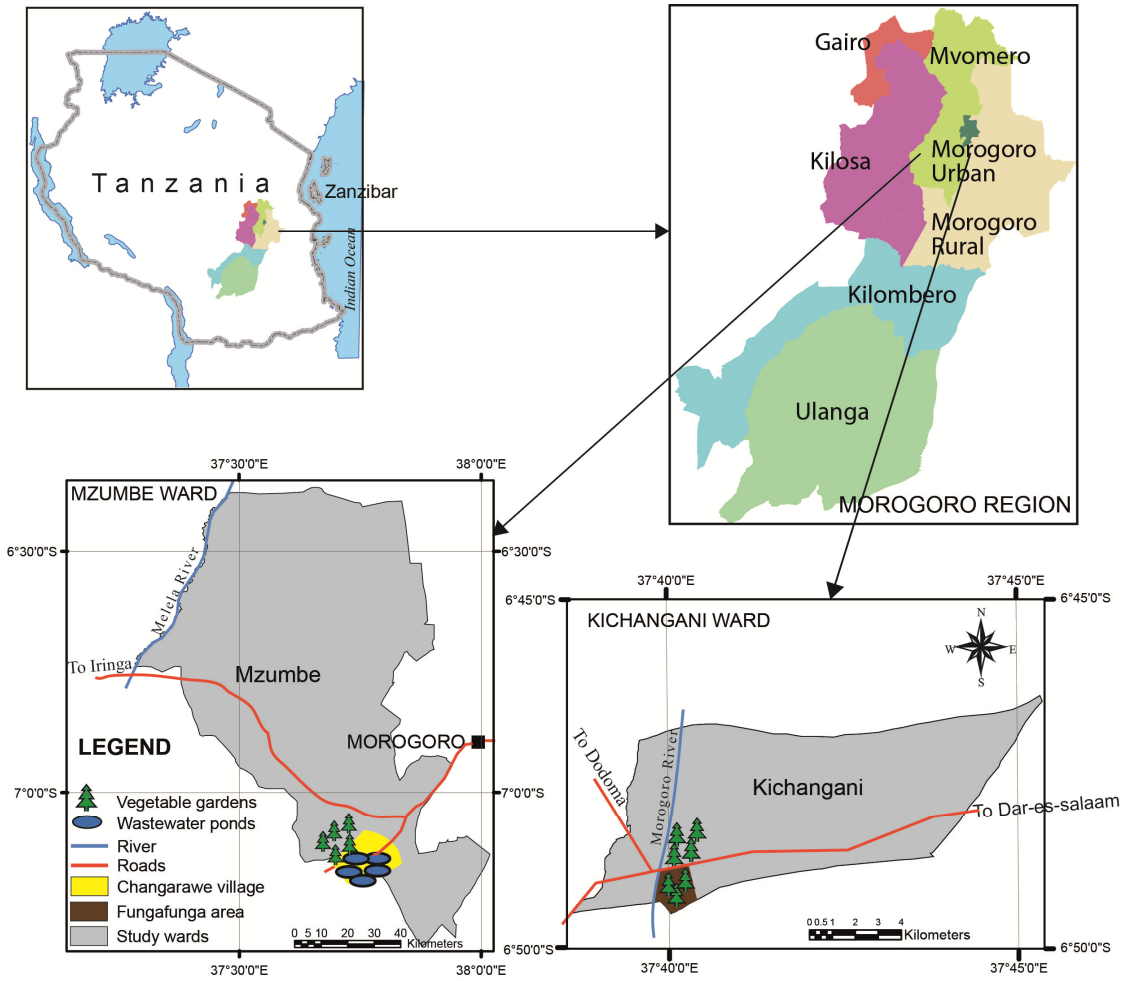

Figure 1. Map of Morogoro Region, Tanzania showing Changarawe and Fungafunga study area

