An integrated risk assessment-contingent valuation analysis for suitable technology adoption: a case study of water pollution in Kenya

by

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"The future of innovation has to include not only the technology but the economic viability."

Dennis Muilenburg

"If you don't invest in risk management, it doesn't matter what business you're in, it's a risky business."

Gary Cohn

"The biggest risk is not taking any risk ... in a world that is changing really quickly, the only strategy that is guaranteed to fail is not taking risks"

Mark Zuckerberg

"The best people possess a feeling for beauty, courage to take risks, the discipline to tell the truth, the capacity for sacrifice.
Ironically, their virtues make them vulnerable; they are often wounded, sometimes destroyed."

Ernest Hemingway

I dedicate this to my mother Hellen Mumbi Wanjiku.

ABSTRACT

An integrated risk assessment-contingent valuation analysis for suitable technology adoption: a case study of water pollution in Kenya

The increased levels of water pollution and declining water quality have greatly affected water resources, which are a major source of ecosystem services. Industrialization, population growth and urbanization have been linked to the increased water pollution levels, which are in turn decreasing the potential of water resources and huge external costs and scarcity of the remaining water resources across the world. Kenya is no different and its classification as water-scarce coupled with poor sanitary conditions in the country exacerbates the water problem. This presents strong motivations to find tailored solutions in the country to manage the scarce water resources and ensure clean water is accessible for use by everyone.

The reliance on a country`s natural resources is a viable option when attempting to find local suitable solutions to address local issues. For example, the use of locally available natural materials such as cactus, plant seeds, and minerals such as diatomaceous earth that are mined inexpensively and locally in treating wastewater to avert water pollution, has been proven to save costs and enhance accessibility and use of technologies that use them as raw materials. The use of diatomaceous earth is thus an alternative to commercially available materials such as activated carbon in mitigating environmental pollution. The adoption of such technology however requires adequate dissemination of information, cooperation among stakeholders and collective action from the government to the public. To achieve this, the issue of water pollution should be dissected from a risk management perspective. This involves understanding the public risk perception, factors

that influence their perception, knowledge and awareness on water pollution issues, the people`s willingness and determination to take action through systems such as payment vehicles and voluntary activities linked to health concerns in affected regions. To develop a holistic view of the effects of water pollution this study sought to investigate empirical issues associated with risk perception and the consequent drive to take action among the affected communities while making financial considerations. The study was conducted along River Sosiani in Eldoret Kenya. The river is crucial to the residents in the region who use its waters for agricultural activities in the region among other domestic uses. The river is also a crucial basin as it harbours one of the tributaries of Lake Victoria, which is shared by three countries namely Kenya, Uganda and Tanzania. The lake is a crucial basin in the three countries and supports a large population. The effects of the pollution of river Sosiani do not only affect the residents living close to the river but the effect trickle down to other end users of the river far from Eldoret town. Therefore, a need to monitor this resource and prevent further deterioration of the river. The research goals were operationalized in three studies that employed both qualitative and quantitative approaches.

Study 1 evaluated the differences between risk predictors and risk perception regarding water pollution. Specifically, it focused on the differences in risk perception between factory workers and laypeople situated in textile industries near the River Sosiani in Eldoret, Kenya. The laypeople were divided into two groups. The respondents living downstream are situated mostly in town centers and at the mid/lower parts of the river, and the respondents living upstream are mainly found at the upper parts of the River Sosiani. Data were obtained from 246 participants using questionnaires. Several factors

influencing risk perception were selected to evaluate the degree of perceived risk amongst the groups. Descriptive statistics mean score and correlation analyses, and multiple linear regression models were used to analyse the data. The one-way ANOVA results showed statistically different levels of risk perceptions amongst the groups. The partial and bivariate correlation analyses revealed the differences in scientific knowledge between respondents upstream and downstream. The multiple linear regression analysis showed that each group used different variables to determine risks in the region. In the factory group, 56.1% of the variance in risk perception is significantly predicted by sensorial factors, trust in the government's capacity to manage water pollution and the impact of water pollution on human health. About 65.9% of the variance in risk perception of the downstream inhabitants is significantly predicted by sensorial factors, the possibility of industries generating water pollution, and previous experience with water pollution. For the respondents located upstream, age, sensorial factors, trust in the government and the possibility of being impacted by water pollution factors significantly predicted 37.05% of the variance in risk perception. These findings indicate that enhanced public participation in water governance amongst the residents of Eldoret town is needed, along with an understanding of the different characteristics of the respondents in the region during risk communication. This will boost awareness in the region and promote the adoption of better practices to minimise the adverse effects of water pollution faced by the region.

Study 2 examined the willingness to pay for and participate in volunteer activities for the restoration of the Sosiani River in Eldoret, Kenya. The willingness to pay was examined through two scenarios that differed in the organizations conducting the proposed project i.e. the government and non-governmental organizations. The study focused on factory workers situated in textile industries and lay people living in the area, who were divided into two groups: respondents living downstream, who are situated mostly in town centers and at the mid/lower parts of the river and the respondents living upstream, mainly found at the upper parts of the River Sosiani. The study employed the double-hurdle model to identify the factors that influence the willingness to pay (WTP) for improved water quality in the area. An ordinal regression model was used to analyze the willingness to participate and its influencing factors. The results of the study showed that an average of 74.4% of the 279 respondents studied was willing to pay for river restoration in the area. The mean willingness to pay for the government proposed scenario was Ksh 182.51 (1.66$) per household/month and Ksh 169.28 (1.54$) per household/month for a non-governmental proposed project. Within the groups, upstream and downstream inhabitants had higher mean scores for a non-government project as compared to a government project, while the reverse was observed in the factory group. The empirical results of this study showed that risk perception, trust and sociodemographic variables were significant factors on the stated amount and the decision to participate of the respondents. The characteristics of respondents with zero WTP, who comprised a significant amount of the respondents (25.6%), were also analyzed in-depth, shaping the recommendations of the study. The empirical results showed that the number of years lived in the community was a major determinant of the willingness to participate and pay for environmental restoration projects in the area. The results of the study could influence decision-makers in general and have potential implications that could be applied in other sectors not necessarily related to water issues.

Study 3 analyzed the cost implications of technological adoption through explicit cost breakdown of environmental restoration projects coupled with averted costs incurred if the situation is left unchecked. This is achieved through developing two main models for costs and benefits. Model one analyzed the costs of using diatomaceous earth for the treatment of textile wastewater with a focus on the operational scope of the technology. The second model analyzed the benefits of a cleaner environment to human health and related benefits. To analyse the health impacts of water pollution in the region, the number of infected patients for three diseases i.e. diarrhoea, amoebiasis and bacterial infection and their cost of treatment was used s indicators with the scope limited to only three diseases and data from one local hospital in the region. The contingent valuation results from the previous study were also incorporated to determine the recurring benefits from the project and potential costs that would be saved. A benefit-cost ratio (BCR) of the two models was developed to show the feasibility of the project. The BCR value of the project was promising and showed that given proper attention making estimates of the costs and potential benefits of an environmental remediation project can help decision-makers fund and support these projects. The outcome of the study was a framework and presentation of numbers and figures presentable to accountants, financial organizations and the government for consideration when making decisions and policies. These figures and numbers could help the government and other authoritative bodies to impose tax and fees on polluters thus establishing green accounting while keeping accurate financial statements for interested parties.

Keywords: appropriate technology; benefits; costs; benefit-cost ratio; public participation; risk perception; willingness to pay; willingness to participate

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Anne Wambui MUMBI

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1.1 Introduction

1.1.1 Overview of water issues affecting water resources

The assessment of water quality is a critical activity in the face of the current decline in freshwater quantity and deteriorating water quality of the remaining available water resources across the globe (A. O. Achieng et al., 2017). At present, 47% of the global population residing in areas that experience water scarcity for at least one month each year (UN-Water, 2018). Water quality is threatened by the continuous population increase, economic developments, industrial and agricultural activities and climate change. These activities and increased water pollution have significantly threatened the hydrological cycle. Water pollution continues to increase mostly as a result of large-scale industrial and agricultural production. Such activities typically generate large amounts of wastewater, which when untreated and disposed in water bodies, contribute to massive water pollution. The major culprits in the industrial sectors are the textile industries, which use large amounts of water and complex chemicals during textile processing (Afanga et al., 2020). These industries use huge amounts of dyes that are necessary in almost all stages of the process, and these constitute a high percentage of the effluents generated by these industries. Such effluents comprise one of the most problematic wastewaters to be treated not only for their high chemical and biological oxygen demands, total suspended solids and content of toxic compounds, but also for their colour (Afanga et al., 2020). The unsafe polluted waters generated by these industries can spread diseases such cholera, typhoid among other water borne diseases amongst the people who use it for food production, washing, cooking, bathing, or other basic daily activities. There is also a high risk of contamination to groundwater, water supplies from wells and users of agricultural water sources (Imandoust et al., 2007).

In developing countries such as Kenya and elsewhere mortality as a result of waterborne diseases especially in children is a major cause of death. In developing countries around 3.2 million children die each year as a result of unsafe drinking water and poor sanitation; this is due to limited access to wastewater treatment facilities in the developing countries (Organization, 2017). Which results to water bodies in developing nations often being used as open sewers for human waste products and garbage.

Consumption of such microbiologically unsafe water leads to water-related diseases like typhoid, diarrhea, dysentery, and paratyphoid (Vaziri et al., 2010). According to (Gwimbi, 2011) the microorganisms that make water not suitable for human consumption are total coliforms (TCs) and Escherichia coli. These microbes are used as indicators for fecal contamination that cause diarrheal diseases (Osiemo et al., 2019). Other parasites that cause waterborne infections include, protozoa: Entamoeba spp. (causing amoebiasis), Cryptosporidium spp. (cryptosporidiosis), and helminths (particularly Schistosoma spp. and Dracunculus medinensis) (Ngowi, 2020). Of these microbes, schistosomiasis has the highest occurrence prevalence followed by giardiasis and then amoebiasis (Ngowi, 2020). These harmful bacteria pose serious health risks resulting from waterborne diseases among the affected communities. Based on these risks, water pollution monitoring and water quality assessment are essential activities to help water management practices address the aforementioned challenges.

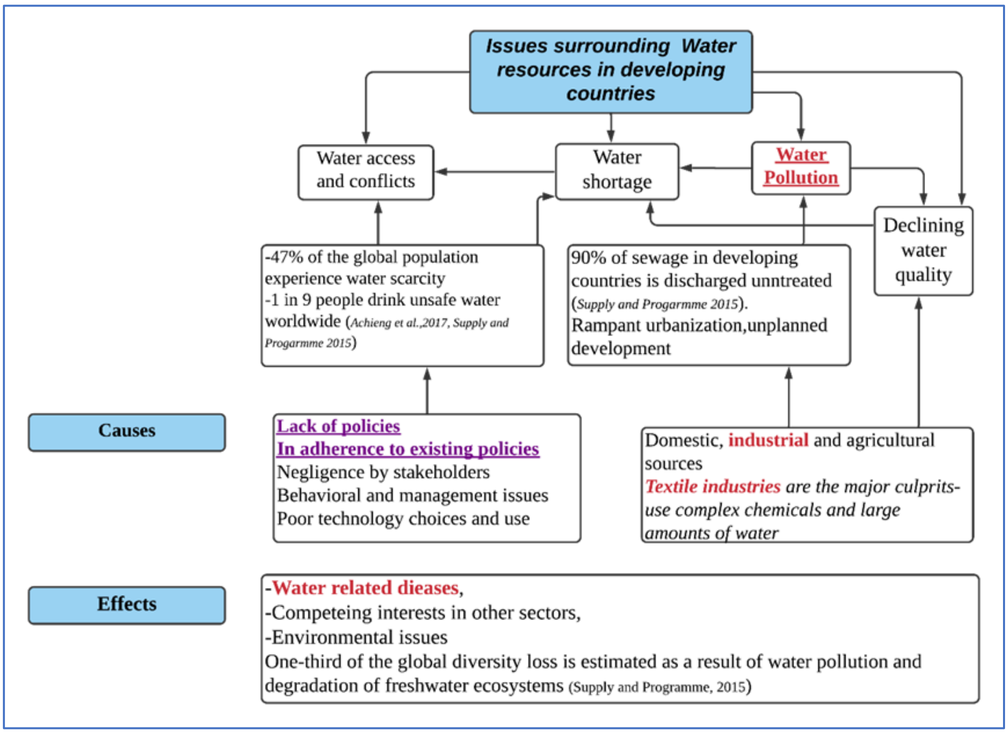


Figure 1.1 Issues surrounding water resources in developing countries

1.1.2 Overview of water issues in Kenya's River Sosiani

In Kenya, river pollution has become more severe over the years, especially in urban areas with the rapid economic development and urbanization (O. Chibole, 2013). Kenya is a water stressed country with a per capita freshwater availability of approximately 440 m^3 and a forecast of 248 m^3 by 2025 (O. Chibole, 2013). With a population of 50 million, approximately 32% of the population rely on unimproved water sources such as rivers, shallow wells and ponds. Forty eight percent of Kenyans lack access to basic sanitation solutions. Kenya has about 650 m^3/year per capita water available with future projections indicating that the value will decrease to 250m^3/year as a result of population growth (Nations, n.d.). The country thus needs to mitigate river water pollution to ensure availability of already scarce water resources in the future (O. Chibole, 2013). This urgently calls for prudent management of the available freshwater resources especially where these resources are scarce. Over time, the catchment of the River Sosiani has experienced massive water pollution because of rapid population growth, industrial development, inefficient agricultural practices, as well as poor land-use planning and solid waste management systems in the area (O. K. Chibole, 2013). The industrial effluents discharged in the River Sosiani from industries in the nearby areas account for a large percentage of water pollution, which has led to a decline in water quality and quantity (Masakha, 2019). To meet daily water demands, residents rely on piped water, borehole water, river water and water sourced from the lakes and ponds. Apart from water shortages in the area, the population also faces large outbreaks of diseases, such as cholera and typhoid, which are often associated with poor and unsanitary water practices. As shown in figure 1.2 the issues surrounding River Sosiani have been studied extensively and certain recommendations put forward.

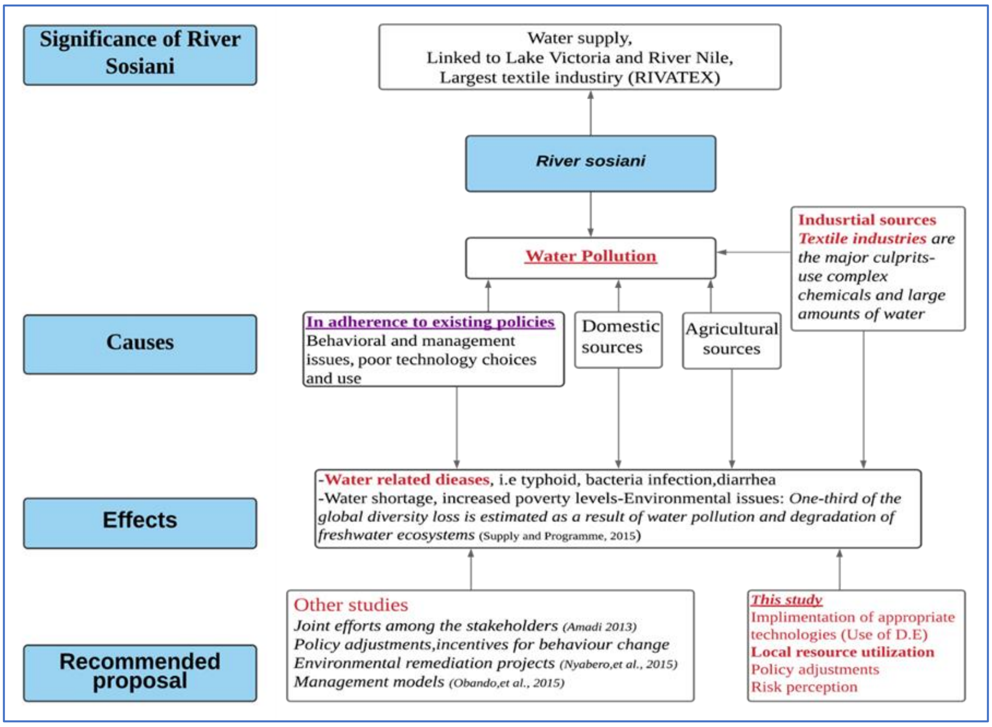


Figure 1.2 Water resource issues in River Sosiani

1.1.2.1 Legal Framework Relating to Water Resources

In Kenya, water resources are governed by the water act 2002 in Kenyan constitution. The ACT defines the duties of the water resource management that is responsible for regulation of water resources. Other ACT`s like the National Water ACT provide fundamental reform of the law relating to water resources in Kenya. As shown in Figure 1.3 at the local level, Water resources Users Association are tasked with service provision to the consumers. Over the years, there have been malpractices and lack of adherence to set policies by different users. Issues such as corruption, bribery mar the water sector in Kenya. Instances of illegal water pollution by industries and lack of proper sewer connections in the country are massive and lead to severe effects such as water shortages, diseases outbreaks and declining water quality in the country.

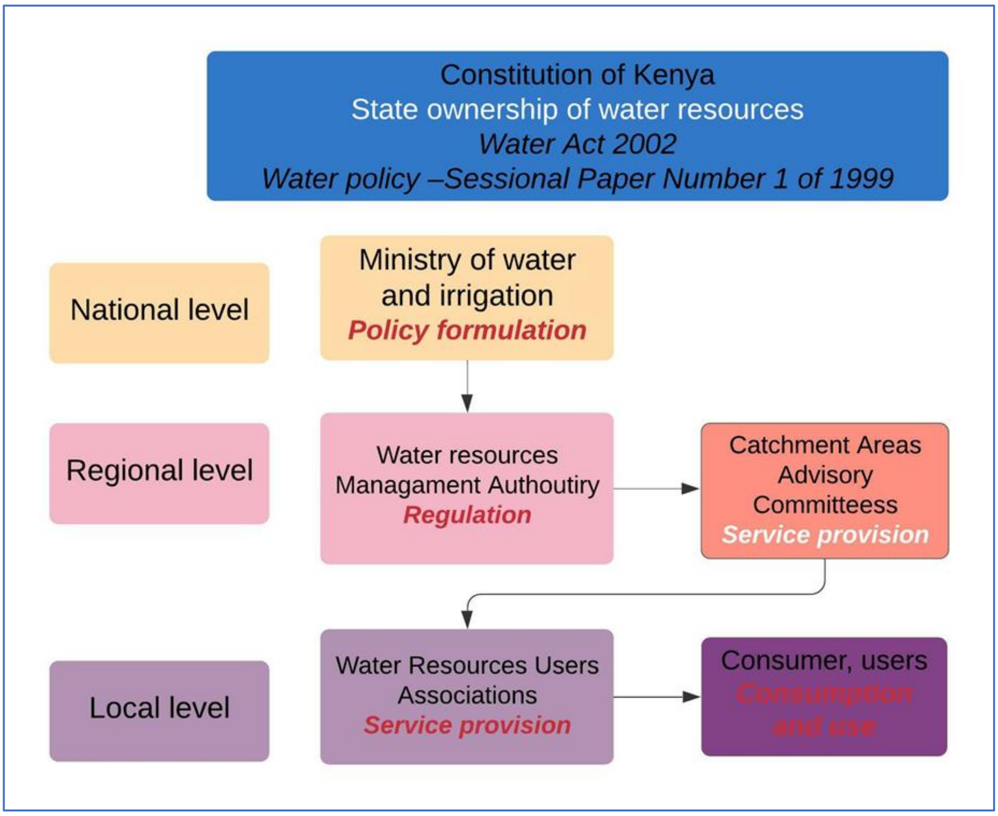


Figure 1.3 Legal framework of water resources in Kenya

1.1.3 Overview of risk and public participation

When addressing risks posed by the declining water quality and water pollution in order to promote better water management practices across the globe, public participation in governance issues regarding water resources has been emphasised in the last two decades (Sharma et al., 2018). Local people's perceptions of water quality are an important aspect of the management of water resources as they inform the dialogue between government officials, who are usually the proponents of remediation projects, and water service providers, environmental agencies and community leaders (Ochoo et al., 2017). Public participation highlights the public's perception of perceived risks, though processes and responses with regards to water quality (Fischhoff et al., 1993; Ochoo et al., 2017; Slovic, 1987). However, little attention has been paid to include the public or promote public participation during decision-making on environmental risks (Frewer, 1999). In this regard, the expertise and judgement of other stakeholders guide the decision-making process even though the local people are the direct recipients of the impacts of deteriorating water quality and the poor management of resources (Janmaimool et al., 2014; Withanachchi et al., 2018). This situation has resulted in a disconnect between the public and the decision-makers, leading to poor communication, lack of collaboration, increased environmental problems and lack of long-lasting solutions to address the problematic issues (Ochoo et al., 2017). To be effective in addressing the risks around water quality, understanding the needs and perceptions of the public is vital. It is therefore imperative that policymakers and researchers engage in an effective public participation process, especially in situations in which public behavioural changes are required to manage water resources (Hu et al., 2011; Larson et al., 2013).

To ensure effective public participation, understanding perceptions and risk judgments among different groups is necessary. This forms a base for the study aimed at understanding how the community understands and perceives the risk, the factors that influence risk perception, the community's valuation and relation to River Sosiani and their feelings about the current situation of the river. The research further investigated how the community understanding of the risks, influenced their willingness to pay for ecosystem management and their willingness to participate in activities aimed at restoration of the river. The results obtained from the study could possibly influence the polluting industries to take up measures such as proper treatment of the wastewater thereafter promote proper the use of the proposed technology, i.e. adoption of diatomaceous earth for textile wastewater treatment after the cost benefit analysis by the industry. Overall, this shall promote the use of available natural resources to solve existing environmental problems in a much cheaper and cost-effective way.

1.2 Problem statement

Pollution of river waters with harmful microbes, chemicals and toxic substances has been steadily increasing in the recent past (Abraham et al., 2007). Rivers like River Sosiani are marred by high pollution levels with pollutants such as heavy metals from industries, toxic dye components and hospital waste making the composition (A. Achieng et al., 2017; G. Ontumbi, Nyabero, et al., 2015). The major cause of water pollution in the area is industrial wastewater with large textile industries in the area such as RIVATEX (Largest textile industry in East Africa located in Kenya) discharging their wastewater into river Sosiani. The use of conventional treatment systems has not been effective for removing the dyes from the textile effluents due to the xenobiotic and recalcitrant nature of most of the dyes. Which results to complex wastewaters causing major concerns for the textile industries, especially due to the presence of the problematic azo-reactive dyes increased usage in the industry. This combined with economic activities such as car washing services, hospitals and the Jua kali sector also. As a result, the river has become extensively polluted and declared “dead” by the environmental agencies. This has resulted in proliferation of water-related diseases, such as typhoid, cholera and diarrhoea, loss of aesthetic, death of fish in the river and end of stream water pollution to receiving water bodies from the river such as Lake Victoria, which supports a huge population merged with a decline in water quality and water shortage in the area. The methods for treating such wastewater have been known to be expensive leaving most industries to partially treat their wastewater, or discharge their wastewater untreated. While expensive methods such as the use of activated carbon are efficient, choices that are less expensive but equally efficient exist for example the use of diatomaceous earth. These alternatives should be encouraged and used widely to save on cost and promote water treatment.

With the introduction of strict environmental legislation concerning colour limits of industrial effluent discharge and the vast negative impacts of water pollution in many regions, the need for an effective process that efficiently remove colour is now a top priority. There are many available technologies being used such as the use of activated carbon however it is limited in many regions due to the high operational charges related to its activation and regeneration. Diatomaceous earth is also known as diatomite is another viable option that is suitable, naturally occurring and efficient in treating wastewaters not only for colour but for COD and Turbidity (Sosiani and Municipality, 2016). Its high permeability, high porosity, low thermal conductivity, and chemical inertness, make it a better alternative for use in treatment of textile wastewater. It is against this background that the feasibility of using diatomite for the removal of colour from textile wastewaters is viewed as the better option especially for a developing country such as Kenya.

1.3 Existing gaps in previous studies and research novelty

In the management of water resources emphasis has been put in the participation of the public in the governance and issues of water resources in the last two decades across the globe. This is because the local people's perception of water quality is an important aspect in management of water bodies. However little focus has been given in this respect during decision making on environmental management issues. Risk perception and judgement from experts majorly guide government's decision-making process yet the local people are the recipients of the impacts of deteriorating water bodies and poor management of the resources. In turn this has resulted in massive environmental health issues, increased water pollution, poor communication among different stakeholders and poor or lack of solutions to address these challenges. Undertaking research such as ours contributes to the limited existing studies.

The point of novelty for this research lies in the exploration of risk perception among factory workers termed as experts in this research. Engaging the industrial workers in the context of experts for this particular study highlights the novel point of view for the research particularly because existing literature strictly focuses on experts in specific fields and contrasts their views to those of the lay people. Specifically the research aims at exploring risk perception of industrial workers and perceive if their relationship with the industries taints their views and opinions or risk perception. Additionally, identify the differences in risk perception between the industrial workers and laypeople in the region.

Furthermore, the research also explores risk and risk perception among residents of river Sosiani for the first time in the region.

Previous studies in the region have mainly focused on water pollution of the river and the sources of pollution and proposed measures to deal with the issue. Some of these proposed include, inclusion of residents living in the area in water governance and promotion of public participation. In light of this public participation and involvement has also been explored in our study with an aim of contributing to the already existing literature. To ensure that public participation is effective in realizing environmental remediation project goals, it is essential to gain deeper insight on the matter through understanding and evaluating the different viewpoints of the people in the region specifically, their perception to risk and risk judgments. This study aims at exploring this niche in the area, with an aim of recommending public participation after gaining insight on the matter.

The current research is also different from other studies conducted on the River Sosiani, which mostly addressed issues of water quality (A. O. Achieng et al., 2017; Amadi, 2013; Chibole, 2006; G. Ontumbi, Nyabero, et al., 2015) and water pollution (Kipyego et al., 2018; Ogindo, 2001; G. Ontumbi, Obando, et al., 2015) of the river and its environs, with few or no studies focusing on risk perceptions and the local factors influencing these. Therefore, this study aims to bridge this gap in the literature. Furthermore, given the strategic importance of the River Sosiani among the residents of Eldoret, its linkages to crucial basins, such as the Nile River through Lake Victoria, and the rapidly declining water quality of the river, this study is critical and necessary. This study also hopes to provide further evidence for the validity of Contingent Valuation as approach to elicit WTP (Platania et al., 2018). Moreover, the results obtained from this study will provide an opportunity for making recommendations with regard to conducting environmental restoration projects and activities in the future, by highlighting important and influential characteristics of the community's views on these projects and activities that determine their behaviour in the area.

1.4 Research questions and objectives

1.4.1 Study one objectives and research questions

To promote better risk management and risk communication the acknowledgment of the different risk perceptions and the factors that influence these perceptions is necessary. Another critical requirement is the identification of the different stakeholders and the roles that they play in risk management especially in the water sector. Importantly, the adoption of different risk perception perspectives involves the collaboration of multiple stakeholders, including the government, environmental and other private organisations, consultants and local residents. This acknowledgment of the different risk perceptions of diverse stakeholders within the water sector is vital to facilitate the adoption of sustainable water use and systems, such as the wastewater treatment of industrial water before discharge in the area. Based on this idea the following research questions are raised: (1) is there a difference in risk perception between factory workers and lay people? (2) Do the two groups (i.e., factory workers and lay people) use different factors to determine risk perception? (3) What suitable recommendations can be put forward to address each groups needs? Answering these questions is vital in designing practical solutions that address the needs of each groups within the society. Therefore, the first study was conducted with the following objectives.

1.1 To provide empirical insights into the factors that influence the risk perceptions of the people living around the River Sosiani based on its decreasing water quality and the resulting adverse effects.

1.2 To gain a better understanding of the differences in risk perceptions between factory workers and lay people through an exploratory analysis of survey data.

1.3 To understand how the community makes risk judgments related to decreasing water quality in the area.

1.4.2 Study two objectives and research questions

The existing literature on WTP has majorly focused on WTP determinants but has not investigated the WTP differences when the proposed scenario is conducted by two different entities/institutions within different groups. The institution tasked with organizing environmental restoration projects matters. For example, in a case where people may not place higher levels of confidence or trust in an institution proposing a project, this might influence their WTP or willingness to participate. Moreover, obtaining this information may provide insight into the longevity and success of the projects oriented towards a better environment, gauge the attitudes of the public towards different institutions in the society and highlight the public's valuation of the ecosystem and potential risks. Breaking down the monetary value that people place on an ecosystem and their willingness to volunteer in marinating the ecosystem provides critical information, necessary to decision makers regarding the public's attitudes and potential success of restoration projects. In a case where an ecosystem is not valued by the community, the percentage of success of restorative measures might be low. Based on these ideologies, the following research questions were investigated for the second study. (1) Does the

WTP vary between lay people and factory workers? (2) Is there a difference in stated WTP between government projects and non-government projects? (3) What is the valuation of the River Sosiani by the community? The outcome of these questions provides a clear picture of the community under study and provides critical information to decision makers to come up with tailored strategies and action plans when promoting environmental remediation projects in the region. Therefore, the following objectives were studied in the second part of the study.

2.1 Identify the different characteristics of the three groups and their influence on WTP and willingness to participate.

2.2 Determine the WTP and to participate in public activities for improvement in environmental quality for the residents in the region and their influencing factors.

2.3 Determine the level of influence that different organizations have on WTP of the public for improvement in environmental quality.

2.4 Identify the characteristics of respondents with zero WTP in the area.

1.4.3 Study three objectives and research questions

The cost of treating wastewater and the willingness of the people to pay for it, are linked to the extent to which wastewater is treated and recycled. The more wastewater is treated the greater the beneficial environmental impact, but the greater the cost. To understand this issue it is necessary to come to terms first with the costs of treating and the lack of treating these wastewaters through the cost of treatment of diseases that result from water pollution. In undertaking, this component of the study various models can be employed. These models are discussed in chapter 3 to explain the cost averted should suitable technology be adopted in wastewater treatment in the region. The following research questions were investigated. (i) What impacts does the firm's action have on the society? (ii) Is the technology economically feasible? (iii) Does the firm meet the standards of discharge? (iv) Are there any risks posed to the environment because of the discharge? The main objectives of study three were as follows:

3.1 To determine the costs and benefits suitable technologies i.e. the use of D.E in textile wastewater treatment industries

3.2 To determine the cost of inaction through deriving potential benefits from pollution control on human health and through the stated preference method i.e. the contingent valuation method (CVM).

