Farmers' perceptions and knowledge of using waste and wastewater in two peri-urban areas of Kathmandu valley of Nepal

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Master in Philosophy Degree in Geography
May-2018

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A thesis submitted for
MPhil. Degree in Development Geography

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May-2018

ACKNOWLEDGEMENTS

This thesis would not have been possible without the direct and indirect support of different people and institutions. My deepest acknowledgement goes to Head of the department, Department of Geography, University of Bergen, Peter Andersen, my supervisor for his continuous encouragements, guidance and great supervision throughout this thesis work.

I would like to acknowledge to all the informants/peri-urban farmers of both study sites, mainly Shyam Koju, Tirtha Maharjan, Hem Bahadur Rai for their kind and valuable support during the fieldwork. I am thankful to the Municipal officials of Kirtipur municipality and Madhyapur Thimi municipality for their assistance to get municipal information and record, also to sister, Tara Khadka and her family for providing me an accommodation in Kathmandu during the fieldwork.

I am grateful to Professor Tor Halfdan Aase, other university teachers, seniors from Nepal Madan Suwal, Yograj Goutam and Dilli Prasad Poudel for their knowledge, inspiration, and motivation to my work. Thanks go to all administrative staffs for their valuable supports and class friends for sharing joys during the study period.

My parents, brother, sisters and my husband Binod Adhikari deserve sincere gratitude for their love, care, encouragement, and support that reinforced me to make this endeavor. I am thankful to the Norwegian State Education Loan Fund (Lånekassen) for the financial support for whole program and Faculty of Social Science of the University of Bergen for the support for my fieldwork.

I wish to thank direct and indirect helps that I got during the whole thesis work.

Bergen, May 2018

Kumari Kamala Chand

THIS THESIS IS DEDICATED

TO MY PARENTS

Abstract

Using waste and wastewater in urban and peri-urban agriculture and its related concerns in developing countries have become the burning issues in academic and non-academic spheres. It is often argued that reuse of waste and wastewater through agriculture is a viable alternative to support small-scale urban and peri-urban farmers, to sustain the urban food system and to maintain the urban environment. However, researches and studies in developing countries have confirmed that the unsafe and unregulated reuse poses several public health and environmental risks. In this context, exploration of farmers' knowledge and perceptions might be an important contribution in the wisdom of knowledge and in the field of research. This study is an attempt to explore farmers' perceived benefits and perceived risks of using waste and wastewater in peri-urban area of Kathmandu valley. The study also tries to establish an association between discourses of waste and wastewater use and the farmers' practices at the local level.

The empirical data for this study was collected from two months of fieldwork in 2016 in two peri-urban sites (site-A and site-B) using semi-structured questionnaires surveys (N=50, 25 in each site, interviews (n=30, 15 in each) and supplemented by observation and participant observation. The theoretical framework has been designed combining FAO's concept of peri-urban agriculture, typology of waste and wastewater use given by Van der Hoek (2004), some discourses of waste and wastewater use documented in multiple literatures and WHO's multi-barrier approach. The result from analysis shows the wastewater is being used in farming in both peri-urban sites; however, use of wastewater for irrigation purpose is common in the site 'B' where the direct pattern of wastewater use (from polluted river water and open sewage) has been found. Farmers of site 'A' are using water from deep boreholes that are locally considered as clean water to irrigate crops, but the vegetable brokers are washing vegetable in polluted river water in this site. Farmers are also using organic waste to fertilize the crops and waste food to feed their livestock (mainly pigs and ducks).

Relating farmers choice of wastewater use with the closed loop discourse, it is concluded that the current use of wastewater in agriculture is found to be a response to clean water scarcity not for the nutrient value whereas farmers have a strong awareness and knowledge of agronomic and economic values of organic waste and food waste. Concerning perceived risks, itching and skin infection, odd smell and mosquito nuisance were responded as common farmers' health-related problems but the higher frequency has been found in site 'B'. Concerning to public health risks, the higher risk might be posed by washing vegetable in contaminated river water but the local chain of food (from farm to fork) can also generate several public health risks. Thus, enhancing farmers' capacity to low-cost and safe ways of handling waste and wastewater and adoption of the multi-barrier approach that prevents health risks in every step of a food chain, need to go hand in hand.