2.3 Description of Data

The research design of the study was cross-sectional. Data were collected from 2nd October, 2013 to 31st July, 2014. Because the size of the population that used low-quality water for irrigation vegetable farming was small, our study population involved all farmers using either wastewater or polluted river water for irrigation vegetable farming in Fungafunga and Changarawe village, all vegetable traders selling vegetables irrigated with low-quality water from Changarawe and Fungafunga area and all consumers of vegetables irrigated using low-quality water from Changarawe village and Fungafunga area. Both quantitative and qualitative data were collected. Qualitative data were collected by interviewing 25 key informants and focus group discussion with seven focus groups. Quantitative data were collected through a sample survey using an interview schedule to a sample of 190 respondents (60 farmers, 60 vegetable traders and 70 consumers).

2.3.1 Key Informant Interviews

Criteria for selecting key informants included: length of time the respondent had been living in the study area; his or her experience in using low-quality irrigation water for vegetable productivity; whether the respondent had experienced or witnessed health hazards related to using low-quality water for irrigation vegetable production and whether respondent is working in the water, health, environment and agriculture sector in the two study sites. In Changarawe village, key informants included one village chairperson, one village agricultural officer, one health and environmental officer, one ward agricultural officer and one ward health officer. Others were five experienced farmers, two vegetable traders and two consumers. In Fungafunga area, key informants included one head of the farming group, one social welfare officer, five experienced farmers, three vegetable traders and one consumer. Each key informant was asked to express her/his perception on the general health hazards experienced when low-quality water is used for irrigation vegetable farming. The interview took about half an hour, used a checklist of questions as a guide, and was done using Kiswahili language which is widely spoken and understood.

2.3.2 Focus Group Discussions

A total of four focus group discussions comprising a group each of male farmers, female farmers, female consumers and female vegetable traders were conducted in Changarawe village. In Fungafunga area, three focus group discussions, one each for male farmers, female farmers and female vegetable traders were conducted. At both field sites, focus group discussions comprised of eight participants in each group. Farmers with a wide range of farming experience, basic educational qualifications and at least 25 years of age were nominated by the village chairperson of Changarawe village and head of the farming group in Fungafunga area. The vegetable traders focus group was conducted in the Changarawe village market about 300 meters from the vegetable fields while a consumer focus group was done at the village chairperson house about 100 meters from the vegetable field. Only consumers and vegetable traders with experience either in consumption or selling vegetables irrigated with either wastewater or water from Morogoro river were included in the discussions. Fungafunga vegetable traders were informed one day before the meeting and the focus group discussion was conducted the day after when they were collecting vegetables from the farming plots for selling. Generally, focus group discussions aimed to explore farmers, vegetable traders and consumers' perceptions of the health hazards experienced when low-quality water is used for irrigation vegetable production. Participants in the focus group discussions were assured of confidentiality and voluntarily agreed to participate in the discussions. The discussions took one hour and were facilitated by a research assistant in the local Swahili language while notes were taken by the researcher.

2.3.3 Survey

A sample questionnaire for the survey was developed and first pretested with 10 farmers to ensure the validity and reliability of the questions. Questionnaires for actual survey were administered to 190 respondents consisting of 60 farmers (thirty from each field site), 60 vegetable traders (thirty from each field site) and 70 consumers (40 from Changarawe and 30 from Fungafunga). Interviews were conducted either at the respondent's home or in the vegetable field after prior appointment. The survey questionnaire consisted of two parts. First part asked respondents on about their socio-demographic characteristics such as age, sex, marital status, and education level. The second part assessed respondents' perception of the health hazards of low-quality irrigation using a questionnaire with 8 Likert scale statements. Statements were phrased in positive and negative direction to avoid respondents' response bias (Schweizer, Rauch, & Gold, 2011). For each statement, respondents were asked to select one among the following five responses: 1 if they strongly disagreed, 2 if they disagreed, 3 if they have no opinion, 4 if they agreed and 5 if they strongly agreed with the statement.

