ECONOMIC COST OF SAFE DRINKING WATER AND SANITATION IN LEKBESI MUNICIPALITY

A Thesis

Submitted to the Department of Economics, Patan Multiple Campus, Faculty of Humanities and Social Sciences, Tribhuvan University, Nepal, in Partial Fulfillment of the Requirements of the Degree of

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By

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DECLARATION

I hereby declare that this thesis entitled ECONOMIC COST OF SAFE DRINKING WATER AND SANITATION IN LEKBESI MUNICIPALITY which I have submitted to the Department of Economics, Patan Multiple Campus, in partial fulfillment of the requirements for the Degree of MASTER OF ARTS in ECONOMICS, is entirely my original work prepared under the guidance of my supervisor. I have made due acknowledgements to all ideas and information borrowed from different sources in the course of writing this thesis. The results of this thesis have not been presented or submitted anywhere else for award of any degree. I shall be solely responsible for any evidence found against my declaration.

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LETTER OF RECOMMENDATION

This thesis entitled ECONOMIC COST OF SAFE DRINKING WATER AND SANITATION IN LEKBESI MUNICIPALITY has been prepared by Mr. BAL MUKUNDA KUNWAR under my guidance and supervision. I, hereby, recommend it in partial fulfillment of the requirements for the Degree of MASTER OF ARTS in ECONOMICS for final examination.

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LETTER OF APPROVAL

We certify that this thesis entitled ECONOMIC COST OF SAFE DRINKING WATER AND SANITATION IN LEKBESI MUNICIPALITY submitted by BAL MUKUNDA KUNWAR to the Department of Economics, Faculty of Humanities and Social Sciences, Patan Multiple Campus, Tribhuvan University, in partial fulfillment of the requirements for the Degree of MASTER OF ARTS in ECONOMICS has been found satisfactory in scope and quality. Therefore, we accept this thesis as a part of the said degree.

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ABSTRACT

The economic cost of safe drinking water and sanitation in Lekbesi municipality, Surkhet explored the cost for safe drinking water. Socio-economic, consumer's preference over treatment methods, costs associated with human health, water-borne diseases, was studied. The descriptive research design was followed supported by quantitative evidence, supplemented by microbial water quality testing at the point of use in systematic random samples of 121 households. 58.7% of the respondents are drinking water directly, followed by 38.8% using a ceramic candle filter, 9.1% and 6.6% are using chlorine and boiling to drink water, respectively. It has been observed that 30.3% and 9% of water samples of filters are in intermediate and high risk, respectively. Out of 625 people in 121 households, 38 households and 62 persons had suffered from diarrhea or worm and had to take rest for 85 working days. The economic cost for selection of water treatment methods was estimated to be NPR 1632.8 with maintenance cost per annum NPR 146.3. The cost of treatment for water-borne disease (diarrhea) was NPR 1500 for all travel, medicine and logistic arrangements the opportunity cost for caretaker was NPR 2436. Overall, the gross economic cost of treatment for unsafe water was NPR 3936 per person per annum.

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LIST OF ABBREVIATIONS

A$	American Dollar
CFU/100ml	Colony Forming Units in 100 milliliter
EAC	Equivalent Annual Cost
E.Coli	Escherichia Coli
FRC	Free Residual Chlorine
GDP	Gross Domestic Product
GoN	Government of Nepal
HHs	Households
HWTS	Household Water Treatment and Safe Storage
LPG	Liquefied Petroleum Gas
ML	Milliliter
NDWQS	National Drinking Water Quality Standard
Nos.	Numbers
NPR	Nepali rupees
RM	Rural Municipality
RO	Reverses Osmosis
SD	Standard Deviation
SDG	Sustainable Development Goals
SoDis	Solar Disinfection
T.Coli	Total Coliform
UV	Ultra Violet
VIP	Ventilated Improved Pit Latrine
WASH	Water Sanitation and Hygiene
WHO	World Health Organization
%	Percent

CHAPTER ONE
INTRODUCTION

1.1 Background of the study

Possessing safe drinking water is crucial for developing sustainable health and a booming economy for any society (Abuzerr et al., 2020). Safe and clean drinking water and sanitation is a human right. The constitution of Nepal, 2072 has provisioned that “each citizen shall have the right to access to clean water and sanitation" as a fundamental right. The UN-SDG goal 6 states that “water sustains life, but safe clean drinking water defines civilization” (United Nations, 2015). In Nepal, more than 90% households have access to an improved drinking water source (World Health Organization, 2011). However, improved water schemes do not ensure that the water is free from fecal contamination. Poor water quality still dooms all the commitment, where 9 out of 10 samples at the point of use had detectable Escherichia Coli (Robinson et al., 2018).

Escherichia Coli (E. coli) is considered a less reliable but acceptable indicator of faecal contamination where populations of thermotolerant coliforms are composed pre-dominantly (WHO, 2011). Microbial in water samples are counted in colony-forming unit (CFU) and table 1 presents the value of CFU and the risk categories of the water.

Table 1: Microbial risk category of water sample

S.No	Risk Category(In conformity with WHO guideline)	Colony Forming Units (CFU/100ml)
I	No risk	0
II	Low risk	1-10
III	Intermediate risk	11-100
IV	High risk	101-1000
V	Very High risk	1001 above

Source: World Health Organization (2011)

Several reports have shown that water borne diseases are still a major challenge in Nepal because of inadequate safe water supply, poor sanitation and living conditions

(Pokhrel et al., 2004). The study further highlights that the several factors such as the literacy rate, socio-economic status, and social, religious, or personal perception of the cause of disease may influence the rate of diarrheal diseases.

The standards of WHO further suggest that household water treatment and safe storage dramatically improve microbial water quality; significantly reduce the incidence of diarrhea; are highly cost-effective; and can be focused to make health improvements among the most vulnerable populations. 74.2% of houses do not practice any water treatment at household, 16.8% houses use water filters and 10.3% practice boiling- overall only 23.5% of household use an appropriate treatment method in Nepal (Bhusal, 2021). To have public health impact at the population level, safe water promotion needs to be implemented and evaluated at scale and address all the factors—social, cultural, economic, demographic, political and ecological—that facilitate and inhibit behavior change (Blum et al., 1983).

Scattered and isolated settlements in the remote areas where the communities must rely on small brooks running from the mountains for drinking water might not always be safe and could be microbial polluted. The World Health Organization (2011) indicated that developing countries face a high number of water-borne diseases multiplied by the unhygienic environmental condition. Drinking water collected from the piped supply if stored in a poor environment could be leading to faecally contamination and thus causing diarrhea (Mintz et al., 1995). Similarly, Shrestha (2018) pointed out that the contamination of water at point-of-use occurs because of the contamination of drinking vessels by domestic animals, which are freely roaming inside the houses.

Thus, the water at the point of use is a high level of consideration and proper measures need to be taken to improve the people's way of handling water. Mintz (1995) further clarifies on the need of water treatment at onsite before consumption and safe storage to reduce the water borne diseases. The author also insists on proper use of sanitation structures such as use of toilet, handwashing with soap and safe food for better water quality. Similarly, the government of Nepal has also initiated a five plus one indicators for sanitation, namely, safe water, use of toilet, safe food, personal hygiene, clean house, and environmental sanitation as a key to the change (Budhathoki, 2019).

The lack of access to safe water, basic sanitation, and good hygiene practices is the third most significant risk factor for poor health in developing countries with high mortality rates (Bartram et al., 2001). The author further illustrated that the diarrheal disease occurrence in the developing countries is the principal result of inadequate water, sanitation and hygiene leading to the death of 1.8 million people every year from diarrheal disease, among whom 90% are children under the age of 5. Also, the study mentioned that not just the diarrheal cases, high-intensity intestinal helminth infections (Ascariasis, Trichuriasis, and Hookworm disease) could lead to severe consequences to cognitive impairment, massive dysentery, or anemia.

A study from Cameron et al. (2011) showed that the improved water supply and sanitation facilities and better hygiene behavior have radically reduced population illness of diarrhea morbidity by up to 25% and 32%, respectively. The study further suggests that the improvement of drinking water quality by adopting water treatment methods at home has reduced diarrhea episodes up to 39%. The author further adds that in addition to the health benefits, safe water and sanitation could save time and energy.

1.2 Statement of problems

People are exposed to unsafe water in the absence of proper treatment thus recurrence of contamination takes place at the sources and at the household level. Proper interventions at the scheme level or measures at the household level could ensure the water quality security for the consumption (WHO, 2011). However, water borne diseases are observed as a major setback in the rural areas, consuming their quality time for treatment and taking care of sick people (Robinson et al., 2018). Similarly, people must spend an abundance of time to fetching minimal quantity of water, whereas exposure to unsafe water has increased the risk of being affected by diseases and its treatment (World Health Organization, 2007). Thus, measurement of the benefits of safe and unsafe drinking water consumption from the point of economic cost needs to be explored.

Alternatively, proper selection of water treatment methods is essential to overcome the burden of disease, followed by proper handling of these treatment methods is very crucial to overcome the challenges and burdens of risk of poor water quality. Thus, the gap between the costs invested for a proper treatment method should be compared with the cost toward treatment whilst being ill. This sort of research is missing and should be properly identified in order to create an equilibrium between good health and proper water quality for safe drinking. Also, in the context of underdeveloped nations like Nepal, cost-effective for the selection of water treatment methods for improved water quality should be properly determined and promoted for improved health of community.

1.3 Research questions

The study performs to resolve following research questions:

- What is the current water and sanitation situation, including the key socioeconomic characteristics at the household level and the incidence of the water-borne disease?
- What are the costs associated with water-borne diseases bear by the households- avoidance, remediation, disease treatment and opportunity costs?
- What are the economic costs of safe and unsafe drinking water?

1.4 Objectives

The main objective of the study is to determine the economic cost of safe drinking water and sanitation.

The specific objectives of this study are.

- To explore the water treatment method adopted and the incidence of water-borne disease.
- To study the economic cost associated with the risk of poor-quality water to human health.

1.5 Significance of study

The study focuses on the economic benefits of safe drinking water and sanitation at rural area. It focuses on consumer’s behavior toward the selection of water treatment methods at the household level, followed by the operation and maintenance of these products, hidden costs due to unsafe water. This information could be further used for designing the projects that target better quality water by adopting new trends of activities and policies to meet the sustainable development goals and ensure the water quality of the rural community.

Generally, the water routes and levels of hygiene increases importance in a community, however, in many poorer tropical countries, the priority is not to improve the quality of drinking water supplies but to provide adequate water close to the home, and supply or maintain adequate sanitation (Bartram et al., 2001). The economic cost of safe drinking water and sanitation could significantly represent this context and identify the hidden costs for the medicinal treatment and the opportunity cost for a caretaker.

1.6 Organization of study

The study compiled in five chapters are explained as; Chapter one is the Introduction of the research that includes the background of the study followed by research gaps and research questions. Thus it provides the information on main objective and specific objectives based on the problem statement. This chapter consists information on the limitations and significance of the study. Chapter two includes literature review, which consists of the findings and recommendations on global and national context from completed studies on similar context and scenarios. Chapter three includes research methodology, which explains the methods, study area, sampling techniques and sizes used for this study, it also includes the techniques and tools applied for the data collection and analysis methods.

Chapter four focuses on the data presentation and analysis of the study based on the field survey and the data generated. It includes discussion on the basis of the objectives and research questions. The findings are thus presented in tabular or in figure, for proper understanding. Chapter five includes the summary and conclusion from the study. It summarizes the entire methodologies adopted and the findings from the study, following the conclusion drawn and the recommendation for further studies. References and appendix are included at the end of this study report.

1.7 Limitations of study

The study was limited on various issues. The study did not cover the fixed cost for establishment of the water infrastructure. No relations of market access, availability and improvement of water quality related to household water treatment methods were explored. The selection of the study area was limited to only one ward of the Lekbesi municipality in Karnali province. The microbial data were collected during the field survey in 2022 and previous information on the microbial test results were excluded. The study focused on the existing behavior of the household sanitation and drinking water and its incidence on the economic cost for treating water borne disease-diarrhea, only.

CHAPTER TWO
REVIEW OF LITERATURE

This section of the report reviews the literature of previously conducted study on the economic cost of the safe drinking water sector. It reviews various journals, websites and documents to summarize and identify the gap in the research. All these collected documents and information are presented in a proper sequence for understanding.

2.1 Theoretical review

Unsafe drinking water and lack of sanitation, followed by poor hand-washing practice among mothers after using the toilet, cleaning the child's bottom, before handling food and before feeding the child are associated with childhood diarrhea. Similarly, inadequate coverage of safe water supply and sanitation coverage has a major contribution to diarrhoea among children in Nepal. Diarrhoeal disease is a common and seasonal public health issue usually triggered by food and water safety or hygiene issues. The disease has been associated with higher temperatures and is one of Nepal's leading causes of morbidity and mortality (Pokhrel et al., 2004). Similarly, regional differences due to differences in socioeconomic status, development level, population density, and access to water sanitation and hygiene are also considered crucial factors for occurrence of diarrhea (Shrestha et al., 2019).

Water sanitation and hygiene need iterative interventions, Figueroa M E and Kincaid D L (2010) stated that improving water treatment interventions should begin with an understanding of the audience and its perspective regarding water treatment technologies and related behavior. The study had further suggested that the field of water, sanitation and hygiene lacks a theory-based approach to the design and evaluation of interventions. In fact, holistic approach to water and the consequences of the poor water quality in the social, economic, health and cultural impacts need to be considered properly. Thus, the human behavior, their motivations, individual choices by utility maximization, their rationality and preferences need to be thoroughly assessed (Becker, 1965). Beside these, another challenge faced in implementing water and sanitation interventions in developing countries is the expenditure patterns required to meet the standards, which somehow are unrealistic in many developing countries in terms of the technology and methods available (World Health Organization, 1997).