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CHAPTER 1: INTRODUCTION

1.1 The context

Over half of the global population resides in the city area (Un-Habitat, 2016) and nearly 15 to 20 percent of food for the city people is produced in and around the cities of the world (Corbould, 2013). Use of wastewater, waste or/and excreta to produce food in the city area is a global practice which has a long tradition in many countries (Scott et al., 2004). Several farmers around the cities area of developing countries have to depend on wastewater to irrigate the cities' food, fodder, and green spaces for their livelihood. The causes and drivers of using wastewater and waste in urban and peri-urban agriculture have been differently explained. One way of explanation is that it is due to increasing demand for fresh water and lack of reliable sources of water for irrigation in the urban area of developing countries (Raschid-Sally and Jayakody, 2009). Rapidly growing population in the city area of developing countries have caused multiple problems and has created uncontrollable pressures on municipal facility management including urban food and water supply. This situation might be one of driving factors of wastewater and waste use in urban and peri-urban agriculture.

In recent years, academic and non-academic researchers have given a great attention regarding this practice and its related issues (Scott et al., 2004, Keraita and Drechsel, 2004, Qadir and Scott, 2010, Lazarova and Bahri, 2005) and they have divergent interpretations about the issues. Some consider that it is an important and viable farming input; for instance, (Smit and Nasr, 1992) appreciated waste and wastewater as a great benefit for urban and peri-urban agriculture. While others raised the issues of human health and environmental risk of using it (WHO, 2006a, FAO, 2012b). One of the greatest challenges created by this practice is to produce safe and hygienic food in which farm workers and farmers' role is very important (Qadir et al., 2010). In this situation, it is important to explore farmers' knowledge and perceptions about both benefits and risks of using it. Farmers' knowledge and perception are important in the discourse of waste and wastewater use. This research is an effort to accumulate the understandings and knowledge about benefits and risks of using different forms of waste and wastewater in peri-urban farming in Kathmandu valley of Nepal from the farmer's perspective.

1.2 Challenges and issues of using wastewater and waste in peri-urban farming in Kathmandu valley

The proportion of urban population in Nepal is still low and the country is positioned as one of the least urbanized countries in the world but it is also recorded as one of the fastest urbanizing countries (UN-DESA, 2015). The rapid growth of urban population in Nepal is largely concentrated in few cities; such as Biratnagar, Pokhara and mainly in Kathmandu Valley (CBS, 2011). Due to this, the production of municipal waste (solid waste and wastewater) is increasing that causes several negative consequences on both human and environmental health (Pokhrel and Viraraghavan, 2005). The concentration of small and some of the large industries and commercial sectors are also located in or around the city area which produces a significant amount of waste and wastewater (UNEP, 2001). The problem of excessive release of industrial waste, other waste, and polluted water might be a consequence of poor urban planning and management mechanisms. Most of the city sewage (domestic and industrial) either mixed into the natural streams and rivers or have been left unmanaged.

People have been doing agricultural activities in and around the core city of Kathmandu but the increasing demand of water supply and growing pollution in available water resources (rivers) hits hard on this sector. Due to the lack of fresh water and treatment facility of wastewater, farmers are utilizing unsafely deteriorated and diluted wastewater for irrigation in urban and peri-urban agriculture (Rutkowski et al., 2007). In addition to wastewater, farmers are using food waste to feed animals and agricultural residuals are used as alternative fertilizer for crops. These all practices can have both positive and negative consequences to the human and environment health so that there is a need for research and developmental intervention that could reduce the risks and increase the benefits.