2.4 Data Analysis

Content analysis was used to analyse qualitative data from focus group discussions and key informant interviews. The interview notes were written down after each interview. Data were analyzed and regrouped in accordance with: (1) residence area of the respondent and source of low-quality water used; and (2) respondents' category. Quantitative data were analyzed using IBM SPSS Statistics Version 19. Both descriptive and inferential statistical analyses were conducted. Descriptive statistical analysis involved computing frequencies, percentages and means. The inferential statistical analysis included Mann-Whitney U-test and Kruskal- Wallis H- test. While Mann-Whitney U-test was used to compare two groups of age, education level, marital status, source of low-quality water and sex against the respondent's mean score on the health hazard perception scale, Kruskal-Wallis H- test was used to compare farmers', consumers and vegetable traders' score on the health hazard perception scale.

2.4.1 Computing Health Hazard Perception Scale

Perception of health hazard from low-quality water in irrigation vegetable production was computed using the summated rating scale method (Spector, 1992). Prior to computing the scale, scale items were subjected to reliability analysis and unidimensionality test through principal component analysis (PCA). The PCA extracted two factors with Eigen values exceeding 1 and 62.57 cumulative percent of the variance. The Kaiser-Meyer-Olkin (KMO) criterion for sampling adequacy was equal to 0.78 and therefore exceeding the recommended value of 0.6, and the Bartlett's Test of Sphericity was equal to 536.207 (with a *p*-value of 0.000) supporting the validity of the scale items. Reliability analysis produced the highest Cronbach's alpha of 0.803 with the following three statements: (i) never experience health hazard when eating low-quality water (LQW) irrigated vegetables, (ii) never experience health hazard when in contact with LQW and (iii) my health is OK regardless of my using LQW. Correlations for the three items included in the scale satisfy the minimum correlation standard of 0.3 (Table 1). A mean total scale score for the three highly reliable statements was computed. Since the three statements are in agreement that the use of low-quality water in irrigation vegetable production presents no health hazards, the mean score of greater than 3 indicates positive perception that LQW has no health hazards while the mean score less than 3 indicates respondent's negative perception that LQW has health hazards and a mean score of 3 means neutral perception.

Table 1. Mean score, item-total correlation and Cronbach's Alpha values of the items used to compute the scale for measuring perception on the health hazards of low-quality water for vegetable production in Morogoro, Tanzania

Statement	Mean	Item-total Correlation	Cronbach's Alpha if Item Deleted
Never experience health hazard[1] when eating LQW irrigated vegetables	2.83	0.70	0.75
Never experience health hazard when in contact with LQW	2.78	0.62	0.79
My health is OK regardless my use of LQW	2.66	0.68	0.76

Note: Mean score >3 indicate agreement with the statement; 3, neutral and < 3 disagreement with the statement.

[1]Health hazard includes both self-reported and physician diagnosed hazards

3. Results

3.1 Respondents' Demographic Characteristics

Demographic characteristics are summarized in Table 2. Findings show that Fungafunga had more (76.6%) male farmers compared to Changarawe site (43.3%). The majority of vegetable traders (83.3% in Changarawe village and 90% in Fungafunga area) and consumers (57.5% in Changarawe village and 56.7% in Fungafunga area) were females. At least 30% of the farmers, vegetable traders and consumers belonged to the age group of 31-45 years, except consumers in the Fungafunga area (13.3 %). About 30% of the vegetable traders at Fungafunga and consumers of Changarawe village had no-formal education. At both sites, at least 70% of farmers were married while 60% of consumers at Fungafunga were not married. No less than 50% of farmers and vegetable traders at both field sites had primary level education while 40% of consumers at Fungafunga had secondary education.