The 'Improved' water supply is generally portrayed as a better physical access and the protection of water sources, including stand post, borehole, protected spring or well, or collected rainwater, however, regular monitoring and preventive measures are not implemented in the standard criteria (Haller et al., 2007). It can be thus referred to the Blum (1983) study which suggests the greatest health risk associated with inadequate or unsafe water, sanitation and hygiene is gastrointestinal illness, or diarrhea, which contributes to 39% of the disease burden associated with poor water, sanitation, and hygiene conditions resulting in 1.5 million fatalities that are largely among children under the age of 5. Diarrhea causing microbes can easily enter water supplies with fecal contamination and in the absence of efficient diagnostic methods for the full range of diarrhea causing pathogens could serve as a proxy for health risk (Daniel et al., 2019). Bhusal (2021) also indicated that providing the safe water through pipe is challenging, as 82.2 percent of household water was contaminated with Escherichia Coli, confirming that monitoring and publishing of microbial drinking-water quality testing could raise the awareness of public health. It was found that 9.7 % of children who are under 5 years old had an episode of diarrhea and 56.9 % of children of them had to seek advice or treatment from a health facility or provider. Water treatment methods adopted at the remote areas thus is influenced by various parameters, other than the quality of the product itself. WHO (2011) focused on the simple and inexpensive technologies for treating drinking water at home and storing it in safe containers.

Safe drinking water can be referred to the water used at the house which are further treated by adopting appropriate water treatment technologies. World Health Organization (2011) has listed ceramic candle filter, boiling, chlorination, sodis etc. as some of the devices as intervention to improve the water quality at the point of use. The cost of these products may vary from accessibility and availability of the products. Generally, the cost of these treatment products in Nepal is on higher side, as most of these are imported from other countries. One of the treatment methods, Chlorination is considered an effective intervention toward the pathogens; however, regular monitoring of the Free Residual Chlorine (FRC) should be carried out frequently as per the World Health Organization (WHO) standards, and the FRC level should be within 0.2-0.5 mg/l (World Health Organization, 2011). Market demand of any product depends on its own price, consumers' income, prices of other commodities, consumer's tastes, income distribution, total population, wealth, credit availability, government policy, past levels of demand and past level of income (Koutsoyiannis, 1979). Haller et al. 2007 identified a positive correlation between increased national income and the proportion of population with access to improved water supply, which suggests the proper treatment methods at source or at households through proper and sufficient investment.

Government of Nepal has implemented the National Drinking Water Quality Standards 2005 which is further revised in 2022 to provide effective monitoring of the water quality. However, the protocol to conduct the microbial test is challenging in the scattered and rural settlement. Similarly, other costs associated with water treatment products are regular involvement in maintenance, replacement of candle in case of broken/long term of use for filters, firewood, or electric bills for electric kettle, purchasing cost of Piyush/chlorine etc. are some costs related to the operating costs of the water treatment methods adopted. Similarly, containers for transportation and storage also play a vital role in the occurrence of re-contamination. Thus, it can be summed up that water treatment had added extra financial burden, especially for the poor households which should be averted or minimized by concerned authorities to provide adequate quantity, quality, and access to drinking water for all (Shrestha et al., 2018). However, cost taken for remediation of healthcare and other hidden costs are not included in the study. Thus, to overcome the consequences of poor water and sanitation, preventive measures by installing proper sanitation facilities with methods for water treatment at households are essential. The economic cost for such water and sanitation facilities should be carried for proper selection and interventions at community level.

The valuation of the drinking water could be done in two ways- direct and indirect (Lal, 2014). The indirect method for evaluating as indicated by the study is a qualitative way where the number of incidents reported, volume and cost of medicines, average time spent by the travelers (patients and caretaker), government recurrent costs, and the household costs could be considered for evaluating the outcomes. The study had stated about the valuation process by identifying the safe drinking water-services which are valued by the HH, followed by the concentration of pathogens. The valuation further measured the context using the avoidance cost-use of proper water treatment methods, remediation cost – cost for the supporting structures in water sanitation and hygiene and the treatment costs through various outlet, consuming medicines and taking days off from normal activities. The results of the study was used as the basis for carrying out further economic analysis on appropriate options for improving existing water and health scenarios. The most relevant methods to figured out the costs are transactions and opportunity costs (Moore et al., 2017). Researcher had further elaborated on the transaction's costs as the price paid by parties while making decisions by involving the exchange of goods or services, which are associated with response and recovery activities. The research had related opportunity costs of the forgone chance to use resources that were deployed to the outbreak for other purposes and the economic cost of the outbreak with the next best alternative use for resources dedicated to the outbreak, such as time spent on treatment and fixed budgets and agreed work plans, diverting resources to the outbreak comes at the cost of the ability to perform their 'normal' activities, even when no additional remuneration could be calculated as the going-rate multiplied by the estimated hours dedicated to treatment.

2.2 Global Context

Various study on the interventions for improving of existing water supply and sanitation conditions had taken place in different part of the world, which were not limited to direct or indirect impacts on the health sector, but flow-on effects on other parts of the economy were also properly considered. Some of the study are included as follow.

Collier et al. (2012) conducted a study on direct healthcare costs of selected diseases primarily or partially transmitted by water in Medicare databases containing anonymized medical and pharmaceutical insurance claim information for over 20 million employees, dependents, and retirees enrolled in primary or Medicare Supplemental insurance coverage through employers across the USA. A complete estimate of the true cost of waterborne illness were included for the cost of mortality and disability, work and time loss, and chronic sequelae. The study figured out that the salmonellosis was estimated to cost \$2.5 billion per year in 2007 US dollars when productivity loss and mortality were accounted. The study further stated that drinking water led to extraordinary costs in a community-wide outbreak, such as the massive 1993 outbreak of cryptosporidiosis in Milwaukee that sickened 400,000 and was estimated to cost \$96.2 million in medical costs and lost productivity. Thus, the study strongly concluded that the unsafe water led to various challenges and threats of disease leading to an economic burden to the household. The study further suggested that providing water security could play a wider role in poverty reduction and improving livelihoods, by reducing uncertainty and releasing resources that could be used to decrease vulnerability. However, study didn't consider the route of water contamination and the water treatment methods to avoid these outbreaks.

Lal (2014) conducted a study on Economic Costs of Inadequate Water and Sanitation in South Tarawa, Kiribati. The primary objective of the study was to estimate the economic costs associated with the current inadequate water supply and sanitation condition in South Tarawa, including the (i) preventative, curative, surveillance, and response measures associated with water-borne and vector-borne diseases incurred by households and the government; (ii) impacts on tourism due to a decline in the aesthetic value of South Tarawa's beaches and lagoon; and (iii) decline in coastal fisheries and overall environmental quality. The study reviewed secondary literature and the analysis of primary data collected from household questionnaire's. The indicators measured were health expenditures, loss in economic productivity, reduced benefits from tourism and environmental pollution. The study revealed that the government, individual households, and economy as a whole shared the burden of annual economic costs between A$3.7 million–A$7.3 million, or 2%–4% of national GDP. The study had undertaken conservative estimates where many costs could not be determined because of the lack of formally recorded disease information, difficulty in differentiating the costs, and/or difficulty in estimating the nonmarket nature of many of the direct and flow-on-costs. This study had limited its objectives on the cost burden after getting sick of water borne disease however cost related to water treatment methods adopted households were not included in the study.

Bedi et al. (2015) conducted reviews on water quality problems and incidence of various water-related diseases and their economic impact on households in Ludhiana. The study was based upon both primary and secondary data. Data regarding the water quality and incidence of diseases were taken from secondary sources. Economic cost of coping mechanisms and disease, cross-sectional data from 360 households were collected for the year 2009-10. The study further illustrated that the quality of water was in major problem because of leaking pipes, water storage and the slow movement of water during transmission and distribution significantly contributed to health problems, especially for the low income group. The calculation for the economic cost of water-related diseases was done calculating total economic cost by addition of cost of treatment and income loss. Similarly, the cost of treatment of water-related diseases were taken as an actual expenditure on treatment. Similarly, income loss for the household were the total days of illness of earning members multiplied by per capita per day income. The per capita per day income taken was the total family income of all households in the category divided by the product of number of households, their working days and family size. The study concluded that although the quality of water at the source was suitable for human consumption, it got polluted during its transmission from the source to the end use. Thus, households focused on proper interventions on treatment methods and their effectiveness towards the microbial effect, based on their income categories and selection of water treatment products.

Butt et al. (2016) conducted a study on cost of illness of water-borne diseases of Quetta city. The study investigated awareness about water quality and water borne diseases; analyzed monetary burden of water borne diseases. Primary data were collected from 200 households selected randomly by using cluster sampling technique. The study concluded that the household's mean frequency of exposure to disease was 2.35 per year and the disease lasted for an average of 2 to 3 days per episode. The research further identified that 44% of the household were affected by diarrhea with hospitalization and medicines, which had caused the highest cost. The research further elaborated that annually each household had to bear Rs. 10,494 cost for treatment of water borne diseases, where most households opted for healthcare services from private and public hospitals (62%, and 26%, respectively), while the remaining opted for either home remedies or herbal medicines. The study did not include the methods adopted by the household for the water treatment and sanitary status of the household. The study only considered the post disease conditions and people's requirements of treating the illness.

Jabeen et al. (2020) conducted a study on environmental and economic impacts of poor water and sanitation in various communities in Pakistan. The study focused on impact of poor water and sanitation on household economy with qualitative and quantitative approaches to assess the impact of poor water and sanitation on household's economy. The study covered people without access to proper sanitation facilities in most of the rural settlements. The study figured out that the disease ratio was very high and unawareness of proper handling of water and sanitation had adversely affected household economy by hospitalization, transportation and medical costs. The study conducted had properly identified the impact on economic sector, such as health care cost and productivity cost. The direct healthcare costs of health-seeking, including formal health care services and traditional healers and indirect costs of stress time loss, family effect care in food/sometimes special food prepared for ill person and traveling cost of the family welfare cost were included. Thus, the study had completed various aspects of the economic cost, however the study lacked the present practices of water handling and sanitation at household level. It clearly missed the inter-relations between the treatment methods adopted at the household and its consequences.

2.3 Nepalese Context

Various study related to safe drinking water and sanitation and its effect on human health had been conducted in Nepalese context. Some of the researches are included in the further section as follow.

Shrestha et al. (2018) conducted study on hidden cost of drinking water treatment and its relation with socioeconomic status in Nepalese urban context. The study was carried out to identify the household water treatment practices, associated costs, and how these costs were associated with the urban socioeconomic context of the Kathmandu Valley. The study used questionnaire survey at the 50 clusters by interviewing heads of 10 randomly-selected households at Chyasal, Lalitpur. The study focused on water treatment cost with socioeconomic variables, social and economic situation and water insecurity perception, average monthly treatment cost in households by using method-specific cost of households. It was found from the study that the water treatment expenditure per households was NPR 380 where serious inequality had existed in water treatment expenditure, which was real but hidden expenditure had been drained from the households. The study had considered the purchasing and operating cost of water treatment cost, however the study did not include the effectiveness of such household water treatment purchased at household. The scenario of microbial contamination in treated water and reduction on water-borne diseases were yet to be identified.

Daniel et al. (2019) has conducted study on understanding the effect of socio-economic characteristics and psychosocial factors on household water treatment practices in rural Nepal using Bayesian Belief Networks. The study focused on water sanitation and hygiene related cross-sectional survey of rural communities in the mid and far-western regions of Nepal. Descriptive analysis of the interactions between socio-economic characteristics and psychosocial factors, and the impact of these interactions on the adoption of household water treatment methods through the lens of the simplified Risk, Attitude, Norms, Ability and Self-reliability (RANAS) model was carried out. Five VDCs were selected in different districts for data collection where semi- structured face-to-face household interviews were carried out by selecting the households randomly. The selected household were enrolled in a two-step randomization process: first, within each VDC, wards (sub-level of VDC) were randomly selected and second a participatory social mapping of the VDC with community members based on the population of the wards. Questionnaire covers household information, information on water access, WASH knowledge (questions on sanitation and hygiene specifically), perception, water related behaviour, health status, and market information. The study figured out that the most important drivers of HWT adoption among individual socio-economic variables were education, wealth level, and HWT promotion, while social norm, and ability to perform the behaviour were influential psychosocial conditions. The results suggested that the piped water supply project were potential entry point for HWT adoption. The study could not further elaborate these water treatments adopted at the households and the significant impact in human health through safe water.

Shrestha et al. (2019) conducted household expenditure on Diarrhea treatment among under five year children in Godawari Municipality of Nepal. It was a community based cross sectional study conducted in 14 wards in 2018. Questionnaire survey on WASH situation and financial burden was conducted. Among 742 households, only in 371 households with under 5 children episodes of diarrhea within one month were found. So, only those households were selected for financial burden questionnaire survey. The study figured out that the average out-of-pocket expenditure of NPR 568.62 (US $5.06) per episode for diarrhea treatment. The total average direct cost for diarrheal treatment was NPR 183.58 (US $1.63). The two major cost driver during each episode were loss of wage by parents NPR 360.97 (US $3.21) and medicine costs NPR 114.15 (US $1.01). The Diarrheal prevalence rate in the study area was found higher than the National, also it was found that the indirect cost of each diarrheal episode is more than three times of the direct cost. However, the study did not consider the water quality and treatment cost of drinking water at household, yet the study concluded on the necessity of properly maintained water and sanitation at household level to cut off the diarrhea treatment expenditure.

2.4 Research Gap

Reviewing various documents, it provided insights into the microbial contamination and occurrence of the diarrheal incidences, however findings that gave a clear value on the cost that occurs for purchasing of these water treatment methods at the nearest market, cost of installation of supportive infrastructure at house for proper sanitation and hygiene and the reflection of these investments to avoid the risk of water-borne disease and treatment costs at the household level seems to be not sufficiently addressed. The contextual understanding on health impacts and associated costs of the community living in rural areas where the households have purchased water treatment devices for safe water and those without any of these treatment devices has not been done yet.