1.3 Empirical review: a global level

Different empirical studies have documented the issues about risks and benefits of using waste and wastewater in urban and peri-urban agriculture around the world. For example, Smit and Nasr (1992) estimated that one-tenth or more of the world's population consumes foods produced through wastewater irrigation. Wastewater and excreta are also used in urban agriculture. A high proportion of the fresh vegetables sold in many cities, particularly in developing countries are grown in urban and peri-urban areas. For example, in Dakar,

Senegal, more than 60% of the vegetables consumed in the city are grown in urban areas using a mixture of groundwater and untreated wastewater (Scott et al., 2004). In Haroonabad, Pakistan, the economic value of using wastewater is significant. Farmers who use wastewater earned $US 300–600 more per year than the canal water user because the supply of wastewater was regular throughout the year whereas canal water users had limited for water supply due to the scheduled system of irrigation. Wastewater user farmers were also able to save the input cost which needs for chemical fertilizer, manure and irrigation services. However, the health risk such as hookworm infection among the wastewater user farmers was higher than the non-user farmers (Van der Hoek et al., 2002). The national assessment on wastewater use in Vietnam reveals that more than one-third percent of the total domestic wastewater in large cities and about half percent in small cities is mixed in the sewer system. Some sewer systems are covered whereas some are open and unplanned which are directly discharged into the river (Van der Hoek, 2004). Nearly half a million people have been assessed as wastewater user for agriculture and aquaculture from those open sewerage. (Raschid-Sally et al., 2004). However, this assessment lacks the systematic evaluation of environmental and health impact of using wastewater.

In most of the cities of developing countries, the sanitation and sewage management is poorly developed. It effects on people's livelihood and their livelihood activities thereby they face several health problems. The use of waste and wastewater in urban and peri-urban farming is linked to the sanitation and sewage management. A study from Ghana shows that several farmers in the urban and peri-urban area use wastewater for irrigation because of poor urban sanitation infrastructure and lack of wastewater treatment facilities. Thus, farmers affected more from high contamination levels in wastewater; for instance, pathogens (Keraita and Drechsel, 2004). Farmers who use wastewater also frequently charged by the legal municipal authorities as wastewater use in this area is illegal. However, the individual and aggregate benefits of using wastewater are noteworthy. In Kumasi, Ghana, open-space vegetables farmers can earn two to four times more than farmers who grow maize and cassava (Danso et al., 2002). This is achieved because of year-round reliable and free water supply for the intensive farming.

The other urban organic waste, particularly use of human excreta (including faeces and urine) on urban and peri-urban farming is considered as an ancient practice. However, the views of these practices are not same. As animal manure, human excreta are beneficial for soil fertility, as it helps to raise the organic matters and nutrients on the soil. Thus, this view

says this is an organic way of farming. However, excreta carries many pathogenic microorganisms, such as bacteria, protozoa, and helminths (Timmer and Visker, 1998). Thus, its usefulness is questioned. But the benefits and risks of using human excreta on urban and peri-urban farming determined by several factors including socio-cultural taboos and consents (Ibid).

The study of faecal sludge use in peri-urban agriculture in two municipalities of Northern Ghana reveals that the worm and hot savanna climate make sludge easy to use as it can be dried. In addition, due to high solar radiation, the health risks of contaminated microorganisms were expected to be less. Nonetheless, some 24 percent of the farmer had experienced the health problem such as itching feet and foot rot (Cofie et al., 2005). The foul smell while using it was identified as a main problem to the farmer. It suggests that awareness and the proper and hygiene handling practices need to be given to the user.

1.4 Empirical review: local level

Various scholars have studied peri-urban farming practices in Kathmandu valley (Sapkota, 2003, Sapkota, 2009, Rana et al., 2015, Bhatta and Doppler, 2016) however; they primarily focused on farming system, its changes, livelihood, and sustainability. None of these scholars has studied the issues of waste and wastewater use. For example, the study of Bhatta and Doppler (2016) assessed the organic farming practices and sustainability in a peri-urban area of Kathmandu valley. The study found that, although there is an increasing trend of organic farming practices, the problems of higher price and lack of certification of organically produced products are the main issues. The study suggested that governmental, non-governmental and communities should be collectively engaged to manage such issues. The literature-based study of Rana et al. (2015) identified the multi-functional potentials of peri-urban agriculture for sustainable and reliable local food access in the Kathmandu valley.