Table 2. Demographic characteristics of farmers, vegetable traders and consumers of urban and peri-urban area of Morogoro, Tanzania

Characteristics		Farmers (%)		Vegetable traders (%)		Consumers (%)	
		Changarawe (n=30)	Fungafunga (n=30)	Changarawe (n=30)	Fungafunga (n=30)	Changarawe (n=40)	Fungafunga (n=30)
Sex	Male	43.3	76.6	16.7	10.0	42.5	43.3
	Female	56.7	23.3	83.3	90.0	57.5	56.7
Age group	16-30	23.3	33.3	16.7	20.0	27.5	73.3
	31-45	36.7	33.3	46.7	53.3	30.0	13.3
	46-60	26.7	33.3	30.0	23.3	27.5	10.0
	>60	13.3	0.0	6.7	3.33	15.0	3.3
Education level	No formal	13.3	6.7	23.3	36.7	35.0	16.7
	Primary	73.3	83.3	73.3	60.0	55.0	40.0
	Secondary	13.3	10.0	3.3	3.33	10.0	40.0
	University	0.0	0.0	0.0	0.0	0.0	3.3
Marital status	Married	76.7	80.0	70.0	36.7	50.0	30.0
	Never married	13.3	10.0	23.3	36.7	40.0	60.0
	Widowed	10.0	10.0	3.3	23.3	7.5	3.3
	Divorced	0.0	0.0	3.3	3.3	2.5	6.7

3.2 Respondents' Perception of Health Hazards of Low-Quality Water for Vegetable Production

Findings show that overall, respondents perceive the presence of health hazards in using low-quality water for vegetable production (mean score 2.75). At Fungafunga, more than half (58.9%) of respondents scored a mean value below 3 indicating that they perceive the presence of health hazards when low-quality water is used in vegetable production. In contrast, more than half (52%) of Changarawe respondents scored a mean value above 3 indicating that they do not perceive the presence of health hazards when low-quality water is used in vegetable production. When perception scores were categorized by respondents' categories and study location (table 3), the results showed that 100% of the farmers in Changarawe village and 73.4% of farmers in Fungafunga area scored beyond 3 mean values. These findings imply that the majority of farmers in both study sites perceives no health hazards from the use of low-quality water in irrigation vegetable production. About 53.3% and 90.1% of vegetable traders of Changarawe village and Fungafunga area scored below the mean value of 3 while 75% of consumers in Changarawe village and 73.4% of consumers in Fungafunga area scored below 3 mean values. These results indicate that the majority of the vegetable traders and consumers from both study sites perceive the presence of health hazards when low-quality water is used for irrigation vegetable production.

Table 3. Respondents mean scores on the health hazard perception scale by study location. Mean score <3, =3, >3 indicates perceived hazards, neutral and less hazards perceived respectively

Mean Likert Score	Changarawe (Response Percent)			Fungafunga (Response Percent)		
	Farmers (n=30)	Traders (n=30)	Consumers (n=40)	Farmers (n=30)	Traders (n=30)	Consumers (n=30)
1.0	0.0	30.0	42.5	3.3	76.7	56.7
1.3	0.0	3.3	10.0	0.0	0.0	0.0
1.7	0.0	3.3	0.0	0.0	6.7	0.0
2.0	0.0	0.0	5.0	0.0	0.0	0.0
2.3	0.0	16.7	12.5	10.0	6.7	16.7
2.7	0.0	0.0	5.0	0.0	0.0	0.0
3.0	0.0	3.3	2.5	13.3	3.3	0.0
3.3	0.0	6.7	7.5	6.7	0.0	0.0
3.7	3.3	26.7	5.0	26.7	3.3	13.3
4.0	0.0	0.0	5.0	3.3	0.0	3.3
4.3	3.3	3.3	0.0	6.7	0.0	3.3
4.7	0.0	3.3	0.0	3.3	0.0	0.0
5.0	93.3	3.3	5.0	26.7	3.3	6.7

3.3 Relationship between Demographic Variables and the Perception Scale Score of Vegetable Farmers, Traders and Consumers