3.3 Derive the economic feasibility of the project using the benefit cost ratio (BCR).

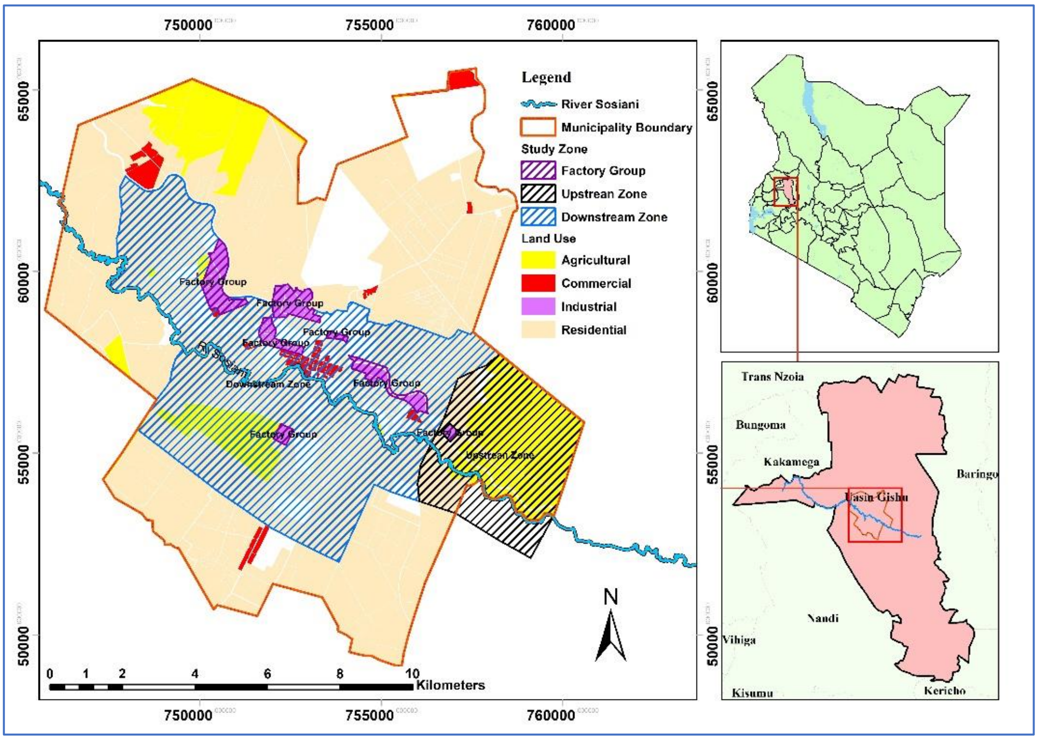
1.5 Study location

The study was conducted in July–October 2019 along the River Sosiani (00°–03′ S and 00°–55' N; 34°–50′ E and 35°–37′ E), a sub-catchment of the River Nzoia, which is a sub-basin that drains into Lake Victoria (Kipyego & Ouma, 2018). The River Sosiani is located in Eldoret (Figure 1.1), a town in the Rift Valley region of Kenya, which serves as the Uasin Gishu County's capital. It is located at latitude 0.514277 and longitude 35.269779 with the GPS coordinates of 0°30′51.3972″ N and 35°16′11.2044″ E (Kipyego & Ouma, 2018). As of 2019, the reported population was 475,716 (statistics, 2019). The area receives an average rainfall of around 1,055 m, with an average temperature of 16.8 °C. The land in Eldoret rises from the Sosiani River Valley. The Sosiani River Basin covers an area of approximately 647 km2, with a length of approximately 67 km. The

River has two main tributaries, the Nundoroto and Ellegeni, which are located in the upper basin and are characterised by a steeper gradient. The main activities within the River Sosiani catchment are wheat, maize and animal farming in the upper zone, which stretches between the plateau and flax areas. The midstream zone consists of human settlements, industries and hospitals; and the downstream zone is an urban environment, which includes the Central Business District (CBD), road networks, garages and car washes as well as other industries. Many industries in the area have mushroomed over the years (Figure 1.1), and the main industries mostly deal with the production of consumer goods, such as plastic, furniture and textiles, food processing, oil refining and cement production. The primary goods found in this area include machinery and transportation equipment, textiles, petroleum products, iron and steel (G. M. Ontumbi, 2015 July).

The industrial effluents discharged in the River Sosiani from industries in the nearby areas account for a large percentage of water pollution, which has led to a decline in water quality and quantity in the river (Masakha, 2019). This has left the government of Kenya with the burden of restoring the river AS the residents lack clean water and experience water shortages (O. K. Chibole, 2013). In the past, the Government of Kenya has initiated rehabilitation activities, such as solid waste management, tree-planting activities, regular inspections, law enforcement and environmental awareness initiatives in the catchment areas of the River. The main outcome of these efforts was the development of the Nandi Park Rehabilitation Project. However over time, these activities failed to revive the almost dead river, which still faces major water pollution issues (G. Ontumbi, Obando, et al., 2015). Moreover, experts warn of a possible complete drying up of the river if the current trends in the area persist (correspondent, 2014; G. M. Ontumbi, 2015 July; Sharon, 2014).

Hence, in addressing the relevant issues in the area, these studies have suggested enhancing public participation in order to achieve long-term results.



. **Figure 1.4** Study area and the selected regions in the area

1.6 RIVATEX East Africa LTD

The target study area of the research among other factories was RIVATEX East Africa. A Textile Company situated in Eldoret town along Kipkaren road off Kapsabet road. The company was established in 1976 and was among the few relatively successful parastatal textile firms in the country. The main product was cloth for kangas with 480000 meters produced monthly in years between 1990and 1991 accounting for 50 per cent of Rivatex`s total production. Besides the cloth, kanga light suiting and school checks were exported. Its other products include Kitenge (an African fashion) camouflage for the armed forces, poplin, khaki, furnishings and fabrics for skirts. The company has three major departments namely, spinning, weaving and finishing. The company`s waste water management is done through a treatment plant in the company area headed by the processing department that is responsible for carrying out tests on the wastewater to determine its properties both before and after treatment.

The treatment plant has four sections: wastewater inlet, mixing chamber, cooling chamber and the aeration chambers. Wastewater from the factory is treated and chemicals like acetic acid added in the aeration chamber to regulate pH before the water is discharged as seen in Figure 1.5. The RIVATEX wastewater is then discharged into river Sosiani which is a tributary of River Nzoia that drains into Lake Victoria.

Figure 1.5 The RIVATEX wastewater treatment plant. Image s*ource author*

A study conducted on wastewater discharged into the river indicated below standards for the wastewater. As shown in table 1.1 the wastewater discharged does not meet the required standards for discharge hence the need for immediate solutions to address this issue.

Table 1.1 Wastewater parameters standards as set by NEMA

Characteristics of RIVATEX wastewater Parameter	Units	Value	NEMA Standards (GOK, 2008)
pH	pH units	10.7	6.5-11.0
Colour	Pt-Co units	1585	<10
COD	mg O_2/L	1174	50
BOD5	mg O_2/L	468	30

1.7 Research framework

This thesis is organized into three studies all related to each other as shown in figure 1.6 and 1.7 in addressing water pollution. The research explores two research groups i.e. factory workers and residents of Eldoret town who live near River Sosiani. Study one investigates what issues matter to the community understudy with regards to water pollution in the region. The study investigates their risk perceptions towards the issue of concern, which is water pollution. There after the study investigates the factors that the community uses in assessing water quality and formulating developed risk perceptions. This is followed by an assessment of the factors that influence these perceptions and how these perceptions highlight the characteristics of each group understudy. Study two assesses the willingness to participate, and pay of the two groups under study to avert the negative effects of water pollution. The study also analyses the underlying factors that determine the level of participation and the willingness to participate of the two groups. The study highlights the possibility of institutions understudy influencing the willingness to participate and the level of participation of the groups under study. This study highlights the opportunities that lie within the community in terms of contributing to aid restoration activities in the region. This can be viewed as the motivation by industries in the area to practise better environmental practises in the region through adopting cost effective suitable technologies. This leads to the third study of the research. That analyses the cost effectiveness of the technologies understudy in an attempt to tabulate actual costs of the water pollution in the region through cost of medical expense as a result of water pollution and tabulating possible costs of technological adoption for comparison. This numbers present decision makers with a clear picture of what is at stake in the area should the current conditions remain constant. As shown in figure 1.4 the findings of the three studies integrated will lead to better environmental conditions in the region and promotion of resource utilization as discussed in the literature review section.

1.8. Structure of the dissertation

The contents of the dissertation are organized in six chapters

Chapter 1 provides a general overview of the state of water resources, water pollution and its impacts, the study area, scope of the research and an introduction to the overall study objectives and framework.

Chapter 2 Assembles the literature review of the three studies in depth and describes highlights various theories and previous studies that have been conducted in relation to the objectives of the dissertation.

Chapter 3-5 presents the individual studies that were conducted in order to achieve the objectives stated in chapter1

Chapter 6 concludes the major findings as well as the general implications and recommendation of the dissertation.

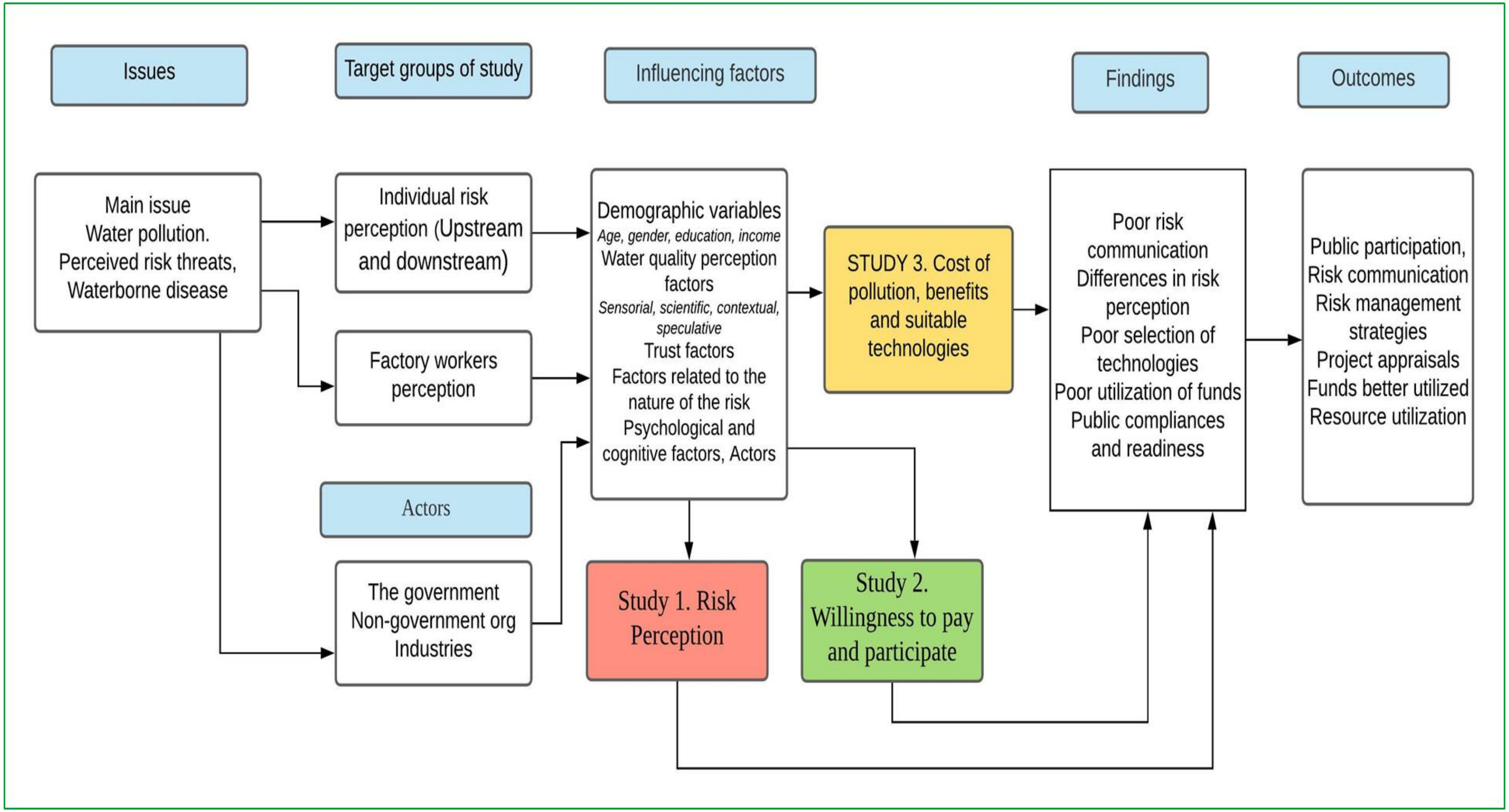


Figure 1.6 Relationship between the three studies in the research

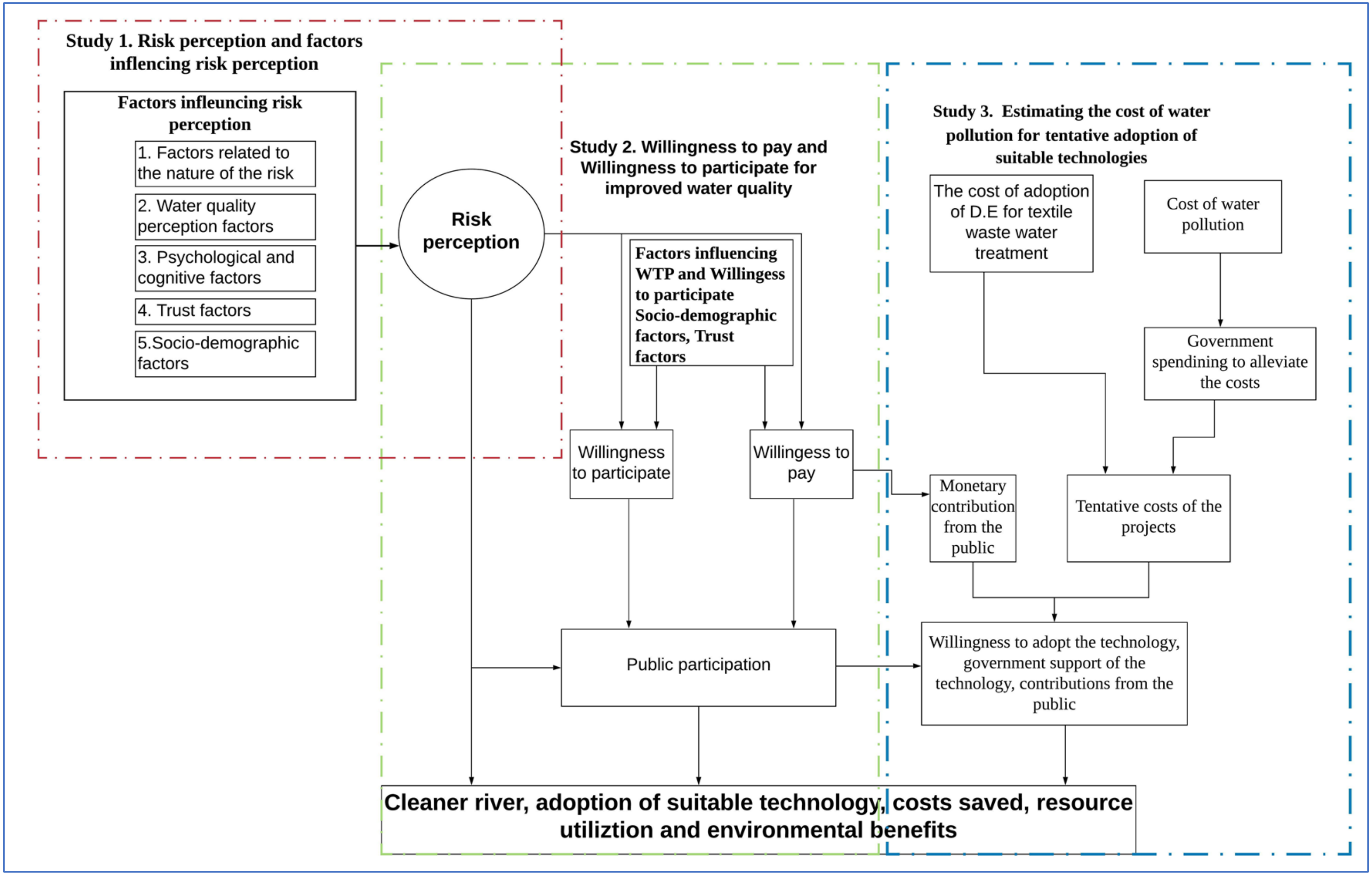


Figure 1.7 Framework of the research

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CHAPTER 2: LITERATURE REVIEW

2.1 Risk and risk judgement

According to Fischoff there is no ultimate correct definition of risk since no suitable one applies to all problems. In its simplest terms, risk can be defined as a situation involving exposure to danger or the possibility that something bad will happen. This normally involves uncertainty about the implications of an activity with respect to something that human's value such as health or wellbeing. Risk may be conceptualized into three approaches: objective, subjective, and perceptive. The objective approach refers to risk as a product of scientific research conducted based on experiments and scientific methods. Subjective approach denotes that risk is not solely objective; it varies depending on people's state of mind influenced by collective experiences, social norms, and uncertainties. Perceptive approach, defines risk as the set of all destructive consequences that are believed to be possible by a person who has evidence about the frequency, severity, and variability of the effects. Other risk approaches include: (i) Sociocultural paradigm that asserts that risk perception is constructed from beliefs influenced by social forces in society and it reflects the interests and values of each group, the diverse meanings of the term "risk" and natural phenomena within each group. (ii) Psychometric paradigm proposed by Fischhoff in 1978 addressed how human risk perception is significantly influenced by the physical properties of risks (voluntariness, familiarity, and catastrophic consequences), as well as psychological and cognitive factors (dread, experience, benefits associated with the risks, controllability, and knowledge). (iii) Interdisciplinary paradigm explains risk perception as being affected by a variety of social processes such as social institutions' roles in communicating risk-related information, and that risk messages are interpreted and perceived by individuals or society as a whole. (iv) The axiomatic measurement paradigm that focuses on how average people subjectively transform objective risk information and believes that risk perception is influenced by possible catastrophic consequences (fatal outcomes, mortality rates, etc.) and likelihood of occurrence.

2.2 Risk perception

Identifying local people's perspectives and judgement of risks is a crucial step in fostering sustainable governance and providing solutions to water problems. Perception is the principal form of cognitive processing between humans and their surroundings (Efron, 1969), and it is thus a key component in understanding human behaviour (Sharma et al., 2018). Thus, a clear comprehension of how people perceive risk is necessary when attempting to design and implement solutions that require changes in behaviours and actions in the management of natural resources (K. L. Larson et al., 2009). In order to do this, however, we must be able to determine the risks, interpret them appropriately and understand the subjective judgements, which are commonly referred to as 'risk perceptions'.

Risk perceptions arise from uncertainties and are based on a person's subjective evaluations and judgements about risks and risk-related choices (Williamson et al., 2005). Early risk perception studies were founded on the idea of a knowledge gap between the public and the experts (Hilgartner, 1990; Irwin et al., 2003). These studies implied that, if the public could comprehend and access all the evidence around a particular situation, their perceptions of its risks would be similar to those of the experts (Hansen et al., 2003;

Kane et al., 2014; Pidgeon, 1998; Touili et al., 2014). However, such an idea has been dismissed in the realisation that risk perception is a complex product of innate factors and that knowledge is just one of several factors that determine risk perceptions (i.e., other risk perception predictors) (Pidgeon, 1998; Touili et al., 2014). Major theories that have dominated the dominated general risk perception research since the 1970s are: the psychometric paradigm and Cultural Theory. These theories provide a context in understanding factors that impact on how people perceive and respond to risk (Silverman 2011) and can be used to in generating ideas and concepts regarding risk perception. Literature suggests that public perception of the quality of water varies with education (Anderson et al., 2007), age, income level (Larson & Lach, 2008), gender (Larson et al., 2010), social and psychological belief (Tran,2006) and geographic proximity of a person to the water source (Hu & Morton, 2011).

2.3 Risk communication

Risk communication refers to the process of interaction and exchange of information between experts and the affected communities about a risk in order to enable them to make informed decisions and protect themselves (Fessenden-Raden et al., 1987). A major factor which influences public perception of water quality is the risk communication process (Canter et al., 1992). As in risk management, the main problem that can arise in the risk communication process is the lack of or inadequacy of the interaction phase (Canter et al., 1992). According to Canter et al., 1992-93 (Fessenden-Raden et al., 1987), risk communication can be enhanced if the interpretation of the information presented during the risk communication process is viewed as the most important element, rather than the accuracy and detail of the information being presented. Some critical issues to consider during risk communication include variation in the reception of information among different communities; the local context in which the risk situation is embedded, i.e., attitudes, beliefs and culture of the community; the medium and the person delivering the message and if the messenger is trusted or distrusted by the recipients of the message; and the knowledge levels of the people involved. For example, the lack of knowledge of toxicology by most participants involved in the risk communication process may result in problems with translating, communicating and comprehending highly technical risk information, which might, in turn, delay or hinder the risk communication process (Canter et al., 1992; Fessenden-Raden et al., 1987). Any miscommunication or mistrust in the people's concerns or understanding of risks could create a gap between the community and the authority in charge of risk communication, which could obstruct successful policy implication. A comprehensive risk assessment process should thus encompass an integrative model that involves all the stakeholders and undertakes both a vigorous technical risk assessment and a risk communication process that takes into consideration the different risk perceptions of all the stakeholders involved. The benefits of an integrative model during risk assessment in the water sector include the identification of new areas vulnerable to hazards, which require further analysis; an opportunity to cross-check available data as a form of verification; communication of hazardous conditions based on local knowledge; and direct participation of the public in monitoring the risk condition (Withanachchi et al., 2018).

2.4 Factors that influence risk perception

The factors that influence risk perception are considered risk perception predictors (Hilgartner, 1990). Although much research and many theories, such as the psychometric paradigm and cultural theory (Janmaimool et al., 2014), pertaining to risk perception and its predictors have been proposed since the 1970s, these have been criticised and modified over the years. For example, according to Sjöberg (Sjöberg, 2000), the size of the community, and education, income and gender variables, which are not included as predictors in cultural theory or in the psychometric methods of risk perceptions, are actually significant predictors of risk. In addition, trust factors and the influence of mass media have been found to be significant predictors of risk perception. The perception of water quality risks is largely influenced by the same cognitive-emotive processes that affect risk perception in general (de França Doria, 2010). Therefore, from the psychometric and cultural theories perspective, a conceptual framework can be developed based on a number of factors that influence risk perception. Discussed below are some of the factors influencing risk perception that were included in this study.

Several studies have found the potential influences of socio-demographic factors on risk perceptions. Gachango et al. [34] and Hodge and Reader (Gachango et al., 2015; Hodge et al., 2010) found that age influenced the likelihood of adopting technologies and schemes introduced to farmers, indicating that older farmers are more likely to adapt to such technologies than younger farmers. In contrast, Giovanopoulou et al. (Giovanopoulou et al., 2011) determined that younger farmers are most likely to adopt certain technologies compared to older farmers. Income levels, education and gender have also been found to significantly predict risk perceptions in previous studies (Carlton et al., 2013; Jingchao et al., 2018; Karki et al., 2020; Wang et al., 2016). Based on the inconsistency of the socio-demographic characteristics, some studies (Wang & Watanabe,

2016) used these factors as predictor variables when making risk assessment. In the current research, these were also used as predictor variables.

Furthermore, trust plays a critical role in people's behaviours and perceptions towards risk (Poortinga et al., 2003). In the current study, 'trust' is defined as the level of trust the respondents have towards an entity be it regulatory, industrial or their own community to minimise and manage risks, as well as the potential impacts of water pollution in the area. This trust may or may not be dependent on the level of capacity that various parties presumably have. Trust has been identified as playing a significant role in the judgement of risks by the public in prior research, which asserted that confidence in the authorities, especially regulatory ones, strongly influences the degree of the public's acceptance of risks (Löfstedt et al., 1999; Poortinga & Pidgeon, 2003; Michael Siegrist et al., 2000; Sjöberg, 2000; Viklund, 2003).

Water quality assessment and judgement influences attitudes towards risks and the formation of such judgement depends on certain factors and the attributes of the water quality. Several factors may influence public perception of water quality and risk, such as bad odour, unusual taste, or change in colour, which may be interpreted as implying poor water quality and health risks (de Franca Doria et al., 2005). Of the factors that rely on the human senses, colour is used mostly when making a judgement on water quality, and this is combined with the psychological effects of previous events and experiences, which are internalised through a person's cognitive responses to dangers (Withanachchi et al., 2018). Other factors, such as past experiences, trust in water service providers, health risk perceptions and demographic variables also impact people's perceptions of water quality (Ochoo et al., 2017). For rivers and lakes, contextual factors, i.e., symbols that are close to water but not part of it, such as those that indicate the cleanness of the river banks or the presence of or lack of aquatic life, as well as the availability of external information from the media, have been found to influence the public's perception and estimation of risks (de Franca Doria et al., 2005). In their study of the River Yamuna, India, Withanachchi et al. (Withanachchi et al., 2018) stated that the aesthetic qualities of taste, colour, smell and clarity were considered when assessing water quality. They also found that sensorial factors are used more when making judgements on the river's water quality than other factors, such as contextual factors and scientific factors relating to the presence of harmful chemicals (Sharma et al., 2018). While this might be the common way of making water quality judgements, emphasis should nevertheless be placed on using classification methods, such as the water quality index, to ascertain the actual composition of various elements present in the water bodies being assessed (Jaimie Sung et al., 1996).

The factors related to the nature of risks have also been demonstrated to influence individuals' risk perceptions. The nature of a risk requires a certain level of technical understanding of the risk, and, when lay people have access to information, this can influence their risk perception (Jaimie Sung & Hanna, 1996). To explain the influence of the nature of a risk to risk perception, Janmaimool and Watanabe (Janmaimool & Watanabe, 2014) based their argument on the axiomatic risk approach that explains that an individual's perceived risk is influenced by the probability of occurrence and likelihood of a negative outcome, and they arrived at a similar conclusion. Sung and Hanna (Sung et al., 1996) also concluded that differences in risk tolerance and acceptance could vary depending on an individual's understanding of the nature of risks, thus underscoring the importance of these factors when understanding risk perceptions. Meanwhile, the psychological and cognitive factors associated with perceived benefits and previous experiences with risks, as elaborated by the psychometric framework, have been applied in previous studies to determine risk perception (Janmaimool & Watanabe, 2014). Importantly, perceived benefits have been identified as factors that influence one's attitudes towards risk (S Georgiou et al., 1998; Keraita et al., 2008; Liu et al., 2013; Michael Siegrist, 2000; Toze, 2006; Yang et al., 2015). In their study on the acceptance of gene technology in food production, Sparks et al. (Sparks et al., 1994) argued that one's attitude towards risk is affected by perceived benefits. Based on economic status and financial differences between the upper class and lower class in Kenya, this factor cannot be ignored. People's struggles to meet their basic needs and survive are at the forefront, especially in Kenya, and may well have an impact on their risk perceptions. The previous research has centred on income when analysing perceived benefits (Chen et al., 2013; Khan et al., 2015; Park et al., 2014; Yang et al., 2015). To further explore this factor, the present study considered the term 'benefits' to capture not only the expected income from industries but also other elements, such as job security and other possible opportunities created by the presence of industries in the area. All the factors discussed above have been shown to have an impact on risk perception (Janmaimool & Watanabe, 2014). Thus, it is imperative to assess the relationship between these factors and assess how they can help shape decision-making and risk communication in the area.

2.5. Risk research in the water sector

Within the water sector, many studies focusing on technical risk assessment have mainly highlighted the issues pertaining to public health risks, since this is the most direct and noticeable effect of water pollution or declining water quality. In addition to technical risk assessments, a few studies have tried to discriminate what risks and types of health risks are perceived to be associated with drinking water (de França Doria, 2010). In a Canadian survey, the respondents identified infectious diseases, gastrointestinal disorders, cancer, contamination and intoxication as the potential risks resulting from water pollution (Levallois et al., 1999). However, the relative significance of the risks relating to water is likely to vary with the type of water system, water source, extent of personal contact and intended water use. For example, the perceived risk of using river water may be low for irrigation but high for drinking. Thus, there should be explicit consideration of the full range of specific risks, about which the respondents might have subjective responses, in order to prevent potential conflicts within technical assessments. In most cases, however, direct experiences of adverse effects of the risk are most effective when making judgements about risk perceptions (de França Doria, 2010). In relation to the analysis of public perception of water quality, with the aim of increasing public participation in water quality restoration, research has been conducted into many successful river management projects, especially in the developed countries (S. Larson et al., 2013) (Le Lay et al., 2013; Lepesteur et al., 2008; Tunstall, 2000) such as the Murray River in Australia (S. Larson et al., 2013) and river Rhine in Europe (Buijs, 2009) . Furthermore, it is interesting to note that most published studies reported above have taken place prior to planning an intervention, which is the case especially in water-related studies. These public risk assessments of water quality are equally as important as the experts' technical assessments to ensure complementary decisions that organise the responses to degradation, implement risk management policies, minimise risks and allocate resources (Dobbie et al., 2014; Renn, 1998; Withanachchi et al., 2018).

Understanding the way a particular society perceives risk is vital for pinpointing the existing vulnerabilities of a water-related occurrence, and appraisals of environmental risks that include all stakeholders are an integral part of promoting environmental sustainability (Whyte et al., 1980).

2.6 Water related diseases and water pollution

Consumption of microbiologically unsafe water leads to water-related diseases like typhoid, diarrhea, dysentery, and paratyphoid (Vaziri et al., 2010). Similar to previous studies, these diseases were taken into account. According to (Gwimbi, 2011) the microorganisms that make water not suitable for human consumption are total coliforms (TCs) and Escherichia coli. These microbes are used as indicators for fecal contamination that cause diarrheal diseases (Osiemo et al., 2019). Other parasites that cause waterborne infections include, protozoa: Entamoeba spp. (causing amoebiasis), Cryptosporidium spp. (cryptosporidiosis), and helminths (particularly Schistosoma spp. and Dracunculus medinensis) (Ngowi, 2020). Of these microbes, schistosomiasis has the highest occurrence prevalence followed by giardiasis and then amoebiasis (Ngowi, 2020). Although these diseases occurrence is mainly associated with domestic water pollution sometimes other factors like industrial or agricultural pollution might cause them hence they were accounted for in this study. Cancer (liver, skin and pancreas), menamomas, endocrine disorders and other related diseases due to high concentration of pesticides in drinking water has been linked to industrial and agricultural pollution, however, there is no quantitative assessment of the link between chemical pollution and health is available for Kenya thus the aforementioned diseases were used in the study.