The valuation of safe drinking water, monitoring of the concentration of pathogens at the point of use at household, sanitation status and the remedial cost could link up together to measure the economic cost, opportunity cost and remedial cost of the area. Due to this, the costs related to water treatment methods, interventions for improved structures within house, disease avoidance costs followed by treatment costs, and time value of life could be identified and enforced to entire society.

CHAPTER THREE
RESEARCH METHODOLOGY

This chapter presents the methodology used in this research. Research methods provide a planned and systematic approach of investigation that denotes the detail framework of the unit of analysis, data gathering techniques, sampling focus and interpretation strategies, and analysis plan. The following section deals with the research design, research methods, and sources of data, data collection techniques, and data processing and analysis plan in detail.

3.1 Research Design

The research design integrates different components of the study in a logical way, ensuring effective address of research problem; it constitutes the outline for the collection, measurement, and analysis of data. Descriptive research design was followed whose nature is quantitative, followed by microbial water quality testing at point of use in every house. The field based microbial test had been carried out by the researcher for Escherichia Coli (E.Coli) of the water sample collected from the point of use. The procedures included membrane filtration followed by incubation of the membranes on selective media at 35±2 °C and counting of colonies after 24 hours (refer 3.5). Cost savings and avoidance methodology for valuation approach had been carried out for the analysis.

3.2 Study Area

The area selected for the study is ward no. 9 Satakhani village of Lekhbesi municipality located in Surkhet district of Karnali state of Nepal. It is situated in the east of Birendranagar Municipality and takes 1.5 hours of drive to reach the area of study. Lekbesi municipality is surrounded by Gurbhakot municipality in the east; Birendranagar municipality in the west; Chingad rural municipality in the north and Bheri River and Bheriganga municipality from South.

There are 10 wards in Lekbesi municipality. Ward no. 9 was selected for the study on the basis of purposive sampling to maintain a wider range of respondents. The area of ward no. 9 covers 23.26 square kilometer (sq.km) of 180.92 sq.km of the entire municipality. There are 756 household (HHs) and 3628 populations out of 6346 HHs and 30295 population of the entire municipality, respectively (Paudel, 2015). Administrative map of the study area and interviewed household of the study area can be viewed from the appendix 2.

Six drinking water schemes which are operated by user's committee (UC) are benefitting 756 households in the ward. These schemes were constructed by the supporting agencies, where all the households had to contribute cash and kind for the completion of the project. On an average, 50 to 175 households were benefitted from one drinking water scheme.

3.3 Sample Size and Sampling procedure

Purposive sampling was considered for the selection of the municipality and ward. Out of the total household of 756 in ward, 15% of the sample that is, 121 households were selected for household interview. A systematic random sampling method was used for the data collection, by selecting one house apart from the nearest five households. Distribution of the households used for data collection can be observed in appendix 2, figure 7.

3.4 Methods of Data Collection

Primary and secondary data were used for the study. Primary data were collected from the household heads or members of the selected households who were above 18 years of age, and responsible for water and sanitation as well as economic activities. On the other hand, secondary data were collected from documents published by government, non-government, or private agencies. For the collection of data, a structured questionnaire was prepared and observation at household surroundings was carried out. All the data were collected by preparing questionnaires in KOBO toolbox in offline and online mode. The data were further sequentially adjusted, and analysis was carried out by using MS excel. Similarly, microbial water quality test was carried out for every household; the samples were collected in a whirlpack bag from the point of use and processed in the field using filter membrane technology, which was further incubated in the incubator located in Birendranagar for 24 hours. The plates were then counted manually and reported in the document. Details on microbial tests are further explained in section 3.5.

3.5 Microbial Water Quality Testing Protocol

The method for water sampling and processing corresponds to the method described by Robinson et al. (2018). Briefly, in the households, 100 mL water samples were collected in a cup of water to drink. All the water samples from a household were collected in sterile 100 mL Whirl-Pak Thio-bags (Nasco, Fort Atkinson, USA) containing sodium thiosulfate to inactivate any residual chlorine. The samples were processed on site within two hours after collection by filtration through 0.45 μm Millipore cellulose membrane filters and filtration funnels of the DelAgua water testing kit. The membrane was then placed on Nissui EC Compact Dry plates pre-moistened with sterile water. The plates were then incubated for 24 hours at 35 ± 2 °C in the electric incubator (Robinson et al. 2018).

3.6 Data Processing and Analysis

Collected data were carefully verified for possible errors and were tabulated, classifying them mainly under different headings and sub-headings. Finally, the collected data were analyzed as per the need of the study using data, tables; numerical, percentage, and figures. MS Excel was used for data analysis for the study. These data were generally presented in the tabulated form with frequency followed by descriptions in the analysis part.

3.7 Methodology Matrix

The methodology matrix consists of rows and columns that guide the researcher to think through the logic of a proposed study, ensuring that the various components of the study link together in a logical manner and that no essential parts of the study are omitted. Table 2 presents the methodology matrix which provides objectives and related variables in terms of measurement and tools for analysis used for the research and the source of data that were used for the analysis.

Table 2: Methodology matrix

S.No	Objectives	Variables	Tool of Analysis	Source of data
1	Economic cost of safe water and sanitation	Socio-economic status Scenario of drinking water and sanitation Water treatment methods Water-borne disease Cost of treatment	Table Graph Statistics tools	Primary Secondary Observation
2	Water treatment method adopted and incidence of water-borne disease	Income Knowledge of water treatment method Utility holding Expenses		Primary
3	Cost associated with the risk of poor-quality water on human health	Treatment cost -Travel cost - Medicinal cost -Opportunity costs of caretaker		Primary

3.8 Ethical Consideration

The study was carried out with the verbal consent of the respondent. No one was forced to participate or select any responses in the study. Preserving participant's anonymity and right to privacy was always followed. Right to be heard, right to be informed and right to choose was considered for the study. Use of special equipment and techniques was carried out to ensure the least distraction. No embarrassment, hindrance, or offense was promoted. Respondents were allowed to discontinue the interview, whenever they wanted or felt difficulties responding to the questions. All the respondents accepted and participated in the data collection work, also provided samples of water for microbial testing of water.

CHAPTER FOUR
DATA PRESENTATION AND ANALYSIS

This chapter includes the details of the data collected and compiled from the field survey. Various tables and figures are included in this section which presents the data in a suitable way for the viewers. Descriptions are added in the tables and figures based on findings of the research.

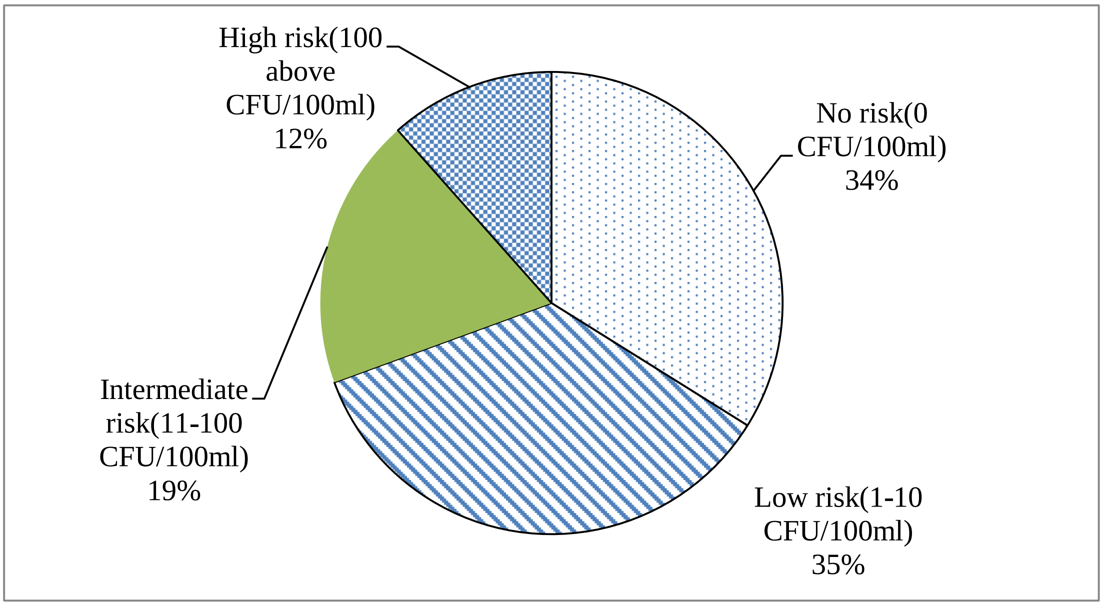
4.1 Microbial water quality

Escherichia Coli and Coliform were measured at the household level. Escherichia Coli is considered as the key indicator for the fecal particles (WHO, 2011). The test was performed using membrane filtration and incubation at 35±2ºC for 24 hours. Samples from point of use (such as: Gagri/Filter/Jerry can) were collected and tested for the study.

4.1.1 Microbial water quality at household level

Escherichia Coli from the water samples at the point of use at the household is presented in figure 1.

Figure 1 : Escherichia coli in the water sample at household

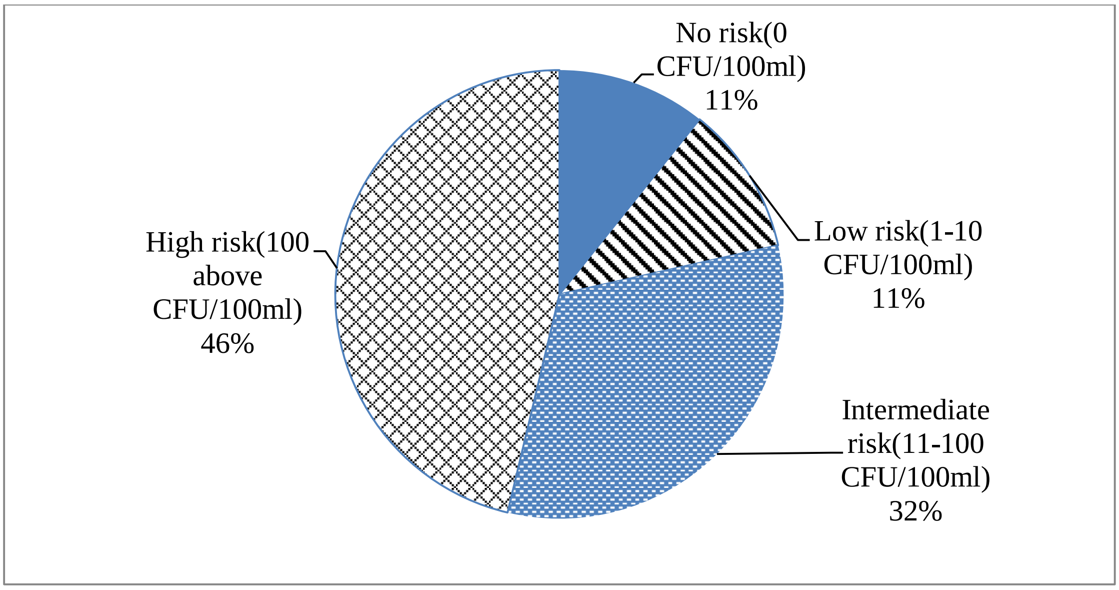


Source: Field survey (2022)

The samples were collected from the jerrycan, filter, *gagri*, and other storage utensils which are used mainly for drinking purposes only. From the study, it was found that 34% of the samples of Point of use (PoU) are in no risk zone. 35% of the samples tested is found to have low risk; 31% of the samples are found to be at risk and 12% of the samples are at high risk. Strong evidence on presence of Escherichia Coli on 80 samples out of 121 samples collected from the house was found.

Similarly, the test results of Coliform in the sample water of the point of use are presented in the figure 2. It was found that 46% of samples were in high risk, followed by 32% intermediate risk and 11% for low risk and similar percentage of samples were in no risk zone.

Figure 2 : Coliform in the water sample of household



Source: Field survey (2022)

Thus, it can be generalized that the 108 samples out of 121 samples collected from the house have Coliform in it. This result shows that quality of water in terms of microbial contamination is at higher risk and water at house are not handled with proper care.

4.1.2 Age of household head and status of water quality

The age of the household head and their preference on water quality decides the importance they give towards the selection of treatment methods. Age distribution of the household head and results of Escherichia Coli contamination are presented in table

3. The age group of respondents signifies the household context on handling of water and economic activities.

The age distribution of the household head shows that 30.6% of the household head belong to the age group of 33-47 years, followed by 28.9% belonging to the age group of 18-32 years. 26.4% in the age group of 48-62 years and 14.1% above 63-77 years.

Table 3: Age of the household head and status of water quality

Age groups	Microbial risk (E. Coli) (CFU/100ml)						Total	
	Low risk		Intermediate risk		High risk			
	Nos.	%	Nos.	%	Nos.	%	Nos.	%
18-32	26	74.3	5	14.3	4	11.4	35	28.9
33-47	25	67.6	7	18.9	5	13.5	37	30.6
48-62	21	65.6	8	25	3	9.4	32	26.4
63-77	12	70.6	3	17.6	2	11.8	17	14.1
Grand Total	84	69.4	23	19	14	11.6	121	

Source: Field survey (2022)

The study shows that 74.3% of the samples collected from the household head of age group 18-32 years are in low-risk zones and 13.5% of the samples collected from the household head of age group 33-47 years are at high risk. The most surprising findings of the study is that there is a presence of Escherichia coli in almost every age category.

4.1.3 Sex of respondents and status of water quality

Household members involved in handling the water and economic activities were selected for the interviews. Details of the sex of respondents interviewed and the status of water quality handled by both male and female during the survey are presented in table 4. `

The data from table 4 shows that 55% of the respondents are female and 45% of the respondents were included in this study.