Due to increased inflow of human inhabitants in Kathmandu, the peri-urban farming land is being continuously converted into urban settlements (Haack and Rafter, 2006). This unplanned urban expansion releases more waste and wastewater. According to an estimation of UNEP, about 29% of the total solid waste and wastewater in Nepal is generated in the Kathmandu valley alone. This includes non-compostable hazardous waste such as medical waste, battery waste, pesticides and industrial waste (UNEP, 2001). Only a few municipalities are composting a small percentage of their compostable waste (Mishra and Kayastha, 1998). Most of the rivers in the Kathmandu valley, including the Dhobi,

Bisnumati and Bagmati Rivers, are polluted with municipal waste and wastewater (Regmi et al., 2014). Because of the poor sewage system, most of the domestic, industrial and other waste and wastewater are being discharged into the river or dumped on to the riverside. Therefore, the river water is polluted and is contaminated by the harmful chemicals (Karn and Harada, 2001).

Except few, most of the peri-urban farmers (who have been relying on river water to irrigate their crops) have now only the option to use that polluted river water. Farmers also use organic waste to fertilize the crops and food waste to feed their livestock. In this situation, there is a pressing need for research to understand the positive and negative aspects of waste and wastewater use. Until the date, limited research has been conducted concerning such issues in Kathmandu valley. For instance, Rutkowski et al. (2007) studied the existing wastewater treatment facility and practices of wastewater use in two peri-urban farming areas of Kathmandu valley. The study found that there is no any proper mechanism of wastewater treatment and the peri-farmers are essentially depending on wastewater for the irrigation. As all the rivers such as Bagmati, Bisnumati, Dhobi, Manohara carry municipal wastewater, farmers located near to these areas use that polluted river water for irrigation. The pattern of using wastewater is different in two different places of the valley. But this study has not considered the farmers' practice of using organic waste and use of food waste as animal feed that is one of the important aspect peri-urban farming in Kathmandu valley. My present thesis also covers the issues related to the use of organic waste and food waste as farm inputs not only the wastewater. Fundamentally, the present thesis seeks farmers' perceived risks as well as benefits of using waste (mainly organic waste and food waste) and wastewater in peri-urban farming practices.

1.5 The objective of the study

The main objective of the research is to assess the farmers' perceptions and knowledge of using waste and wastewater in a broad range of peri-urban farming activities in Kathmandu valley.

To fulfill this objective subsidiary question have been raised.

- What is the existing situation of waste and wastewater uses in peri-urban farming?
- How farmers perceive the benefits as well as risks of using waste and wastewater?
- What factors explain the farmers' practices of using waste and wastewater?

1.6 Structure of thesis

The thesis is structured into seven chapters. Chapter two provides information about two study sites. Chapter three highlights the theory and concepts of related to the research theme. Particularly, conceptual clarification of urban and peri-urban agriculture, waste and wastewater, discourses about waste and wastewater use. Chapter four deals about the methodology and methodological processes of fieldwork, challenges, positionality and interaction with the local people, issue of validity and reliability. The chapter five, six and seven comprise the analysis of the empirical evidences. Each of these three chapter include the summary. The chapter five explains the existing situation of peri-urban farming. This chapter also shows the current pattern of waste and wastewater use. The chapter six discusses about the farmers' perception about waste and wastewater use. Discussion will be based on analyzing farmer's responses and storylines. Chapter seven focuses on discussion about the real practice of waste and wastewater use in relation to the discourses on it. The final chapter include the concluding remark of the thesis.