2.7 CVM

A number of approaches have been used when valuing water resources, such as the travel cost method (Smith et al., 1985), the benefit and cost method (Choe et al., 1996) and the contingent valuation method (CVM), which is the most commonly used method (I. J. Bateman et al., 2006; Del Saz-Salazar et al., 2009). The CVM explores an individual's willingness to pay for a change in public goods and reveals the benefits that a society receives from the good/service (Downs et al., 2002; Li et al., 2014; J. B. Loomis, 1996; Schmidt et al., 1998; Shang et al., 2012; Zhongmin et al., 2003). The method consists of asking people directly what value they would attribute to a service or good, i.e. their willingness to pay (Amirnejad et al., 2006). According to Haneley et.al (Hanley et al., 2016), the WTP extracted from this method is an individual's personal economic valuation of the goods/services in question, resulting from a clear explanation of the aspects that need to be evaluated. In social sciences and economic studies more specifically relating to water resources, the CVM has been widely applied to evaluate public preferences on ecosystem services, WTP for improvement in the quality of surface waters and river restoration projects. For example, Loomis et al. (J. Loomis et al., 2000) applied the CVM to measure the economic value of restoring the ecosystem services of an impaired river basin in Platte River. Zhao et al. (Zhao et al., 2013) reported on the integrated contingent valuation of the ecosystem services of Zhangjia Bang Creek in Shanghai. Cooper et al. (Cooper et al., 2004) highlighted the non-market benefits of improving the status of rivers and the motivations behind it. Nallathiga and Paravasthu (Nallathiga et al., 2010) estimated the economic value of conserving river water quality at the Yamuna river basin, India. Bateman et al. (I. J. Bateman et al., 2006) estimated the benefits improving urban river water quality. Del Saz-Salazar et al. (Del Saz-Salazar et al., 2009) considered the willingness to pay as willingness to accept the economic valuation of the non-market benefits derived from improving water quality for people living in Serpis basin in Spain.

2.8 WTP design

The willingness to pay certain amounts can be estimated using a number of different designs in the CVM. The most commonly utilized methods are open-ended (OE) and dichotomous choice (DC). Studies that use either of these methods point out different advantages of selecting their preferred design. For example, Mitchell and Carson (Mitchell et al., 1989) point out that some researchers advocate for the use of the discrete choice or close-ended elicitation format because they believe that this technique makes the task of answering a contingent valuation question easier and results in lower item non response rate. Critiques of these designs, however, argue that in these methods the WTP is usually inferred and the resulting estimates may be sensitive to the assumptions made about the specific utility function (J. B. Loomis, 1990). OE, on the other hand, has been praised and preferred due to the fact that the WTP is directly elicited and inference is not required. DC methods have been known to result to much higher mean values for WTP than OE methods (Brown et al., 1996). Loomis (J. B. Loomis, 1990) evaluated the comparative reliability of dichotomous choice and OE contingent valuation methods and deduced that the test-retest correlations were not statistically different between the two methods (J. B. Loomis, 1990). Brown et al. (Brown et al., 1996) found that DC designs resulted in a greater hypothetical market error than an equivalent OE. Therefore, OE designs are preferred, as they offer conservative design of the survey (Alvarez-Farizo, 1999). When an open-ended question is used in the valuation scenario, this model distinguishes between factors affecting whether or not respondents are in the market for this public asset and considers the factors that affect the stated amount that they are willing to pay.

2.9 Econometric analysis

The technique used for econometric analysis of WTP data is critical because an inappropriate choice can lead to erroneous inferences about the determinants of WTP and consequently about their validity (Remonnay, 2008). According to Donaldson et al. (Donaldson et al., 1998), the type of model used is largely dependent on the type of question asked and the selected model should fit the WTP questions asked. When a payment scale, bidding approach or open-ended questions are adopted, the outcome is continuous monetary WTP values (Donaldson et al., 1998) and the WTP is usually censored, so that the data contains a large proportion of zero values, for which there is a range of possible explanations, such as protest responses or real zeros consistent with economic decisions. On the other hand, the close-ended approach and a dichotomous choice with follow-up valuation only provides qualitative binary values. For such questions, binary logit and probit analysis is highly recommended. For payment scale, data-ordered logit/probit are the most appropriate methods. For open-ended questions, the resulting values are quantitative (Donaldson et al., 1998) and modelling methods, such as standard linear models by ordinary least squares (OLS), Tobit regression, double-hurdle models and truncated regression models, have been recommended (Donaldson et al., 1998; Johannesson et al., 1991; O'Brien et al., 1996; Thompson, 1986; Yasunaga et al., 2006).

The selection of these models however are largely dependent on the treatment of zero responses in any case.

The estimation in OLS is believed to be biased and inconsistent, because it fails to account for the qualitative difference between limit (zero) observations and non-limit (continuous) observations with potential erroneous results. The most frequently advocated method is the Tobit model, especially when dealing with censored data in contingent valuation (Remonnay, 2008). However, there have been numerous debates on the treatment of zeros in this model, implying that the underlying assumption in the Tobit model does not differentiate between the continuous zeros and the zero-decision process. That is, the Tobit specification is relevant only if all zero realizations represent an economic decision, i.e., a real zero preference for the programme or issue in question. Recent research suggests that the cause of zeros observed in survey data has important statistical consequences (Humphreys et al., 2009). Common practice in the treatment of the zeros in the data involves identifying the two types of zeros and discarding them from the analysis. This introduces potential biases if other characteristics of the respondents in the protest group are different from the population sample. According to Donaldson et al. (Donaldson et al., 1998), positive WTP values and zero values could significantly differ in their determinants. Therefore, they should not be discarded rather differentiated (Donaldson et al., 1998).

The type II Tobit model (Amemiya, 1984) is a more flexible model and has been proposed to accommodate the different patterns that arise from the questions of how much and whether to pay for a proposed project. However, this model does not differentiate zeros generated by economic decisions (genuine zero values) from zeros generated by non-economic decisions (protest zeros), which makes interpretation difficult. Another popular approach that tries to differentiate the zeros is the double-hurdle model, originally proposed by Cragg (Cragg, 1971).

This model assumes that two separate hurdles must be passed before a positive level of consumption can be observed. Each of these hurdles is determined by a different set of independent variables. The first hurdle involves the decision to participate or not to participate in the event, i.e., to protest or not, and the second hurdle then determines the amount decision, i.e. the degree of participation through payment amount. The double-hurdle model is characterized by the relationship in the following equation:

$$y_i = s_i h^*_i, \qquad \textbf{(Equation 2.1)}$$

Where y_i is the observed value of the dependent variable

s_i = the selection variable

h^*_i =the continuous latent variable

The selection variable = 1 if the dependent variable is not bounded and 0 otherwise as shown in the selection model.

$$\text{Selection model} : \quad s_i = \begin{cases} 1 \text{ if } z_i \gamma + \varepsilon_i > 0 \text{ (participation)} \\ 0 \text{ otherwise} \quad \text{(protest)} \end{cases}$$

Where z_i = vector of the explanatory variables

γ = coefficient vectors

ε_i = standard normal error term

The double-hurdle model can determine the socioeconomic and personal characteristics of protest respondents by relaxing the assumption that the participation decision is irrelevant, as observed in the Tobit models. This is observed in the probit model aspect of the participation decision in the double-hurdle model. The double-hurdle model accounts for the presence of zeros in the population by allowing for observable and unobservable factors that affect the participation equation and also allows for some factors to affect only the participation decision and not the amount decision and vice versa. Additionally, the double-hurdle model treats the participation decision and the amount decision separately in the case of WTP (Humphreys et al., 2009).

The double-hurdle model has been applied in many social science studies (Humphreys et al., 2009). For example, Blundell et al. (Blundell et al., 2007) utilized the model to examine the relationship between participating in the labor force and the number of hours worked. Abdel-Ghany and Sharpe (Abdel-Ghany et al., 2001) used the model to investigate consumer participation and expenditure on lotteries in Canada. This model has also been used to examine the determinants of participation and intensity of cigarette smoking (García et al., 1996; A. M. Jones, 1989), physical activity and exercise (Humphreys et al., 2007). In the aforementioned studies, the double-hurdle model has yielded satisfactory results and accounted for the two decisions that a respondent faces in a CVM interview (del Saz-Salazar et al., 2008). Further, apart from the estimation of the social benefits, applying this method allows researchers to deal with the issue of zero responses in their responses (Cragg, 1971). Similarly, we applied the double-hurdle model in our study to evaluate the determinants for agreeing to participate in the proposed programme and influence the amount decision for residents living near River Sosiani.

2.10 WTP Determinants

According to Bateman (I. Bateman, 2011), it is vital to understand the determinants of WTP relating to unfamiliar goods where preferences for the investigated good may not be clear. Previous research has found the various significant determinants of WTP, such as sociodemographic factors, age and income (Platania et al., 2018). Other studies have observed that younger people have higher WTP compared to older people (Bowker et al., 1999; Reynisdottir et al., 2008). Nationality and the amount of time an individual has lived in an area have also been proven to influence an individual's WTP for ecosystem restoration (Davis et al., 1999). The size of the household, i.e. family size, is also an important factor (Wentz et al., 2007). Previous studies have also shown that an individual's perceptions towards risk influences their WTP. More specifically, individuals who perceive there to be a greater risk are generally more likely to have a higher WTP to reduce the risk. For example, Georgiou et al. (Stavros Georgiou et al., 1998) deduced that an individual's WTP for improvements in bathing water quality was influenced by their socioeconomic status and was highly correlated with their perception of the health risks from exposure to polluted coastal bathing waters. Similar observations were made about the perceived risk in Nebraska, USA, where an individual's WTP for groundwater improvements increased in cases where the perceived risk was greater (Sukharomana et al., 1998). Trust factors have also been identified to influence WTP. Some studies have asserted that as a factor of social trust, some individuals will be willing to pay more to save water resources (Jorgensen et al., 2009). Those who believe that their fellow citizens will comply with a new environmental regulation concerning water resources will perceive less social costs from a proposed policy (Nikoleta Jones, 2010).

Institutional trust, on the other hand, has been associated with the effectiveness of the institution (Kim, 2005). Thus, higher trust may imply positive perceptions concerning the effectiveness of the proposed project or policy (Beierle, 2010; Cvetkovich et al., 2003; Nikoleta Jones et al., 2011; Tortajada et al., 2013). This may result in lower or no willingness to pay (WTP) or participate in any projects if they do not trust the institution undertaking the project.

2.11 Low-cost adsorbents

In wastewater treatment, the cost of adsorption processes is dependent on the adsorbent material being used. The most common adsorbents used is activated carbon. Activated carbon is a form of processed carbon that has higher surface area from its low volume pores. The high surface area increases its adsorption capacity and chemical reactions sites. Activated carbon is efficient but expensive and makes the adsorption process costly as a result. This can be problematic especially in developing countries where the cost might be too high as they rely on importation of the material. As a result, there is need for alternative, efficient options that utilize locally available materials. These materials should have equally efficient adsorption capacity, economically feasible and readily available. Multiple studies have assessed the use of natural resources as treatment options of wastewater especially for developing nations (Al-Ghouti et al., 2003; Wagai et al., 2011); for example the study by Wagai, Samuel et al., (Wagai et al., 2011) on harvesting surface rainwater purification using Moringa oleifera seed extracts and aluminum sulfate to address the issue of water problems in the country. Diatomaceous earth has also shown promising results in the removal of dyes from wastewaters and is a promising alterantive to high cost adsorbents used in wastewater treatment (Al-Ghouti et al., 2003; Gupta, 2009).

Diatomaceous earth also known as diatomite is another viable option that is suitable and cost effective as it is naturally occurring and efficient in treating wastewaters not only for colour but for chemical oxygen demand (COD) and turbidity (Sharon, 2014). Its high permeability, low density (1.95 to 2.3 g/cm3), high porosity 80-85%, low thermal conductivity, and chemical inertness, makes it a better alternative for use in treatment of textile wastewater. The mining and processing of diatomite is delicate and complicated as it requires large processing facilities and heavy earth moving equipment. To minimize costs, diatomite is usually mined in open-pit, surface mines or underground extraction methods. Diatomite processing is usually done near the mine to reduce the cost of hauling up to 65% water, but the cost of delivering energy (electric power and fuel) to the site is an offsetting consideration. Processing typically involves a series of crushing, drying. The ore is heated to temperatures in excess of (1800 degrees Fahrenheit).

In Kenya Diatomite is mined at Kariandusi near Gilgil and Soysambu on the floor of the Rift Valley. Since its establishment in 1942, Africa Diatomite Industries Limited (ADIL) has been exploiting diatomite in Gilgil, a town north west of Nairobi (Kenya), for export. ADIL has access to good quality diatomite deposits estimated at over 6 million tons and currently boasts having the only known viable quality deposits of diatomite in Kenya (Maghanga, 2014). In Kenya a kilogram of KensilF (locally branded diatomite) costs approximately 0.2$ (dollars) (African Diatomite Industries Company) making it affordable in the country for retail to individuals and industries who use it for many various uses.

2.12 Cost analysis of suitable technology

Cost analysis is the most common method used in decision-making and selection of alternative and suitable technologies. In water and wastewater treatment processes, it is the most important criteria for the selection of any treatment choices. Cost estimates should not only be done for the technology in question but also there should be estimation of the effects and severity of the problem i.e. contaminants if left in place. This provides a more persuasive case when lobbying authoritative bodies, the government and companies to adopt new technologies. The CBA (cost benefit analysis) is commonly used to determine the economic feasibility associated with the implementation of different proposals. CBA operates under the premise that the benefits of a proposed project exceed the aggregated costs. In wastewater treatment, an economically feasible proposal means that the benefits arising from the process exceed the costs, thus the proposals not only offers environmental benefits but also economic benefits.

2.13 Cost estimation methods

Various methods have been used to estimate the cost of toxic pollution. (1) avoidance-costs (AC); (2) recreational-choice (RC); and (3) cost-of-illness (COI) (work days lost plus medical expenses) or value-of-statistical-life (VSL) approaches. The avoidance cost methods refer to actions taken to reduce damages from exposure to the contaminants thus avert the cost. This includes methods such as point of use treatment systems, use of cleaner water e.g. bottled water, and changing behaviors to avoid exposure to the contaminants e.g. frequency or length of showers if a volatile organic chemical were present. This can be achieved with a household system or organizational level (Abdalla, 1990). The recreational site choice includes the indirect benefits from the use of surface waters. For example water use through fishing, swimming, boating and site seeing (Abdalla, 1990).

The cost of illness is the most common approach in estimating welfare costs when the contaminants damage the human body. The cost of illness can be measured in a number of ways. (i) The number of work days lost multiplied by the commensurate wage rate. (ii) Medical expenses paid for treating the sickness and (iii) contingent valuation to estimate reduced health risks. Where the diseases are curable and treatable, the first and second methods can be used. Contingent valuation may be used to estimate the value of avoiding life threating illness such as cancer (Easter et al., 2006). The cost of illness approach has been used in air pollution studies, however the major difficulty with this method is that the contaminants have multiple health effects (Alberini et al., 2000).

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CHAPTER 3: DIFFERENCES IN RISK PERCEPTION AND FACTORS INFLUENCING RISK PERCEPTION OF WATER QUALITY IN WATER MANAGEMENT: LAY PEOPLE VERSUS FACTORY WORKERS. A CASE STUDY OF WATER POLLUTION IN RIVER SOSIANI, ELDORET MUNICIPALITY KENYA

3.1 Introduction

Research on risk has attracted much interest in the last few decades, specifically the study of the differences in risk judgement among different groups of people (Fischhoff et al., 1982; Flynn et al., 1992; Savadori et al., 2004; Paul Slovic et al., 1980; Paul Slovic et al., 1995). The prior literature has concluded that different groups of people perceive and react to risks differently based on their location and proximity to a hazard or risk, and their understanding of risk, based on different cultures and knowledge (Fischhoff et al., 1982). Some studies have also suggested that the general reaction of the public to potential risk could be impacted by social and psychological aspects that are beyond the capabilities of standard technical risk assessments (Morgan, 1990; Paul Slovic et al., 1980; P. E. Slovic, 2000). Most of the studies on risk perception have employed either convenient or population samples of experts with certain skill sets (Perko, 2014; Reiko Kanda et al., 2012; M. Siegrist et al., 2007). Studies to elucidate the differences in risk perception between groups have been conducted mostly between the public and expert groups, and in highly technical fields, such as nuclear power, as illustrated by Kanda et al. (2012) (Reiko Kanda et al., 2012), nanotechnology by Siegrist et al. (2007) (M. Siegrist et al., 2007) biotechnology and genetically modified organisms by Perko (2014) (Perko, 2014) and other fields, such as industrial safety (Morgan, 1990). The findings of these studies reveal that experts generally have lower risk perceptions than lay people, which suggests that greater communication efforts directed at the public are required for effective risk management. Within the factory context, the existing literature that has attempted to highlight risk perceptions has focused mainly on evaluating the use of personal protective equipment (PPE), occupational safety and accidents (Ellaban et al., 2018; Kakaei et al., 2014; Leiter et al., 2009; West et al., 1990). To the best of our knowledge, no study has attempted to investigate whether or not working for particular industries can influence risk judgements, especially in cases in which industries are responsible for certain environmental issues, and there is a difference in risk perception between these workers and the public. Investigating such a relationship is important because in order to have effective solutions for different risks faced by a society, an analysis and understanding of the different ideologies underlying the risks from all viewpoints is important. For example, important insights can emerge through investigating if, and to what extent, working in certain industries and corporations taints the workers' perspectives with respect to the organisations' activities. In situations in which the true feelings of individuals may be overlooked based on their affiliations or jobs, it is important to understand if a natural bias might develop which may hinder or slow down problem-solving activities when such institutions are involved. Furthermore, this knowledge is imperative because employees constitute an important target group in the research on risk perception, since they work in situations in which their own actions are likely to have consequences on the actual risks they are exposed to, and to which the public is also exposed (Sjöberg et al., 1991). Moreover, knowledge about these relationships and viewpoints is important because, if the workers have erroneous conceptions of the risks their actions pose to the community, leaving the risks unchecked can cause unintended damage to both them and the community at large. It is therefore important to improve their knowledge and that of the public (Sjöberg & Drottz-Sjöberg, 1991).

In the water sector, there has been little examination of the role of risk perception in relation to advancing more sustainable practices in the water management of centralised and decentralised systems with multiple sources (M. F. Dobbie et al., 2014). Recognising and understanding the mix of risk perceptions can lead to the development of a more effective water management system, through collaboration of all parties and stakeholders aiming to adopt sustainable practices. Thus, the water industry should accommodate multiple risk perspectives in the implementation and management of water bodies and wastewater treatment systems, such as sewage treatment plants and common and combined effluent treatment plants (CETPs).

In addition, the findings from this study can facilitate behavioural changes among the industries in the region through the adoption of potential low-cost technological options to treat their wastewater before discharge in the river in order to minimise the adverse effects of industrial water pollution in the area. For example, the use of locally available options, such as cactus and diatomaceous earth for wastewater treatment as adsorbents. They have been proven to be as equally effective as activated carbon, which is the most widely used adsorbent in the treatment of industrial and municipal wastewater thus, can be adopted by industries in the region (Al-Ghouti et al., 2003; Semião et al., 2020; Vijayaraghavan et al., 2011; Zhi-qiang et al., 2006). Given the minimal success of previous environmental restoration efforts in the River Sosiani area, there is a need to identify the type, scope and scale of engagement and the corresponding possible methods for inducing behavioural changes in the people in order to gain insight into the public perception of risk (Clay et al., 2007; M. Dobbie et al., 2013; Tran, 2006). Therefore, a more effective communication process is necessary to gain a detailed understanding of risk perception and the factors affecting risk judgement to ensure long-term successful projects and effective water quality management (Canter et al., 1992).

3.2 Study Framework and Hypothesis

Based on the literature review of previous studies presented in chapter two. The psychometric paradigm and cultural theories (Canter et al., 1992; de França Doria et al., 2009; Janmaimool et al., 2014; Reid, 1999) that identify the scope of factors that influence public perception and response to risk, a conceptual model was formulated for this study. This included applying a structure that can provide a hypothetically thorough outline of the key determinants of risk perceptions amongst different groups and highlight risk levels with regards to water quality (de França Doria et al., 2009; Ochoo et al., 2017) . These determinants were organised into five categories, as shown in (Figure 3.1). The first category included the nature of environmental risks, such as the possibility of industries generating water pollution, the possibility of being impacted by water pollution and the impacts of water pollution on human health. The second category included factors influencing public risk perception of water quality, namely, (a) sensorial factors, (b) contextual factors, (c) scientific factors and (d) speculation and feeling factors. The third category consisted of psychological and cognitive factors, such as previous experiences concerning the impacts of water pollution and the effects and perceived benefits of industry. The fourth category included trust factors, which included trust in the government and local industries, and the local people’s capacity to manage water pollution. Finally, the fifth group of socio-demographic factors consisted of the respondent's gender, age, and income and educational levels.

(1) People working for industries and people living in different locations of the River determine risk perception differently.

(2) Risk perception is influenced by trust factors, socio-demographic characteristics, water quality perceptions, the nature of the risks involved and psychological and cognitive factors.

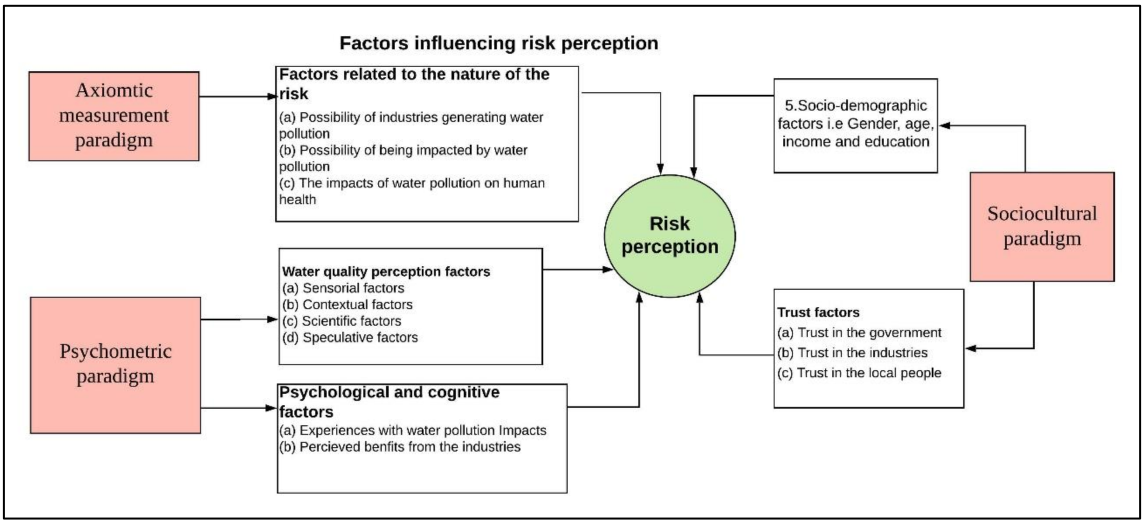

Figure 3.1 Conceptual framework of the study

3.3 Methodology

3.3.1 Methods used for data collection

This study used a mixed research approach with questionnaires and informal interviews. A pilot survey involving 50 respondents was conducted to determine the effectiveness of the questionnaire in meeting the objectives of the research, determine whether the selected variables and factors selected to represent risk and risk perception were comprehensive, and ascertain whether the target respondents could understand and interpret the questions easily. The pilot survey results indicated that there was a need to administer the questionnaire in the local language (Kalenjin (The Kalenjin language is a southern Nilotic language spoken in Kenya, mostly by the Kalenjin tribe)) or the national language (Kiswahili) in cases where there was difficulty in reading and writing in English. After the pilot survey was completed, the actual survey was conducted, and a total of 350 questionnaires were administered randomly to the communities residing along the River Sosiani and to the workers in factories along the river. In total, 246 questionnaires (70.2%) were returned fully completed and were used in the data analysis. The participants included in the study were divided into three groups. The first group comprised respondents located midstream and downstream around the town area where the factories were located, who throughout the study are referred to as downstream inhabitants/respondents. The second group consisted of respondents upstream, whose main activities involved agriculture and farming, and they are referred to as upstream inhabitants. Finally, the factory group comprised respondents working in the factories throughout the region. The selection of factories was made based on their proximity to the River Sosiani, and only major textile industries in the region were surveyed. The factories selected were both private and government-owned, as long as they allowed the study to be conducted within their premises; in total, three factories agreed to participate in the study. For the inhabitants located upstream and downstream, the questionnaires were randomly distributed, while the questionnaires administered in the factories were dropped off at the trainers’ offices, to human resource managers, or at the factory gates, as instructed by the administration. The survey forms were collected after one week or as advised by the responsible personnel. Accordingly, follow-up was done to collect any unreturned questionnaires.

3.3.2 The questionnaire design

The questionnaire was developed based on selected variables and factors obtained from previous studies and investigations on risk perception. In order to compare different groups, each respondent received the same set of questions. Where relevant, additional questions were added which were specific to one group (e.g., the number of years working in the industry). Items related to collecting general socio-demographic information included gender, age, educational level, occupation and income. Additionally, information about the number of family members working for the local industries in the area, the name of the industries, the position held and the number of years working in the industry was collected. A five-point Likert scale, using a single select method ranging from 'Not at all' = 1 to 'Very high' = 5 was employed to measure the variables to the questions discussed below.

In terms of risk perception, a total of eight questions were used to determine the degree of risk according to the respondents. The set of questions was based on the pilot survey that contained in-depth discussions and interviews to help determine the questions that could be used to measure risk perception of respondents in the area, unlike previous research in which relevant characteristics and rating scales have been based on a literature review. Furthermore, some of the selected questions had been applied in previous research to measure risk perception. These questions included the impacts of industrial activity on their careers; their health; worry about their future life as a result of increased industrial activities in the area; potential diseases, such as cholera, typhoid and cancer caused by the poor water quality in the area; and the potential nuisances caused by the smelly and noisy activities of the industries, congestion and traffic jams. The respondents were also asked a direct question aimed at measuring the degree of perceived risk based on the water quality in the area, i.e., perceived level of risk based on the quality of water, which was measured using a Likert scale ranging from 'None' = 1 to 'Very high' = 5. The results from all the variables were summed up and calculated as a mean score representing a degree of risk perception, with higher scores indicating higher perceived risks.

Information on the main source of water for daily use was collected to determine the water usage in the community. To determine the importance of the river to the residents, a dichotomous question with a 'yes' or 'no' response was used. To assess the factors affecting the respondents' perception of water quality, four factors were assessed, namely, sensorial (factors based on the basic senses), contextual (factors based on a particular context), scientific (factors based on evidence) and speculation (factors based on opinion, intuitive judgement or guessing). All the parameters in each of the factors were summed up and calculated as a mean score representing each variable. The respondents were asked to rate the level of importance of these parameters when making judgements about the water quality of the River Sosiani. The parameters for each of the variables were as follows: (a) sensorial factors based on the taste, colour and smell of the water, as well as the age of the different types of pipes (visual aspect of sensory factors). (b) Contextual factors based on the presence of refuse in the water and along the riverbank, the presence of fish in the river and the presence of sewer lines nearby. (c) Scientific factors based on knowledge of water-polluting chemicals in the river through hearing or reading about scientific findings proving that the water is not clean. (d) Speculation and feelings based on observed changes in water quality, an intuitive sense that the water is not clean and hearsay regarding people becoming ill after using the water.

To measure trust factors, the respondents were asked to rate the degree of trust they had in three institutions. As well as the perceived ability of, the following: (1) the government and its capacity to control risk through water pollution management in the area, (2) the industries' capacity to protect and manage water pollution in the area and (3) the local people's capacity to manage and control risks in the area. In terms of the last factor, the question was set to gauge the level of control the community members felt towards managing water pollution in the area through collective actions, such as riverbank clean-up, and sustainable practices concerning water management. Higher scores indicated greater trust in the selected institution's ability to manage risk in the area. Three questions were used to assess the effects of factors related to the nature of the risk. The respondents were asked to rate the following: the possibility of industries generating water pollution, the possibility of being affected by water pollution and the impacts of water pollution on human health, i.e., when judging risks. For the psychological and cognitive factors, two items were used, namely, the perceived benefits from industries and previous experiences with water pollution in the area.

3.3.3 Statistical analysis

In order to understand, compare, characterise and draw conclusions about the three groups, multiple statistical methods were used to analyse the data. Analysis of Variance

(ANOVA) was applied to identify significant differences in risk perception among the three groups and determine what group had higher risk perception scores. Mean scores analysis was used to characterise the inhabitants of the three groups and provide possible explanations for the results obtained. For further characterisation, Pearson correlation analysis was conducted to identify the relationship and direction of the dependent variables (risk perception) and the independent variables i.e. water quality perception factors, trust factors, psychological and cognitive factors, nature of environmental risk and socio- demographic factors (see Figure 3.1). Thereafter, partial correlation analysis was conducted to identify the relationship between risk perception (dependent variable) and all the other independent variables, without the influence of sensorial factors. This is because sensorial factors were the only significant risk predictor common among all the three groups and understanding the contribution of the other independent variables would help in further characterising the groups. These analyses helped provide an understanding of the groups and why certain predictor variables were selected by each group. Multiple regression analysis was then conducted to identify the factors determining risk perception (dependent variable) among the selected predictive factors (independent variables), such as water quality perception factors, trust factors, psychological and cognitive factors, nature of environmental risk and socio- demographic factors (gender, age, income and education levels). The regression analysis helped to make conclusions about the characteristics of the groups, and possible explanations for why certain predictor variables were dominant for each group were highlighted and described in detail. Finally, based on these results and in-depth discussions, recommendations for including public participation in risk communication were provided.