Table 4: Sex of respondents and status of water quality

Sex	Nos.	%	Microbial risk (E. Coli)

			Low risk		Intermediate risk		High risk	
			Nos.	%	Nos.	%	Nos.	%
Female	67	55.4	47	70	10	15	10	15
Male	54	44.6	37	68.5	13	24.1	4	7.4
Total	121	100	84	69.4	23	19	14	11.6

Source: Field survey (2022)

The result of this study shows that females are responsible for handling the water majority of household. The microbial results show that 70% of the samples collected from the house with female head are at low risk, whereas 15% of the water samples collected are at high risk. Surprisingly, 24.1% of the samples collected from household with male heads were at intermediate risk.

4.1.4 Family size and microbial (Escherichia Coli) risk

Family with many members needs extra time and large size devices for the treatment, which could cause people drink water directly from the tap without prior treatment. Family size and microbial (Escherichia Coli) risk at the household based on the family size is presented in table 5.

Table 5: Family size and microbial (Escherichia coliform) risk

Family size	Microbial (Escherichia Coli) risk								Grand Total	
	No risk		Low risk		Intermediate risk		High risk			
	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%
1-4	16	33.3	15	31.3	12	25.0	5	10.4	48	39.7
5-8	24	35.3	25	36.8	11	16.2	8	11.8	68	56.2
9-12	1	20.0	3	60.0	0	0.0	1	20.0	5	4.1
Grand Total	41	33.9	43	35.5	23	19.0	14	11.6	121	100

Source: Field survey (2022)

The study results show that no significant difference was found for different family groups; instead, significant percentage of microbial risk was observed with the smaller size of the family.

4.1.5 Major occupations of the household

Occupation plays a significant role in daily behavior and sanitation status around the house. Occupation of the household and the microbial risk based on occupation is presented in table 6.

Table 6: Reported major occupation of the household

Occupations	No risk		Low risk		Intermediate risk		High risk		Total	
	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%
Agriculture	7	5.8	11	9.1	6	5.0	4	3.3	28	23.1
Casual employment	1	0.8	1	0.8	1	0.8			3	2.5
Daily labor	1	0.8	1	0.8	2	1.7			4	3.3
Wages and salaries	3	2.5	2	1.7	1	0.8			6	5.0
Money from abroad	1	0.8							1	0.8
Home produce sale (sewing etc)			1	0.8					1	0.8
Agriculture with one additional sources of income	24	19.8	20	16.5	9	7.4	6	5.0	59	48.8
Agriculture with two additional sources of income	1	0.8	3	2.5	3	2.5	2	1.7	9	7.4
Agriculture with four additional sources of income	1	0.8							1	0.8
Wages and salaries with one additional sources of income	1	0.8	1	0.8			1	0.8	3	2.5
Wages and salaries with two additional sources of income	1	0.8	3	2.5	1	0.8	1	0.8	6	5.0
Grand Total	41		43		23		14		121	100.0
Percentage	34		36		19		12		100	

Source: Field survey (2022)

The result from the study found that 80.1% of the household had agriculture as their main source of income. However, only 23.1% household fully rely on agriculture; 5% of the households depend on wages and salaries, and, 3.3% of the household rely on labor works only. Other occupations listed include home produce sale (sewing etc), pension, and other.

It was found that 12.4% of the households with agriculture as major occupation and one extra occupation and 4.2% of the households with agriculture as major occupation and two extra occupations have significant presence of the Escherichia Coli in their sample water.

4.1.6 Utility and assets holding of the households

The utility holding of the household indicates the well-being status of the households. The holding of the utility was calculated using easy-to-collect data on a household's ownership of selected utilities, such as televisions and bicycles; materials used for housing construction; and types of water access and sanitation facilities. Detail of the utility and assets held by the houses is presented in table 7.

Table 7: Utility and assets held by the household

Description	Nos. of respondents (n=121)	Percentage
Electricity in house	118	97.5%
Mobile phone	113	93.4%
Television	53	43.8%
Refrigerator	21	17.4%
Motorbike	20	16.5%
Solar panel	19	15.7%
Car	2	1.7%

Source: Field survey (2022)

It has been found that, 97.5% of the respondents had access to electricity; 93.4% had mobile phones followed by 43.8% had television. Only 17.4% had a refrigerator, 16.5% had a motorbike, and 15.7% had solar panel in their house. Only 1.7% of the respondent had a car in their house.

Details of utilities and assets available at the household level and their adoption of water treatment methods are presented in table 8.

Table 8: Utility and assets holding, and the water treatment methods adopted

Utility and assets holding	Boiling		Boiling Ceramic candle filter		Boiling Ceramic candle filter Piyush/waterguard (chlorine)		Ceramic candle filter		Ceramic candle filter Boiling		Ceramic candle filter Piyush/waterguard (chlorine)		Drink directly without treatment		Grand Total	
	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%
1-2							8	6.6			2	1.7	40	33.1	50	**41.3**
3-4	2	1.7	1	0.8	1	0.8	18	14.9	1	0.8	4	3.3	28	23.1	55	45.5
5-6			1	0.8	1	0.8	7	5.8			2	1.7	3	2.5	14	11.6
7-8					1	0.8							1	0.8	2	1.7
Grand Total	2	1.7	2	1.7	3	2.5	33	27.3	1	0.8	8	6.6	72	59.5	121	100

Source: Field survey (2022)

It is interesting to note that 41.3% of the households are holding utility and assets up to 2 units. However, only 6.6% of these household use ceramic candle filter for water treatment and 1.7% of the house ranging in this category use multi treatment methods including ceramic candle filter and chlorine for water treatment. Also, 41.3% of the house having less than 2 utility and assets are drinking water directly without any treatment. Household possessing 3-4 utility and assets have practiced entire combination of water treatment methods. However, 23.1% of the houses are drinking water directly without any treatment, followed by 14.9% using only ceramic candle filter for water treatment.

Similarly, 13.3% of the household possess 5 or above utility and assets at their household; yet it was observed that the practice of drinking water directly without any treatment method at the household by 3.3%. Thus, utility possession alone cannot withdraw any group of households and their preferences. However, low possession of utility and assets had limited households to select water treatment methods at household level.

4.2 Income and expenses at household

Income and expenses of a household were collected to figure out the range of the income and the areas where the expenses took place.

4.2.1 Income distribution and microbial in drinking water

Income of a household could determine their capability to purchase proper water treatment methods at household level. The range of income distribution and diarrheal incidence of the household is presented in table 9. Individual household members were asked about the earning they made during the last fortnight. It has been found that most of the members in a house are involved in different activities. Most of them are involved in seasonal labor works and agriculture. The data here in table 9 represents the income of the household in the last two weeks.

Table 9: Range of income and microbial risk in drinking water

Income range	Microbial risk (E. coli)							
	Low risk		Intermediate risk		High risk		Total	
	Nos.	%	Nos.	%	Nos.	%	Nos.	%
Upto 5000	4	50.0	3	37.5	1	12.5	8	6.6
5000-10000	16	69.6	5	21.7	2	8.7	23	19.0
10000-20000	28	70.0	7	17.5	5	12.5	40	33.1
20000 above	36	72.0	8	16.0	6	12.0	50	41.3
Grand Total	84		23		14		121	100.0

Source: Field survey (2022)

The data from the study shows that 41% of household have income above NPR 20000 per month followed by 33% household reported their monthly income within the range of 10000-20000 and 19% household reported their income between 5000-10000 NPR per month. However, 7% of household reported their monthly income is up to NPR 5000 per month.

Similarly, 50% of the samples collected from households with income less than 5000 per month have half of their water contaminated with Escherichia coliform. However, in all other, cases two third of their samples are in low-risk zones. It has been observed that HHs with income range above NPR 20000 had more safe water in terms of microbial contaminant with 72% of samples in low-risk zone. However, the data show that the presence of Escherichia Coli is in every income range of the study area. Contrary to expectations, this study did not find a significant difference in the status of water quality and the presence of Escherichia coli in the sample water collected from the household.

4.2.2 Expenses

Expenses of the household are represented in a quantitative amount and categorized under various sectors of expenses to figure out their topics for expenses at household level and is presented in table 10.

Table 10: Average expenditure of the household per month

Description	Average expenses HHs per month, NPR	SD
Household rent or loan	3902.89	7931.65
Food and household items	3608.68	2273.59
Electricity, water and sewerage	268.35	286.17
Regular medical treatment	780.33	1536.87
Wood, Kerosene and cooking gas	610.33	465.78
Mobile phone and telephone	563.22	714.17
Children clothes and fees	561.82	735.36
Bus and other transport	497.52	538.47

Source: Field survey (2022)

Of the total expenditure of a family, majority of expenses are incurred in household rent or paying interests of loan taken for improvement which is around NPR 3902.89 followed by NPR 3608.68 in food and household items and NPR 780.33 in regular medical treatment including the disease except the water- borne disease. Similarly, wood, kerosene and cooking gas used for cooking costs NPR 610.33 followed by NPR 563.22 expenses in mobile phone and NPR 561.82 for children's clothes and fees of the school, and NPR 497.52 for bus and other transport to the nearest market except the cost for treatment of diarrheal disease. However, NPR 268.35 was paid for electricity and water bills.

Microbial results based on the expense of the household are presented in table 11.

Table 11: expenses of the household and microbial contamination

Expenses	Microbial (Escherichia coliform)						Total	
	Low risk		Intermediate risk		High risk			
	Nos.	%	Nos.	%	Nos.	%	Nos.	%
0-5000	25	64.1	9	23.1	5	12.8	39	32.2
5001-10000	26	63.4	9	22.0	6	14.6	41	33.9
10001-20000	19	70.4	5	18.5	3	11.1	27	22.3
>20000	14	100					14	11.6
Grand Total	84	69.4	23	19.0	14	11.6	121	100.0

Source: Field survey (2022)

The result of this study shows that, the houses whose expenses are above NPR 20000 have water quality in the low-risk zone. However, for all other range of expenses it was found that there was significant presence of the Escherichia coli in the water at point of use, where one third of the sample collected from all these expense group had Escherichia coli in them.

4.3 Scenario of Water Sanitation and Hygiene

For this section of study, structured questionnaires were asked to the household as well as observation of the water sanitation and hygiene setups, such as drinking water facilities, toilet, availability of water and soap for hand washing at hand washing station

(HWS) was carried out. The first section here provides the summarized information of the available structures followed by the detailed breakdown of the resources at household (HH) with the entire facility.

4.3.1 WASH structures of the study area

WASH refers to water sanitation and hygiene where structures related to WASH indicate better access and use of drinking water, toilet, hand washing station and availability of the soap. Summary of the WASH facilities at HH is presented in table **12**.

Table 12: Summary of the WASH facilities at HH

S. No.	Water source	Nos.	%
A	Drinking water supply at household		
1	Piped water to yard/plot	98	81.0
2	Unmanaged piped water to yard/plot	12	9.9
3	Public tap/standpipe	11	9.1
B	Toilets in HH		
1	Pit latrine	39	32.2
2	Flush/pour flush	78	64.5
3	Ventilated improved pit latrine (VIP)	4	3.3
Total		121	100.0
C	Other WASH structures at HH		
1	HWS at house (n=121)	103	85.1
2	Water available in the hand washing station (n=103)	97	94.2
3	Availability of soap in HWS (n=103)	99	81.8

Source: Field survey (2022)

The study shows that 81.0% of the HHs had piped water to yard/plot and 9.9% of the HHs were using unmanaged piped water. The entire HHs had constructed toilet at their house and using them. 85.1% of HHs had a hand-washing station (HWS) at their house, followed by 94.2% and 81.8% had water and soap available at the HWS, respectively. Combination of all these setups had ensured quality environment for safe water and sanitation. Existing scenario of water sanitation and hygiene of the study area with the microbial contamination is presented in table 13. This portion of the study only covers the household details who had constructed all the WASH structures as envisioned by the research concept- construction of hand-washing station and the availability of the water and soap for regular purpose.

Table 13: Scenario of water sanitation and hygiene and microbial risk

	Availability (Yes/No)	Microbial risk							
		Low risk		Intermediate risk		High risk		Grand Total	
		Nos.	%	Nos.	%	Nos.	%	Nos.	%
Piped water to yard/plot		72	73.5	14	14.3	12	12.2	98	81
Flush/pour flush		38	66.7	12	21.1	7	12.3	57	47
Hand washing station	Yes	37	67.3	11	20.0	7	12.7	55	
Water available	Yes	36	66.7	11	20.4	7	13.0	54	
Soap available	Yes	34	65.4	11	21.2	7	13.5	52	
Pit latrine		30	81.1	2	5.4	5	13.5	37	31
HWS	Yes	22	81.5	1	3.7	4	14.8	27	
Water available	Yes	21	87.5	1	4.2	2	8.3	24	
Soap available	Yes	21	91.3	1	4.3	1	4.3	23	
Ventilated improved pit latrine (VIP)		4	100.0	0	0.0	0	0.0	4	3
HWS	Yes	4	100.0	0	0.0	0	0.0	4	
Water available	Yes	4	100.0	0	0.0	0	0.0	4	
Soap available	Yes	4	100.0	0	0.0	0	0.0	4	
Public tap/standpipe		5	45.5	5	45.5	1	9.1	11	9
Flush/pour flush		5	45.5	5	45.5	1	9.1	11	9
HWS	Yes	4	40.0	5	50.0	1	10.0	10	
Water available	Yes	3	33.3	5	55.6	1	11.1	9	
Soap available	Yes	3	33.3	5	55.6	1	11.1	9	
Unmanaged piped water to yard/plot		7	58.3	4	33.3	1	8.3	12	10
Flush/pour flush		6	60.0	3	30.0	1	10.0	10	
HWS	Yes	4	57.1	2	28.6	1	14.3	7	
Water available	Yes	4	66.7	1	16.7	1	16.7	6	
Soap available	Yes	4	66.7	1	16.7	1	16.7	6	

Source: Field survey (2022)

Six different scenarios were observed for the drinking water sanitation and hygiene setup in the study area. 81 % of the households had piped water to the yard where 47% of the households have flush/pour toilet. 31% pit latrine and 3% had Ventilated improved pit latrine (VIP) at their household. Two houses with flush/pour toilet do not had HWS followed by 10 HH with pit latrine. 26.5% of these households with piped water in the yard have Escherichia Coli present in their water. 55 households with the connection of piped water had hand washing station; 54 of them had water in it and 53 HH had soap available in it.