CHAPTER 2: THE STUDY AREA

2.1 Kathmandu valley: a short history

Kathmandu valley is historically, culturally and politically a significant place. According to a legend, the valley was a lake and historically it was known as 'Nepal' (Bell, 2014). In the early times, *Gopalas and Mahispalas*, the pastoral dynasties ruled the valley (The World Bank, 2001). After that, the *Malla* and *Shah* Dynasties came, during that time Nepal was divided in several nation-states called *Baise Rajya (22 states)* and *Choubise Rajya (24 states)*. Several cultural monuments and arts built during the *Malla* dynasty (Whelpton, 2005) which still exists. *Shah* dynasty (particularly of the Gorkhali King Prithivinarayan Shah) merged such small nation-states. After the unification of such small nation-state, Kathmandu has become the capital city of the greater Nepal and the ruling powers were centralized on it (Shrestha, 1999). The city grew more rapidly and become a populated and urbanized city in the present day.

Newars are considered as Kathmandu's indigenous inhabitants and still, the valley is a hub of *Newari* customs, architectures, rituals, traditions, cultures, and arts. One of the traditional styles of architecture, the '*pagoda'* (many-tiered) can be seen in different temples and buildings that are widely recognized in the world (Gurung, 1980). *Newars* speak "*Nepalbhasa*" which is a Tibeto-Burman language promoted by *Mallas.* Religiously, *Newars* follow Hinduism and Buddhism separately (Shrestha, 1999). Several cultural and religious monuments such as, *Darbar* squares, Swoyambhu, Pashupatinath etc. that have already been registered in UNESCO's world heritage lists. The valley was also an ancient trading center. The Nepalese and Indian traders conducted the trade between Nepal, Tibet (Lhasa) and India. The valley was rich in an agricultural land so that it is also known as the historical center of agriculture (Ibid).

2.2 Physical characteristics

The Kathmandu valley covers 684 km^2 area and the urban centers occupy only 14% of the land (Thapa and Murayama, 2010). Geographically, the valley is located between the latitudes 27º 38' 32" and 27º 45' 70" North and longitudes 85º 16.5' 5" and 85º 22' 32" East and is located at a mean elevation of about 1,300 meters (4,265 feet) above sea level (Thapa et al., 2008). It is filled by thick lacustrine (lake sediment) and fluvial deposits (deposited by rivers) and is more than 550m thick. The valley's sedimentary basin was formed in the early

Pliocene (Yoshida and Igarashi, 1984) and from the Late Pleistocene to Holocene (1,000,000-10,000) age (Yoshida and Gautam, 1988). Valley encloses the entire area of Bhaktapur district, 85% of Kathmandu district and 50% of the Lalitpur district. It is bowl-shaped lies in the middle of the Lesser Himalayas and bounded by the Phulchowki and Chandragiri hills in the south and Shivapuri hills in the north. There are two landform units: the alluvial plains along the rivers, and the elevated river terraces, locally called '*tars*'. The valley is drained by the Bagmati river and its tributaries system (Thapa and Murayama, 2010).

It has three climatic zones: sub-tropical, temperate, and cool-temperate climatic zones that have four distinct seasons: pre-monsoon, monsoon, post-monsoon, and winter. The minimum and maximum temperatures of the valley is measured -3° C and 35.6° C, respectively (ICIMOD, 2007; UNEP, 2007 cited in Dixit et al., 2014). More than 90 percent of the valley's total rainfall occurs during the four months of the monsoon which begins from mid of June. The amount of rainfall varies but on an average, the valley receives 1600 mm of rainfall annually. Differences in elevation create orographic effects which cause spatial variations in rainfall: the valley floor receives about 1400 mm; the adjoining hills, more than 2 000 mm (Ibid).