3.4 Results and Discussion

3.4.1 Descriptive statistics of the respondents

The overall ratio of male to female respondents was 124 (50.4%) males to 122 (49.6%) females. Gender did not vary significantly amongst the three groups as shown in Table 3.1; however, there was a slightly bigger difference in the ratio for males vs. females for upstream inhabitants compared to the other groups. There was a notable difference in educational levels amongst the groups: there were three and one respondents from the downstream and upstream respondents respectively without education, whilst in the factory group had no count for the no education level category meaning that, all of the respondents had some level of education. The factory group also had the highest number (N = 45) of respondents who had tertiary education compared to downstream respondents (N = 30) and upstream respondents (N = 25), as presented in Table 3.1.

The largest variation in the sample was found in average household income. In general, the highest incomes ranged between 0–20,000 Ksh (Kenyan shilling: the currency used in Kenya—1USD= 100.3 Ksh) amongst 73.2% of the population surveyed. In the no-income category, downstream (N = 25) and upstream (N = 17) had the highest numbers, whilst there were only two respondents in the factory group. These two respondents were registered as attachés in their occupation, which explained their lack of earnings. The findings suggested that a significant population of the respondents did not have any income and still lived below the poverty line (US $1.90 per day in 2011 purchasing power parity PPP). Whilst the monetary and non-monetary poverty indicators of Kenya show that Kenya performs better than most Sub-Saharan countries, given the overall income levels and poverty rate, human development indicators are still relatively high, indicating

Table3. 1. Summary statistics of demographic characteristics.

	Factory Group		**Upstream Inhabitants**		**Downstream Inhabitants**	
	Count	%	Count	%	Count	%
Female	46	51.7	30	42.3	46	53.5
Male	43	48.3	41	57.7	40	46.5
Education:						
No education	0	0	1	1.4	3	3.5
Primary school	7	7.9	8	11.3	18	20.9
Secondary school	37	41.6	37	52.1	35	40.7
Tertiary Level	45	50.6	25	35.2	30	34.9
Age						
(20–29)	43	48.3	31	43.7	26	30.2
(30–39)	35	39.3	33	46.5	41	52.3
(40–49)	7	7.9	5	7.0	12	9.3
(50–59)	2	2.2	0	0	3	3.5
(60+)	2	2.2	2	2.8	4	4.7
Income in Ksh [1]						
(No income)	2	2.2	17	23.9	25	29.1
1–20,000	59	66.3	42	59.2	35	40.7
20,001–40,000	17	19.1	8	11.3	16	18.6
40,001–60,000	6	6.7	2	2.8	5	5.8
60,001–80,000	2	2.2	1	1.4	0	0
80K+	3	3.4	1	1.4	5	5.8
Observations	89		71		86	

[1] Ksh—Kenyan shilling, the currency used in Kenya.

that Kenya performs better on non-monetary dimensions of poverty. To cope with this challenge, the population resorts to acquiring casual jobs, such as laundry cleaning and manual labour, which are not steady. When these jobs fail to provide any consistent income, they rely on growing crops to feed their families and to purchase food and other daily necessities, as evidenced by the results.

Table 3.2 presents the distribution of families with members working in local industries in the area. As can be seen, upstream inhabitants had the highest number of families (N = 55) with no members working in the local industries. The count for downstream inhabitants was N = 35 families, whilst the factory group had at least one family member working for local industry, as expected. This count included respondents working for local industries as well as any other family member of the household. Another notable difference amongst the groups was the varied response in the factory population on the numbers of year lived in the community. Most of them indicated that they lived temporarily in the region or had just relocated based on job opportunity, with no intention of staying in the region for long periods of time. For downstream and upstream respondents, most of the respondents had lived in the area their whole life.

Table 3.2 Number of people working in local industries per family in different groups.

Count	0	1	2	3	4	5	6	Total (N)
	Number of Family Members Working for Local Industries							
Group								
Factory	0	71	11	5	1	1	0	89
Downstream	35	23	16	9	2	0	1	86
Upstream	55	7	5	3	1	0	0	71
Total	90	101	32	17	4	1	1	246

3.4.2 Characteristics of the different groups of respondents: mean scores analysis

To further determine the characteristics of each group, mean scores and standard deviation analysis of the independent variables was conducted (see Table 3.3). From the mean scores, the following conclusions about the three groups can be derived. First, the respondents in the factory group had experiences of water pollution in the area based on the mean scores for experiences with water pollution (M = 3.966, SD = 0.804). However, despite these experiences, they rarely felt that their health was threatened based on the low mean scores for the variable impact of water pollution on human health (M = 3.112, SD = 1.172). This could be attributed to a number of factors, such as their limited experiences of water pollution given that most of them could be living outside the region and only working seasonally in the area. For example, expert skilled workers are hired occasionally and would only live in the area temporarily. Such situations would lower their experience of water pollution in the area. Furthermore, the possibility of a stable income and the ability to afford basic utilities, such as clean water, cannot be ignored.

This is because members of this group mostly generate stable incomes and can afford better health and water services. Second, the factory group respondents felt a sense of responsibility in managing risks in the area based on the trust mean scores: despite the high placement of trust in the government's capacity (M = 4.247, SD = 1.376), compared to that of industry (M = 4.169, SD = 1.236), this group felt that industries should also manage risks in the area and possess some capacity to manage the risks.

The findings suggest that the adverse impacts of water pollution in the area are felt by the respondents downstream. This is based on the highest mean levels for the following variables: the possibility of industries generating water pollution (M = 4.279, SD = 0.929), the possibility of being impacted by water pollution among the three groups (M = 4.395, SD = 0.858) and the impacts of water pollution on human health (M = 4.407, SD = 0.742). Although the mean levels for the variables of experiences with water pollution and the impacts of water pollution on human health had slightly lower mean scores compared to the two other groups (M = 3.884, SD = 1.522), the high standard deviation suggests that the result was not a generalised feeling. Based on the trust scores for industries (M = 4.326, SD = 0.789), these findings also imply that the respondents in this group placed the responsibility for managing the water problems on industry, with whom they assumed the responsibility lay. Given that industries had been identified as major polluters in their area, the people may well have expected them to manage the situation.

From the analysis of the upstream inhabitants, we can see that the effects of water pollution in the area cut across all sections of the river, not only the industrial zones. The variable experiences of water pollution had the highest score among the groups (M = 4.085, SD = 1.432), thus supporting the main observations stated above. This is because the respondents in this group are located mostly upstream, where a combination of other factors not necessarily industry-related could be responsible for water pollution, for example agricultural sources and domestic sources of water pollution. This finding is a potential indication that urgent action is needed to remedy the water pollution problem in the river. Furthermore, this finding suggests an opportunity to find a common ground of understanding among the three groups and provides a starting point for collaboration, while understanding the background of the main stakeholders, which is critical in promoting public participation. Notably, scientific factors ranked the highest among the respondents in this group (M = 3.923, SD = 0.607), thus asserting the importance of having better scientific knowledge and understanding of these factors. The overall analysis demonstrated that sensorial factors had the highest mean scores (M = 4.434, SD = 0.694) in all the groups, thus emphasising the importance of these factors in the formation of public perception of water quality. These findings agree with those reported by Sharma et al. (Sharma et al., 2018), who also found that, in the independent variables in their analysis, these factors emerged as the most important factors in the formation of public perception of water quality in the areas surveyed. Moreover, de França Doria (2010) found that sensorial information has an important role in quality perception and risk perception when assessing water quality. In the current study, the overall results for speculative factors, trust in the government and trust in industry were high (Table 3.3).

Table 3.3 Mean scores and standard deviations of risk perception and influencing factors.

	Factory group N=89		Downstream inhabitants N=86		Upstream inhabitants N=71		Overall N=246	
Variables	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Risk perception	4.354	0.365	4.606	0.371	4.039	0.389	4.351	0.436
Gender[1]	1.48	0.503	1.47	0.502	1.577	0.497	1.500	0.501
Age	31.22	8.602	34.21	10.011	32.056	9.339	32.510	9.378
Income	22000	23400	21700	35900	13100	16400	19300	27200
Education[2]	3.427	0.638	3.070	0.837	3.211	0.695	3.240	0.742
Sensorial factors	4.581	0.508	4.314	0.840	4.394	0.677	4.434	0.694
Contextual factors	3.966	0.641	3.616	1.070	3.662	1.133	3.756	0.968
Scientific factors	3.772	0.961	3.597	1.261	3.923	0.607	3.754	1.003
Speculative factors	4.266	0.493	3.837	0.987	4.042	0.662	4.052	0.764
Trust in the government	4.247	1.376	4.163	0.824	3.817	1.324	4.090	1.203
Trust in the industries	4.169	1.236	4.326	0.789	3.887	1.076	4.140	1.061
Trust in the local people	3.573	1.658	3.558	1.369	3.451	1.556	3.530	1.527
Possibility of industries generating water pollution	3.966	1.283	4.279	0.929	3.056	1.698	3.810	1.402
Possibility of being impacted by water pollution	3.112	1.172	4.395	0.858	2.958	1.292	3.520	1.283
Impact of water pollution on human health	3.483	1.407	4.407	0.742	3.789	1.158	3.890	1.201
Experiences with water pollution	3.966	0.804	3.884	1.522	4.085	1.432	3.972	1.276
Perceived benefits from industries	3.910	1.379	3.756	1.564	3.634	1.376	3.780	1.444

[1] Gender is a dummy variable that takes the value of 1 when the subject is male and 2 when female. [2] Education is a dummy variable that takes the value of 1 for no education, 2 for primary school, 3 for secondary school and 4 for tertiary level

3.4.3 Risk perceptions amongst the groups

As presented in Tables 3.4 and 3.5, the three groups exhibited high risk perceptions. The results of the Pearson's correlation analysis (Table 3.5) also revealed that most of the perception variables were positively correlated with one another. The Bartlett's test of sphericity and the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy analysis revealed high correlations amongst the variables (KMO = 0.635, Bartlett's test of sphericity = 310.819, df = 28 and p = 0.000). The sampling is deemed sufficient or adequate if the KMO value is larger than 0.5 (Andy, 2000) or if the value is 0.6 and above (Pallant, 2013). Therefore, these variables could be used to analyse risk and indicate a degree of risk perception.

The mean scores of risk perception exhibited by the three groups were compared (Table 3.4), and the differences were statistically proven. Based on the one-way ANOVA between groups, there was a statistically significant difference amongst the three groups (F (2243) = 46.482, p = 0.000). Tukey's post-hoc test also revealed a statistically significant difference amongst the groups, concluding that the three groups assessed risk perception differently based on their locations and other factors. Respondents located downstream had a significantly higher risk perception compared to respondents located upstream and the factory group, as shown in Table 3.4. These results suggest that risks perceived by the respondents are related to the degrees of water pollution in the area, as indicated by the experts (correspondent, 2014; Ontumbi, 2015 July; Sharon, 2014).

Table 3.4 Results of Tukey's post-hoc analysis showing differences in risk perception amongst the groups.

				Mean Difference (Comparison within the Groups)		
Group	N	Mean	SD	Factory	Downstream Inhabitants	Upstream Inhabitants
Factory group	89	4.354	0.365	-	0.252 *	−0.315 *
Downstream inhabitants	86	4.606	0.371	−0.252*	-	−0.567 *
Upstream inhabitants	71	4.039	0.389	0.315*	0.567 *	-

Notes: Tukey HSD (Honestly significant difference) F = 44.688, p = 0.000. * The mean difference is significant at the 0.05 level.

3.4.4 Multiple regression analysis and correlation analysis

The Pearson correlation method was used to measure the correlations between the dependent variable risk perception and the independent variables presented in Table 3.6. The partial correlation analysis between risk perception and the independent variables, (gender; age; education; contextual, scientific and speculative factors; trust factors; the nature of environmental risks; and psychological and cognitive factors as controlled by sensorial factors) was conducted to determine the strength and direction of the linear relationship between risk perception and all other independent variables without the effect of sensorial factors. This is because, amongst all the variables, sensorial factors are the only variables that predicted risk in all the groups; thus, there is a need to determine the influence of other factors on risk perception after eliminating the sensorial factors. All these hypothesised predictors of risk perception were also analysed based on linear regression.

Table 3.5 Correlation coefficients of risk perception variables.

Variable	1	2	3	4	5	6	7
What is the perceived level of risk to your life, based on the water quality in the area?	1						
Have industrial activity in the area impacted your career in anyway?	0.017	1					
As a result of industrial development do you feel worried about our health?	0.015	0.565**	1				
As a result of industrial development do you feel worried about your future life in the area?	0.254**	0.162*	0.018	1			
Has water quality in the area led to water related diseases amongst the residents?	0.042	0.336**	0.314**	0.12	1		
Has water quality caused several kinds of cancer amongst the residents?	0.02	0.094	−0.043	0.009	0.171**	1	
Have industrial activities in the area led to nuisances such as noise, smell, etc.?	−0.022	0.154*	0.007	0.084	0.356**	0.360**	1
Has the current condition of the community caused nuisances, such as traffic jam, congestion, etc.?	−0.151*	0.306**	0.468**	−0.043	0.306**	−0.022	0.077

Note: * $p < 0.05$. ** $p < 0.01$.

The ENTER method of variable selection was adopted during the regression setup, and the multi-collinearity was examined based on the extracted variance inflation factors (VIFs) (Table 3.7). All the VIFS obtained were less than 5 (i.e., the acceptable threshold was 10 (Hair et al., 1998)); thus, we concluded that the selected variables exhibited acceptable multi-collinearity.

Meanwhile, the results of the multiple regression analysis showed that the three groups used different predictor variables to determine risks in the area. In the factory group, the results showed that sensorial factors, trust in the government's capacity to manage water pollution and the severity of the impact of water pollution explained 56.1% of the variance in risk perception ($F (16, 72) = 5.745$, $p < 0.000$, adj R2 = 0.463). For downstream respondents, sensorial factors, the possibility of industries generating water pollution and previous experiences with water pollution were significant predictors that explained 65.9% of the variance in risk perception ($F (16, 69) = 8.346$ $p < 0.000$, adj $R^2 = 0.580$). For respondents located upstream, 37.05% of the variance in risk perception ($F (16, 54) = 1.980$, $p < 0.032$, adj $R^2 = 0.183$) was accounted for by risk perception predictors, including age, sensorial factors, trust in the government and the possibility of being impacted by water pollution. Of the predictor variables used, the nature of environmental risk factors and perception of water quality factors were significant predictors in all three groups. Meanwhile, psychological and cognitive factors were significant predictors of respondents located downstream.

Among the water perception factors, sensorial factors were risk predictors in all three groups. These results are consistent with previous studies, which emphasised the idea that sensorial factors mostly based on visual characteristics greatly influence people's perceptions when making judgements on water quality (Anadu et al., 2000; Sharma et al., 2018). In as much as contextual, scientific and speculative factors may have been presumed to have an influence on risk perception (Sharma et al., 2018), these factors did not significantly predict risk perception in any of the three groups in the current study. The Pearson's correlation analysis results (Table 3.6) of the variables (sensorial factors, contextual and speculative factors) indicated positive correlations with risk perception. On the other hand, scientific factors were negatively correlated with risk perception and also had a negative beta coefficient in the regression analysis (Table 3.7), implying that increased scientific knowledge led to decreased risk perceptions amongst the respondents in all the groups. Additionally, for scientific factors, when sensorial factors were controlled in the partial correlation analysis, there was a notable difference in the coefficient changes for downstream respondents and upstream respondents (Table 3.6). For the downstream inhabitants, there was a significant increase in the absolute values for the correlation coefficients of scientific factors. Contrastingly, difference in change for scientific factors and education was smallest for the upstream respondents. The results indicate that differences in change could possibly indicate a difference in the interpretation of scientific factors between the respondents in the two groups, specifically suggesting that upstream respondents understood or interpreted these factors much better compared to downstream respondents. Based on the location and characteristics of respondents located upstream, such as consistent practices of agriculture coupled with the use of chemicals, which require some level of scientific understanding, this observation is not surprising. This difference in understanding of scientific knowledge underscores the importance of effectively educating the public and promoting scientific knowledge when conducting environmental awareness programs and promoting public participation activities.

Table 3.6 Bivariate and partial correlations of the three groups

	Bivariate Correlation	Partial Correlation	Bivariate Correlation	Partial Correlation	Bivariate Correlation	Partial Correlation
	Factory		Downstream inhabitants		Upstream inhabitants	
Risk perception	1.000	1.000	1.000	1.000	1.000	1.000
Gender	0.017	0.022	0.103	0.078	−0.016	−0.020
Age	0.011	−0.049	0.006	0.021	−0.259 *	−0.254
Income	−0.175	0.077	−0.124	−0.101	−0.149	−0.121
Education	0.167	−0.086	−0.066	−0.176	−0.128	−0.130
Contextual factors	0.149	0.061	0.079	0.026	0.01	0.025
Scientific factors	−0.018	−0.114	−0.113	−0.322	−0.076	−0.124
Speculative factors	0.292 **	0.083	0.031	−0.198	0.16	0.091
Trust in the government	−0.199	−0.355	−0.043	−0.062	−0.156	−0.357
Trust in the industries	−0.134	−0.147	−0.416 **	−0.325	−0.028	−0.011
Trust in the local people	−0.085	−0.245	0.111	0.152	−0.003	−0.007
Possibility of industries generating water pollution	−0.017	−0.250	0.208	0.267	0.167	0.152
Possibility of being impacted by water pollution	−0.097	−0.099	0.213 *	0.291	0.085	0.088
Impact of water pollution on human health	0.366 **	0.314	0.05	0.070	0.046	0.042
Experiences with water pollution	−0.273 **	−0.118	0.048	0.158	0.18	0.178
Perceived benefits from industries	−0.148	−0.226	0.081	−0.016	0.027	0.011
Sensorial factors	0.599 **		0.704 **		0.146	

Notes: * $p < 0.05$. ** $p < 0.01$.

Table 3.7 Results of regression analyses of predictor variables for environmental risk perception

	Factory Group			Downstream Inhabitants			Upstream Inhabitants		
Independent Variable	Beta	Std. Error	VIF	Beta	Std. Error	VIF	Beta	Std. Error	VIF
Gender	0.028	0.067	1.385	0.058	0.059	1.295	0.021	0.096	1.301
Age	−0.077	0.004	1.318	0.003	0.003	1.318	−0.298 *	0.005	1.185
Income	0.127	0	1.243	−0.057	0	1.319	−0.199	0	1.679
Education	−0.062	0.051	1.287	−0.128	0.036	1.317	−0.058	0.079	1.713
Sensorial factors	0.554 **	0.081	2.104	0.692 **	0.036	1.323	0.566 *	0.136	4.811
Contextual factors	0.166	0.078	3.073	0.082	0.03	1.499	0.256	0.066	3.178
Scientific factors	−0.197	0.064	4.693	−0.109	0.032	2.369	−0.076	0.107	2.407
Speculative factors	0.116	0.101	3.042	−0.094	0.034	1.7	−0.125	0.118	3.433
Trust in the government	−0.224 *	0.024	1.325	−0.003	0.047	2.204	−0.538 **	0.046	2.108
Trust in the industries	−0.108	0.025	1.19	−0.174	0.046	1.955	−0.065	0.044	1.289
Trust in the local people	−0.058	0.037	4.532	−0.073	0.026	1.88	−0.296	0.069	6.443
Possibility of industries generating water pollution	−0.176	0.046	4.243	0.207 *	0.033	1.419	0.169	0.028	1.27
Possibility of being impacted by water pollution	0.206	0.024	1.39	0.048	0.039	1.665	0.256 *	0.037	1.269
Impact of water pollution on human health	0.037 *	0.028	1.37	0.041	0.049	1.935	0.227	0.093	6.616
Experiences with water pollution	−0.045	0.044	1.568	0.174 *	0.02	1.412	0.217	0.038	1.691
Perceived benefits from industries	0.105	0.045	4.669	0.03	0.018	1.171	0.06	0.063	4.313
R^2	0.561			0.659			0.37		
F	5.745			8.346			1.98		

Notes: * $p < 0.05$. ** $p < 0.01$. Std.Error = Standard error

The nature of the risk factors was also significantly related to how the respondents made risk judgements. Similar to the findings of Janmaimool and Watanabe (Janmaimool & Watanabe, 2014) and Barseghyan et al. (Barseghyan et al., 2013), the nature of the risk highly influences the public's risk perception; hence, the respondents may use self-appraisal to judge and perceive risks (Barseghyan et al., 2013; Janmaimool & Watanabe, 2014; Scherer, 1990). Respondents located downstream, judged risks based on the perceived possibility of water pollution generated by industries. A possible explanation for this could be the fact that downstream respondents are located in the town centre where many industries that pollute the river are located, thus influencing their judgment and risk perceptions. Furthermore, the correlation analysis for the possibility of being impacted by water pollution is significantly correlated with risk perception, and the partial correlation analysis of the correlation coefficient for this variable increases significantly. This finding indicates that their interaction with water pollution adversely affects their lifestyle, possibly through the contamination of drinking water, loss of aesthetic value of the river and health impacts, thus explaining their overwhelming experiences of water pollution in the area.

Meanwhile, respondents located upstream, judged risks on the probability of being impacted by water pollution, whilst the factory group judged risks by considering the impacts of water pollution on human health, whose variable was also significantly correlated with risk perception. Based on the correlation analysis results, these findings indicated that respondents in this group were worried about their health and had higher risk perceptions, as indicated by the negative correlation coefficients of the possibility of being impacted by water pollution and the possibility of industries generating water pollution.

The risk perceptions exhibited by downstream respondents were not only determined by factors related to the nature of environmental risk but were significantly influenced by the psychological and cognitive factor of having experience of water pollution. A plausible explanation for the selection of this variable would be that, because the river flows in this area, the collected waste upstream from agricultural activities (amongst other activities) and the water pollution generated by the industries result in extreme pollution. Hence, downstream inhabitants had more experiences of possible adverse effects compared to upstream inhabitants.

Meanwhile, the perceived benefits from industries were not significant predictors of risk perception in any of the groups. These findings are in contrast to those of previous studies, which found a significant relationship between perceived benefits and risk perception, revealing that perceived benefits may result in greater acceptance of risk (Gregory et al., 1993; McDaniels et al., 1997; Michael Siegrist et al., 2000; Sparks et al., 1994). A possible explanation for these discrepancies would be that respondents in these regions do not simply accept risks based on any possible benefits they obtain from the industries in the region but are rather rational in their risk judgement formation.

The regression analysis for trust factors revealed that trust in management authorities, especially in the government, had a high influence on risk perception for the upstream respondents and the factory group. This variable was negatively associated with risk perception in both groups, thus suggesting that increased trust in the government lowered the risk perception of the respondents. Additionally, this variable was negatively correlated to risk perception (Table 3.6). These findings are similar to those of Ross et al. (Ross et al., 2014), who determined that increased trust in the fact that authoritative bodies, such as the government, can deliver better water services was generally associated with lower risk perception. In addition, other studies also identified trust as a characteristic of risk perception in various forms (Wang et al., 2016). In fact, trust in authorities could also be attributed to other factors, such as expectation of government ion them against risks and confidence in the government's capacity to manage risks. Other factors, such as knowledge, could also influence trust factors. According to Siegrist et al. [16], the higher the knowledge of the respondents, the greater the insights they have into the effectiveness of the actions performed by the authorities to protect them against risks. With the factory group containing the majority of educated people in the sample, i.e., the highest number of respondents with tertiary education and no respondents with no education (Table 3.1), this would explain why risk perceptions of the respondents in this group were influenced by trust in the government variable. Additionally, higher levels of scientific knowledge and better understanding of these factors amongst the upstream inhabitants explains their selection of this variable.

For respondents located downstream, trust factors were not significant risk predictors. A plausible interpretation of this result could be that adverse experiences of water pollution without any changes over time have led to a sense of hopelessness, resulting in misplaced trust or no trust at all in the idea that they can be protected against the perceived risks. The results indicating that the people basically trust the government to manage and regulate risks in the area, especially the respondents located upstream and in the factory group, can provide an opportunity for the government to advocate for better water practices in the region, especially amongst the locals and those working in the industries, in order to alleviate the current crisis. There is no doubt that higher trust in regulators results in the ready acceptance of policies, changes or technologies (Bronfman et al., 2008; Irwin, 2009; Ormerod et al., 2013; Viklund, 2003) when proposed or initiated by such regulators.

Meanwhile, age was only a significant risk predictor in one group (i.e., upstream) in which it exerted a significant negative effect on the respondents' risk perception: the older respondents had lower risk perceptions compared to the younger respondents. This finding is significantly consistent with those presented in previous research (Aziz et al., 2006; Dosman et al., 2001), which indicate that an individual's age influences his/her risk perception. In the correlation analysis in the current study, age was also significantly correlated with risk perception amongst the upstream respondents.

3.5 Implications for promoting public participation

In prior studies on risk and risk perception, risk perception was identified as a complex process that is influenced by a myriad of factors, as has been highlighted in this research. For risks to be effectively managed, proper risk communication that involves widespread consultation is vital; however, it can only be effective if the contributions of the affected public, other stakeholders and experts are considered and better communication strategies are developed to communicate the risks (Reid, 1999). In this way, the different viewpoints of each party can be comprehensively assessed and understood. The results of the study suggest that the perception of the sources of pollution among the groups is largely based on personal experience and that their preferences vary geographically. This highlights the necessity of undertaking surveys and focused group discussions, in order to acquire useful insights into knowledge, public perceptions and preferences before planning any interventions in the area. As revealed in the discussion section, each of the three groups had different characteristics that uniquely influenced their interpretation and perception of risks. For instance, respondents located downstream have had multiple experiences with water pollution, making them more desperate than others. However, the upstream inhabitants seem to understand the causative pollutants of the river in their region according to different age groups and to have a better understanding of the effects of their actions and their implications on the ongoing water pollution in the river. The factory group also seems to understand and acknowledge water pollution in the area. However, they are more worried about their health and are inclined towards letting the government handle the issue at hand. In accordance with these findings, an understanding of the perceptions of each group could help authorities address the major issues in the area based on the needs of the particular community. Perceived risk among the groups was hardly uniform; the respondents situated downstream and closer to the industries exhibited the highest risk perception among the three groups, while unexpectedly the community located upstream exhibited a relatively higher risk perception, indicating pollution of the river across all sections. This finding underlines the urgency for remediation and river clean up in the area. The prior assumption that only downstream sections of the river need urgent action was proven false in the study, as the results show that river pollution upstream is an issue of concern to those residents as well. Therefore, during the planning process, the whole river should be considered. The risk view of the factory workers added an interesting corollary to the narrative, as they appeared more concerned with their health and less about the repercussions of their actions on the environment, despite the small sense of responsibility in aiding risk management in the area displayed by the correlation and mean score results discussed earlier. With industrialisation on the rise in Kenya as countries are encouraged to be self-sustaining economically, the magnitude of environmental problems, such as industrial pollution, agricultural runoff, deforestation and flooding has increased. This industrial development has produced numerous severe problems, and exposure to environmental risk has particular significance since, if left unchecked, these problems will result in undesirable, possibly catastrophic, effects. The divergent views on industrial water pollution in this study highlight the key issue of what role public perception and participation should play in shaping risk management efforts. Understanding the patterns of risk perception among stakeholders is important because public perceptions of risks routinely influence the priorities and expenditure of regulatory agencies responsible for environmental oversight (Paul Slovic, 1997). Therefore, for risk management to succeed, public participation and the collaboration of all stakeholders is necessary (Baggett et al., 2006; Frewer, 1999). Furthermore, the understanding of and emphasis on the distinct characteristics of each group can be useful in designing solutions for the community. Another opportunity for the government and environmental agencies lies in encouraging behaviour change in the residents in the area. This is possible based on the fact that the results indicate that the populations surveyed have some knowledge and idea of the poor conditions in the River Sosiani and they have a clear understanding of the causes and effects of water pollution. Thus, based on this understanding, the residents in the area would be likely to be amenable to behavioural change that would benefit them.

Another critical issue lies in the differences in the interpretations and perceptions of risks among the three groups. Some studies agree that knowledge and familiarity (M. Siegrist et al., 2007) chelp to explain the differences in risk perception among groups, especially those between experts and lay people. The results of this study revealed that public perceptions regarding water quality are primarily based on sensorial parameters, which underscores the primacy of aesthetic factors in risk perception. On the other hand, the inability of the respondents to perceive water quality based on scientific factors could lead to the misestimating of the risks (Larson et al., 2009; Sharma et al., 2018). As highlighted by the correlation analysis, there was a difference in scientific knowledge among the groups, such that the respondents upstream seemed to be more scientifically aware of water quality parameters than the other two groups. Therefore, outreach and communication personnel attempting to communicate risks in the area should consider fostering a holistic understanding of the issues affecting water quality, with additional emphasis placed on the promotion of scientific knowledge through the use of compelling communication means and more comprehensible language. The study further suggests the sharing of existing scientific information about the water quality problem in the region with the residents to ensure that the community has a firm understanding of the scientific evidence related to the issues at hand. This would encourage the public to participate in activities aimed at addressing the issues affecting them. In conclusion, assessment and planning, experts' opinions, inclusive communication practices and public participation are all vital components of a successful risk management programme.

Another key consideration would be to engage influential actors, such as religious groups, local elected officials and community leaders, in promoting positive behavioural change among the community members. This would help in the community members being more able to relate to and accept proposed interventions, as opposed to relying only on the authoritative bodies to enforce behaviour change. Furthermore, for effective risk communication, community level engagement cannot be ignored (Larson et al., 2009).

It is also important to note that, particularly in risk perception studies, some reported results might be sensitive to the hazards and variables selected for each specific study. As neither, the whole region was covered in the study nor all the factories and factory workers employed therein, caution should be made when extending the results to other specific groups or regions, who are unlikely to have the same types of knowledge, cultural characteristics, or backgrounds as the sample in this study.

3.6 Conclusions

This study examined the factors that influence risk perceptions of water quality and whether there were distinct risk perceptions amongst different groups of people. Unlike previous studies, this study considers the possibility that working in certain industries has an impact on risk perception in general.

A set of predictor variables was used to assess the difference in risk perceptions and determine what each group of respondents used when determining such perceptions. As highlighted by previous studies, different groups of people determine risks in varying ways based on a number of factors. In this study, on the one hand the concept of 'experts' was redefined as workers in industry with some level of expertise because of their environment. The term 'lay people,' on the other hand, was redefined to mean all other residents not working for industry but residing within the region.

The results of this study revealed significant differences in risk perceptions among the three groups, with the residents located in the downstream area, characterised by many industries, registering higher risk perceptions compared to the other two groups. Similarly, in determining the risk perceptions in all the groups, the study found that each group used different predictors to assess risks in their water quality perceptions and in the nature of the environmental risk factors. Moreover, trust factors were significant predictors in the upstream and the factory group, while psychological and cognitive factors were significant predictors among the downstream inhabitants.