It is interesting to note that 37 HHs of piped water with pit latrine, 27 HHs had HWS followed by 23 HHs had water in HWS and 25 HHs had soap in them. 4 HHs of piped water had Ventilated improved pit latrine (VIP) where all the HHs had HWS with water and soap available in them.

It was found that 9% of the HHs are drinking water from public tap/ standpipe where 54.6% of HHs had significant amount of microbial contamination. All households had flush/pour toilet where 10 HHs had HWS where both water and soap were available in them.

The study shows that 10% of the HHs had connected with unmanaged piped water to yard/plot, where 41.6% of the HHs had significant presence of microbial contamination. 10 HHs had flush/pour toilet in them, where 7 HHs had HWS in their HH and 6 HWS had water available in it and 7 HHs had soap in them. Two of the HHs connected with the unmanaged piped water to yard/plot had pit latrine in them, where none of the HHs had HWS, water available for hand-washing or soap available them.

This result also indicates that the HHs with proper piped water taps built in their yard had structures like HWS, water and soap available rather than those HHs where piped water systems were either public tap/standpipe or unmanaged piped water to yard/plot.

4.3.2 Knowledge of water treatment methods

Knowledge is considered as the information conceived and expressed by the respondents about the issue; however, attitude is the measurement of the practice by the respondent (Figueroa, 2010). Knowledge of the respondents on water treatment methods at household level is presented in table 14. Respondents were asked about household water treatment methods, they might have learned through various training, audio/visual advertisements, friends/relative or book/newspaper.

Table 14: knowledge of respondents on household water treatment methods

Water treatment at household level	Ceramic candle filter	Boiling	Piyush/ Chlorine	SODIS	Filtration by clothes	Do not know
Nos. of respondent	93	40	35	13	5	26
Percentage	76.9%	33.1%	28.9%	10.7%	4.1%	21.5%

Source: Field survey (2022)

It was found that 76.9% of respondents had recalled ceramic candle filters as the water treatment method, followed by 33.1% who confirmed boiling as a treatment method. Similarly, 28.9% respondents recalled for Piyush/chlorine drops. 10.7% respondents had responded for SODIS. However, 21.5% respondent agreed they do not know of any water treatment methods and 4.1% respondent ensured that filtration by clothes is also a treatment method.

4.3.3 Water treatment method at practice

Safe and unsafe water, as discussed earlier in this research, is categorized by either observing presence of Escherichia Coli in the water or adoption of water treatment methods by the household. Here, water treatment method as the treatment technologies, such as filter, boiling, chlorination and SoDis to improve the water quality of the drinking water at the household level are considered.

Information on the water treatment practice of the household for the last two weeks is presented in table 15. It was observed that 58.7% of the respondents confirmed that they were drinking water directly without any treatment at household level, followed by 38.8% of respondent using ceramic candle filters. 9.1% of respondents were using chlorine for treatment and only 6.6% of the respondents were boiling drinking water.

Table 15: Water treatment in practice at household

Water treatment at household level	Nos. of respondents	Percentage
Drink directly without treatment	71	58.7%
Ceramic candle filter	47	38.8%
Piyush/Chlorine	11	9.1%
Boiling	8	6.6%
Filtration by clothes	1	0.8%

Source: Field survey (2022)

Despite the respondents reporting Chlorine as a treatment method adopted at HHs; no devices were seen at household level for treatment.

4.3.4 Water treatment method at practice and microbial contamination

Safe water is referred to as water with low risk of Escherichia coli or the HHs who had adopted any of the five treatment methods (WHO, 1997). Considerable numbers of respondent were using ceramic candle filters for the treatment of water. From the study, it was observed that the households were using different sets of combination for the water treatment methods, such as.

1. Ceramic candle filter only- Using ceramic candle filter only
2. Ceramic candle filter and Piyush/chlorine- treating water with chlorine and filtering it.
3. Boiling, ceramic candle filter and Piyush/chlorine- Chlorinated water is boiled and then filtered for drinking purpose.
4. Boiling and ceramic candle filter- Water is boiled and then filtered.
5. Boiling- Use of firewood/lpg to boil the water and storing it.

Water treatment methods adopted and microbial contamination observed from the microbial test at the point of use of the household is presented in the table 16.

Table 16: Water treatment methods and E. Coliform in sample

Combination of water treatment methods	No risk (0 CFU/100ml)		Low risks (1-10 CFU/100ml)		Intermediate risk (11-100 CFU/100ml)		High risk (101 above CFU/100ml)	
	Nos.	%	Nos.	%	Nos.	%	Nos.	%
Drink directly without treatment (n=72)	23	32	25	34.7	14	19.5	10	13.8
Ceramic candle filter (n=33)	10	30.3	10	30.3	10	30.3	3	9
Ceramic candle filter Piyush/chlorine (n=8)	4	50	3	38	0	0	1	13
Boiling Ceramic candle filter Piyush/chlorine (n=3)	2	67	1	33				
Boiling Ceramic candle filter (n=3)	1	33	2	67				
Boiling (n=2)	1	50	1	50				

Source: Field survey (2022)

The study shows that water samples collected from these filters had shown that 30.3% of these had no risk; 30.3% had low risk; 30.3% of samples had intermediate risk and 9% of these samples from the filter had high risk. Despite small sample size- it was observed that boiling or combination of multiple water treatment methods had contributed to low risk of microbial contamination at the HHs water sample. Contrary to the treatment methods adopted, HHs who were drinking water directly without any treatment methods had 68% of water samples microbial contaminated.

4.3.5 Discontinuity of Water treatment method at practice

The water treatment method is an iterative process of devotion and effort for safe water; however, the practice shows the discontinuity of the treatment methods at household level. Among the households who discontinued or did not prefer water treatment methods at households are presented in the table 17. The table shows tha cause for discontinuity or no use of household the water treatment methods.

Table 17: Reasons for no use of household water treatment methods

Reasons (n=72)	Nos. of respondent's	Percentage
No need to do the treatment	48	67.6%
Not available in nearest market	14	19.7%
Did not know of the product	5	7.0%
Do not know	5	7.0%

Source: Field survey (2022)

It was found that 67.6% of the respondents referred that they do not need the water treatment method at household, followed by 19.7% of respondents referred that the new products or spare parts of water treatment method were not available in the nearest market. Similarly, 7% of the respondent confirmed they did not know of the product and a similar percentage of respondent reported that they do not know. Also, no one had reported that they did not purchase water treatment products because of cost.

4.4 Water- borne disease

Water-borne diseases are caused by the ingestion of water contaminated by human or animal feces or urine containing pathogenic bacteria or viruses; includes cholera, typhoid, amoebic and bacillary dysentery, and other diarrheal diseases. The author further suggests that water-borne diseases are generally considered to be more prevalent in children below five years of age or elderly people. So, from the study it was focused on figuring out the prevalence in various age groups. The following section further explores the findings of the results in the study area.

4.4.1 Occurrence of water borne disease in the study area

Pathogens that are known to be transmitted through contaminated drinking-water lead to severe and sometimes life-threatening disease, such as; typhoid, cholera, infectious hepatitis (caused by hepatitis A virus or hepatitis E virus) and disease caused by Shigella spp. and E. coli O157 and less severe as self-limiting diarrheal disease (e.g.

noro viruses, Cryptosporidium) (World Health Organization, 2011). However, from this study diarrhea, dysentery and worm as water-borne diseases were studied.

Household suffering from water-borne disease last year are presented in table 18.

Table 18: Cases of water borne diseases

Water borne disease	Nos. of household	Percentage
Diarrhea	34	28.1%
Dysentry	2	1.7%
Worm	2	1.7%
Total	38	31.4%

Source: Field survey (2022)

It was found that out of 121 houses; 34 houses had suffered from the diarrheal cases, followed by 2 houses by dysentery and 2 houses by worm, respectively. Overall, 62 nos. of family members from 38 HHs had suffered from the water-borne disease during the previous year. The study shows that the period of such sickness last for 2-3 days only for majority household.

4.4.2 Diarrheal disease cases for water treatment methods adopted

This section here has tabulated the diarrheal cases occurred at the household and the method of water treatment adopte of the household. Water treatment method is taken as a point of collection of water sample for the field based microbial test to be carried out at the household.

Water treatment methods adopted, and occurrence of diarrheal cases is presented in the table 19. From the household members suffering from the water-borne disease, it was observed that households who drink water without treatment covered majority of 74.2% followed by 22.6% of households who use ceramic candle filter for water treatment method. However, 1.6% households have also suffered from water-borne disease that has used multiple methods of treatment.

Table 19: Water treatment methods adopted and diarrheal cases

Water treatment methods adopted	**Household member suffered from diarrhea**	
	Nos.	%
Drink directly without treatment (n=72)	46	74.2
Ceramic candle filter (n=33)	14	22.6
Boiling (n=2)	1	1.6
Boiling, Ceramic candle filter and Piyush/waterguard (chlorine) (n=3)	1	1.6
Grand Total	62	100

Source: Field survey (2022)

Despite the treatment method adopted, various diarrheal cases were found at the household level. Poor water quality, inefficient technology or method, poor handling of the technology, damaged treatment method and re-contamination might be the causes for the occurrence of the diarrheal disease.

4.4.3 Income range and diarrheal cases in the household

The occurrence of diarrheal cases and the income range of the household were studied and the income range of the household and the occurrence of the diarrheal cases in the family members of the households are presented in table 20.

Table 20: Income range and the diarrheal cases in the household members

Income range, NPR	Family members suffered from diarrhea		Days out of work		Average day out per HHs
	Nos.	%	Nos.	%	
Upto 5000 (n=8)	4	50.0	4	4.7	1
5000-10000 (n=23)	17	73.9	10	11.8	0.6
10000-20000 (n=40)	20	50.0	48	56.5	2.4
20000 above (n=50)	21	42.0	23	27	1.1
Total	62		85	100	1.28

Source: Field survey (2022)

This table provides the range of income of the household and household suffering from the diarrheal cases during the past year. Also, numbers of days out of work in different income ranges are also provided. From the study, it was found that the diarrheal cases observed was high for the income categories of NPR 5000-10000 was 73.9% followed by the Income of up to NPR 5000 and NPR 10000-20000 of 50% each. However, 42% of the diarrheal cases happened for the income of above NPR 20000.

Based on the family members who suffered from the diarrhea, significant days for each household member had to take a day off from the work. From the table 18, it was found that total of 48 days was observed as a day out of work for the family with income range of NPR 10000-20000 followed by 23 days, 10 days, and 4 days for households with income of NPR 20000 above, NPR 5000-10000 and up to NPR 5000, respectively. The average day out of work for each HH was 1.28 days, including all the HH who seek health treatment or not, whereas, family with the income range of NPR 10000-20000 had maximum of 2.4 days out of work.

4.4.4 Correlation between age group and diarrheal cases

It was found from previous literature reviews that children below 5 years and elderly above 65 years are more sensitive towards water-borne disease (diarrhea).

Table 21: Correlation between age groups and diarrheal cases

Correlation between age group and diarrheal cases		
	less than 5 or greater than 65	Nos. of family member sick
less than 5 or greater than 65	1	
Nos. of family member sick	0.05	1

Source: Field survey (2022)

Following the given scenario, table 21 presents the correlation between the age groups and diarrheal cases that had occurred. The correlation between the age of household members less than 5 and greater than 65 was carried out with the numbers of family members who were sick. The result generated does not show significant correlation between these two parameters and on 0.05 was observed between these two parameters, presenting not much significant relationship between these two factors.

4.4.5 Family size and diarrheal incidence

Family size is directly proportional to the amount of need for safe drinking water for drinking, seeking lots of care and attention for the treatment. Large family size generally refers to the increased requirements for safe drinking water. Family size, and diarrheal incidence occurring in the household are presented in table 22.

Table 22: Family size and diarrheal incidence

Family size	Diarrheal occurrence				Grand Total	
	No		Yes			
	Nos.	%	Nos.	%	Nos.	%
1-4	35	72.9	13	27.1	48	39.7
5-8	47	69.1	21	30.9	68	56.2
9-12	1	20.0	4	80.0	5	4.1
Grand Total	83	68.6	38	31.4	121	100

Source: Field survey (2022)

It was found that the diarrheal cases were in ascending order with the increase in family size. 27.1% of families sizing up to 4 has reported diarrheal cases, followed by 30.9% by the family with 5-8 members and 80% by the family with more than 9 members.

4.5 Cost associated with the risk of poor-quality water on human health

As an avoidance cost, most of the houses focus on avoidance cost by constructing proper infrastructure to maintain safe and sound sanitation and hygiene environment around the household, as well as carry out water treatment before risking water-borne disease (diarrhea). Annual cost associated with the water treatment methods at local context and availability of the market in the perception of achieving the safe water is presented in table 23. The initial cost of the filter was found to be NPR 1632.8 and the Equivalent Annual Cost (EAC) for the filter has been used for the estimating the cost of water treatment methods.