Table 4 summarizes results from the Mann-Whitney U-test on the association between demographic variables and scores on the perception of health hazard scale. Demographic variables included sex, age, district and education level and each was measured at two levels. Score on the perception of health hazard scale was measured at three groupings of vegetable farmers, vegetable traders and vegetable consumers. Results showed that there was an association between farmers' score on the health hazard perception scale and the study area where farmers belong ($p < 0.001$). Thus, with a median of 3.7, Fungafunga farmers perceived more hazards in using low-quality water compared to Changarawe farmers who had a median score of 5. Farmers' perception of health hazards from the use of low quality water in irrigation vegetable production is also associated with their sex ($p < 0.05$). Female farmers perceived less health hazards in using low-quality water (median 5) compared to male farmers (median 4.5). Results further showed that there was an association between vegetable traders' perception of health hazards and the study area where the traders belong ($p < 0.001$). Vegetables traders from Changarawe where wastewater is used for producing vegetables perceived less health hazards in using wastewater for producing vegetables (median score 2.3) when compared to vegetable traders of Fungafunga where polluted river water is used for vegetable production (median score 1.0). Consumers' perception was associated with their education level ($p < 0.05$). Consumers with no formal education perceived less health hazards in using low-quality water for vegetable production (median score 2.7) in comparison to consumers with formal education (median score 1.0).

Table 4. Mann-Whitney U-test for testing association between demographic variables and farmers', vegetable traders' and consumers' score on health hazard perception scale

Variable	Group	Farmers (n=60)		Vegetable traders (n=60)		Consumers (n=70)	
		Median Score	*p*-value	Median Score	*p*-value	Median Score	*p*-value
Sex	Male	4.5	**0.016****	1.0	0.594	1.7	0.865
	Female	5.0		1.0		1.0	
Study area	Changarawe	5.0	**0.000***	2.3	**0.000***	1.3	0.658
	Fungafunga	3.7		1.0		1.0	
Age in years	<45	5.0	0.181	1.0	0.091	1.3	0.984
	≥45yrs	5.0		2.3		1.3	
Education level	No- formal	5.0	0.365	1.0	0.225	2.7	**0.001****
	Formal education	5.0		1.3		1.0	
Marital status	Married	5.0	0.715	1.0	0.080	1.0	0.157
	Not- married	5.0		2.0		2.3	

*Significant at $p < 0.001$, ** Significant at $p < 0.05$

Kruskal -Wallis test was also used to compare the score of farmers, vegetable traders and consumers on health hazard perception scale. This test was used because it allows comparing scores of three or more respondents' categories. The results produced Chi- Square value 84.89, degree of freedom 2 and a significant *p* value = 0.000. An examination of the mean ranks of the groups suggest that farmers had the highest Mean Rank score on the health hazard perception scale (147.98) followed by consumers (Mean Rank 72.68) and vegetable traders (Mean Rank 69.64). The high Mean Rank score of farmers implies that they perceive no health hazard of use of low-quality water compared to consumers and vegetable traders as they have a low Mean Rank score on the scale.

3.4 Findings from Focus Group Discussions and Key Informants Interviews

We take point of departure on the themes by considering the framework of social amplification of risk which categorizes health hazard perception based on the social-demographic factors and respondents' categories mentioned in the methodology section. Health hazard perception was categorized by the group respondents belong to and the source of low quality water used to produce vegetables.

3.4.1 Health Hazards Perception among Farmers, Vegetable Traders and Consumers

The results of the focus group discussions and in-depth interviews supports our quantitative study findings that most farmers from both field sites perceive less health hazards in using low-quality of their vegetable production compared to consumers and vegetable traders, this is what farmers say:

> *"..I have never experienced any health hazard, what I know is some of the plants like tomatoes when grown using this water becomes weak and harvesting is only once, but in other areas you can harvest the same tomato plants 2 to 3 times*" (Male farmer in Changarawe focus group discussion).