These findings imply the need to include the public in the decision-making process on issues affecting them. The common practice is to engage institutions and experts based on the industry's ease of access to these people; hence, fact-based decision-making has been the trend in relation to current projects in the country. To create long-term successful results, however, public participation and effective risk communication should be vigorously pursued in the area in order to ensure that multiple risk perspectives are taken into consideration in the implementation and management of water resources in the area. Furthermore, such collaborative efforts can lead to a deeper understanding of the perceptions of the community, which is critical to the process of risk management and decision-making, because members of the communities are the end receivers of the decisions made and the actions taken. In the end, environmental reclamation activities should strive to promote good environmental practices that are both sustainable and inclusive.

Chapter Three References

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CHAPTER 4: WILLINGNESS TO PAY AND PARTICIPATE IN IMPROVED WATER QUALITY BY LAY PEOPLE AND FACTORY WORKERS: A CASE STUDY OF RIVER SOSIANI, ELDORET MUNICIPALITY, KENYA

4.1 Introduction

In an effort to avert the water pollution crisis and ensure clean water for use to its citizen over the years, the government of Kenya has resorted to action measures tailored to restore river networks and diminish the negative effects of water pollution across the country. As discussed in chapter 1, the severity of water pollution especially in major river networks requires immediate attention. Rivers like river Sosiani are marred by high pollution levels form agricultural and organic pollution sources and contain pollutants like heavy metals from industries, toxic dye components and hospital waste. This has resulted in proliferation of water related diseases such as typhoid, declining water quality and water shortage in the area. The government of Kenya in an effort to avert this crisis, over the years has resorted to actions to save river Sosiani. For example, along River Sosiani, the government has initiated rehabilitation projects such as the Nandi Park Rehabilitation Project, which yielded temporarily results as the river continues to experience major water pollution issues. Such projects, among others in the country and other developing nations, mostly lack longevity and only have temporary success, as the rivers continue to suffer from continued decline in water quality. For such activities and initiative to succeed long-term, there has to be a clear evaluation of the public concerning the community's views, attitudes and behaviour towards environmental issues. With this understanding, solutions specific to the community can be reached.

In most cases, the solutions proposed to deal with such environmental issues involve changes in policies or policy evaluations that must be imposed on the citizens. However, the level of social acceptability is majorly connected to citizens' individual behaviors and attitudes (Tortajada et al., 2013). In order to reveal the citizens' attitudes towards environmental issues and policies, it is important to evaluate their behaviors and any factors influencing their understanding of environmental matters. This involves exploring explanatory factors such as social capital (Jones et al., 2011; Jorgensen et al., 2009; Tortajada & Joshi, 2013). Social capital factors include compliance with social norms, e.g. paying taxes for the protection of common goods among members of a community; social trust, i.e. trust between individuals; institutional trust, referring to trust in institutions, such as the government and social networks, i.e. the membership of individuals in organized activities. According to Solow (Solow, 1992), where social norms, such as additional taxes for environmental remediation are necessary, destitute nations appear to have a choice between cooperating in the degradation of their own environment and acquiescing in their own poverty. Recently, however, the argument that environmental quality should not be sacrificed for economic growth has been on the forefront, with emphasis upon acting and protecting the environment before it is too late (Mohan Munasinghe, 1992; Mohan Munasinghe, 1993). This has prompted developing nations to undertake environmental restoration projects.

To determine the welfare gains and benefits of these projects, there has to be some valuation of the ecosystem and its services. For water resources, this valuation is especially difficult because the benefits provided by improved water quality in an area do not have direct market value that can be immediately observed (Ndunda, 2018). However, there is a need to quantify the value of these resources because better knowledge of the value of clean water will lead to informed decisions by private and public sectors (Ndunda, 2018), resulting in economic implications, such as appropriate wastewater treatment approaches that can be taken into account. Additionally, assessing the monetary value of these resources provides the necessary information, including water use and availability, to help decision makers obtain the costs and benefits for any planned projects (Khan et al., 2019). This provides an opportunity to understand the public attitudes and preferences for environmental restoration, which are crucial in aiding the evaluation of alternative policies on environmental improvement. It may highlight the link between policy making and human behaviour regarding the natural ecosystem (Li et al., 2014). Finally, this valuation reveals the people's attitudes towards the future of the environment and future generations.

As discussed in chapter 2 literature review, in CVM, most studies employ convenient population samples mainly consisting of the lay people with minimal differentiation of the population under study. This is because the focus is usually the valuation of the resource in question. Those that attempt to focus on different groups have focused on gender differences, groups that have children as opposed to those without and populations located close to the resource in question as opposed to those far from it. Other studies have sought to analyze whether time and the scenarios presented to the respondents influence their decisions. The findings in all these studies have shown that different characteristics or groups of people think differently or are impacted directly by different phenomena. For example, the view that the more one is concerned with the risks associated with a poor-quality environment the more one is willing to pay for any improvements has been supported by a large amount of literature. Besides risk perception, socio-demographic factors including income, education, age and use of the resource in question influence an individual's WTP. For WTP studies that do not pay attention to lay people and focus on skilled workers instead, the attention has mainly been on occupational health and safety (House et al., 1979), social opportunity cost (Gupta, 1976) and health insurance premiums and wellbeing of the workers (House et al., 1979; Susairaj, 2019). Few of these studies have attempted to contrast this population to lay people and solicit their willingness to pay jointly. This group of respondents possesses unique characteristics, especially when they work in situations where their own actions are likely to have consequences on the public by exposing them to risks and contributing to increased environmental degradation. Furthermore, analyzing the viewpoints of this group and that of the lay people highlights the differences in attitudes, behaviour and beliefs of each group. This information is important, as it, helps identify the different characteristics of each group that determine how they make WTP decisions. Importantly, including this group can help alleviate problems in the community by encouraging them to comply to set laws and regulations that help minimize pollution or harmful effects to the community and correct an erroneous conception about their actions within the community. This can also bridge any existing gaps between the workers and lay people, where their actions are viewed as the cause of the problems in the community. Furthermore, for longevity and success of environmental efforts, there has to be an understanding of all stakeholders and parties involved so that all viewpoints can be analyzed and understood.

The interest of the paper is also linked to the fact that literature on this topic has majorly focused on WTP determinants but has not investigated the WTP differences when the proposed scenario is conducted by two different entities/institutions within different groups. The institution tasked with organizing environmental restoration projects matters.

For example, in a case where people may not place higher levels of confidence or trust in an institution proposing a project, this might influence their WTP or willingness to participate. Moreover, obtaining this information may provide insight into the longevity and success of the projects oriented towards a better environment, gauge the attitudes of the public towards different institutions in the society and highlight the public's valuation of the ecosystem and potential risks. It will also provide information to policy makers about the community's view of not on only environmental goods and services but also the different actors and stakeholders in the community. This information would enable decision makers to use favored stakeholders or actors to conduct community outreach activities to encourage public participation and finally acceptance and longevity of any efforts to remedy the environment. This information can also be of value to public decision makers in areas characterized by difficult governance due to either the presence of many stakeholders or the lack of support, by helping them come up with tailored strategies and action plans that better suit each group in the community.

Another critical element of our study is the analysis of respondents with zero WTP, especially protest zero responses, which are defined as responses that do not state the true WTP (Meyerhoff et al., 2008). A larger number of protest responses in WTP studies could be an indicator of the existence of certain factors such as moral or political attitudes, which should be substantiated. This not only helps reveal the correct WTP of the respondents and promote correct policy decisions but also reveals the characteristics of the respondents in question. In the past, a few studies that have been conducted in Kenya to gauge the WTP of respondents with regard to water resources (Brouwer et al., 2015; Samuel O Omondi, 2014; Samuel Onyango Omondi et al., 2014). In this paper, we present the first results of the research on willingness to pay (WTP) for river restoration of River

Sosiani in Eldoret Kenya and highlight the different determinants of WTP while exploring the impacts of different organizations or entities on the WTP. The present study also aims to contribute to the massive literature that exists on WTP and bridge the gap on the missing literature on factory workers and lay people as well as institutional scenarios pertaining to WTP.

4.2 Methodology

4.2.1 Study hypothesis

Based on the literature review of the determinants of willingness to pay and willingness to participate, two research hypothesis of interest were proposed for this study: (1) There is a statistical difference in WTP between the lay people and factory workers. (2) There is a difference in WTP1 and WTP2 between the groups.

4.2.2 Sampling and population sample

Prior to the actual survey, a pretest of 50 respondents was chosen to assist in the modification of the questionnaire and to determine the effectiveness of the questionnaire in interpretation and understanding. The pretest survey results revealed a need to administer the questionnaire in the local language *Kalenjin (a southern Nilotic language spoken in Kenya, mostly by the Kalenjin tribe) or the national language (Kiswahili) were used in cases where there was difficulty reading and writing in English. 300 questionnaires were administered randomly to the communities residing along the River Sosiani and the workers in factories along the river. The participants included in the study were divided into three groups. The first group comprised of respondents located midstream and downstream around the town area where the factories were located;

throughout the study, they are referred to as downstream inhabitants/respondents. The second group consisted of upstream inhabitants/respondents. Finally, the factory group comprised respondents working in the factories surveyed from the three factories that agreed to participate in the study. The factories were from both private and government sectors and chosen based on their close proximity to River Sosiani. Random distribution methods were utilized to fill in the questionnaire and used for upstream and downstream respondents. In the factory group, the questionnaires were collected after an agreed period from the trainers' offices, gates or human resource offices, with follow up collection where necessary.

4.2.3 Survey design and data collection

The questionnaire was designed to gather data on the respondents' understanding of water pollution in the area and their perceptions of water quality. To understand the socio-demographic characteristics of the respondents, information about their age, gender, number of family members, number of children under 18 years per family, income, occupation, education level, and the number of years lived in the community was collected. Additional information about water consumption sources and use was collected. Knowledge about the existence and importance of the river were also assessed. To assess the trust factors used in the study, the respondents were asked to state their level of trust toward (1) the government, (2) local firms and (3) fellow local people's capacity in managing water quality in the region through various community efforts. These were measured using a 5-point Likert scale, ranging from 1 = Not at all to 5 = Very high. The respondent's level of risk perception was also solicited in order to assess the impact on WTP and willingness to participate of the respondents. Three questions, using the 5-point

Likert scale, were selected to represent the respondents risk levels and perception. This were designed after the pilot survey had been conducted. These included (1) a direct question asking the respondents to state their level of perceived risk in their lives based on water quality in the area. (2) The extent to which they felt worried about their health as a result of water pollution in the area due to increased industrial activities. (3) The scope of impact i.e., the degree of impact through contracting diseases as a result of the declining water quality.

Additional information about the degree of industrial risk and the underlying understanding of risk related judgement was also collected for use in our other study (Mumbi et al., 2020). The willingness to participate and the contingent valuation question was presented in the final section of the questionnaire. A hypothetical scenario was provided, where the expected activities to be undertaken were listed out and the recurring benefits from these activities were clearly stated as follows:

Suppose that the County government and central government is considering implementing a program to ensure river Sosiani clean up in order to improve the water quality of the river through a proposed list of activities. The activities proposed include: cleaning the rivers through solid waste removal, removal of structures from the river, planting of trees along the river bank. The program would lead to major ecological benefits in the area such as improved water quality and water clarity in the river leading to improved water quality within the required standard. The river water will also be improved for use and in a much better condition as a result of the activities.

Thereafter, the respondents were asked to state if they would participate in such a programme, using a 5-point Likert scale ranging from 1 = Very likely to 5 = Unlikely.

The respondents were asked, using a dichotomous choice question, to state if they were willing to pay an additional fee collectable every month to support the program in the area and, if yes, what amount they were willing to contribute, i.e. WTP1. A similar question was asked to determine the amount if another organization beside the government was responsible for the programme, termed as WTP2. The respondents who answered yes were asked to state their reason for supporting the program. To understand the zero responses, the respondents who answered no were also asked to select reasons for their responses from a number of choices aimed at identifying protest voters. Respondents who made the following choices were considered as non-protest votes: “The program would not be worth anything to me”, “I cannot afford to pay for the restoration of the river” and “I am planning to relocate”. While respondents with the following choices were considered protest votes: “It is unfair to expect me to pay for this program”, “I do not think this program would work”, “It is the responsibility of the government” and “I object to this question”. Respondents could also choose “Other” for specifying other reasons and write in their reasons.

4.2.4 Statistical analysis

Multiple statistical analyses were performed in the study to achieve different objectives. Analysis of Variance (ANOVA) was applied to identify significant differences in WTP among the three groups. To compare and identify characteristics of each group of respondents, mean scores and standard deviations of the independent and dependent variables were analyzed. To measure the willingness to participate and its influencing factors, ordinal regression analysis was employed using IBM SPSS version 25. The willingness to participate was used as the dependent variable and selected variables (gender, age, income, education levels, the number of years lived in the community, the number of children, risk perception variables and trust factors) as the independent variables. To measure WTP and its influencing factors, the double-hurdle model was used and estimated using Stata version 16; StataCorp, which has an inbuilt command to run the analysis. WTP1 (amount when the government is running the project) and WTP2 (amount when other organizations, such as local NGOs or community groups that are not government-related are running the project) were used. In both the analyses, the dependent variable was the WTP amount and the independent variables were gender, age, income, education levels, the number of years lived in the community, the number of children, risk perception variables and trust factors. Zero responses were also analyzed to better understand the respondents and highlight their characteristics to provide better recommendations using the results.

4.2.5 Double-hurdle model specification

In order to satisfy the normality assumption of the model, as in previous studies, the dependent variable (WTP) was transformed into a logarithmic function so as to avoid the conversion of the zeros into missing values after transformation (Angula, 2010; Shumeta et al., 2018). The model requires explanatory variables to be included in the two hurdles. This selection is arbitrary and does not rest on any set theory (Aristei et al., 2008). Following previous research, the study selected the explanatory variables to be included in each hurdle in the model. Moreover, including the same set of explanatory variables in each hurdle makes it difficult to correctly identify the parameters of the model. Thus, exclusion restrictions must be imposed (Aristei & Pieroni, 2008; Newman et al., 2003). In previous studies, the first hurdle is usually assumed to be a function of noneconomic factors affecting the household’s decision. Hence, economic variables, such as income, can be excluded from this hurdle. According to Pudney and Yen (Pudney, 1989; Yen, 2005), this move is motivated by the discrete random preference theory, according to which sample selection is determined exclusively by noneconomic factors. This is in line with previous studies that have justified the inclusion or exclusion of certain factors, such as economic, demographic and sociological factors (Aristei & Pieroni, 2008; Balli et al., 2017; Krishnamurthy et al., 2016; Pudney, 1989; Yen, 2005). Based on the claims above and the gathered evidence, we excluded some variables in the first hurdle based on the fact that our independent variables were aimed to encompass the determinants influencing both the amount offered in the programme, i.e. a higher or lower amount, and the decision to participate in the programme (Newman et al., 2003). Our criteria for exclusion included variables that were somewhat related and their influence on the decision to participate in the programme were of critical importance to the study and impact when omitted. For example, the number of children and the years lived in the community are somewhat related to the family size and age of the respondents, respectively. Therefore, their omission in the first hurdle (i.e., decision to participate) would not necessarily impact their decision amount in the second hurdle (i.e., decision amount). Income was also not included in the first hurdle based on it being an economic factor. Perceived risk was only excluded in the first hurdle among the downstream respondents based on the prior conclusion that they had higher risk perception levels and this was a highly influential factor in participation decision. However, the amount decision was of more importance to the study. Furthermore, its inclusion in the model would be redundant. However, all the variables were accounted for in the second hurdle. To enable easier interpretation of the results of the first hurdle equation, marginal effects using Stata version 16 (Stata Corp,

2016) are reported and discussed. This is because the outcome variables from the double-hurdle model are latent and the maximum likelihood estimates cannot be interpreted in the same way as ordinary least square estimates.

4.3 Results and discussion

4.3.1 Descriptive statistics

The results of the socio-demographic characteristics of the respondents are presented in Table 4.1. The population surveyed included 146 (52.3%) males and 133 (47.7%) females with a low variation in gender ratio among the groups. The largest variation among the groups was in the education levels, with four and three respondents from the downstream and upstream respondents, respectively, having no education levels and zero respondents in the factory group. That is, all the respondents had some level of education. Another notable variation was in the level of primary school education, where the downstream group had the highest percentage (24.5%) compared to the other groups, as presented in Table 4.1. The factory group also had the highest number (N = 46) of respondents who had tertiary education compared to downstream respondents (N = 32) and upstream respondents (N = 29). A majority of the population sampled 149 (53.4%) had income levels of between 1–20,000 KSh (Kenyan shilling; 1 USD = 100.3 KSh). A small population of the sample 15 (5.4%) earned more than 60,000 KSh. As of 2015, Kenya's poverty rate (the percentage of the population living on less than $5.50 a day) was 86.50%; that is, a majority of the population still lives below the international poverty line (Bank, 2020). As highlighted in the results obtained, a majority of the population in this area are low-income and middle-class earners. Another distinct aspect was that only the factory group had a larger number of the respondents earning more than 40,000 KSh

(USD 400) per month, compared to the two groups. However, given the fact that the respondents from this group were selected from a working environment, this result was expected.

Table 4.1 Descriptive statistics of the demographic characteristics.

	Factory Group		Downstream Inhabitants		Upstream Inhabitants	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Male	48	48.0	48	51.1	37	43.5
Female	52	52.0	46	48.9	48	56.5
Age groups						
(20–29)	44	44.0	26	27.7	31	36.5
(30–39)	41	41.0	49	52.1	43	50.6
(40–49)	9	9.0	13	13.8	5	5.9
(50–59)	2	2.0	3	3.2	2	2.4
(60+)	4	4.0	3	3.2	4	4.7
Education						
No education	0	0.0	4	4.3	3	3.5
Primary school	6	6.0	23	24.5	8	9.4
Secondary school	48	48.0	35	37.2	45	52.9
Tertiary Level	46	46.0	32	34.0	29	34.1
Number of family members						
(1–3)	29	29.0	23	24.5	33	38.8
(4–6)	60	60.0	62	66.0	39	45.9
(7+)	11	11.0	9	9.6	13	15.3
Income in KSh [1]						
No income	2	2.0	23	24.5	19	22.4
1–20,000	61	61.0	42	44.7	46	54.1
20,001–40,000	22	22.0	18	19.1	15	17.6
40,000–60,000	9	9.0	5	5.3	2	2.4
60K+	6	6.0	6	6.4	3	3.5
Observation	100		94		85	

[1] KSh: Kenyan shilling, the currency used in Kenya.

4.3.2 Mean score differences of the dependent variable WTP and independent variables across the groups

The overall percentage of respondents that were willing to pay for the program, both for WTP1 and WTP2, was 208 (74.6%) and 207 (74.2%) respectively. This indicates that residents in this region are concerned and willing to take measures to help alleviate the problems brought about by the decreasing water quality in the region. According to Choe et al. (Choe et al., 1996), there is a general conception among development economist and policymakers that, in developing countries, improved environmental quality is a luxury for the world's poor. The assumption being that people in these countries do not place much value on improvements in environmental quality, mainly because they cannot afford to pay for it (Choe et al., 1996). However, our results indicate otherwise. In the area, the average mean score for a government-proposed projects (WTP1) is 182.51 KSh ($1.66), while that of the non-governmental project (WTP2) is 169.28 KSh ($1.54). This result can be attributed to the fact that a majority of the respondents are low-class and middle-class income earners. The high average WTP for WTP1 is mainly a result of the high WTP1 scores for the factory group compared to those of the upstream and downstream respondents who had the highest mean scores for WTP2 (see Table 4.2). The mean differences of WTP1 and WTP2 were statistically proven by the results of the one-way ANOVA as shown in Table 4.2. First, the test of homogeneity of variances showed unequal variances across groups for WTP1 (sig = 0.008). Therefore, the results of Welch's t-test were used instead of the regular ANOVA test. The findings showed that WTP1 significantly differed among respondents living in the three groups ($F (51,261.908) = 4.473$, $p = 0.000$). A post-hoc analysis using Dunnett T3 was then performed to demonstrate multiple comparisons. For WTP2, the test of homogeneity of variances showed equal variances of the mean score across groups (sig 0.172) with the no significance in difference within the groups (F (39,106.700) = 2.335, p = 0.099).

Table 4.2 Mean comparison of WTP1 and WTP2 across the groups

				Mean Difference (Comparison within the Groups)		
Dependent Variable	Group	N	Mean	Factory Group	Downstream Inhabitants	Upstream Inhabitants
[*1] **WTP1**	Factory group	100	227.10	-	0.547	0.008 *
	Downstream inhabitants	94	185.00	0.547	-	0.145
	Upstream inhabitants	85	127.29	0.008*	0.145	-
Total		279	182.51			
[*2] **WTP2**	Factory group	100	172.60	-	0.782	0.397
	Downstream inhabitants	94	197.66	0.782	-	0.101
	Upstream inhabitants	85	134.00	0.397	0.101	-
Total		279	169.28			

Notes:[*1] WTP1= Government proposed project (Welch's *t*-test analysis) F = 5.035, *p*= 0.007 [*2] WTP2= Non-government proposed project (Welch's *t*-test analysis) F = 2.370, *p* = 0.96 *The mean difference is significant at 0.05.

As shown in Table 4.2, there were observable mean differences in the WTP1 and WTP2 amounts of the three groups. For downstream respondents, the mean scores increase slightly from M = 185.00 to M = 197.66. The increase in mean could be attributed to the fact that the number of zero responses decreases from N = 25 for WTP1 to N = 21 for WTP2, as discussed in section 4.3.8 characteristics of zero respondents. That is, the mean WTP1 for positive respondents is lower than that of positive WTP2 respondents. A plausible explanation for this observation specific to this community is that given the history of governmental projects in the area that have not yielded sufficient results–for example, the Nandi rehabilitation project–the residents may feel less attached to the government's propositions to support the projects. Another possibility for the observed results would lie in the fact that the continuous experiences with water pollution and decreasing water quality in the area may result in the residents feeling let down by the government that is supposed to use the taxpayer's money to run similar projects as opposed to asking for more from them.

Table 4.3 Mean scores and standard deviations of the dependent variables and independent variables used in the study.

	Factory Group N = 100		**Downstream Inhabitants N = 94**		**Upstream Inhabitants N = 85**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
WTP1	227.100	269.092	185.000	219.294	127.294	172.767
WTP2	172.600	189.052	197.660	221.692	134.000	178.767
Gender [1]	1.520	0.502	1.489	0.503	1.565	0.499
Age	32.460	9.894	34.468	9.384	33.471	10.471
Years lived in the community	12.450	14.641	11.691	12.833	9.518	11.612
Education [2]	3.400	0.603	3.011	0.874	3.176	0.743
Number of family members	4.470	1.817	4.415	1.602	4.376	1.711
Number of children	1.850	1.381	1.532	1.373	1.612	1.423
Income	24,000	23,000	22,000	31,000	15,000	18,000
Worry about possibility of impacts	3.770	1.004	4.230	0.926	3.894	1.165
Level of perceived risk	4.084	0.949	4.336	0.897	4.159	0.803
The scope of impact through contracting diseases	3.890	0.863	4.324	0.835	4.035	0.823
Trust in the government	4.370	1.253	4.138	0.837	4.024	1.263
Trust in the local firms	4.220	1.151	4.404	0.766	4.000	0.964
Trust in local people's capacity	4.000	1.393	3.894	1.121	3.694	1.528

[1] Gender is a dummy variable that takes the value of 1 when the subject is male and 0 otherwise. [2] Education is a dummy variable that takes the value of 1 when the subject has education levels of secondary school or above and 0 when otherwise.

For upstream inhabitants, as shown in the table, there is an increase in the mean score for WTP2 (M = 127.29) from WTP1 (M = 134.00). However, the number of zero responses slightly increases from N = 27 to N = 28. The increase in mean score would mean that respondents with a positive WTP stated higher amounts for WTP2 than WTP1. A plausible explanation for this would be that they feel that a non-governmental organization would benefit more from their financial contribution than the government.

For the factory group, there was a significant decrease in the stated amount, indicating an increased potential contribution for governmental-run projects as opposed to non-governmental ones. This change in mean score can be explained by the number of increases in zero responses from N = 19 to N = 23 and lower stated amount for WTP2 compared to that of WTP1. This indicates that respondents of this group highly favor governmental projects. These observations show that there is a difference in stated WTP between the lay people and factory workers. This highlights differences in perspective and views between the two groups, providing an insight into their attitudes and behaviors. This understanding is important when coming up with solutions and policies for this particular community, because it is clear that one solution might not be effective for them.

Table 4.3 provides the mean scores and standard deviation analysis of the independent variables, giving useful insights that define the characteristics of the three groups. From the data in Table 4.3, the following conclusions can be made. Downstream respondents have the highest risk perception in the area given the higher mean scores for the three risk perception variables (levels of perceived risk (M = 4.336, SD = 0.897), the scope of impact (M = 4.230, SD = 0.926) and increased worry as a result of industrial activities in the region (M = 4.324, SD = 0.835)), which are the highest among all the groups. This result is not surprising because the respondents are located in the mid-stream and downstream sections of the river, where the river is most polluted, as it collects waste upstream. Their lo-cation also has a large number of industries in the town center among other developmental aspects of town centers, such as road networks, hospitals etc. Upstream respondents have slightly higher levels of perceived risk (M = 4.159, SD = 0.803) in the region, which indicates that while industries are at fault for major water pollution in the area, the river is also polluted upstream, causing concern for the residents. This is an opportunity for urgent action to be taken in the area, as the community is being greatly affected by the de-creasing water quality of River Sosiani. For factory respondents, the high mean scores for trust in the government and firms indicate that, for this group, they also to some extent feel the responsibility of managing risks in the area. The implication of this finding is useful as it may help bridge the gap between them and the public by encouraging them to practice safer environmental practices such, as proper wastewater disposal that will minimize water pollution in river Sosiani.

4.3.3 Determinants of willingness to pay for the government proposed project

Tables 4.4 and 4.5 presents the results for the double-hurdle model estimation for both the WTP1 (government-proposed project) and WTP2 (non-government proposed project) with the associated robust standard errors reported in parentheses. The results under the participation equation represent the results of the first hurdle, while those under the amount equation represent the results of the second hurdle, as discussed in the method-ology section. The dependent variable is the log WTP. Both the log likelihood and pseudo R2 measures have been identified and presented in the tables 4.4 and 4.5. Significant variables in the first hurdle equation (participation equation) influence the decision of whether or not to participate and can be interpreted as increasing or decreasing the likelihood of saying yes to participate in the program. For this equation, the term ‘likelihood’ refers to the influence of a change in the level of an exogenous variable on the likelihood of participation. The estimated marginal effects for the variables, along with their delta-method standard errors, were reported, as they are easier to interpret. A positive significant variable implies that the variable influences the probability of saying yes to participating in the program, while a negative value would imply the converse. In the second hurdle equation, termed the “amount equation”, a significant variable indicates the influence the variables exert on the amount of money pledged for the program, and the effect of the variable can be interpreted as increasing or decreasing this amount. The discussion focuses specifically on the significant variables and their interpretation

In the payment amount equation in all the groups, i.e., second hurdle equation, the sign and significance of the estimated coefficients are generally consistent with our expectations. Most of the socio-demographic characteristics were significant predictors of WTP, as shown in Table 4.4. The positive and significant estimated coefficient on income in all the groups reveals that the river restoration is viewed as a normal economic good and that an increase in income levels leads to an increase in the pledged WTP amounts. Furthermore, the analysis on the characteristics of zero respondents show that most of the respondents with zero WTP had the lowest income levels and a majority had no income levels, explaining the significant outcome of this variable in predicting pledged WTP amounts. This result is also consistent with the previous findings of Richard et al. (Ready et al., 2002) and Xiong et al. (Xiong et al., 2018), who also found that increased income leads to higher WTP amounts and vice versa (Moffat et al., 2011).

Similar to findings from earlier studies (Xiong et al., 2018), the estimated coefficient of the education variable was significant in both downstream and upstream respondents, with a positive coefficient. That is, higher education levels lead to increased WTP amounts. This result is consistent with economic theory, in that education helps respondents understand the challenges (benefits) of restoring an environmental asset. A plausible explanation specific to respondents located upstream would lie in their consistent use of river water for agriculture. The process involves use of chemicals, which requires some level of scientific understanding/education.

In contrast to previous studies, such as that of Adhikari et.al (Adhikari et al., 2017), who did not find any impact in gender in their WTP studies, gender was a significant variable only in upstream respondents. This indicates that females in the region were most likely have a higher WTP compared to the male respondents. Age, on the other hand, was a significant variable in the downstream and factory respondents, with a negative coefficient an indication that the older population were willing to pay less compared to the younger respondents in these two groups. Taking into account the social characteristics of the specific community, it would be expected that the younger population in the region feel enthusiastic about the future possibility of changes in the region. On the other hand, the older population may have seen similar projects implemented in the area over the years and might feel some level of pessimism, especially those located in the downstream region that experiences severe pollution.