Table 23: Annual cost associated with the water treatment methods

Description	Cost, NPR
EAC of ceramic candle filter	265.73
Operation cost of ceramic candle filter	163.8
Operation cost for boiling	146.3
Operation cost for Chlorine	36.4
Total	612.23

Source: Field survey (2022)

The operating cost of boiling water at a household was found less because of the use of fuel wood available in the nearest forest, which is NPR 146.3. Similarly, NPR 36.4 is the cost for the chlorine/piyush used for chlorination at HH. The operating cost for the filter was NPR 163.8 and EAC of the initial investment for the filter was NPR 429.53.

From the previous research carried out, it was found that the monthly average water treatment cost per household estimated from a questionnaire survey in a Nepalese urban context was NPR 380 (Shrestha et al., 2018). From these research findings as well, it is in line for the cost that takes place for water treatment lies in the range of around NPR 400. Economic cost of water thus comprises of two separate components - the use cost and the opportunity cost (Briscoe, 1996). The avoidance cost from the selection and adoption of proper water treatment methods was calculated in this section however, cost of such treatment methods may vary for other context.

4.5.1 Cost for Water Sanitation Hygiene structures

Cost of household in terms of cash, kind works and support from other organizations to improve the structures related to safe water, sanitation, and hygiene in the house is presented in the table 24. Construction of systematic schemes needs proper design and construction, with active participation from the community. The cost comprises of the cost to construct or improve drinking water through construction of proper tap stand and management of the pipe works; construction of hand washing station and making available water for basic sanitation and soap for hygiene. The contribution for such construction is from the kind works where people work as a labor for construction works; cash for purchasing non-local material such as cement, sand, reinforcement bar and skilled manpower, and others here represent the contribution from various organization.

Table 24: Cost for Water, sanitation, and hygiene

Description	Kind, NPR	Cash, NPR	Others, NPR	Total, NPR
Drinking Water Supply system	2204.13	5209.92	800.83	8214.88
Toilet	3295.04	16790.08	43.80	20128.93
Hand-washing station with drum	533.88	2029.75	65.70	2629.34
Garbage pit	87.60	31.40	5.79	124.79
Total, NPR				31097.94

Source: Field survey (2022)

The total cost reported for the construction of drinking water structure for household, toilet, hand washing station and garbage pit is NPR 8214.88; NPR 20128.93; NPR2629.34 and NPR124.79, respectively. Although, the cost for construction of garbage pit was very less, majority of houses did not have any garbage pit around the house and wastes could be seen all around.

To obtain the uniformity and annual operational cost, the investment in water sanitation and hygiene is further evaluated in terms of Equivalent Annual Cost (EAC). The following equation was used to calculate the EAC (Park, 2012).

$$EAC = \frac{Asset\ price\ x\ Discount\ rate}{1 - (1 + Discount\ rate)^\wedge(-n)}$$

Here, Asset price- Cost for the construction and contribution from the house

Discount rate- 10% (Followed World Bank reference)

n- Number of years

The Equivalent annual cost (EAC) of in-house water sanitation and hygiene infrastructures with considerable life cycle of the setup is presented in table 25.

Table 25: EAC of in-house water sanitation and hygiene infrastructures

Description	Total, NPR	Discount rate, %	Nos. of year	EAC, NPR
Drinking Water Supply system	8214.88	10%	15	1080.04
Toilet	20128.92	10%	20	2364.34
Hand-washing station with drum	2629.33	10%	10	427.91
Garbage pit	124.79	10%	1	137.27
Total, NPR	31097.92			4009.56
Filter	1632.8	10%	10	265.73

Discount rate for water and sanitation projects are considered different such as, Copenhagen Consensus used a 3–6% range of discount rate (assuming that governments in developing countries have ready access to capital and it would be the rate of return if donor money was invested in alternative projects), the World Bank used a 10% discount rate for (water infrastructure) project evaluation, assuming that investment capital in developing countries is scarce and the opportunity costs of the project being evaluated are therefore high and Carlevaro (2010) has used an 11% discount rate for a WHO cost benefit analysis study of water and sanitation projects (Fonseca et al., 2011). Based on this information, the discount rate for the existing structure was 10%.

4.5.2 Treatment outlets for water borne disease

There are various ways where a sick person could seek the treatment; it depends on the knowledge, sensitive towards health and availability of the outlet for further treatment. Outlets for treatment of water-borne disease are presented in table 26.

It has been observed that, among 38 households who suffered from the water borne diseases, 39.5% of the respondents did not seek the treatment and got well within a day or two taking rest at house, 50 % of the respondent had to visit nearest hospital for the treatment. Similarly, 7.9% of the respondent had visited district hospitals/others for treatment and 2.6% respondent visited traditional doctor for the treatment.

Table 26: Outlets for treatment of water-borne disease

Income range	Treatment sought	Grand Total

(NPR)	District hospitals /others		Nearest hospitals/clinic/ health center		No treatment sought		Traditional doctor			
	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%
10000-20000	2	14.3	8	57.1	4	28.6			14	36.8
20000 above	1	7.1	6	42.9	6	42.9	1	7.1	14	36.8
5000-10000			5	71.4	2	28.6			7	18.4
Upto 5000					3	100			3	7.9
Grand Total	3	7.9	19	50	15	39.5	1	2.6	38	100.0

Source: Field survey (2022)

When categorizing the treatment sought with the income range, it was found that family with the income above NPR 20000 had visited various outlets for the treatment. However, family with income less than NPR 5000 had not visited any of the treatment outlets.

4.5.3 Cost of treatment of water-borne disease

The diarrheal diseases have been treated in various outlets which are explained in the section 4.5.2. The cost of treatment for water-borne diseases includes the cost of traveling to reach the hospital and return home; cost of medicine, food and other items that were consumed during the visit to the hospital for the treatment of water-borne disease.

The cost of treatment that was incurred to recover from the diarrheal disease is presented in table 27. The cost of treatment of diarrheal cases was asked with all respondents. It included travel, medicine, food, and any other cost incurred during the treatment. It was found that median NPR. 1500 were spent (n=27) by those who sought the treatment. A minimum cost for treatment was NPR 40, whereas the maximum cost of treatment was NPR 10000.

Table 27: Overall Cost of treatment

Cost of treatment	NPR
Mean	2366
Standard Error	523.08
Median	1500
Standard Deviation	2718.00
Range	9960
Minimum	40
Maximum	10000
Sum	63870
Count	27

Source: Field survey (2022)

A total of 85 days from all the families who seek for treatment was taken as an off day to recover for entire respondents from the water-borne disease. The total cost of treatment for the 27 households for the water-borne disease is NPR 63870.

Various family members were asked about their involvement in income-generating activities in the last fortnight and the reporting from the respondents was listed and analyzed for further steps. Detail of the numbers of days involved in the last two weeks and the earning made by an individual member is presented in the table 28.

Table 28: Earning made in last two weeks

Mean/Family Member	Days of work (last two weeks)	Earning per day, NPR	Earning for last two weeks, NPR
Total	12	774	9249

Source: Field survey (2022)

It was found that for 12 days in last two weeks, family members were involved in earning activity where they had earned NPR 9249 with a daily income of NPR 774.

So, from the calculated data where one family member makes an earning of NPR 774 per day and the total days off from the work as a caretaker can be summed up as due to sickness of water-borne disease, the total economic cost for 85 off days is NPR 65,785.

Thus, for 27 houses who seek treatment of diarrheal disease, NPR 2436 the cost was calculated as an opportunity cost that the caretaker of family was paying to recover the sick person. Overall, NPR 3936 was the gross economic cost of a single family suffered paying to the treatment of the disease.

4.5.4 Correlation between cost of treatment and WASH investment

The correlation between the economic cost for construction of water sanitation and hygiene (WASH) infrastructures and the cost of treatment for diarrheal disease is presented in table 29.

Table 29: Correlation between cost of treatment and WASH investment

	WASH cost, total	Cost of treatment
WASH cost	1	
Cost of treatment	0.14	1

Source: Field survey (2022)

Positive correlation was found between these two indicators of cost of treatment and WASH investment. The positive correlation between the cost of investment and diarrheal incidence represents the limitation of the sample size, poor selection of the WASH investment and improper handling of this WASH infrastructure.

4.6 Discussions

From the economic cost of safe drinking water and sanitation in Lekbesi-9, it had been observed that most of the households were directly drinking water from the tap, where one third of the households had suffered from the diarrhea.

The water quality of the filter has shown that 40% of the samples were at microbial risk, similar findings has been observed from the study carried out by Khayyat et al., 2000 concluding that the ceramic candle filter as a point-of-use treatment device was effective in reducing turbidity, however, microbial removal was incomplete. Households referring to the chlorination here suggested that the structural chlorination was done during the collection of the data, as most of the HH failed to show the treatment device at the HH.

Table 30: Cost of avoidance and treatment

Total Population, HH	756	
People seek for treatment (n=38)	27	
Percentage of HH seeking treatment	22%	
Total HH seeking for the treatment	168.7	
Average day out of work	1.28	
Cost Savings and Avoidance	**Annual cost of operation for the single HH (NPR)**	**Annual cost for entire ward. 9, Lekbesi (NPR)**
Avoidance costs (Boiling, filter and chlorine)	346.50	261,954.00
Remediation costs (Improved water structure, toilet, hand-washing station, garbage pit and ceramic candle filter)	4,275.29	3,232,119.24
Disease treatment costs (Transportation costs, costs of traditional and modern medicines, operating costs of hospitals/clinics)	1500.00	399,130.51
Opportunity cost of the caretaker	2,436.00	526,002.06

Source: Field survey (2022)

Cost of avoidance and treatment is presented in table 30. It was found that 76.9% of the respondents had knowledge about the filter as a treatment method followed by 33.1% only of the boiling method. However, almost half of the households using filters had diarrheal cases, which indicate the preventive cost for filters as a treatment method needs to be re-assessed and further improvement in filters should be considered.

The annual cost of avoidance by using the proper water treatment method at individual household level costs NPR 346.50 and for the entire ward was NPR 261,954. Similarly, the need to construct the structure to maintain the proper sanitation, hygiene, and safe water; individual households need to spend NPR 4,275.29 and for the entire ward the cost rises to NPR 3,232,119.24. On the other hand, disease treatment costs, which consist of transportation, medicine and logistic are NPR 1500 (median) and NPR 399,130.51 and the opportunity cost of the caretaker is NPR 2,436 and NPR 526,002.06, respectively.

Thus, the economic cost for the treatment of water-borne disease and unsafe water is NPR 925,132.57 in ward no. 9 of Lekbesi municipality. A similar study conducted by Lal (2014) suggests that the whole share of the burden of annual economic costs between A$3.7 million–A$7.3 million, or 2%–4% of national GDP. Also, Sancturay (2005) suggest that the around $34 billion economic costs of ill health, medical treatment, lost time, and opportunities caused by lack of access to these basic services accounts for an estimated cost in South Asia.

CHAPTER FIVE
SUMMARY AND CONCLUSIONS

This chapter focuses on the summary and conclusion of the study. It is comprised of the methodology adopted for the study to the findings achieved from the field survey. The conclusion part concludes the study. Few recommendations are included for academicians and stakeholders working in this sector.

5.1 Summary

The study on economic cost of safe drinking water and sanitation was carried out in ward no. 9 of the Lekbesi municipality of Surkhet, Karnali, Nepal. The selection of the study area was done on a purposive basis. The study covered 121 houses, where sampling was done based on systematic random sampling. Descriptive study was carried out by conducting household surveys with structured questionnaires followed by water quality testing of samples collected from the point of use in the surveyed house. Access to safe drinking water supply and sanitation services is fundamental to improving public health by reducing the high burden of disease. This study focused on determining the economic cost of safe drinking water and sanitation. Water quality sampling from the point of use was done followed by field testing of E. coli by using membrane filtration method and Nissui compact dry (EC) plates were used. These membrane plates were then incubated for 24 hours, and colonies formed in the plates were counted and sorted based on WHO guidelines for risk categories-No risk, low risk, intermediate risk and high risk.

It was found that 81% of the households had private tap connected in the yard which had no obstruction for last six months. 32.2% had pit toilets and 64.5% had flush/pour toilet at their house. 85.1% of the respondents had a proper hand washing station at the premises of the house, where 94.2% of the hand washing station had water and 81.8% of these stations had soap available in it. From the water quality tests conducted at the house, it was observed that 69% of the samples tested were at low risk and 31% of the samples were in intermediate risk and 12% of the samples were at high risk.

It was found that nearly half of the respondents had monthly income more than NPR 20000, however, 6.6% of households had income of less than NPR 5000 per month. From the water quality results, it was found that 72% of the sample collected the household with income more than NPR 20000 were in the no risk zone. Majority of expenses of the family was in the household rent or loan taken for improvement, which was around NPR 3902.89, followed by NPR 3608.68 in food and household items and NPR 780.33 for medical treatment. 97.5% of the respondents had electricity; 93.4% had a mobile phone followed by 43.8% had a television. From the study, it was found that household whose expenses are more than NPR 20000, their water quality was at no risk.

It was observed that 76.9% had recalled for the ceramic candle filter for the treatment followed by 33.1% confirmed boiling followed by 28.9% for Piyush/chlorine drops. 58.7% of the respondents confirmed that they were drinking water directly without any treatment at household level, followed by 38.8% of respondent using ceramic candle filters. 9.1% of respondents were using chlorine for treatment and only 6.6% of the respondents were boiling. 30.3% of water samples collected from the filter were in intermediate risk and 9% of these samples from the filter were at high risk. 67.6% of the respondents referred that they do not need the water treatment methods at households, followed by 19.7% of respondent referred that the water treatment method was not available in the nearest market. 7% of the respondents confirmed they did not know about the product.

The average operating cost for houses that use boiling water for treatment was observed NPR 146.25. The construction of drinking water structure for the household, toilet, hand washing station and garbage pit was NPR 8214.88, NPR 20128.93, NPR 2629.34, and NPR 124.79, respectively. Out of 38 respondents who suffered from the water-borne disease, it was observed that 39.47% of the respondents did not sought the treatment and got well within a day or two. However, 47.37% of the respondent had to visit nearest hospital for the treatment.