Female farmers from Fungafunga focus group discussion also said: "*we don't have the expertise to know the health risk, but in the normal use they are okay"*. However, in both field sites small numbers of farmers showed their concern on the presence of health hazards when using low quality water. In both field site skin itching and bilharzias were mentioned as the most common health problems facing farmers when using low-quality water:

> *"In the dry season we experience skin itching when in contact with water either through stepping in with bare feet or touching"* (Male farmer Fungafunga area), *"wastewater cause itching of the skin because water is still, not moving"* (Male farmer, Changarawe).

Farmers who mentioned Bilharzias as the health hazard said: *"Most of us have suffered from bilharzias mostly in*

dry season when the volume of water is low" (Male farmer Fungafunga); *"I suffered from bilharzias two times in my farming experience, though I really don't understand the real cause of it"* (Male farmer Changarawe village). Other health hazards mentioned by farmers from Fungafunga included injuries from sharp objects such as nails and broken bottles while stepping in the river water with bare foot and body wetting through leaking water pumps. At Changarawe, fungal disease was also mentioned as among the health hazards experienced by farmers.

Consumers in the focus group discussions hold dual opinions on the presence of health hazards when low-quality water is used in vegetable production. The reason for their perception for those who perceive less health hazards was due to their experience in consuming low-quality water irrigated vegetables:

> *"This water doesn't have any hazard otherwise we could have been affected long ago, we eat these vegetables every day, we have never seen people vomiting or having diarrhea because of eating vegetables from this area"* (Respondent from consumers' focus group discussion, Changarawe).

Consumers with concerns on the presence of health hazards from using low-quality water in vegetable production recommend to the government authority to intervene on the use of LQW in irrigated vegetable production;

"*I think the government authority should stop farmers from using wastewater for vegetable production, the water is not safe for human health*" (a female consumer from Changarawe village focus group discussion).

Other consumers in the focus group discussions at Changarawe were not happy with the soapy smell, reddish color and bad taste of the low-quality water irrigated vegetables:

> *"Wastewater irrigated vegetables are good but tasteless, vegetables are produced using soap and dirty water from students' toilets, the vegetables produced are dirty, and that is why you should wash them with clean water*" (a female consumer from Changarawe village focus group discussion).

On the other hand, the majority of respondents in vegetable traders' focus group discussions perceives less health hazards in using low-quality water for vegetable production. *"We never experience any health hazards; we have been doing the vegetable business for years"* (vegetable trader in focus group discussion, Fungafunga area). Results also showed that vegetable traders were more concern on the profit gained and not the origin of the produce:

> "*We have been eating them for ages and we don't dare to find out its source, I only think in business perspective as long as I can get profit*" (vegetable trader in focus group discussion, Changarawe village).

Nevertheless, one of the vegetable traders of Changarawe focus group discussion complain of the bad smell of the vegetables produced from wastewater: "*some of our customers complain of the smell of the vegetables produced using this water"* (vegetable trader, Changarawe village focus group discussion).

The findings also showed that, majority of key informant interviews in both field sites perceives the presence of health hazards when low-quality water is used for vegetable production:

> *"The use of low-quality water in irrigation farming may cause skin diseases to farmers, worm infestation and stomach pain diseases like typhoid to farmers, worm infestation because worms prefer soil conditions and in* dirty moist area" (female Ward health officer, Mzumbe).

Other key informants were concerned with the presence of green color and bad odor in low-quality water:

> *"Wastewater has strong smell and is greenish in color that is why farmers with plots close to the wastewater ponds are not using this water"* (village leader, Changarawe village).