Table 4.4 Double-hurdle model results for willingness to pay for a government-proposed projects

	Factory Group				Downstream Respondents				Upstream Respondents			
	Amount Equation		Participation Equation		Amount Equation		Participation Equation		Amount Equation		Participation Equation	
WTP1	Coef.	$p > \|z\|$	dy/dx	$p > \|z\|$	Coef.	$p > \|z\|$	dy/dx	$p > \|z\|$	Coef.	$p > \|z\|$	dy/dx	$p > \|z\|$
Gender [1]	−0.011	0.930	−0.313	0.930	−0.127	0.078	−0.193	0.405	−0.291	0.034	−0.124	0.608
	(0.127)		(0.223)		(0.088)		(0.232)		(0.127)		(0.242)	
Years in the community	0.016	0.010			0.012	0.008			0.048	0.535		
	(0.006)				(0.004)				(0.007)			
Education [2]	−0.034	0.395	0.332	0.567	0.032	0.051	0.685	0.001	1.384	0.000	1.185	0.002
	(0.117)		(0.141)		(0.074)		(0.214)		(0.313)		(0.375)	
Age	−0.018	0.009	0.014	0.268	−0.018	0.010	−0.004	0.749	−0.005	0.493	0.009	0.572
	(0.008)		(0.015)		(0.005)		(0.013)		(0.007)		(0.016)	
Family size	−0.058	0.340	0.258	0.103	−0.075	0.140	0.264	0.016	−0.181	0.008	0.924	0.516
	(0.061)		(0.114)		(0.041)		(0.109)		(0.065)		(0.142)	
Number of children	0.163	0.047			0.108	0.978			0.299	0.001		
	(0.08)				(0.057)				(0.083)			
Income	0.001	0.001			0.001	0.001			0.001	0.001		
	(0.000)				(0.000)				(4.511)			
Worry about possibility of impacts	0.073	0.390	0.317	0.141	0.183	0.132	0.343	0.017	0.115	0.153	0.047	0.641
	(0.085)		(0.123)		(0.099)		(0.143)		(0.061)		(0.100)	
Level of perceived risk	0.309	0.001	0.265	0.007	0.688	0.001			0.502	0.001	0.551	0.001
	(0.085)		(0.069)		(0.114)				(0.116)		(0.159)	
The scope of impact through contracting diseases	0.165	0.029	0.213	0.037	0.148	0.025	0.214	0.116	0.586	0.003	1.309	0.001
	(0.075)		(0.124)		(0.06)		(0.136)		(0.145)		(0.184)	
Trust in the government	−0.108	0.037	−0.165	0.071	0.036	0.775	0.228	0.134	−0.026	0.673	−0.017	0.855
	(0.052)		(0.093)		(0.054)		(0.152)		(0.051)		(0.094)	
Trust in firms	−0.036	0.523	0.064	0.428	0.045	0.527	0.181	0.221	−0.087	0.406	−0.053	0.668
	(0.057)		(0.089)		(0.059)		(0.148)		(0.086)		(0.123)	
Trust in local people	0.036	0.518	0.121	0.082	−0.037	0.132	0.092	0.354	0.031	0.393	0.0084	0.283
	(0.056)		(0.069)		(0.04)		(0.099)		(0.047)		(0.079)	
Insigma	2.81	0.001			−1.083	0.000			−0.779	0.000		
	(0.726)				(3.542)				0.0928			
Log likelihood			−71.67				−41.20				−55.56	
R^2			0.57				0.72				0.60	

Notes: Robust standard error reported in parenthesis. dy/dx= Marginal effects reported for the participation equation. [1] Gender takes the value of 1 when the subject is male and 0 otherwise. [2] Education takes the value of 1 when the subject has education levels of secondary school or above and 0 when otherwise.

Table 4.5 Double-hurdle model results for willingness to pay for a non-government proposed projects

	Factory Group				Downstream Respondents				Upstream Respondents			
	Amount Equation		Participation Equation		Amount Equation		Participation Equation		Amount Equation		Participation Equation	
WTP2	Coef.	$p > \|z\|$	dy/dx	$p > \|z\|$	Coef.	$p > \|z\|$	dy/dx	$p > \|z\|$	Coef	$p > \|z\|$	dy/dx	$p > \|z\|$
Gender [1]	−0.249	0.074	0.053	0.074	-0.155	0.082	0.178	0.415	0.191	0.095	0.306	0.308
	(0.142)		(−0.242)		(0.089)		(0.218)		(-0.114)		(-0.286)	
Years in the community	0.008	0.254			0.008	0.084			0.002	0.700		
	(0.007)				(0.004)				(0.006)			
Education [2]	0.419	0.372	0.537	0.074	0.135	0.056	0.523	0.084	0.744	0.037	1.125	0.014
	(0.47)		(−0.235)		(0.071)		(0.136)		(0.006)		(0.459)	
Age	−0.007	0.398	−0.006	0.067	-0.008	0.098	-0.004	0.001	−0.008	0.148	0.018	0.314
	(−0.009)		(−0.016)		(0.005)		(0.013)		(0.007)		(−0.018)	
Family size	−0.126	0.064	0.119	0.372	-0.039	0.320	0.159	0.761	−0.014	0.857	0.373	0.032
	(0.068)		(−0.094)		(0.040)		(0.097)		(0.058)		(0.169)	
Children	0.267	0.003			0.149	0.001	0.113		0.083	0.102		
	(0.892)				(0.058)		(0.044)		−0.072			
Income	0.006	0.001			0.001	0.001	0.001		0.001	0.001		
	(4.166)				(0.000)		(0.000)		(4.244)			
Worry about possibility of impacts	0.171	0.054	0.382	0.206	0.065	0.496	0.315	0.010	0.021	0.988	−0.111	0.492
	(0.888)		(−0.122)		(0.096)		(0.141)		(0.052)		(−0.125)	
Level of perceived risk	0.306	0.002	0.25	0.003	0.94	0.001			0.445	0.001	0.45	0.029
	(0.096)		(−0.079)		(0.106)				(0.108)		(0.201)	
The scope of impact through contracting diseases	0.114	0.175	0.127	0.448	0.189	0.001	0.008	0.001	0.293	0.019	1.075	0.001
	(0.084)		(−0.161)		(0.059)		(0.142)		(0.128)		−0.236	
Trust in the government	−0.089	0.148	−0.065	0.366	0.093	0.079	0.365	0.953	−0.011	0.856	−0.042	0.714
	(−0.058)		−0.109		(0.053)		(0.163)		(0.046)		−0.1119	
Trust in firms	−0.089	0.164	−0.013	0.723	0.04	0.504	0.200	0.025	0.057	0.358	0.035	0.842
	(-0.064)		(−0.113)		(0.059)		(0.141)		(0.077)		−0.157	
Trust in local people	0.101	0.104	(0.052)	0.003	-0.027	0.512	0.095	0.154	0.089	0.026	0.163	0.092
	(0.062)		(−0.085)		(0.040)		(0.141)		(0.042)		−0.096	
Insigma	2.161	0.004			-1.287	0.102			0.093	0.001		
	(−0.757)				(0.788)				(-0.114)			
Log likelihood		−93.31				−43.41				−52.72		
R^2		0.44				0.71				0.59		

Notes: Notes: Robust standard error reported in parenthesis. dy/dx= Marginal effects reported for the participation equation.
[1] Gender takes the value of 1 when the subject is male and 0 otherwise. [2] Education takes the value of 1 when the subject has education levels of secondary school or above and 0 when otherwise.

The number of years lived in the community was significant for downstream inhabitants and the factory group, with positive estimated coefficients. This indicates that families that had lived in the area for many years were willing to pay more for the program compared to those that had stayed in the region for a shorter period of time. This result is complemented by the analysis of zero respondents in the area which show that respondents with a zero WTP had spent fewer years in the community compared to those with a stated positive WTP. The significance of this variable could be attributed to the fact that those who had stayed in the community longer had more experiences with water pollution in the region, compared to their counterparts who had either just moved in the region or lived in the region for a shorter period of time. Another significant explanation for this could be that those who had lived in the region longer had more attachment to the natural resources in the area and were thus willing to spend more to conserve it.

Family size was significant and inversely related to WTP for upstream respondents. The assumption would be that larger households would be willing to pay less as opposed to smaller ones due to budgetary constraints, similar to previous findings (Moffat et al., 2011). The number of children in a family was also a determinant to the amount of money pledged for the factory group and upstream inhabitants; i.e., families that agreed to participate in the program and had a higher number of children were more likely to have higher amounts. A plausible explanation for this is that families that have children who are more susceptible to diseases would be willing to pay more to protect them from the adverse effects of water pollution in the region.

Among the trust variables, trust in the government was the only significant factor in one group, the factory group, with a negative coefficient sign. This finding of a negative influence of institutional trust is consistent with previous findings (Adler et al., 1999). There was an indication that increased trust levels in the government led to a decrease in the amount pledged. This finding contradicts that of Halkos et al. (Halkos et al., 2011), who found that citizens with lower trust levels in the institutions of their community were more positive in stating a specific amount, because they linked this with perceived levels of effectiveness. An explanation for this inverse observation is based on the observations of mean and SD of this variable, where the protest respondents seem to have higher mean scores and low SD (M = 4.909, SD = 0.302), the high SD value for positive WTP respondents (M = 4.395, SD = 1.221) is an indication that their trust in the government is lower, which explains the negative coefficient observed in the double-hurdle model results. Also, the high SD for trust in the government of respondents with real zero observation (M = 3.375, SD = 1.847) (see section 4.3.8) is an indication that that this does not influence the negative correlation and thus the negative coefficient of the significant variable of trust in the government.

Meanwhile, the risk variables level of perceived risk and scope of impact through contracting diseases are significant, with a positive coefficient in all the three groups. That is, generally increased risk perception levels lead to an increase in the amount pledged, as observed in similar studies (Huang et al., 2013; Hunter et al., 2012). Further, the analysis of zero respondents compliments this result in that most respondents who had lower risk perception scores had zero WTP.

Regarding factors explaining the decision to participate in the program, education in socio-demographic factors was a significant determining factor on the individual's decision to participate in the program. That is, individuals with higher levels of education were more likely to say yes to the program. Among risk perception variables, the level of perceived risk and the scope of impact through increased diseases in the area were significant factors across all groups and influenced the respondent's decision to participate in the program. The positive coefficient sign indicates that those with higher risk perception levels were more like to say yes to the program than those with lower risk perception in the area. The possibility of impact, i.e., worried residents as a result of increased industrial growth in the region, was a determinant in the downstream respondents, with a positive coefficient. This indicates that for respondents in this group, the more worried they were, the more likely they were to participate in the program. A plausible explanation for this would be that, given the location of these respondents, i.e., the city area, full of industrial activities, they probably feel the effects of water pollution the most and are worried about the increase of industrial growth and industrial water pollution in the region. Unexpectedly, none of the trust factors were significant indicators on the decision to participate for respondents in any of the groups.

4.3.4. Determinants of willingness to pay for a non-government proposed project

The double-hurdle model results for WTP for a non-governmental project are presented in Table 4.5. The significant explanatory variables in the participation equation and amount equation for WTP2 did not vary from those of WTP1. However, the following notable changes were observed. For upstream respondents, trust in the local people's capacity was a significant variable in the amount equation, with a positive coefficient, meaning that increased trust led to higher WTP amounts. The trust variable can also be a causative factor for the significance of this variable. For this group, the mean and standard deviation for the variable trust in the local people for respondents with a positive WTP is the lowest; (M = 3.845, SD = 1.484) and (M = 3.877, SD = 1.477) for WTP1 and WTP2, respectively. This indicates that the responses were highly varied. Thus, respondents in this group with higher trust in the local people's capacity stated higher amounts for WTP2 than for WTP1. Another possibility lies in the relatively high mean scores for willingness to participate observed. This reveals that respondents in this group somewhat feel a sense of responsibility towards environmental issues in the area. This could be because the respondents in this group view their personal contributions as a possible resolution for environmental issues. They could also be hopeful that their own contributions and efforts can help improve the poor environmental conditions. Another noteworthy fact in the significant predictors of WTP2 was that the number of children was no longer a significant determining factor in the amount equation in this group. For the participation equation, the family size was a determinant for the decision to participate or not in the program, with a positive sign. This means that people with larger family sizes were more likely to say yes to the program.

For downstream respondents, the years lived in the community and age were no longer significant variables. However, the number of children was an influencing factor in the amount pledged for the program, with household that had higher number of children more likely to pledge a higher amount than those with few children in their household. Family size was not a significant variable for WTP2. The other notable change was the significance of the variable scope of impact through contracting diseases in influencing the decision of the household in participating in the programme. Individuals who were worried about contracting diseases in the area were more likely to participate in the programme. In the factory group, changes included trust in the local people, which was a significant determinant in the participation equation. In the amount equation, worry about increased industrial activity was a new significant predictor for this group, with a positive coefficient, meaning that respondents who perceived higher risks as a result of industrial growth in the region pledged more money. Trust in the government and the years lived in the community were no longer significant for WTP2.

4.3.5. Willingness to participate

The mean score and standard deviations of the willingness to participate are also presented in Table 4.6. As shown in the table, downstream respondents had the highest mean scores for willingness to participate compared to the other two groups. The factory group had the lowest mean sores. This means that upstream and downstream respondents are more willing to participate in volunteer activities in the area compared to those in the factory group. A number of factors could be attributed to this observation. The factory population could view the activities as being too engaging, given that they have day jobs and hence have less time to volunteer for the program. On the other hand, they also might not be as enthusiastic as the other respondents in the two groups. Meanwhile, upstream and downstream respondents might view this as an opportunity to be engaged in local activities to better their community, having witnessed the extreme eventualities of water pollution in the area. This observation presents an important characteristic of these three groups. Downstream respondents, who face extreme water pollution in the area, are still hopeful and willing to be engaged in volunteer activities to help improve the conditions in the area. Upstream respondents, who also face water quality problems and rely on the river mostly for agricultural activities, also seem enthusiastic about cleanup activities. This indicates that although the severity of the pollution might not be as high for them as downstream respondents, they are concerned about the welfare of the other citizens in the area. The factory group, who are part of the institution accused of water pollution in the area, appear to be less enthusiastic about volunteering their time but more eager to volunteer financially, as shown in the WTP results.

Table 4.6 Mean scores of willingness to participate for the three groups

	N	Mean	SD	Std. Error
Factory group	100	3.75	1.058	0.106
Downstream respondents	94	4.28	0.809	0.083
Upstream respondents	85	4.09	0.881	0.096
Total	279	4.03	0.95	0.057

Notes: Std.Error = Standard error.

4.3.6 Determinants of willingness to participate

The determinants of the willingness to participate among the three groups in the proposed scenario were obtained using an ordinal scale response, as described in the methodology section. Therefore, ordinal regression models were designed using the logit function to identify the determinants of the willingness to participate; the results presented in Table 4.7. The goodness-of-fit and pseudo R^2 were used to ascertain the validity of the results. The Pearson chi-square test and the deviance test respectively of downstream respondents [$\chi^2(173)$ =147.921, p = .917], [$\chi^2(173)$ =109.488, p = 1.000], upstream respondents [$\chi^2(155)$ =107.206, p = .314], [$\chi^2(383)$ =66.904, p = 1.000] and the factory group [$\chi^2(383)$ =395.867, p = .314], [$\chi^2(383)$ =243.929, p = 1.000] were all non-significant, suggesting that the model is a good fit. The pseudo R^2 -Cox and Snell are shown in Table 4.7 and treated as rough analogues of the r-square value in the OLS regression (Lomax et al., 2013; Osborne, 2014; Smith et al., 2013; Stevens, 2012).

Table 4.7 Ordinal regression results for the willingness to participate.

	Factory Group				Downstream Inhabitants				Upstream Inhabitants			
	Estimate	Log Odds	Wald	Sig.	Estimate	Log Odds	Wald	Sig	Estimate	Log Odds	Wald	Sig
[WTPA = 1]	−6.998	0.001	10.776	0.001	-		-	-	-		-	-
[WTPA = 2]	−4.775	0.008	5.486	0.012	-		-	-	-		-	-
[WTPA = 3]	−3.485	0.031	2.979	0.068	3.913	50.053	1.760	0.185	2.660	14.298	0.325	0.569
[WTPA = 4]	−1.355	0.258	0.464	0.517	6.877	969.934	4.989	0.026	6.109	450.003	1.669	0.196
Gender [1]	−0.037	0.964	0.008	0.928	−0.833	0.435	2.147	0.143	−2.027	0.132	6.049	0.014
Age	0.044	1.045	2.980	0.043	−0.112	0.894	10.253	0.001	−0.056	0.945	1.951	0.163
Years lived in the community	0.005	1.005	0.053	0.817	0.019	1.020	0.309	0.579	0.039	1.040	0.721	0.396
Education [2]	−0.239	0.788	0.411	0.521	0.443	1.558	1.235	0.266	−0.797	0.451	1.251	0.263
Number of family members	−0.108	0.898	0.311	0.577	−0.374	0.688	2.127	0.145	−0.436	0.646	1.560	0.212
Number of children	−0.393	0.675	2.325	0.127	0.675	1.965	3.050	0.081	1.337	3.808	9.368	0.002
Income	1.546	1.000	1.559	0.212	1.990	1.000	1.008	0.315	0.000	1.000	9.858	0.002
Trust in the government	0.008	1.008	0.002	0.962	0.363	1.437	1.216	0.270	−0.225	0.799	0.570	0.450
Trust in the local firms	0.260	1.296	2.125	0.145	0.308	1.361	0.741	0.389	−0.810	0.445	2.670	0.102
Trust in local peoples capacity	0.010	1.011	0.005	0.941	0.224	1.251	0.835	0.361	−0.064	0.938	0.069	0.792
Worry about possibility of impacts	−0.127	0.881	0.284	0.907	0.597	1.817	2.711	0.100	0.534	1.705	2.993	0.084
Level of perceived risk	−0.772	0.462	6.971	0.004	1.204	3.333	6.202	0.013	0.061	1.063	0.013	0.908
The scope of impact	0.012	1.013	0.003	0.835	−0.248	0.780	0.518	0.472	2.802	16.473	9.166	0.002
R^2 (Cox and Snell)		0.284			0.597				0.738			

Notes: WTPA- Willingness to participate, [1] Gender is a dummy variable that takes the value of 1 when the subject is male and 0 otherwise. [2] Education is a dummy variable that takes the value of 1 when the subject has education levels of secondary school or above and 0 when otherwise.

Based

Based on this, significant predictors in the upstream inhabitants explained 73.8% of the variation in willingness to participate. While the significant predictors of downstream respondents and the factory group explained 59.7% and 28.4% of the variation in willingness to pay, respectively.

There was not much variation in the predictors of willingness to participate for the factory group and downstream respondents. While age and the levels of perceived risk were significant for these two groups, they had different coefficient signs. In the factory group, the coefficient sign was positive, meaning that for every one unit increase in age, there was a predicted increase of 0.044 in the log odds of a respondents participating in the program. That is, participants who were older were more likely to participate in the program compared to the younger counterparts.

The coefficient sign for perceived levels of risk were negative, indicating that for every increase in one unit of perceived risk, there is a predicted decrease of 0.772 in the log odds of participating in the program. That is, those with higher risk perception levels were less likely to participate in the program. While this result was unusual, as the reverse would be expected, the WTP levels were higher in this group, meaning that they were more inclined to participate in the environmental issues financially rather than by volunteering. A plausible explanation for this observation would lie in the results that show that respondents with zero WTP generally had higher willingness to participate and those with zero responses (Tables 4.9 and 4.10) generally had higher risk perceptions.

For downstream respondents, the age variable was significant with a positive coefficient sign and so was the perceived risk variable. That is, for every one unit increase in age and level of perceived risk in this group, there is a predicted increase of 0.112 and

1.204 in the log odds of the respondents participating in the program. This means that younger respondents who had higher risk perception levels were more likely to volunteer in the program. It is no surprise that those with high levels of perceived risk were more likely to volunteer in the program. As mentioned earlier, this group seems eager for change in the area and more hopeful about finding solutions. They believe that they can help bring change in the region through both financial contribution and volunteer activities.

For upstream respondents, a number of factors were significant in predicting the probability of participating in the program. Apart from gender, the number of children, income and one variable for risk perception (the possibility of impacts of water pollution through contracting diseases) were significant determinants of the likelihood for respondents participating in the program, all with a positive coefficient sign. This indicates that the more the number of children, increased income and increased risk perception levels, the higher the predicted probability of participating in the program.

A plausible explanation for this observation is that, like downstream respondents, they are also eager for change in the environmental conditions in the area and are ready to put in the effort and work to realize that goal. This presents an opportunity for policy makers and actors to include enthusiastic community members in future decision-making and implementation processes of any proposed initiatives, since they appear receptive and ready to engage in activities for improving their community. Furthermore, this provides an opportunity for public participation.

Table 4.8 Mean scores of the willingness to participate for both positive and zero responses.

	Factory Group			Downstream Inhabitants			Upstream Inhabitants		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
Positive WTP1	81	3.506	0.976	69	4.551	0.718	58	4.603	0.560
Zero WTP1	19	4.767	0.681	25	3.55	0.495	27	3.000	0.000
Positive WTP2	77	3.442	0.953	73	4.479	0.766	57	4.596	0.563
Zero WTP2	23	4.762	0.682	21	3.611	0.637	28	3.100	0.316

Table 4.9 Characteristics of real zeros and protest zeros respondents for WTP1

		Factory Group						Downstream Respondents						Upstream Respondents					
WTP1		**Real Zeros**			**Protest Zeros**			**Real Zeros**			**Protest Zeros**			**Real Zeros**			**Protest Zeros**		
		N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Gender	Female	6	4.5	1.22	6	4.83	0.41	4	3.75	0.5	3	3.33	0.58	11	3	0	5	3	0
	Male	2	5	0	5	5	0	6	3.67	0.52	12	3.42	0.51	7	3	0	4	3	0
Age	20–29	3	4	1.73	8	5	0	0			9	3.56	0.53	6	3	0	3	3	0
	30–39	4	5	0	3	4.67	0.58	6	3.67	0.52	6	3.17	0.41	10	3	0	6	3	0
	40–49	1	5		0			3	4	0	0			0	3		0		
	50–59	0			0			1	3		0			1	3		0		
Education	No education							3	4	0	1	4		3	3	0			
	Primary school	2	5	0	2	5	0	4	3.5	0.58	12	3.42	0.51	4	3	0	1	3	
	Secondary school	6	4.5	1.22	9	4.89	0.33	3	3.67	0.58	2	3	0	9	3	0	6	3	0
	Tertiary Level	0			0			0			0			2	3	0	2	3	0
Family Members	1–3	8	4.63	1.06	10	4.9	0.32	8	3.75	0.46	8	3.63	0.52	14	3	0	6	3	0
	4–6	0			1	5		2	3.5	0.71	7	3.14	0.38	4	3	0	3	3	0
Number of children	1–3	8	4.63	1.06	11	4.91	0.3	10	3.7	0.48	15	3.4	0.51	17	3	0	9	3	0
	4–6	0			0			0			0			1	3		0		
Income in Ksh	No income	2	5	0	0			9	3.67	0.5	14	3.36	0.5	12	3	0	5	3	0
	1–20,000	6	4.5	1.22	11	4.91	0.3	1	4		1	4		6	3	0	4	3	0

		Factory Group						Downstream Respondents						Upstream Respondents					
WTP1		**Real Zeros**			**Protest Zeros**			**Real Zeros**			**Protest Zeros**			**Real Zeros**			**Protest Zeros**		
Years lived in Community	1–5	8	4.63	1.06	11	4.91	0.3	10	3.7	0.48	15	3.4	0.51	14	3	0	9	3	0
	6–10	0			0			0			0			4	3	0	0		
Willingness to participate		8	4.63	1.06	11	4.91	0.3	10	3.7	0.48	15	3.4	0.51	18	3	0	9	3	0
Risk perception	Worry about possibility of impacts	8	2.63	1.19	11	2.45	0.69	10	3.23	0.74	15	3.11	0.95	18	3.4	0.78	9	3.22	0.83
	Level of perceived risk	8	3.34	0.48	11	2.82	0.43	10	3.2	0.79	15	3.07	0.46	18	3.6	0.73	9	3.58	0.83
	The scope of impact through contracting diseases	8	3.25	0.71	11	3.45	0.52	10	3.4	0.84	15	4.13	0.75	18	3.2	0.65	9	3.11	0.33
Trust factors	Government	8	3.38	1.85	11	4.91	0.3	10	3.8	0.63	15	3.67	0.9	18	4	1.41	9	4.11	1.27
	Firms	8	3.63	1.41	11	3.91	0.94	10	4.3	0.82	15	4.13	0.83	18	3.8	1.06	9	3.78	1.09
	People	8	2	0.93	11	2.64	1.29	10	3.8	1.62	15	3.73	0.88	18	3.4	1.69	9	3.22	1.48

Table 4.10 Characteristics of real zeros and protest zeros respondents for WTP2

		Factory Group						Downstream Respondents						Upstream Respondents					
WTP2		Real Zeros			Protest Zeros			Real Zeros			Protest Zeros			Real Zeros			Protest Zeros		
		N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Gender	Female	7	4.57	1.13	6	4.83	0.41	3	3.67	0.58	2	3	0	11	3	0	5	3	0
	Male	2	5	0	8	4.88	0.35	6	3.67	0.52	10	3.4	0.52	7	3	0	5	3.4	0.89
Age	20–29	3	4	1.73	10	4.9	0.32	0			7	3.43	0.53	6	3	0	4	3.5	1
	30–39	5	5	0	3	4.67	0.58	5	3.6	0.55	5	3.2	0.45	10	3	0	6	3	0
	40–49	1	5		0			3	4	0	0			0			0		
	50–59	0			1	5		1	3		0			1	3		0		
	60+	0			0			0			0			1	3		0		
Education	No education	0	0	0	0	0	0	2	4	0	1	4		3	3	0	0		
	Primary school	2	5	0	2	5	0	4	3.5	0.58	10	3.3	0.48	4	3	0	2	3	0
	Secondary school	6	4.5	1.22	12	4.83	0.39	3	3.67	0.58	1	3		9	3	0	6	3.33	0.82
	Tertiary level	1	5		0			0			0			2	3	0	2	3	0
Family Members	1–3	8	4.63	1.06	11	4.82	0.4	7	3.71	0.49	7	3.57	0.53	14	3	0	7	3.29	0.76
	4–6	1	5		3	5	0	2	3.5	0.71	5	3	0	4	3	0	3	3	0
Number of children	1–3	8	4.63	1.06	11	4.91	0.3	9	3.67	0.5	12	3.33	0.49	17	3	0	8	3	0
	4–6	1	5		3	4.67	0.58	0			0			1	3		2	4	1.41
Income in KSh	No income	2	5	0	0			9	3.67	0.5	11	3.27	0.47	12	3	0	7	3.29	0.76
	1–20,000	7	4.57	1.13	14	4.86	0.36	0			1	4		6	3	0	3	3	0

		Factory Group						Downstream Respondents						Upstream Respondents					
WTP2		Real Zeros			Protest Zeros			Real Zeros			Protest Zeros			Real Zeros			Protest Zeros		
		N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Years lived in Community	1–5	9	4.67	1	13	4.92	0.28	9	3.67	0.5	12	3.33	0.49	14	3	0	9	3	0
	6–10	0			1	4		0			0			4	3	0	1	5	
Willingness to participate		9	4.67	1	14	4.86	0.36	9	3.67	0.5	12	3.33	0.49	18	3	0	10	3.2	0.63
Risk perception	Worry about possibility of impacts	9	2.78	1.2	14	2.71	0.83	9	3.26	0.78	12	3.14	1.07	18	3.39	0.8	10	3.7	0.95
	Level of perceived risk	9	3.31	0.46	14	3	0.57	9	3.33	0.71	12	3	0.43	18	3.56	0.7	10	3.83	0.93
	The scope of impact through contracting diseases	9	3.44	0.88	14	3.43	0.65	9	3.56	0.73	12	3.99	0.74	18	3.22	0.7	10	3.4	0.7
Trust factors	Government	9	3.56	1.81	14	4.86	0.53	9	3.89	0.6	12	3.5	0.8	18	4	1.4	10	4.2	1.23
	Firms	9	3.78	1.39	14	4	0.96	9	4.44	0.73	12	4.25	0.87	18	3.78	1.1	10	4	1.15
	People	9	2.33	1.32	14	2.71	1.38	9	3.67	1.66	12	3.67	0.89	18	3.44	1.7	10	3.1	1.45

4.3.7 Willingness to Participate for respondents with positive and zero WTP1 and WTP2

The study further analyzed the willingness to participate mean scores of both positive and zero WTP1 and WTP2. The results are presented in Table 8. In the factory group, zero WTP respondents had a higher willingness to participate in the program, while those with a positive WTP had lower mean scores, meaning that they were less likely to participate in the program. For WTP2 observations in this group, the mean scores for both upstream and downstream respondents with a positive WTP were high, meaning that they were more willing to give both financial and volunteer support to the program than those with zero WTP. However, in WTP2, there is a slight increase in the mean scores of willingness to participate, meaning that when a different organization runs the project, respondents with an initial zero WTP are more motivated to volunteer their time and contribute to activities aimed at environmental remediation. This could possibly indicate that they favor non-governmental agencies projects as opposed to government-run ones.

4.3.8 Characteristics of real zeros and protest respondents

The study further analyzed the characteristics of respondents who had zero WTP for both WTP1 and WTP2 with regard to their willingness to participate, as reported in Tables 4.9 and 4.10 respectively. This is because these descriptive statistics compliment the econometric results of the survey, as discussed earlier, and help reveal characteristics of protest respondents. In the factory group, the respondents had lower income levels (less than 20,000 KSh), smaller family sizes and low levels of education. The major difference was the trust towards the government, where the protest voters had significantly lower mean scores while real zeros had relatively higher mean scores for this variable.

For downstream respondents, 80% of protest voters were male. This is similar to previous findings; for example, García-Llorente et al. (García-Llorente et al., 2011) found that males had a higher probability of being protest voters. A majority of protest voters were also younger (20–29 years old), which is similar to the findings of Frey et al. (Frey et al., 2019). Most zero respondents had no income and lower levels of education. Notable differences between the two WTP amounts were that, for stated WTP1, the respondents had lower mean scores for risk factors (worry about their health and levels of perceived risk) and trust towards the government. The risk measure of scope of impact through contracting diseases was much higher for protest voters than real zeros. For WTP2, the means scores for trust towards the government was much higher for the real zeros as compared to protest zeros.

For upstream respondents, zeros respondents had the following characteristics: A majority of them were female, in contrast to the results of downstream respondents, and had low education levels of mostly up to secondary school level. All of them had lived in the community for relatively shorter periods and had no income. These respondents also had fewer number of children recorded. Other interesting characteristics were their mean scores for trust in the government, which were slightly higher. There were no notable differences between WTP1 and WTP2 for this group.

From these characteristics, it is evident that for respondents with zero WTP and mostly protesting voters, a number of factors influence their decisions, attitudes and behaviors. For example, low levels of education observed in the results are similar to previous studies that found that being less educated is generally associated with protesting behaviors (Grammatikopoulou et al., 2013). This could possibly mean a lack of understanding of the seriousness of the matter and the detrimental effects of polluted water. Another plausible explanation would be the lack of environmental awareness through knowledge acquired from school. The influence of the number of years lived in the community cannot be ignored, as it seems to be a factor in the decision to pay for the program or not. Plausible explanations for this behavior would be that these respondents might view the area as a temporary location and thus feel no attachment or care about the existing condition. They might also have less experience with water pollution in the area and thus their risk perception levels would be low. The lack of income is also a striking characteristic of these respondents. This is similar to findings from previous studies (Dziegielewska et al., 2007; Frey & Pirscher, 2019; Grammatikopoulou & Olsen, 2013; Meyerhoff et al., 2006; Meyerhoff et al., 2014) that concluded that low-income levels were a significant characteristic of protest voters. This may be attributed to the fact that making financial contributions would be a burden to their already strained financial situations. Owing to the lack of trust in the government, it is no surprise that they would choose not to contribute to government projects financially.