It was observed that 72.6% of household's drink water without treatment, followed by 22.6% of households who use ceramic candle filters for water treatment method. A total of 34 houses had suffered from the diarrheal cases, followed by 2 houses by dysentery and 2 houses by worm respectively, in the period of last year. The cost of treatment of diarrheal cases including travel, medicinal, food and any other cost incurred during the treatment was found to be median NPR 1500 (n=27). Similarly, the opportunity cost for the caretaker during the period of treatment was found to be NPR 2436. Overall, the gross economic cost for the recovery of the sick was NPR 3936.

5.2 Conclusions

Most of the households have private tap connected in the yard indicating saved time to fetch the water. It was observed that majority of the households are not using any water treatment method at household followed by ceramic candle filters. Most of the houses had been practicing better sanitation and hygiene practices, such as hand-washing practices. Also, it was observed that poor knowledge on better and quality products has significance cases of diarrhea the previous year. The microbial tests carried out at household level have shown poor water quality even after the treatment. Despite the initial investments carried out by the households for improved water sanitation and hygiene structures and drinking water treatment methods, it was observed that Escherichia coli was significantly present in the drinking water indicating poor handling water exposing household to disease. Significant numbers of family members from numerous households had suffered from the diarrheal cases; considerable amount of active working days was affected leading to considerable loss of the economic activities.

The cost of treatment and opportunity cost of the caretaker here suggested that the family had to expense a considerable amount of money and time to recover from the disease, which could have been avoided with proper adoption of the household water treatment methods. This study considered the valuation of the economic cost by considering the direct medical treatment cost, travel cost to receive the treatment and all logistic arrangements for the treatment. Similarly, the indirect or opportunity cost of the caretaker was also calculated. Generalization of the daily earning has been carried out based on the involvement in economic activities and estimating the total opportunity cost for the active working days. Valuation of the investment made in the water sanitation and hygiene structures was carried out based on the equivalent annual cost and total economic cost of prevention and treatment has been figured out. Thus, the study concludes that poor selection of water treatment method followed by poor handling had exposed households to microbial risk and significant occurrence of diarrheal cases leading to extensive cost burden for treatment.

5.3 Recommendations

From the study carried out, following recommendations are made for further study and approaches.

- For the users of drinking water scheme, it is recommended to use the combination of water treatment available in the nearest market. Study shows that depending only on a single water treatment method (especially, filter) could expose users to diarrheal risk.
- For policy maker- it is suggested to intervene on the water quality at the distribution point rather than on household water treatment methods, as there is a significant number of HHs suffering for the diarrheal disease, annually.
- For academicians, the scope of study should include the market chain supply of proper treatment methods, medicines and equipment, availability of the health officials for epidemic and regular treatment should be covered in order to address the emergency situation.
- For researchers, ground level information of community, their behavior challenges, economic status, social diversity, psychological ownership and environmental impact that causes poor water quality should be studied and reported to rectify and reduce water borne diseases.

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APPENDIX

APPENDIX-A Questionnaires

Economic Cost of Safe water and Sanitation **A case study of Satakhani,Lekhbesi Municipality ward no. 9, Surkhet**

Name of the respondent :	
Address :	

Contact Number :	
Date of Data Collections:	

This survey is carried out to meet the Partial Fulfillment of the Requirements of the Degree of MASTER OF ARTS In ECONOMICS, Department of Economics, Patan Multiple Campus, Faculty of Humanities and Social Science, Tribhuvan University, Nepal. Any personal information will not be diclosed for financial or other beneficiary and will be used only for the academic purpose only. Do you agree to continue the survey? Yes ( ) No ( )

Code No.	

A.	**Household Characteristics**					
1	Are you the head of the household? (Circle)			Yes	No	
a	*If not head of the household*, how would you describe your relation to the head of the household? Circle one.					
	1. Husband/wife/partner	2. Adult child	3. Grandchild	4. Parent/ Parent in-law	5. Other (specify)	____________
b	Number of families living in this household (give a number)				____________	
c	Number of persons living in the household				____________	
d	What is the highest level of education in the household (Circle as relevant):					
	1. Primary school	2. Seconda	3. Graduate	4. Post graduate		

ry
school

2	Please enter for each member of the household, their age, education, employment status, hours worked, etc. For children, at school, enter N/A in relation to employment questions and tick (please insert extra rows if necessary).									
1. Family members (starting with the oldest progress to the youngest)	2. Sex	3. Age	4.Relationship with the household head	5. Formal employment status	6. Type of work (if Column [5] is coded a / b / c)	7. Number of days worked in the last 2 weeks	8. Income earned in a day NRs.	9. Income earned in the last fortnight by that person NRs.	10. At school (Please tick as relevant)	11. For calculating fortnightly income

4. Relationship with the household head	a. Household head
	b. Husband/ wife
	c. Child
	d. Grandchild
	e. Parent/Parent in-law
	f. Other

5. Formal employment status	a. Working full-time for someone else
	b. Self-employed
	c. Working part-time for someone else
	d. Not working

Type of work (if Column [5] is coded a, b, or c)	a. Government employee
	b. Private employee
	c. Employer
	d. Agriculture, fishing for sale
	e. Aggregate mining
	f. Producing goods for own consumption

	g. Unpaid voluntary work
	h. Unpaid family work
	i. Other

B.	Sanitation and Hygiene
1	What type (s) of toilet system does your family use? Circle all the ones used.

a. Own toilet   b. Shared toilet   c. Pubic toilet   d. bush/ open space   e. ecosan toilet

2 Circle the type of toilet system your household has? Circle the one that is relevant.

a. Flush toilet connected to PUB   b. Flush toilet (connected to own septic)   c. Pour flush (pit)   d. Compost toilet   e. None (Use bush)

3 If you have a flush toilet with septic tank system, how many times did it overflow in the last 12 months? Circle one.

a. Every time it rains   b. At least once in 6 months   c. At least once last year   d. Did not overflow in the last 12 months.

4 If you use a septic tank-based toilet system, and have had overflow problems in the past, what is the main reason for your septic tank overflow? Circle the relevant one.

a. Old and leaking   b. Poorly designed   c. Other (specify)

5 If you use a septic tank-based toilet system when did you last have the septic tank cleaned? Please circle one.

a. This last year   b. 5 years ago   c. 10 years ago   d. Cannot recall   e. Never – explain why not ……………………..................................

6 Is the user able to access the latrine right now (it is not locked, or they can open it)?

a. Yes   b. No

7 Can you please show me where and how you usually wash your hands?

a. Yes, shows the place	b. Yes, doesn't show place		c. No		

8 Does the respondent use soap, ash, or another cleanser?

a. Yes b. No

9 Does respondent show water to wash their hands?*

a. Yes b. No

10 What are the critical moments of handwashing ?

a. After working in the dirt	b. After toilet	c. After cleaning baby's toilet	d. Before cooking food	e. Before eating	f. Before feeding child

11 Could you please recall when are those moments of hand washing?

a. After working in the dirt	b. After toilet	c. After cleaning baby's toilet	d. Before cooking food	e. Before eating	f. Before feeding child

12 Is there hand washing station at house?

a. Yes b. No

13 Structural condition of handwashing station.

a. Good	b. Fair	c. Bad, could be used though	d. Bad, could not be used

14 Is there soap available in the hand washing station?

a. Yes b. No

15 Is there water available in the hand washing station?

a. Yes b. No

C. Drinking and Other Water Sources

The following questions will help us understand if there is relationship between the level of water and vector-borne diseases suffered by the household and the source of water used for drinking and/or washing.

1 What **sources of drinking water** does your household use? **Circle** as relevant.

a. Private tap piped water system (PUB)	b. Own rainwater tank	c. Open well water	d. Protected well water	e. Community tap piped water system	f. Get water from neighbors	g. Buy water from the PUB (tanker)	h. Buy bottled water

Rank the three most important sources of drinking water

2 When your **own** source of drinking water is not sufficient to meet your household's needs, where do you get additional drinking water from? **Circle** only once.

a. Own rainwater tank	b. Open well water	c. Protected well water	d. Use community water	e. Get water from neighbors	f. Buy water from the PUB (tanker)	g. Bottled water

3 Do you buy water from PUB Tanker? **Circle** one.

i. Yes ‹ (Answer Q4) ii. No ‹ (Answer Q5)

4 If you regularly buy water from PUB (tanker) (to supplement your main sources of drinking water), how much water to do you purchase and how much does it cost you?

i. **Tons** (cubic meters) /per tanker-trip .... ii. **Number** of tanker-trips per month .... iii. Payment per tanker-trip NRs..................

5 Do you normally buy bottled water? **Circle one.**

i. Yes ‹ (Go to Q6) ii. No ‹ (Go to Q7)

6 Do you treat water for drinking? Please **circle** one.

a. Yes (If yes, go to ii) b. No ……..…

ii. For each of the drinking water sources you use, indicate how you treated it. (**Tick relevant cell**)

	Boil	**Chlorine**	**Water filter**	**Other (specify)**
	(1)	(2)	(3)	(4)
a. Private piped tap water system (PUB)				
b. Community tap piped water system				

7 If you treated your drinking water using material bought from the shop, how much did it cost you to use the different methods where you had to buy material?

Drinking water system	Chlorine (liquid or tablets)		Water filter		Others, ……......................................		Explain if the materials are provided in subsidy
	Last week (NRs.)	Last month (NRs.)	Last week (NRs.)	Last month (NRs.)	Last week (NRs.)	Last month (NRs.)	
a. Private Tap Piped system (PUB)							
b. Community Tap piped water system							

D **Water-borne and vector infectious diseases and related costs This set of questions is designed to identify the costs associated with water- and insect-borne diseases to your family.**

1 **Has anyone in the house suffered from these water- and vector-borne diseases in the last 4 weeks? Circle all those that are applicable.**

	a. Diarrhea (If Yes, Answer Q2a)	b. Dysentery (running stomach with blood/pus in the stool) (If Yes, Answer Q2b)	c. Worm (If Yes, Answer Q2c)

2 **For Enumerators Information. For each of the diseases you will ask respondent about things like:**

i How many adults, children, and infants in your household suffered from that illness?

ii How many days did the disease last for each sick person in the family?

iii How many days an adult was away from work?

iv How many days a child was away from school sick?

v What treatment was sought?

vi How much did the family spend for the treatment of the illness in each case (include cost for transportation, consultation, medication, special food, if relevant)?

Fill out the answers to the above questions by filling in the appropriate table cells.

NB. Make sure you include all members of households that had the disease, in each table for the different diseases. Make sure the age and sex of the person is consistent with what was reported in A2.

Code for Column 7: Treatment Outlets

1	Traditional Doctor
2	Shop
3	Hospitals/clinic/ Health center
4	No treatment sought

Comments (such as if someone died from the illness; or had repeat illness this year, and/ or was admitted to the hospital; got traditional medicine from bush)

i **How many members of the household suffered from this illness in the last 4 week?**

ii **Write down the ages of people who suffered from this disease in the LAST 4 WEEKS. Enter these ages below in the first column, making reference to ages listed in Question A2 above. For each person, then fill each box in each column.**

2a **DIARRHEA**

Person # (1)	Age (year) (2)	Sex of the person (Insert M, F) (3)	# of days sick (4)	# Days away from work (or could not do any work at home) (5)	# Days away from school (as relevant) (6)	Treatment Outlet (see Code below) (7)	Cost (NRs. treatment) (bus fare, medicine, special food, etc.) (8)	Days admitted in hospital (8a)	Comments (9)	Column for adding costs (10)

2b DYSENTERY (Diarrhea with blood/pus in stools)

Person # (1)	Age (year) (2)	Sex of the person (Insert M, F) (3)	# of days sick (4)	# Days away from work (or could not do any work at home) (5)	# Days away from school (as relevant) (6)	Treatment Outlet (see Code below) (7)	Cost (NRs. treatment) (bus fare, medicine, special food) (8)	Days admitted in hospital (8a)	Comments (9)	Column for adding costs (10)

2c WORMS

Person # (1)	Age (year) (2)	Sex of the person (Insert M, F) (3)	# of days sick (4)	# Days away from work (or could not do any work at home) (5)	# Days away from school (as relevant) (6)	Treatment Outlet (see Code below) (7)	Cost (NRs. treatment) (bus fare, medicine, special food, etc.) (8)	Days admitted in hospital (8a)	Comments (9)	Column for adding costs (10)

3i Did the household lose someone (i.e., someone died) in the last 5 years due to any of the above diseases? (Circle the relevant answer below)

1. Yes 2. No

3ii Please indicate the age of the person(s) who died.

a. Infant (less than 12 months) : ________ months old b. child (1–15 years) ________ years old c. adult (15–60 years) ________ years old d. elderly (> 60)

E Household income and expenditure

This set of questions will help us understand the costs for your illnesses relative to what the household income may be (indicative only) as well as relative to your overall household expenses.

1i List main sources of income in the family (if any). Circle the ones that are relevant below.

a. Wages and salaries		c. Daily labour	d. Home produce sales, including sewing	
b. Agriculture	e. Casual employment	f. Pension	g. Money from abroad and gifts	h. Other: (specify)

ii In the adjacent column indicate the three most important sources of income in the household (insert the letter in the order of importance—highest income source at the top, second most important in the middle box, and the lowest at the bottom box.

2	Which range would best describe your household's TOTAL FORTNIGHTLY income? (Circle the relevant answer)	a. Nil	b. Upto 1000	c. 1001-5000	d. over….........