Few key informants interviewed perceive no health hazards and others were not sure of the presence of health hazards in using low-quality water and argue for further research:

> *"… Have never experience any health hazard from using this irrigation water, unless you spray insecticides and harvest the vegetables on the same day, but we don't do that"* (Male farmer with more than 5 years farming experience, Fungafunga), "*No complains my office have received so far of any problem from using this water, if there are hazards probably the long term, we don't have the short term hazards, further research is needed*" (Male village agricultural officer, Changarawe).

4. Discussion

Results from our quantitative study generally showed that respondents perceive the presence of health hazards in using low-quality water in vegetable production. However, respondents' perceptions of health hazards differ by their category as farmers, vegetable traders or vegetable consumers and by the source of low-quality water used. Farmers perceived less health hazards in using low-quality water in vegetable farming compared to the rest of

the group. The health hazard perception of farmers was associated with the district they belong and their sex while consumers' perception was associated with their level of education. Vegetable traders perception was influenced by the district vegetable traders belongs. Findings from a qualitative study showed skin itching, bilharzias and fungal diseases as among the health hazards experienced by respondents from both field sites when using low-quality irrigation water for vegetable production.

Skin itching was mentioned by most of the respondents in our study sites as among the major health hazards experience when using low-quality water in irrigation farming. Inappropriate irrigation techniques and lack of using proper protective gears while working with low-quality water could be the reason for farmers' exposure to skin diseases. The evidence from the study in Southeast Asian cities on perceived health hazards among users of wastewater also found skin problem as the most important health hazard mentioned by farmers who had prolonged contacts with wastewater (Anh, Van der Hoek, Dac Cam, & Dalsgaard, 2007). Jimenez (2011) further pointed out that the major health hazards of the exposed group to low-quality water in Africa is caused by diseases such as cholera, schistosomiasis, typhoid, shigellosis, gastric ulcers, giardiasis, amoeba-sis, and skin diseases. All these hazards were either due to improper treatment of low-quality water, poor irrigation techniques, lack of using proper protection gears and inadequate post-harvest handling.

Farmers' perception on the presence of less health hazards in using low-quality water can be explained by their experience in using the resource in their farming activities. There is a strong relationship between farmers' behavior toward risk and the farming experience (Kalogeras et al., 2012). Farming experience increase farmers' capacity to control the use of low- quality water and hence less health hazards experience. Work from Jordan on water reuse for irrigation showed that farmers who had control on the use of low-quality water showed positive perception on its use compared to farmers who had no control (Carr, Potter, & Nortcliff, 2011). Also, farmers less health hazard perception in using low-quality water could be due to their recognition of the economic benefits of low-quality water in vegetable production that override the presence of health hazards (Owusu et al., 2011). Literature has also pointed out an inversely relationship between perception of food benefits against hazards. Respondents with a positive perception of the benefits gained often had a low health hazard perception (Ueland et al., 2012).

In our study, perception of farmers towards the use of low-quality water is also affected by the district where farmers belong. In such, the higher perception on the presence of health hazards was observed in Fungafunga farmers who used polluted river water for irrigation vegetable production compared to farmers who used wastewater at Changarawe. This could be an indication of the uncontrolled level of pollution occurred in Morogoro water bodies. Study by Shayo et al. (2007) on the quality of water in Morogoro, Tanzania also noted the contamination of the water bodies by lead, copper and feacal coliforms. It is also possible that Changarawe farmers who used wastewater tend to underestimate risk as they knew that the practice is socially unacceptable (Keraita et al., 2008b). Moreover, the significant difference in the health hazard perceptions of the farmers from the two districts may stem from the levels of awareness shown by wastewater farmers of the Changarawe village on the potential existence of health hazards. Literature shows that farmers with awareness on the existence of health hazards from using low-quality water perceive such health hazards to be low (Owusu et al., 2011). Peres and Moreira (2006) emphasized that awareness on the health hazards influence how the hazard is perceived by exposed group. People perceive health hazards when its effects became visible and have a negative perception of the existence of the hazards if there is no observable effect of an exposure. Our findings also indicate the relationship between farmers' health hazard perception and sex. Male farmers perceive more health hazards in using low-quality water compared to female farmers. This could be explained by their long hours of exposure to low-quality water resources when doing the manual labor in farming workloads such as pumping low-quality water from the source to the farms, irrigating the farms using water cans and harvesting activities (Abdulai, Owusu, & Bakang, 2011).