The following insights and implications from the study can be deduced. From an in-depth analysis of the study and the descriptive statistics, key opportunities for potential environmental actors and the government of Kenya were identified. It is evident that factory workers are more inclined to contribute to the welfare of the region through monetary support as opposed to volunteer actions in outreach programs. Moreover, respondents in this group seem to support the government's initiatives and have more trust in the government as compared to the other two groups. For this group, the opportunity lies in reaching out to them at their locations and emphasizing the importance of their compliance to set regulations in the region. This is because they still possess some level of responsibility, as revealed by their high WTP. Encouraging this group to volunteer in community activities is another opportunity to help bridge the gap between them and the community members, especially in cases where they are viewed negatively because of their activities that lead to water pollution (discharge of wastewater). The high levels of trust in the government exhibited by this group provides an opportunity for the government to reinforce sustainable practices in the area and promote better wastewater treatment technologies in the factories, which will reduce water pollution in the region.

Downstream respondents, on the other hand, exhibit characteristics that make them appear to be the most distraught and affected by pollution levels in the region. Despite this, the results show that they are the most enthusiastic group for volunteering and also have relatively higher mean scores for WTP amounts. Another characteristic revealed about this group is that they are more financially supportive of non-governmental projects. Upstream respondents are also equally concerned about the decreasing water quality in the region. This is an indication of the poor state of the river, because not only are the effects of the declining water quality felt mid-stream and downstream but also upstream. Like their downstream counterparts, they are eager for the conditions to improve and are willing to support programs in the area through monetary support and being involved in activities. This group also favors non-governmental projects based on the higher mean scores for WTP2. For these two groups, opportunities lie in the following areas: (i) incorporation of elements, such as volunteer activities, in the projects conducted in the area and inclusion of them in the decision-making processes. This will enable them to contribute and participate in the projects, thus promoting ownership and leading to longevity of the projects. (ii) Promotion and support for local environmental groups by the government in this region. (iii) Promotion of sustainable water practices, such as sustainable agriculture (especially for upstream respondents) and proper domestic wastewater management to help minimize the non-point sources of water pollution in the area.

An analysis of respondents with zero WTP across all groups revealed that a majority of zero respondents had lived a fewer number of years in the community. It is possible that they were unaware about the reality of the situation or did not care because they would eventually move to other regions. Thus, further follow-up studies are recommended to determine any possible changes in their attitudes and behavior over time. For such respondents, it would be interesting to understand whether any changes in behavior and attitudes took place over time while staying in the area. This understanding would make clear the impact of this variable on WTP and willingness to participate.

An interesting observation from the study was that despite the high poverty levels in the region, the respondents were willing to contribute financially to remedy the water problems in the region. This is encouraging for any environmental organizations and especially the government, as it highlights the need to engage all stakeholders in the region despite the poverty levels. Moreover, it is an indication that people value the water resources in the region. This could be a starting point for future policy makers and advisors creating programs that require behavioral changes or participation in developing countries.

Ultimately, a limitation of this study as in other WTP studies is that there is no way of assessing what the actual WTP would be in our case since the scenario is hypothetical. More so, the stated amount and the willingness to participate are self-reported and some respondents may have been reticent to express their true feelings. Another limitation of the study lies in the fact that the results obtained from this study are specific to the region and the textile industries surveyed thus caution should be taken when extending the results to other regions and other factory set ups that vary broadly.

4.4 Conclusions

The study presents the findings of three different analyses: (1) the willingness to pay, observed under two scenarios that differ in the organization conducting the project; (2) the willingness to participate and (3) the unique analysis of zero respondents between the two groups, i.e., the lay people located in different sections of River Sosiani and factory workers. Further, the determinants willingness to pay and willingness to participate were also identified and discussed. The findings show that different factors, such as trust, risk perception and socio-demographic characteristics, influence the willingness to pay and participate among lay people and factory workers. The empirical results also indicate a difference in stated WTP for different organizations. Factory workers have higher stated WTP for governmental based projects, while the lay people have higher stated WTP amounts for non-government based projects. This provides an opportunity for decision makers as highlighted in the discussion when selecting target audiences and leaders for future projects they plan to undertake in the area. The results also reveal deeper insights into the characteristics of each group through the analysis of respondents with zero WTP. Respondents with zero WTP have characteristics such as low income, shorter periods lived in the area and lower education levels. This revelation is important as it presents information that calls for clear, precise communication and possible tailored approaches when approaching these respondents in future. The study thus not only makes unique contributions to the CVM studies conducted in developing nations but also explores many methodological issues, such as the in-depth analysis of respondents with a zero WTP and the effects of this characteristics not only on the willingness to pay but also the willingness to participate. The study also attempts to provide solutions to residents of Eldoret, Kenya, and the government, based on the declining water quality in the region aggravated by the lack of longevity of the projects and efforts that have been put in place over the years to avert this crisis. From the results, it is clear that the factors related to WTP are highly linked to an individual's characteristics, risk perception and trust factors. This implies the need for public participation and effective risk communication processes for longevity of future environmental restoration projects.

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CHAPTER 5: ESTIMATING THE COST OF WATER POLLUTION FOR THE ADOPTION OF SUITABLE WATER TREATMENT TECHNOLOGY

5.1 Introduction

The health impacts of water pollution and the declining water quality are of increasing concern especially for policy makers (Wang et al., 2016). Globally one billion people lack access to potable water and 2.5 billion people have inadequate sanitation facilities (Osiemo et al., 2019). These poor inadequate sanitation facilities worldwide results to 4 billion cases of water-related diseases that is the leading cause of deaths especially in children under 5 years. In developing countries the situation is worse (Organization, 2017) where around 3.2 million children die each year as a result of unsafe drinking water and poor sanitation. Studies have reported connections between water pollution and acute waterborne diseases such as hepatitis, cholera, dysentery, cryptosporidiosis, giardiasis, diarrhea and typhoid (Cutler et al., 2005; Dutta et al., 2016; Roushdy et al., 2012; Wang & Yang, 2016). With increased risk of carcinogenic diseases because of the negative effects of water pollution (Ebenstein, 2012; Lin et al., 2000; Lu et al., 2015). This is a result of limited access to wastewater treatment facilities especially in the developing countries and malpractices such as water dumping of human waste products and garbage into water bodies that are treated as open sewers.

One of the major reasons behind the absence of adequate water treatment facilities and regulations in developing countries is the lack of finances available for funding infrastructure that can regulate water pollution. This in turn leads to environmental and human health costs, which results to higher economic implications of water pollution. For example, it is estimated that around $7.3 million is spent on healthcare for waterborne diseases alone in the world (Dakkak, 2020). Furthermore, large amounts of money are lost due to the deteriorating health of a country's population with many citizens unable to attend school or work due to health issues. The situation in developing countries also exacerbated by the lack of standards or adherence by industries to follow already set guidelines when discharging their waste in water bodies. In Kenya for example, the implementation of standards has been constrained by lack of baseline data for the review of issued guidelines. Thus, changing environmental conditions are not factored in over the years as the guidelines are rarely reviewed. Other issues that have constrained enforcement of standards in the country include: lack of incentives for cleaner production, standard testing methods, accreditation of water testing laboratories, and lack of continuous monitoring (Ntambirweki, 1997). Moreover, the lack of gazetted interim pollution limits has resulted to a persuasive (negotiation) approach that has been marred by cases of non-compliance caused by low awareness, lack of incentives, outright dishonesty, political interference, and lack of motivation for enforcement. Thus increased effects of water pollution in the country and resulting economic losses (Ntambirweki, 1997).

To cut down on the economic costs there is need for affordable cost effective, suitable solutions. This involves the reliance of natural resources in developing countries to avert the wastewater menace. The use of local resources reduces the burden of importing wastewater treatment material thus cutting down on the cost of water treatments. Furthermore, reliance of naturally available materials avails the technologies and materials easily to the users thus cutting down of time and cost among other benefits.

For such and similar technologies to be introduced and adopted in a country or region, the project feasibility should be done. A project feasibility is important as it determines the decision on whether a project can be conducted, delayed or canceled. Part of a project feasibility analysis involves cost estimation and analysis. Cost estimations of toxic chemical contamination have received relatively little attention partly because of the complexity of the process especially in water pollution cases (Easter et al., 2006) and the lack of adequate data. Other factors include the availability of public information, the severity of the situation and factors like water demand for the contaminated bodies. These cost estimations are an important component of societal costs of water pollution and the cost of proposed projects or technological changes should not exceed the projected benefits of cleaner water (Dearmont et al., 1998). Calculating costs requires formal costs of water pollution that would require hydrological, agronomic, medical and behavioral models (Maria, 2003) for accuracy and certainty in the numbers, however, such information is not available in Kenya at the moment.

This forms the premise of the current research that attempts to analyze the cost of using diatomaceous earth as an adsorbent in textile wastewater treatment and the recurring benefits from pollution control. The cost of the improvement should provide a lower bound on the benefits of cleaner water brought about the technological changes. Following other studies, we use waterborne diseases as a primary indicator of water quality and water pollution impacts and employ adsorption technology using Diatomaceous Earth based on the results obtained during experimental work conducted in a laboratory. The experiments used diatomaceous earth as an adsorbent using simulated textile wastewater in the removal of Methylene blue dye component. The objectives of the study are thus, (1) To conduct a cost benefit analysis of treating wastewater using

D.E., (ii) determine the cost of inaction through deriving potential benefits from pollution control on human health and through the stated preference method contingent valuation method (CVM) and (iii) analyze the benefits of implementing technological changes using the benefit cost ratio (BCR).

5.2 Methodology

5.2.1 Data collection

The CVM data used in this study was already reported in our previous publication (Mumbi et al., 2021). The data were collected using a questionnaire survey with a pretest survey of 50 respondents done prior to the actual survey. 300 questionnaires were administered randomly to the communities residing along the River Sosiani and the workers in factories along the river. The participants included in the study were divided into three groups as shown in figure 1. The first group comprised of respondents located midstream and downstream around the town area where the factories were located; throughout the study, they are referred to as downstream inhabitants/respondents. The second group consisted of upstream inhabitants/respondents. Finally, the factory group comprised respondents working in the factories surveyed from the three factories that agreed to participate in the study. The factories were from both private and government sectors and chosen based on their close proximity to River Sosiani. The questionnaire was designed to gather data on the respondent’s socio-demographic characteristics of the respondents and to solicit their willingness to pay (Mumbi & Watanabe, 2021) . The willingness to pay was presented as a hypothetical scenario where the expected activities to be undertaken were listed out and the recurring benefits from these activities were clearly stated. Thereafter, the respondents were asked to state if they were willing to pay an additional fee collectable every month to support the program in the area and, if yes, what amount they were willing to contribute, i.e. WTP (Mumbi & Watanabe, 2021).

5.3 Analysis and models used

Multiple calculations and analyses were done in order to attain the objectives. Three models were developed for the study. Mean scores analysis was used to compare the WTP among the groups. Model 1: analyzed the cost breakdown of using the proposed materials in the wastewater treatment. For this model, data on a cost effective adsorbent (D.E) were outlined based on previous experiments conducted in the laboratory using D.E as an adsorbent and simulated textile wastewater using Methylene blue dye and Polyacrylamide (PAM) as a coagulant in the experiments. The detailed procedures are described in the results section.

Model 2 attempts to make calculations that determine the cost of inaction through deriving potential benefits from pollution control on human health. Here survey data from the hospitals in the area was collected on the occurrence of three diseases that were identified associated with water pollution in the area i.e. amoebiasis, diarrhea and bacterial infection. The number of daily recorded cases of the diseases and their treatment costs estimates were obtained to model the cost of treatment calculations.

Model 3 determines the cost of inaction through deriving potential benefits from pollution control through the stated preference method Contingent Valuation Method (CVM). Data collection procedures and the CVM analyses were reported in our previous published publication (Mumbi & Watanabe, 2021). To determine the sample size of the affected population, estimates were done based on the size River Sosiani basin. The results from the three models were then combined to map a cost benefit ratio that can evaluate the economic feasibility of the proposed project cost.

5.4 Assumptions of the study

Calculating the impacts of water pollution requires access to detailed data that may be limited in some cases where there is minimal record keeping or no data available at all. In such scenarios, making assumptions enables researchers proceed with the study despite the limited resources available to them. In estimating the costs and benefits, the study made certain underlying assumptions as follows:

1. It is assumed that the D.E purchased is already dried during its processing, thus used in its purchased form, the costs for purchasing the installation materials such as stirrers, plastics, storage costs and disposal cost are considered as negligible and a one time off cost thus not included in the calculations.
2. The value placed on one's life after death cannot be calculated hence the assumption that the affected population eventually receive treatment and recover completely.
3. The benefits derived are calculated from saving cots that would otherwise be used to treat a sick patient.
4. The rate of infections of water related disease is not affected by the weather conditions i.e. dry and wet period.
5. The entire population of the region is eligible to pay the pledged WTP and that WTP is similar among the groups surveyed.

As shown in Figure 5.1, certain assumptions were made in line with the scope of the study that was narrowed done. Outlining the scope of the study limits the assumptions of the research to the elements that are specific to the study. In model 1, the only costs that were accounted for were operational costs related to the technology adoption. For model 2, only data from one hospital and 3 diseases were accounted for. This scope allowed the study to focus on common water related diseases in the region similar to previous research. The scope for the third model was restricted to the WTP being representative of the region of study. This was based on the assumption that the observed WTP from study 4 was representative of the whole region and was similar among the groups.

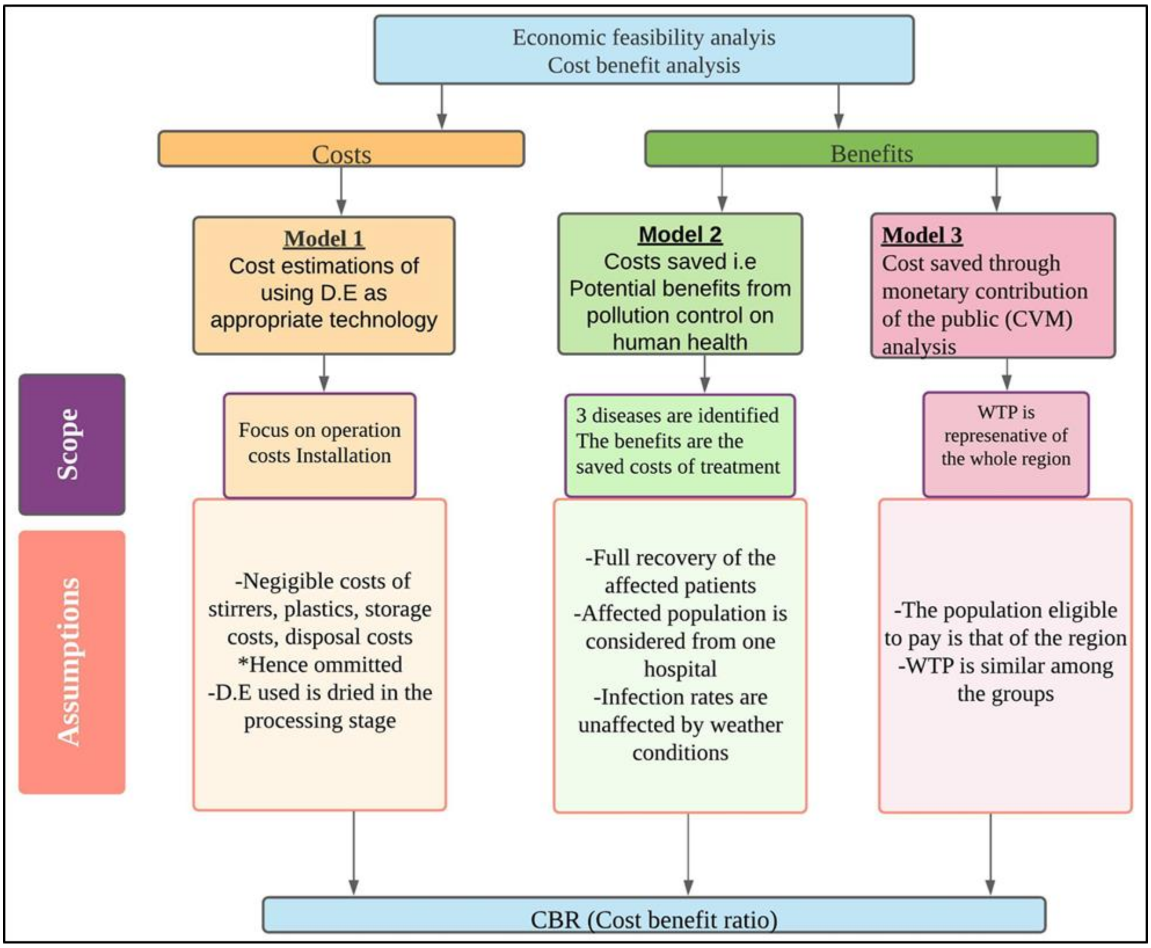

Figure 5.1 Scope and assumptions of the study

5. 3. Results and discussion

5.3.1 Partial cost analysis

The partial cost analysis model analyzes the costs that would be incurred in adopting the proposed technology in a factory. The initial cost of setting up new technologies are a onetime cost, these costs are mainly incurred on machinery installation and new constructions or modifications (Reddy et al., 2008). Some of these costs can be negligible hence the term partial cost analysis. The partial costs that would be incurred in this study are calculated based on the assumptions provided in section 3. The amount of wastewater discharged by textile industries vary depending on the output, type of output, fashion season, fabric type etc. According to (Weru, 1978) the dyeing and bleaching departments account for the highest percentage of wastewater water produced per day at 102,000 and 238,000 liters per day. Given the same trajectory, a hypothetical scenario is evaluated as follows. Using a sample factory that, while in production and processing will produce 20 tons of textile products while discharging 3,000 m3 in wastewater containing dyes. The amount of dyed wastewater for every metric ton produced is 150 m3 of dyed wastewater.

The amount of adsorbent used was determined by previous experiments conducted (Mumbi, 2018). To determine the amount of D.E used, simulated textile wastewater was made using methylene blue dye. A stock solution for the dye was made by weighing 100 mg of methylene blue dye and dissolving it in 1,000 ml of distilled water. The stock solution was diluted and 50 mg/L of the resulting solution were tested against the adsorbent solution. To make the adsorbent solution, 20 g of D.E powder was mixed with 180 ml of water and 10 ml of the solution was used to decolorize the 50 ml of the dye concentration. The resulting solution was put on a magnetic stirrer for 3 minutes at a speed of 350 rpm. Thereafter 2 drops of PAM added to aid the coagulation process. The mixture was stirred again at a speed of 150 rpm and allowed to settle for two hours. The samples were then pipetted into the clear tubes and measured for color, turbidity and COD (Mumbi, 2018).

To determine how much quantity of D.E is required to treat 150 m3 of dyed wastewater. Using the experimental results that show that 50 ml of Methylene blue is decolorized by 10 ml of the adsorbent solution. The amount of D.E would be 1.0*(150 m3) / 50 which is (1.0 g* 15*107)/50 which is 33*106g of D.E to treat 150 m3 of wastewater which translates to 3.0 MT for every 150 m3 per day. This is 1,095 MT of D.E per year for this particular factory. The total costs can be obtained as shown in table 1. Other than the adsorbent material, an important material for the proposed adsorbent to work includes coagulants. Coagulants bind with impurities to form particles of sufficient size and mass for removal by sedimentation or filtration (Dearmont et al., 1998). Depending on the type used, the cost of the coagulants used varies. PAM a flocculant is used in wastewater treatment as a coagulant. Because of its nature, it is mostly preferred in cases where the wastewater has high turbidity such as textile wastewater. The amount used as per the experiments is 2 drops that are roughly 0.1ml. Based on the amount of wastewater sample, 300 liters would be needed i.e. 300 kg of PAM.

As observed from Table 1 the total cost incurred when using activated carbon is six times the cost incurred when using D.E. Therefore, selecting diatomaceous earth would be a much more economically feasible option especially for developing countries that have to import the product.

Table 5. 1 Cost breakdown of the materials used in the treatment process

Material	Unit cost	Amount	Net price
Raw D.E	200$ per MT	1,095 MT	219,000 $
PAM	2$ per Kg	300 Kg	600 $
Total cost			219,600 $

AC cost: https://www.alibaba.com/showroom/activated-carbon_2.html, D.E cost: https://www.exportersindia.com/nova-industries-limited/diatomaceous-earth-powder-2979495.html

5.3.2 Calculations of the potential benefits from pollution control

The closest attempt to calculate the cost of inaction is by (Brandon et al., 1995) who have attempted to calculate the cost of environmental degradation in India. The aim of their study was not to provide precise figures but provide gross estimates of the different economic burden put on India by environmental degradation (Brandon & Homman, 1995). As mentioned earlier such studies are limited due to unavailability of data required to capture all the effects of environmental degradation (Maria, 2003).

In order to determine the possible benefits that would be incurred if suitable technologies were put in place; the costs that would be averted to treat the diseases that result from water pollution are calculated and termed as possible benefits. There exists logical models to estimate the cost of direct damages on human resources induced by water pollution through accounting for the additional cost of medical treatment from diseases resulting from water pollution. These include direct costs such as the cost of medicine, soft equipment, medical services and wages of doctors among other related cost that are as a result of water pollution (Al Barghouthi et al., 2016). It is important to note that the only quantified cost in our study was the health burden due to water pollution in the study area similar to (Brandon & Homman, 1995).

As proposed by (Al Barghouthi & Marie, 2016), we employed a model that takes into account these costs and made calculations for the estimated treatment costs (ETC) using equation 1 as follows:

$$E\,(TC_1) = \sum^{d}_{i=1} N_i AY_i AC_i P_i \qquad \textbf{(Equation 5.1)}$$

Where:

N_i = the number of affected individuals with a certain disease (obtainable from the health records maintained at the Ministry of Health)

P_i = the probability of diseases due to water pollution

AY_i= the average period of time,

AC_i = the average cost of treatment and follow up (obtainable from the patients' registers at medical centers Ac).

The average cost of treatment for a set of diseases (d) due to water pollution is estimated by counting the number of individuals (N) affected with a certain disease (i) in a polluted area. Assuming that the medical treatment of this disease requires an average period of time (Ay), as well as an average cost of medical treatment and follow up per day (Ac), along with the probability that the disease (i) is due to water pollution (Pi).The number of affected individuals with a certain disease (Ni) can be obtained from health records maintained at the Ministry of Health. The probability of diseases due to water pollution (Pi) can be computed as the difference between the number of medical cases of diseases in a polluted area (Npa). The number of diseases in a clean area (Na) expressed as a percentage of (Npa): Pi= (Npa − Nca) Npa The average period of time (Ay), and average cost of treatment and follow up (Ac), can be obtained from the patients' registers at medical centers.

The study identified certain diseases that result from water pollution, i.e. amoebiasis, diarrhea and bacterial infections (Maria, 2003; Yongguan et al., 2001). The omitted health cost in the study was the association to cancer occurrences due to chemical pollution in the water. The public records for these diseases were obtained from one local hospital (Uasin Gishu Hospital) in the area as shown in Table 5.2. As shown in Table 5.2, amoebiasis is the most prevalent disease in the region and has highest number of reported daily cases while bacterial infections were the least reported cases. The reported cases in table 5.2, were used to make cost estimation using equation 1.

Table 5.2. Public data records from one hospital in the region below

Number of cases	**Daily**	**Monthly**	**Yearly**
Disease type			
Amoebiasis	7	210	2555
Diarrhea	5	150	1825
Bacterial infection	4	120	1460

To estimate the affected population required for the calculation the study similar (Chibole, 2013) used certain locations within the basin area to make estimations. Chibole

(2013) to capture the effect of sewage treatment effluent on the river Sosiani. delineated the study area by dividing the area into according to various uses and locations i.e. forested zone, agricultural zone, urban zones which were divided into upstream and downstream similar to our study (Chibole, 2013). From his study from a basin size of 647km^2, an area of 225 km^2 was selected for the study based on these characteristics and similarly we employed the same basin size in our study. With the population density of 343 (people per sq. km of land area) (Kenya, 2019) and a selected basin area of 225 km^2, the affected population could be estimated as (343*225) = 77,175 (people per sq. km of land area on the River Sosiani basin). However, based on factors such as proximity to the river, differences in water usage and water sources, the affected population could vary. As shown in the results the treatment cost for the bacteria infection was the highest among the three diseases while the estimated costs for treating diarrhea was the lowest. This is because despite the number of bacterial infection cases being lower than those of Amoebiasis the treatment costs are different.

Table 5.3. Sample calculations using available data

	N	**AY**	**AC**	**P**	**ETC**
	Annual number of cases	Average period of time	Average Cost of treatment $	Probability that the cause is water pollution	Estimated treatment cost $
Diarrhea	2,555	5	8	0.5	51,100
Amoebiasis	1,825	10	5	0.5	45,625
Bacterial infection	1,460	7	10	0.5	51,100

Notes: Number of affected individual = the population size of basin area. Average costs and periods are estimates. Number of diseases in a clean area= half the number of diseases in a polluted area.

5.3.3 Cost benefit analysis

The third analysis included the CBA. The CBA is a useful methodology for informing decision making on resource allocation regarding important public policy issues. The CBA cannot fully capture and quantify everything that may be of concern in the public policy process or costs and benefits estimations. When conducting a CBA, the cost-benefit ratio (BCR) is used to summarize the overall relationship between the relative costs and benefits of a proposed project. As a general rule of thumb, if a project has a BCR greater than 1.0, the project is expected to deliver a positive net present value when implemented. The BCR for a tentative project that incorporates data obtained in Tables 1 and 3 were developed to analyze the feasibility of the project. Both diatomaceous earth and activated carbon were analyzed for all the recurring diseases in the region as shown in table 5.4.

As shown in Table 5.4 the BCR for diatomaceous earth was above 1 in all the three diseases in the region, indicating that in the treatment costs of diarrhea, amoebiasis and bacterial infection the benefits of utilizing the material would be 7, 8.8, 28.1 times the costs respectively thus a feasible choice. As amoebiasis is more prevalent in the region, the selection of this material would not be a feasible option financially.

Table 5.4. Cost benefit analysis for using D.E

Treatment cost	Diarrhea	Amoebiasis	Bacterial infection	Total
Cost of new technology	219,600	219,600	219,600	219,600
Benefits (Amount saved from treating the diseases)	51,100	45,625	51,100	147,825
Cost benefit ratio	0.23: 1	0.21 : 1	0.21 : 1	0.67 : 1

Notes: Cost in USD, * significant value, ratio > 1

5.3.4. Contingent valuation method analysis

The direct approach of CVM was used to collect information on the willingness to pay for improved water services in the region. The CVM explores an individual's willingness to pay for a change in public goods and reveals the benefits associated with the good or service in question. The CVM has been applied in many studies measure the economic value or resources and aid decision makers and governing bodies in policy adjustments and formation (Cooper et al., 2004; Li et al., 2014; Loomis et al., 2000; Mumbi & Watanabe, 2021; Shang et al., 2012; Zhongmin et al., 2003). The results obtained indicated that 79% of the 279 surveyed respondents were willing to pay an average of KSH 182.51(1.66$) for improved water conditions if the government would run a project in the region (Mumbi & Watanabe, 2021).

5.3.5 Implications of the study

Overall, the findings hint at valuating natural resources (the CVM analysis) and conducting cost-benefit analysis related to water resources and technological adoptions. This is because such issues will become critically important in Kenya and other developing countries paced for economic growth. The results from such analyses will thus promote better allocation of project funds and resources in future. Especially through project evaluations. From the cost analysis of the study and the results obtained, other implications can be summed up as shown in table 5.6 below.

The Environmental and water conservation costs are obtained from the annual budget reading for the country. The government of Kenya sets aside a given amount of money to invest in clean water supply and protection of the environment every financial year (planning, 2020). The proposed amount is a significant amount that if proper measures are put in place can be geared up towards other sectors of the economy to better the country. For the year 2020, the annual amount of money allocated for environmental remediation projects was 10 billion Kenya Shillings. As shown in table 5.6, putting up side-by-side cost estimations of the total benefits and the costs helps highlight missed opportunities in utilizing local resources to solve local problems in the country.

Table 5.5 Benefits vs cost of the project

	Benefits		**Cost**
	Total WTP	ETC	Treatment cost
	768,663.00	6,174,000	219,600
WTPa	X		Environmental and water conservation cost
			100,000,000

Therefore, similar studies should be conducted in various regions of the country to draft proposals that would help better allocation of resources. In this case, it would be wise for the government to invest in technological changes that would be a onetime cost that would offset future costs of environmental pollution.

The CVM analyses results should also not be ignored, as the amount pledged by community members is insignificant but would aid greatly in offsetting the cost of environmental pollution o the community members. Furthermore, involving the public through financial contributions and participation in projects would help them take ownership of the projects initiated in the region thus promoting longevity of the projects. After all, public participation is key component of the success of local projects targeting them. As shown in table 5.7 the calculations done are without uncertainties. However based on the limited scope used some of the uncertainties are addressed by making assumption.

Table 5.6 Tabulation of the uncertainties in the study

Category	Variables	Uncertainty	Description
Wastewater treatment	Exact volume of water	Relationship between textile production & waste water volume	Hypothetical scenario based on previous literature was used for this study (Weru, 1978)
Benefit Estimation	Affected population	Number of affected people	The basin area of River Sosiani was used as the baseline
	Number of cases in an affected area	Number of cases (daily fluctuation)	Hospital data was used however; it does not capture the patients who do not pay a visit to the hospitals. Only records from one hospital was used
	Probability	Probability of disease occurrence due to treatment Probability that the diseases are fully caused by water pollution	Calculations require data on number of cases in a clean area which was estimated based on a hypothetical probability
WTP	Total WTP	Distribution of WTP among affected people	The population in the whole region is assumed as willing to pay in the CVM analyses
Treatment cost	Number of cases	Minimum value estimated	Records from one hospital used

5.4. Limitations of the study

This paper has certain limitations. The selected pollution effects are restricted due to the data constrain. Additionally, as noted in previous literature the problem with identifying accurate health costs is that individuals compensate for the increased pollution by reducing their exposure to protect themselves and their health e.g. through sourcing alternative means of accessing water (Gómez et al., 2012; Moretti et al., 2011; Zhang et al., 2010). The results of the diseases used do not capture migrating individuals into the area and out of the area that might fluctuate the impacts recorded leading to underestimation or over estimation. This might be the case if the population is characterized by constant free migration (Gómez et al., 2012). In addition, although we capture several important aspects, we do not capture all aspects of resource costs such as costs of additional purification for drinking water and health damages related to other issues not tied to water pollution.