3	How much money and in-kind gift does your household receive from family members in village or abroad?	a. Cash: NRs.___________ /month	b. Describe the kinds of in-kind contribution (such as food, clothing, etc.) you get from family in the last 12 months____________	c. Value of the in-kind support/gifts you received last year in NRs.____________ in the last 6 months

4	**What is your household's average expenditure in a fortnight? Space for calculation**	For Expenditure calculation	Food and household items (soap, etc.)	Electricity	Medical treatment	Kerosene and cooking gas	Mobile phone	Children clothes, fees	Bus fares	Others
Enumerators estimate costs per fortnight costs for things that may be spent in month (like electricity), in a year (like lease rent). Total expenditure NRs. ………………./fortnight										

5 **Interest for upgradation**

5a If the government used money raised to improve these services such that no one in the family would suffer from serious water- and insect-borne disease, would your household be willing to pay for better water and sanitation services? (Circle only one)

1. Yes (   ) (Answer Q6)   2. No (   ) (Answer Q5b)

5b If not willing to pay, explain why

6 If you are willing to pay, how much will the household be willing to pay?
a. NRs. ______________/fortnight   b. NRs. ______________/month

7 Expenses for WASH structures

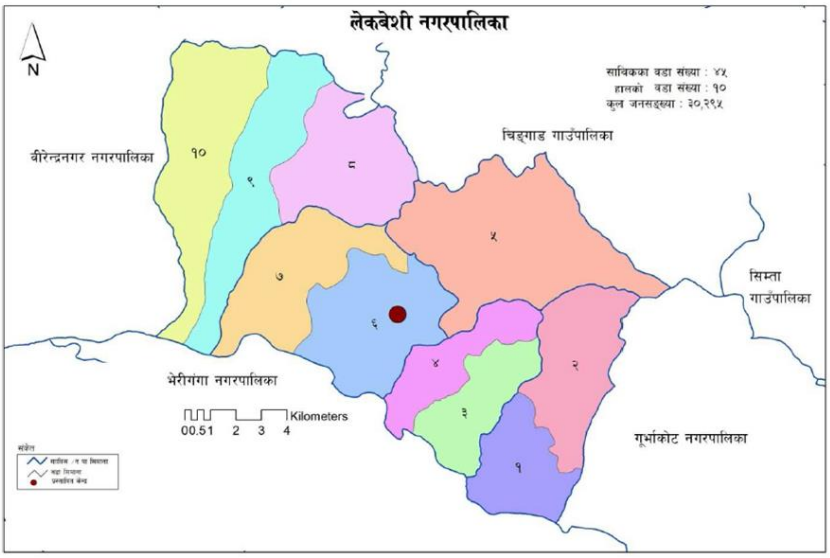
7a Construction of toilet   Kind ____________________   Cash ____________________   Others

7b	Construction of drinking water systems at household	Kind		Cash		Others
7c	Construction of handwashing station	Kind		Cash		Others
7d	Construction of grabage pit	Kind		Cash		Others
7e	Construction of the waste collection pit at village	Kind		Cash		Others

	F. Other comments
1	Any other comments about the state of water and sanitation services in the country, your experiences about diseases, and what can be done.

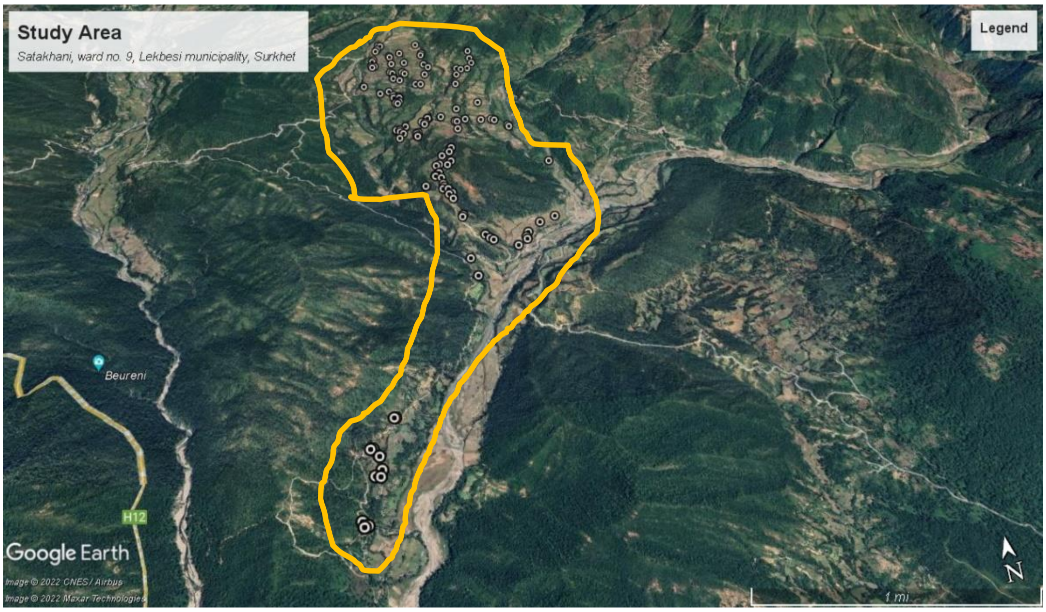
APPENDIX-B Maps

Figure 3 : Administrative map of Lekbesi Municipality, Surkhet



Source: Lekbesi municipality profile (2074)

Figure 4 : Distribution of samples in google earth view



Source: Google Earth (2022)

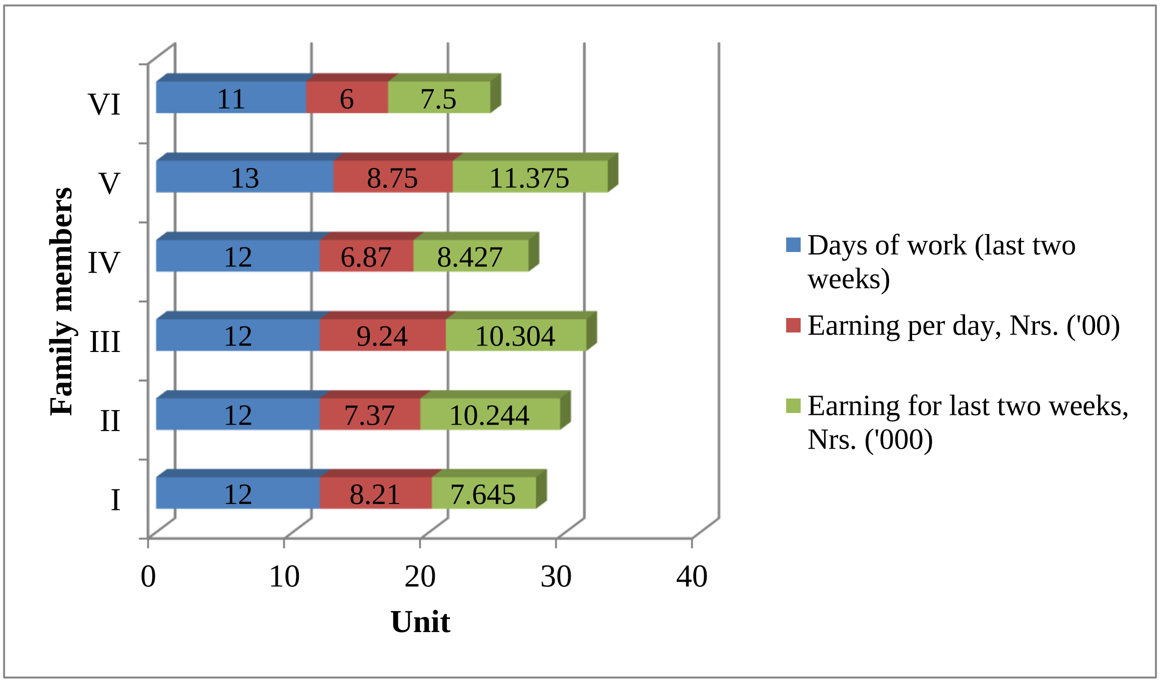
APPENDIX-C Divisions of earning within family member

Table 31: Divisions of earning within family members

Mean/Family Member	Days of work (last two weeks)	Earning per day, NPR	Earning for last two weeks, NPR
I	12	821	7645
II	12	737	10244
III	12	924	10304
IV	12	687	8427
V	13	875	11375
VI	11	600	7500
Total	12	774	9249

Source: Field survey (2022)

Figure 5: Divisions of earning within family members



Source: Field survey (2022)

APPENDIX-D Scenario of water sanitation and hygiene and microbial risk

Table 32: Scenario of water sanitation and hygiene and microbial risk

		Yes /No	Low risk		Intermediate risk		High risk		Grand Total	
			n	%	n	%	n	%	n	%
Piped water to yard/plot			72	73.5	14	14.3	12	12.2	98	81
Flush/pour flush			38	66.7	12	21.1	7	12.3	57	47
A1	HWS	No	1	50.0	1	50.0	0	0.0	2	
	Water available	No	1	50.0	1	50.0	0	0.0	2	
	Soap available	No	1	50.0	1	50.0	0	0.0	2	
A2	HWS	Yes	37	67.3	11	20.0	7	12.7	55	
	Water available	No	1	100.0	0	0.0	0	0.0	1	
	Soap available	Yes	1	100.0	0	0.0	0	0.0	1	
A3	Water available	Yes	36	66.7	11	20.4	7	13.0	54	
	Soap available	No	2	100.0	0	0.0	0	0.0	2	
	Soap available	Yes	34	65.4	11	21.2	7	13.5	52	
Pit latrine			30	81.1	2	5.4	5	13.5	37	31
B1	HWS	No	8	80.0	1	10.0	1	10.0	10	
	Water available	No	8	80.0	1	10.0	1	10.0	10	
	Soap available	No	8	80.0	1	10.0	1	10.0	10	
B2	HWS	Yes	22	81.5	1	3.7	4	14.8	27	
	Water available	No	1	33.3	0	0.0	2	66.7	3	
	Soap available	No	1	100.0	0	0.0	0	0.0	1	
	Soap available	Yes			0	0.0	2	100.0	2	
B3	Water available	Yes	21	87.5	1	4.2	2	8.3	24	
	Soap available	No			0	0.0	1	100.0	1	
	Soap available	Yes	21	91.3	1	4.3	1	4.3	23	
Ventilated improved pit latrine (VIP)			4	100.0	0	0.0	0	0.0	4	3

C1	HWS	Yes	4	100.0	0	0.0	0	0.0	4	
	Water available	Yes	4	100.0	0	0.0	0	0.0	4	
	Soap available	Yes	4	100.0	0	0.0	0	0.0	4	
Public tap/standpipe			5	45.5	5	45.5	1	9.1	11	9
Flush/pour flush			5	45.5	5	45.5	1	9.1	11	9
D1	HWS	No	1	100.0	0	0.0	0	0.0	1	
	Water available	No	1	100.0	0	0.0	0	0.0	1	
	Soap available	No	1	100.0	0	0.0	0	0.0	1	
D2	HWS	Yes	4	40.0	5	50.0	1	10.0	10	
	Water available	No	1	100.0	0	0.0	0	0.0	1	
	Soap available	Yes	1	100.0	0	0.0	0	0.0	1	
D3	Water available	Yes	3	33.3	5	55.6	1	11.1	9	
	Soap available	Yes	3	33.3	5	55.6	1	11.1	9	
Unmanaged piped water to yard/plot			7	58.3	4	33.3	1	8.3	12	10
Flush/pour flush			6	60.0	3	30.0	1	10.0	10	
E1	HWS	No	2	66.7	1	33.3	0	0.0	3	
	Water available	No	2	66.7	1	33.3	0	0.0	3	
	Soap available	No	2	66.7	1	33.3	0	0.0	3	
E2	HWS	Yes	4	57.1	2	28.6	1	14.3	7	
	Water available	No			1	100.0	0	0.0	1	
	Soap available	Yes			1	100.0	0	0.0	1	
E3	Water available	Yes	4	66.7	1	16.7	1	16.7	6	
	Soap available	Yes	4	66.7	1	16.7	1	16.7	6	
Pit latrine			1	50.0	1	50.0	0	0.0	2	
F1	HWS	No	1	50.0	1	50.0	0	0.0	2	
	Water available	No	1	50.0	1	50.0	0	0.0	2	
	Soap available	No	1	50.0	1	50.0	0	0.0	2	

Source: Field survey (2022)

APPENDIX-E Some Photographs

Figure 6; Test plates for the microbial

Figure 7: Field test for the microbial water quality

Figure 8: Existing toilet and improved hand washing stations at community

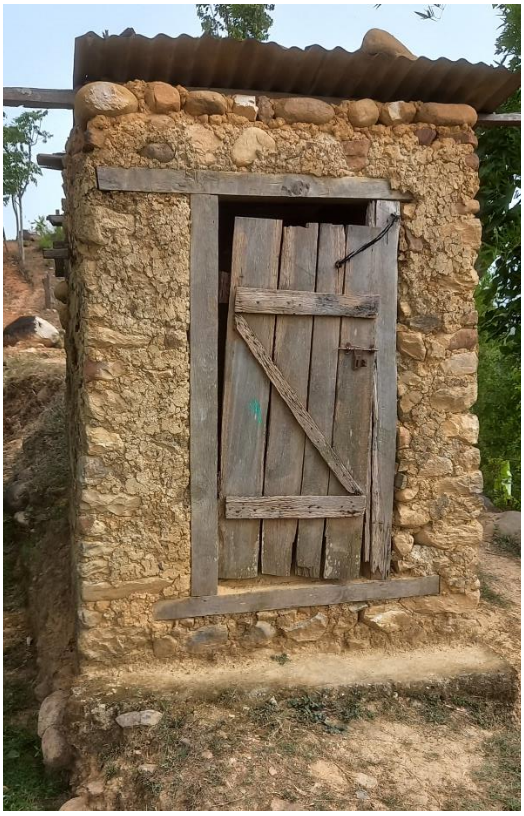


Figure 9: House at the community

Figure 10: Researcher with respondent (different household scenario)

Figure 11: Researcher with respondent (different household scenario)