The consumers and vegetable traders perceived health hazards in low-quality water irrigated vegetables are linked to their concerns on the dirtiness, soapy smell and taste of low-quality water irrigated vegetables. The perceived dirty, tasteless and soapy smell of the Changarawe vegetables could be driven by consumer awareness of the source of water used for irrigating vegetables. This finding was also observed in the study conducted in Poland on assessment of the functioning of smell sense among sewage treatment workers. In such study, higher risk of smell from wastewater caused smell dysfunctions sense among sewage treatment workers with long duration employment in treatment plants (Dzaman, Wojdas, Rapiejko, & Jurkiewicz, 2009). In addition, vegetable traders in our study were more concern on the occupational hazards such as physical pains when walking on the street looking for a customer. This relates to the market challenges faced by traders forcing them to find an innovative way to gain the profit by reaching customers at their households' areas. Occupational health hazards such as

physical pain from working with low-quality water in irrigation agriculture was also noted by Keraita et al. (2008) study in Ghana. In contrary to the current study, these hazards were mentioned by older farmers and were mostly associated with the manual labor inputs and irrigation method used.

Furthermore, the lower health hazard perception of using low-quality water irrigated vegetables seen in consumers with no formal education justify the argument that educated people are more likely to be aware of the potential health hazards from using low-quality water than non-educated respondents (Owusu et al., 2011). Freudenstein, Wiedemann and Varsier (2015) study, for example, found that knowledge about the consequences of the exposure to health hazards influence people health hazard perception. Additionally, Cummings, Berube and Lavelle (2013) pointed out that perception of health hazards is influenced by the characteristics of the hazard itself and distinctiveness of individuals responsible for judging the effects of hazards.

The information on the perceived health hazards of the exposed groups and factors influencing respondents' perception have a special contribution to the growing field of wastewater use in irrigation agriculture. The perceived health hazards results are crucial in creating awareness of the key players and investors of low-quality water resource on potential health hazards perceived by farmers, vegetable traders and consumers and hence proper designing of health promotion programs that will enable users to practice safe use of low-quality water in irrigation agriculture for benefit maximization. Moreover, our study suggests that strategies aiming at reducing health hazard from low-quality water in irrigation agriculture should target a specific group of users, social demographic status and the source of low-quality water used. It is therefore advisable that the awareness campaign on health hazards reduction measures from using low-quality water in irrigation agriculture should target specific exposed group at all stages of the food chain (Lagerkvist Hess Okello Hansson & Karanja, 2013). As suggested by Drechsel et al. (2008) people in our study sites should also be taught and offered cheap, suitable and low-cost methods for filtering low-quality water, such as drums filled with sand and watering can covered with cloth or mosquito netting so as to reduce the number of pathogens in the irrigation low-quality water. Furthermore, findings from the current study are important because successful implementation of low-quality water projects in irrigation agriculture should precede by clear information on the users' perceptions in using the resource as well as the health hazards experienced (Friedler, Lahav, Jizhaki, & Lahav, 2006). The current study presents an overview of farmers, consumers, and vegetable traders' perceptions of the health hazards of using LQW in irrigation agriculture. However, the study cannot say anything about the actual risks involved when low-quality water is used in irrigation agriculture. Though the health hazards of low-quality water perceived by respondents from the current study could be associated with other risk factors, we cannot ignore them. As water scarcity grows, sustainable use of low-quality water resource in irrigation agriculture is inevitable. Our study recommends government and all key players to advocate for health hazards promotion programs that will target specific exposed group at all stages of the food chain.

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