5.5. Conclusion

Through employing the proposed and existing models to estimate, the cost of direct damages to human resources caused by water pollution results in actual numbers and figures presentable to accountants, financial organizations and the government for consideration when making decisions. These figures and numbers could help the government and other authoritative bodies to impose tax and fees on polluters thus establishing green accounting while keeping accurate financial statements for interested parties (Al Barghouthi & Marie, 2016). When effective technologies are adopted, the resulting effects are, better aquatic environmental conditions, better usage of resident's incomes through reduced diseases, better use of the citizen's tax in other sectors of the economy, overall improved environmental conditions and promotion of the utilization of local resources exploitation. The study also acknowledges that the available estimates of the costs and benefits of water pollution programs are incomplete and do not conclusively determine the discount rates as the these estimates are an annual for one year.

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CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

The research combined a social science and an engineering perspective to curate the adoption of suitable wastewater treatment technologies to address the water pollution issue along River Sosiani in Eldoret, Kenya. The engineering perspective was drawn from my master's thesis that assessed the use of Diatomaceous Earth as a cost effective method to treat wastewater. While the social science aimed at identifying risk perceptions related to the declining water quality of River Sosiani, thereafter develop risk communication strategies among the various stakeholders who aim at conducting restorative projects on the river and in the area. Merging the two perspectives the study also attempted to analyzes the cost benefit of adopting appropriate technologies i.e. the use of Diatomaceous Earth for wastewater treatment the region to promote better wastewater treatment practices among the industries. Based on this background the aim of the research was to (i) Conduct a risk assessment to determine risk perception and the factors influencing risk perception of the community. (ii) Conduct a contingent valuation analysis to determine the willingness to pay and willingness to participate of the community. (iii) Determine the economic feasibility of the adoption of D.E technology for wastewater treatment by outlining the costs and benefits of the proposed project. The outcomes of studying these objectives are presented in Figure 6.1. The main findings from the study were as follows.

(1) From the risk assessment analysis, it was evident that risk perceptions in the region were high and were influenced by different factors. The findings also suggested the need to develop compelling risk communication strategies in the region. Through identifying the risk perception gaps in the society, they can be minimized; trust levels and public

involvement in remediation projects can also be increased. Finally, tailored solutions that target the community can be put forward to address the issue of water pollution of River Sosiani.

(11) The findings from the contingent valuation indicated that upstream and downstream respondents preferred non-governmental organizations lead projects while the factory group preferred the government led projects in the region. The downstream and upstream respondents were also more willing to participate (high mean scores) compared to the factory group (lowest mean scores) for the willingness to participate. These findings lead to the recommendations such as a need to use local environmental groups and local leaders for community outreach in the area especially for downstream and upstream respondents. There is also a need to bridge the gap between the factory workers and the community members, which can be done by the government as the factory group favor them more. Follow up studies were also recommended for the respondents who had lower to zero WTP in the region to determine their changes in the perception over time.

(111) The study using water related diseases in the region and tentative costs of the proposed technology (the use of D.E) determined the benefit cost analysis of the proposed project with an aim of providing decision makers with information on the feasibility of the project. The results were: estimations of the cost of direct damages to human lives as a result of water pollution, the presentation of numbers and figures presentable to accountants, financial organizations and the government for consideration when making decisions and accurate financial statements that can aid in better financial planning and management of future environmental projects

6.1 The major core findings of the study.

- The public's awareness on the declining water quality in the region is high.
- The perception of the sources of pollution among the groups is largely based on personal experience and that their preferences vary geographically.
- There is a significant difference in risk perception among the three groups understudy i.e. the factory group, downstream inhabitants and upstream inhabitants.
- The risk perceptions among the groups are influenced by different predictor variables.
- Participants in the region are willing to volunteer their time and pay for better environmental conditions in the region.
- Government led initiatives in the region are likely to succeed if they target the factory group as opposed to the residents in the region.
- Non-governmental led initiatives are mostly supported and preferred by the downstream and upstream inhabitants in the region and are most likely to yield long-term results if they target these groups.
- The willingness to pay and willingness to participate in environmental remediation processes of the residents differs among the three groups and is influenced by different factors.
- The adoption of suitable wastewater treatment technologies would help avert huge costs that are incurred through medical costs in treatment of water pollution related diseases.
- Downstream respondents are the most affected by water pollution and most worried about increased industrial growth in the region. They are also the most enthusiastic about volunteer activity.

- ✧ The factory group has the highest level of income, education levels, moderate risk perception and highest trust in the government.
- ✧ Upstream inhabitants have high support for volunteer activities, moderate education levels, concern about water pollution in the region and high risk perception levels.
- ✧ Different approaches and strategies are needed when addressing each of the groups based on the different characteristics and resulting behaviors.

6.2 Research implications

✓ Promotion and sharing of existing scientific information, based on the differences in scientific understanding about the water quality problem in the region. This will compel the people to want to take more actions and improve the conditions in the region.

✓ Urgent and compelling risk communication methods through building capacity for communicating risks in the region. Methods such as flyers, education seminars, advocacy, interactive panel discussions, brochures and media based platforms can be adopted in the region.

✓ Immediate actions on water quality management based on the high risk perceptions in the region.

✓ Collaborative measures among all the stakeholders are necessary for successive risk management. Stakeholders' participation is key in the region for any initiatives in the area to succeed. Thus identifying them and engaging them in the decision making process is necessary for the success and longevity of the projects in the region.

✓ Encouraging behaviour change in the residents in the area. This is possible because the results indicate that the populations surveyed have some knowledge and idea of the poor conditions in the River Sosiani and they have a clear understanding of the causes and effects of water pollution. Thus, based on this understanding, the residents in the area would be likely to be amenable to behavioural change that would benefit them.

✓ Interventions geared towards behavior change to curb all sources of water pollution in the region from point sources to non – point sources , this can be achieved through increased knowledge on the impacts of the poor conditions of the River Sosiani to the human health, economy and general wellbeing of the people.

✓ To engage influential actors, such as religious groups, local elected officials and community leaders, in promoting positive behavioural change among the community members. This would help in the community members being more able to relate to and accept proposed interventions, as opposed to relying only on the authoritative bodies to enforce behaviour change

✓ For downstream and upstream inhabitant the following implications are deduced: (i) incorporating elements, such as volunteer activities, in the projects conducted in the area and including them in the decision-making processes. This will enable them contribute and participate in the projects, thus promoting ownership and leading to longevity of the projects. (ii) Promoting and supporting local environmental groups by the government in this region. (iii) Promoting sustainable water practices, such as sustainable agriculture (especially for upstream respondents) and proper domestic wastewater management to help minimize the non-point sources of water pollution in the area.

✓ The government should reinforce and educate the factory group on the importance of compliance with set regulations by the government

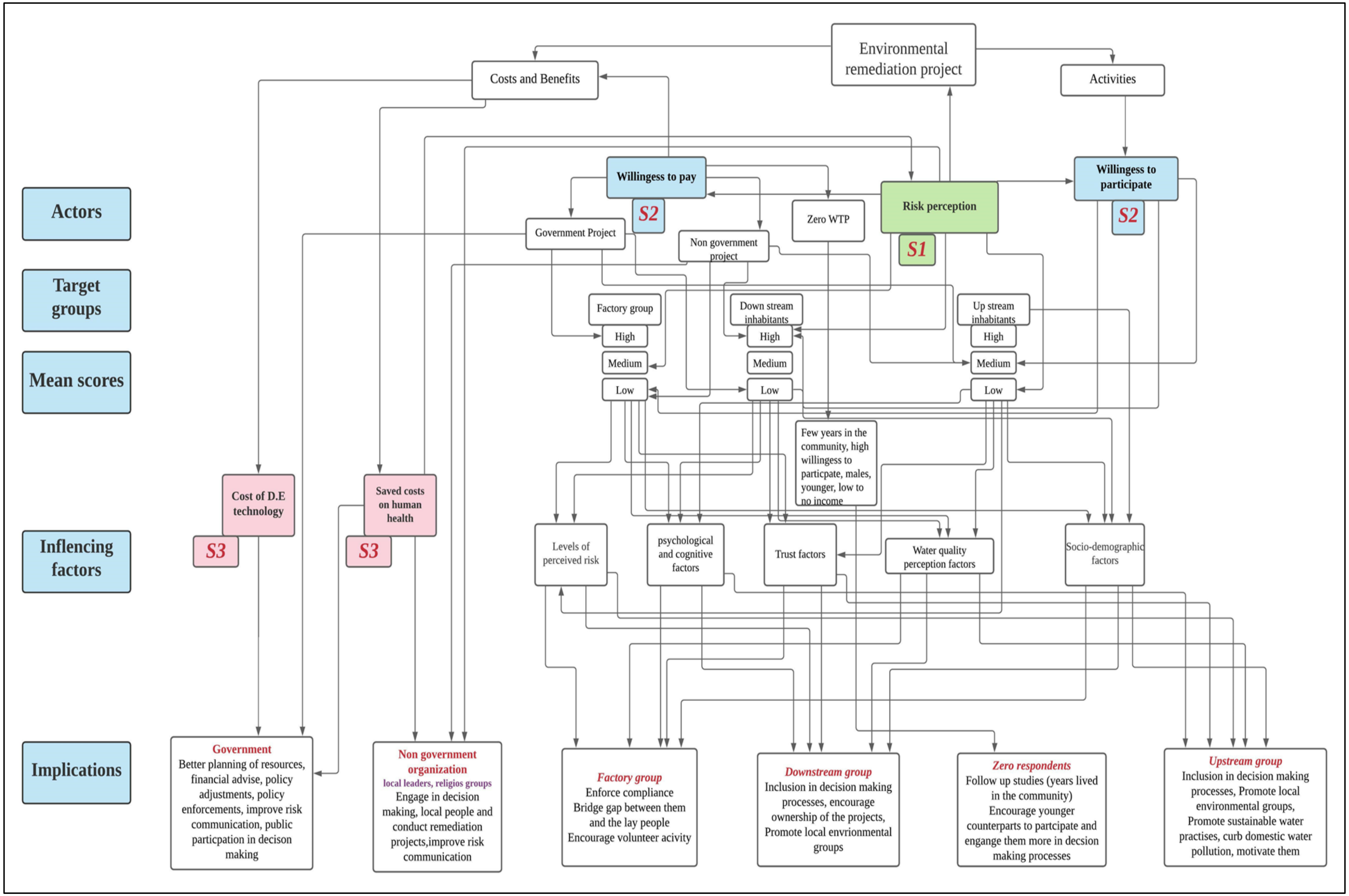

Figure 6.1 Flow chart of an integration of the three studies and the findings

6.3 Theoretical contributions

- The employment of non-convenient population sample: factory workers and treatment of these groups of respondents as different entities from the institution that they work in.

- The introduction of new constructs of water perception variables in the risk perception theories and framework.

- Additional literature in CVM studies through separating the proposed actors in the hypothetical scenario deployed in the willingness to pay amount.

- Modelling and cost breakdowns of appropriate technologies

- Determination of BCR for tentative project adoption

- *Promotion of natural resource utilization to solve environmental issues

The findings can be of interest to:

- The government in their endeavor to improve the quality of the environmental and health of the people of Kenya

- Policy decision makers, specific actors and decision makers who are seeking approaches to improve water quality in Kenya.

- Researchers keen in the study of risk perception among various target groups such as the factory group; our findings of the factory groups' perspective have been outlined and providing opportunities for further investigation.

- Non-governmental agencies, human right groups that want to aid in environmental remediation projects in specific areas and within the country.

- Industries that are seeking alternative available technologies that are cost effective for adoption in the systems

- The general public that is interested in understanding their communities and are willing to participate in the promotion of better environmental conditions in the region.

6.4 Limitations of the research

i. As in previous risk perception studies, some reported results might be sensitive to the hazards and variables selected for each specific study in our study the major point of focus was water use and water pollution in River Sosiani declining water quality in nearby waterbodies and other water sources was not factored in our study

ii. The study did not cover the whole region or all the factories and factory workers employed in the region thus the findings should be cautiously used when extending the results to other specific groups or regions, who are unlikely to have the same types of knowledge, cultural characteristics, or backgrounds as the sample in this study.

iii. When making cost implications calculations, the assumptions made as stated in chapter 5 were specific to this study and region and not all diseases that could be possible caused by water pollution in the region were identified.

iv. Additional statistical analyses such as measuring the robustness of the WTP variables in the double hurdle implementation were omitted based on the assumption that other tests such as collinearity checks and data suitability to the model were sufficient.

6.5 Recommendations for future research

The research aimed at solving the issue of water pollution in Kenya through integrating social sciences and engineering aspects to design adoptable wastewater treatment designs for Kenya. Through recommending collaboration of various actors as presented in Figure 1.3 among the various target groups and actors as identified in the figure. Acknowledging the limitations and uncertainties of study various recommendations for future studies are worth exploring as outlined below.

Follow up studies are recommended to determine any possible changes in the attitudes and behavior over time in the region for respondents with ze4o WTP. An analysis of these respondents revealed that a majority of zero respondents had lived a fewer number of years in the community. It is possible that they unaware about the reality of the situation or did not care because they would eventually move to other regions. For such respondents, future research is recommended to understand whether any changes in behavior and attitudes take place over time while staying in the area. This understanding would make clear the impact of this variable on the WTP and willingness to participate of the respondents in the region.

The risk perception and risk analyses comparison in this research was within the water quality context. Other researchers can expand this work by conducting similar research within other pollution contexts that were evident during the research for example, solid waste management, air pollution, noise pollution etc. to ascertain the findings on differences in risk perception and the influencing factors.

Future research should look into undertaking actual programmes that collect the pledged amounts in the willingness to pay and design activities for participation of the community members. This will ascertain the findings from previous studies and ours on the likelihood of participation and contribution of the actual amount. This s because our study used a hypothetical scenario to acquire the values and figures that were given by the respondents

Future studies should include metatheory analyses for risk perception to ascertain the conceptual framework for risk perception utilized in this study. Similarly, additional variables and influencing factors of risk perception, willingness to pay and willingness to participate could be identified and investigated. The study also recommends robustness checks using other methodologies for the data in the double hurdle model.

Similar studies could be conducted on other river networks and water sources for comparison purposes and application of the current research methodologies in such studies. The study also recommends drafting a comprehensive plan that extends beyond the scope used in the cost and benefit analysis to indicate clear costs and benefits that takes account implementation of the project and account for not only the financial/economic feasibility of the project but also other aspects such as design, social designs , historical elements etc.

APPENDIX

APPENDIX 1 Field surveys

The first field survey during 15th July - 4th October

1. Study 1. Risk perception and response by the society: Understanding public perception, knowledge and behavior for water quality management.

Research objectives

1.1 The aim of this study shall be to explore risk perceptions and responses of the public towards their perception on river water quality.

1.2 To explore societies understanding of risks related to water pollution.

1.3 To understand the societies perception towards the firms activities and their perception towards the firms actions.

1.4 Determine factors influencing risk perception of the people living around River Sosiani, perception about sources of pollution and its impacts.

1.5 Determine if risk perception and understanding possibly leads to action (risk behavior).

Survey activities

Investigating location: Eldoret county- areas Kapsoya, Saroiyot, Huruma, Kilimani, Langas and Kapsaos

Investigation people: Local residents of the area and Factory workers in textile industries

Investigation method: Questionnaire

In depth interviews

Investigation contents

- Societies understanding of the firm's activities and their implication on the environment.
- Community understanding of the impending risk and their role in the issue.
- The relationship among the various stakeholders in the issue.
- How does the community feel about the company and its activities?
- Does the community feel that they have a voice in issues affecting them?
- Can risk perception promote better management policies?

The second field survey during 7th – 18th October

2. Study 2: Economic cost feasibility analysis of diatomaceous earth for the removal of color from textile wastewater in Kenya.

2.1 Objectives:

1. To assess the use of D.E as low cost treatment option compared to other methods used for textile wastewater treatment.
2. To analyze the cost implications of adapting the new technology by the industries.
3. Evaluate the economic feasibility of introduction of new technology and the cost benefit of the new technology.

2.2 Survey activities

Investigating location: Eldoret county- areas Kapsoya, Saroiyot, Huruma, Kilimani, Langas and Kapsaos

Investigation people: Hospital staff , Local Hospital personnel and officers

Investigation method: Informal interviews , Data inquiry and records

Investigation contents

- ✓ Local area medical cases related to water related pollution in River Sosiani. Cost of treatment related to water pollution incidents.

Figure 7.1 Dyeing department at RIVATEX
Source: Taken by author (August 2019)

Figure 7.2 RIVATEX sewing room
Source: Taken by author (August 2019)

Figure 7.3 RIVATEX foundation stone
Source: Taken by author (August 2019)

Figure7.4 Dyeing components at RIVATEX
Source: Taken by author (August 2019)

Figure 7.5 Questionnaire survey
Source: Taken by author (August 2019)

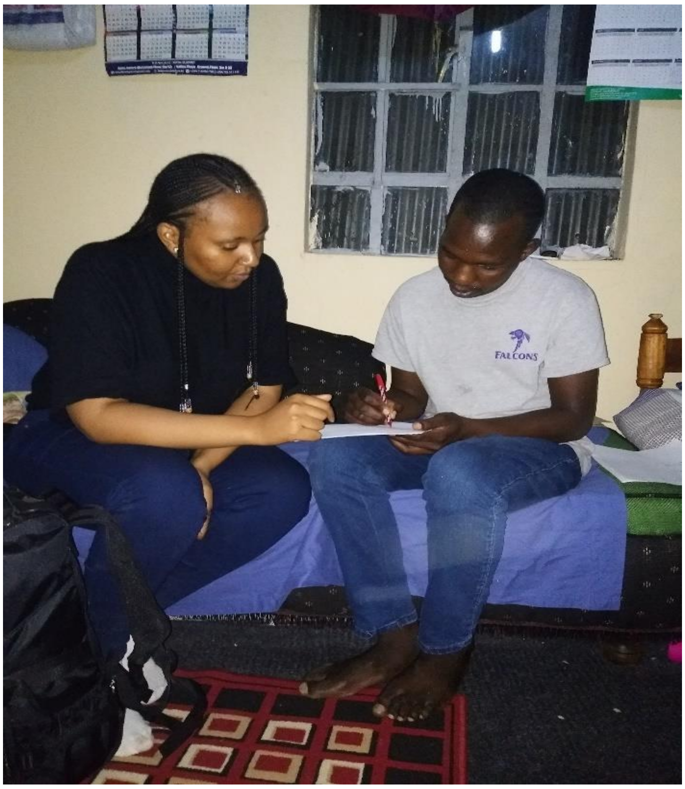

Figure 7.6 Questionnaire survey
Source: Taken by author (August 2019)

Figure 7.7 Hospital data collection survey
Source: Taken by author (August 2019)

Figure 7.8 Hospital data collection survey
Source: Taken by author (August 2019)

APPENDIX 2 Questionnaire sheet

Questionnaire Survey for the Study of Public Risk Perception and Factors Influencing Water Quality.

The survey is being conducted with an aim to identify factors that determine risk perception among the community residing along River Sosiani, and to determine the community willingness to pay and participate in activities aimed at improving the water quality in the river getting your feedback is important to the process.

We will ask you a series of questions regarding your interactions with the Sosiani River and your preferences and opinions related to water quality in the river. Your responses are voluntary and will be confidential. Responses will not be identified by individual. All responses will be compiled together and analyzed as a group. Please answer all the questions to the best of your ability. We value your opinions greatly and need your help. **Thank you for your time!**

Conducted by Anne Wambui Mumbi.

KOCHI UNIVERSITY OF TECHNOLOGY

Graduate School of Engineering, Kochi University of Technology, Japan

QUESTIONNAIRE SHEET

- ☐ The Sosiani River, a tributary of the river Nile that runs through the city is important to the people of Eldoret.
- ☐ The river is important to the people who use it for agriculture, recreational activities and other purposes.
- ☐ However in the past years the River has become threatened by pollution and decreased water quality.

Part 1: Personal Information

1.1 Gender_________________________

1.2 Age____________________ Years old

1.3 Occupation_____________________

1.4 Average Monthly Income _______Ksh

1.5 Educational level________________

1.6 Years lived in your Community

_________________years

1.7 Years expected to live in the community____________________ years

1.8 Number of family members____persons

1.9 Number of children (under 18 years) ______persons

1.10 Number of family members working for the local industries_____________

1.11 Name of the local industries

____

1.12 Position at the Local industry

____

1.13 Number of years working at the industry

____________________years

Part 2: Water Consumption, Use and Source

2.1 What is your **main** source of water for daily use?

___Mineral Water

___Private connection

___Water vendors

___ Public Well

___Rain water

___River or pond

___Other source

___Government Water Company

2.2 Water Use by Sectors: can you estimate the degree of use of water by the sectors provided below

2.2	Water use by sectors	Degree of use				
		Not at all	Less	Medium	High	Very High
2.21	Domestic use Drinking, cooking, cleaning utensils					
2.22	Personal hygiene Washing clothes, flushing toilets and bathing, brushing teeth					
2.23	Agriculture Food growing , back yard agriculture					
2.24	Other activities Car wash activities,					

2.3 Can you estimate the amount of water used for basic needs such as drinking and cooking per day, and how much it costs?

Amount of water used/day:	The cost:/month
.... drums/buckets/liters	Ksh................/month

2.4 Do you have enough water for your daily need? (If no direct to 2.5)

___Yes

___No

___Maybe

___I do not know/ I have never thought about it

2.5 Why don't you have enough water?

___No regular supply

___Water is too expensive

___Water shortage in the area

___It has always been like this

2.6 If not enough, how much water do you really need (for drinking and cooking and basic use) per day? And how much will that cost?

2.7 How do you manage to make up for the shortfall in your needs?

___Purchase water from vendors

___Tap rain water

___Survive with the little that I have

___Recycle water for use

___I Get from local river /well/pond

2.8 In your opinion who do you think is responsible for ensuring that there is a constant supply of clean water?

___Local government

___Local residents

___Central government

___Environmentalist and NGOs

Part 3: Significance of the river to the people

3.1 Are you aware of the existence of river Sosiani?

___Yes I do

___No I do not

3.2 In your opinion how important is the river and its water quality to you?

___Not at all

___Low

___Medium

___High

___Very High

3.3 What do you use the river for? (You can select more than one)

___Daily needs, such as cooking, washing, cleaning

___Occupational use

___Recreational use

___Agricultural use

___Emotional relief

___Cultural practices

___Other: ____________

___I do not use the river

3.4 In your opinion has there been changes in the water quality in the river over the years?

___Not at all

___Yes

3.5 Compared to 5 years ago, what is your opinion of the water quality in River Sosiani?

__Much better

__A little better

__No change

__A little worse

__Much worse

__Not applicable

3.6 What do you think are the main reasons for changes in the quality of river water?

___Residents' daily activities

___Industrial activities

___Natural events

___Agricultural activities

___Other factors (please state) ________________________________

3.7 How important is it to you to protect River Sosiani from pollution?

___Not Important

___Somewhat important

___Important

___Very important

___Extremely important

Risk perception based on water quality

3.8 Do you think that changes in the quality of the water in the river Sosiani will affect the quality of your life?

___Yes I do

___No I do not

3.9 If yes, what would be the level of risk to your quality of life, if the water quality went down?

___Not severe

___Severe

___Moderately severe

___Highly severe

___Extremely severe

3.10 What areas of your life are changing as a result of changes in water quality?

___Health

___Economic

___Environmental

___Socio-cultural

___Other areas (please specify) ________________________________

Part 4: Perception of water quality and sources of pollution

4.1 How would you describe the water quality of river Sosiani?

___Extremely low ___Low ___ Medium ___ High ___ Very high

4.2 When you are judging the water quality and level of pollution of the river Sosiani, how important are the factors listed in the table below.

4.3	Quality of water based on sensorial factors	Degree of Impact/Level of Agreement with Statement				
		Not at all	Less	Medium	Highly	Very Highly
4.31	The taste of water					
4.32	The color of the water					
4.33	The smell of the water					
4.34	The age and type of the pipes					
4.4	**Contextual factors**					
4.41	Refuse in the river					
4.42	Refuse along the river bank					
4.43	Fish in the river					
4.44	A sewer line near the river					
4.5	**Scientific factors**					
4.51	I am aware of certain chemicals in the water					
4.52	I have heard or been told that the water is not safe for drinking					
4.53	I have read about the scientific findings proving that the water is not clean					
4.6	**Based on speculation and feeling**					
4.61	I have seen changes in the water quality					
4.62	I just somehow know that the water is not clean					
4.63	I have seen and heard people get sick after the using the water					

4.7 In your opinion, what is the main sources of water pollution in the area?

___Domestic

___Industrial

___Agricultural activities

___Customs and rituals

___Any other sources

4.8 To what extent /degree do the other sources of pollution contribute to water pollution in your opinion?

No	Source of pollution	Degree /Level of pollution				
		Not at all	Low	Medium	High	Very High
4.8.1	Domestic sources					
4.8.2	Industrial activities in the area					
4.8.3	Agricultural activities					
4.8.4	Various customs and rituals					
4.8.5	Other sources					

Part 5: Degree of industrial risks judged by residents and its effect on health

No	Potential Impacts of industrial activities on human health and well-being	Degree of Impact/Level of Agreement with Statement				
		Not at all	Low	Medium	High	Very High
5.1	Industrial development in the area has generated more income to your family					
5.2	Industrial activities in the area have impacted on your career					
5.3	As a result of industrial development, you feel worried about your health					
5.4	As a result of industrial development, you feel worried about your future life in the area					
5.5	Water quality in the area has caused diseases among residents					
5.6	Water quality in the area has caused several kinds of cancer among residents					
5.7	Industrial activities have caused nuisance such as noise, smell, etc.					
5.8	The current condition of the industries has caused nuisance such as traffic jam, congestion, noise, smell, etc.					

Part 6: Nature of the risk and underlying understanding of risk-related judgment

6.1 How much possibility do industrial activities in the area still generate water pollution?

___ Not at all

___ Low

___ Medium

___ High

___ Very High

6.2 How much possibility are you impacted by water pollution in the area?

___ Not at all

___ Low

___ Medium

___ High

___ Very High

6.3 How severe does contaminated water in the area effect on human health?

___ Not severe

___ Slightly severe

___ Moderately severe

___ Highly severe

___ Extremely severe

Part 7: Risk mitigation and participation of various parties

Willingness to participate in activities for water improvement (validation in section 8)

7.1 Would you be willing to participate in activities to help improve water quality in river Sosiani (through activities such as collection of waste around the river, river bank protection etc.)?

___Yes

___No

___Considering

Perceived ability to control risk by various stakeholders and parties

No	What capacity does the following have to protect/manage water pollution in the area	Degree /Level of capacity				
		Not at all	Low	Medium	High	Very High
7.2	Government					
7.3	Industries and other firms					
7.4	Local people living in the area					

Part 8: Willingness to pay and participation in activities

Suppose that the County government and central government is considering implementing a program to ensure river Sosiani clean up through a proposed list of activities In order to improve the water quality in the River such as:

- ✧ Cleaning rivers through solid waste removal,
- ✧ Removal of structures from the river,
- ✧ Planting of trees along the river bank,

The program would lead to major ecological benefits in the area such as improved water quality and water clarity in the river leading to improved water quality within the required standard. The river will also be improved and in a much better condition as a result of the activities.

8.1: How likely would you be willing to participate in such a program?

___Very likely

___Likely

___Somewhat Likely

___Somewhat Unlikely

___ Unlikely

Factors that determine participation in the program

If you would participate in the project to what extent do you agree or disagree with the following statements

No 8.2	I would participate in the activities because	Degree of agreement				
		Strongly disagree	Disagree	Undecided	Agree	Strongly agree
8.2.1	It is important to manage water resources					
8.2.2	I feel a personal obligation to contribute to the environment					
8.2.3	The opinions of people who I value expect that I take care of water resources					
8.2.4	Most important people in my life would approve supporting the proposed plan					

Subjective norms and social norms

No 8.3	How are the factors below likely to influence your participation level	Degree of impact on your willingness to participate				
		Not at all	Low	Medium	High	Very High
8.3.1	Type of activities involved					
8.3.2	Length of the activity					
8.3.3	Authority running the activities					
8.3.4	Payment					
8.3.5	Time and day of the week of the activities					
8.3.6	My availability for the activities					

8.4 Suppose the funding for this program would come from an additional fee collectable every month from all the households in the area. Would you be willing to pay the additional fee collectable every month to fund the program?

___Yes (Please follow with question 8.5)

___ No (Please follow with question 8.7)

8.5 Please state the amount you would be willing to pay to support the program per month.

___________________Ksh per month

8.6 Why would you pay the stated amount? (Please check **only** the most important **one**)

___The program is worth at least this much to me

___I feel we have a duty to protect the river

___To contribute to a good cause

___To pay my fair share to protect the river

___Other reasons______________________

8.7 If you answered **No** in question 8.4 please check the reason below that **best** describe why you answered no.

___The program would not be worth anything to me

___It's unfair to expect me to pay for this program

___I cannot afford to pay for the restoration of the river

___I object to the question

___I do not think this program would work

___Other

8.8 If the same project were to be carried out by an **NGO** or a **charitable** organization how much would you be willing to contribute towards the program per month?

__________________Ksh per month

Thank you very much for your participation

LIST OF PUBLICATIONS

Mumbi, A. W., & Watanabe, T. **(2020)**. Differences in Risk Perception of Water Quality and Its Influencing Factors between Lay People and Factory Workers for Water Management in River Sosiani, Eldoret Municipality Kenya. Water, 12(8), 2248. (Q2, Impact Factor =2.069). https://doi.org/10.3390/w12082248

Mumbi, A. W., & Watanabe, T. **(2021).** Willingness to Pay and Participate in Improved Water Quality by Lay People and Factory Workers: A Case Study of River Sosiani, Eldoret Municipality, Kenya. Sustainability, 13(4), 1934. (Q2, Impact Factor =3.251). https://doi.org/10.3390/su13041934

Estimating the cost of water pollution for the adoption of appropriate water treatment technology (Preparation for submission).

International conferences attended

** The 12th International Conference on Applied Human Factors and Ergonomics, New York, United States of America, 25-29, July 2021*