2.3 Urban expansion and its challenges

Kathmandu valley includes Kathmandu Metropolitan, Lalitpur and Bhaktapur sub-metropolitans and other municipalities[1]. It is one of the most populated areas of Nepal. As the capital city, a vast majority of the urban population is concentrated in this place. People form the other part of countries are continuously moving into the valley area to find the opportunities. According to the population census of 2011 of Nepal, about 29 percent (1311307.8) of the total urban population of Nepal (i.e. 4,523,820) live in the Kathmandu valley (Bakrania, 2015, CBS, 2011). In terms of area cover, it occupies only about 0.5% of the total land area of Nepal (CBS, 2011). Size of the population is growing at the rate of four percent per year, that is one of the fastest-growing metropolitan areas in South Asia, and the

[1] In Nepal, according to the Local Self Government Act, 1999 (LSGA), the urban centers are categorized into metropolitan, sub-metropolitan and municipalities. These are primarily based on the number of population, the availability of infrastructure and total revenue collected. Since the implication of act, the declaration of more urban center has been happened. So the number of sub-metropolitan and municipalities have been added.

first region in Nepal to face the unprecedented challenges of rapid urbanization and modernization at a metropolitan scale (The World Bank, 2013).

The fig. 2.1 depicts how urban expansion has happened during last 50/60 years in the valley. During the first census (i.e. 1952/1954) of Nepal, the population size of Kathmandu valley was just around 0.20 million but the population has skyrocketed after the 1990s and during 2011 census the valley population size has crossed one million. One of the main driving forces behind rapid urban growth in the Kathmandu valley is centralization. As power, wealth, and services have been historically concentrated, it has attracted people from all over the country. In addition, it has become one of the most urbanized regions in Nepal. Immigrants have greatly increased in the valley during the decade of 1990-2000 from other areas as a consequences of security risks created by Maoists insurgents (Haack and Rafter, 2006). Most of the urban growth has occurred without effective planning causing serious problems including environmental pollution, rising unemployment, inadequate infrastructure facilities and conflicting land use demands.

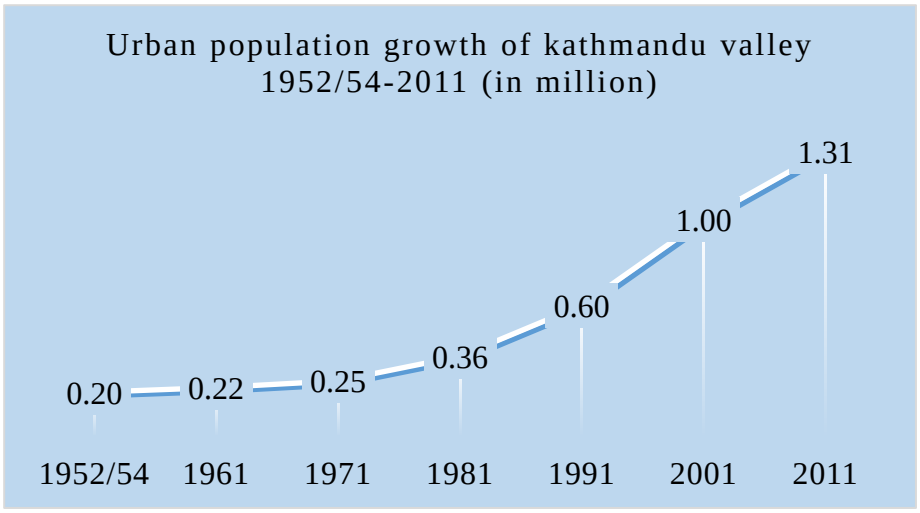


Figure 2.1 Population growth of Kathmandu valley

(CBS, 2011, Haack and Rafter, 2006)

2.4 Agriculture: contextualizing the peri-urban agriculture

Historically, the land of Kathmandu valley is considered as one the most productive agricultural region of Nepal (Haack and Rafter, 2006). Most of the local people grew different types of crops as well as keep livestock. There was good irrigation facility through the traditional canals, which was known as *rajkulo*. These canals were used for irrigation of

land as well as to fill the water ponds around the valley (Shrestha, 1999). The caste group of *Newars* was known as *Jyapu,* which locally refers as hardworking farmers in the valley. They used to produce enough grains and vegetables for the valley people before the population increased (Dixit et al., 2014). Their traditional way of food production was more organic as they preserved seeds themselves, used local fertilizer (compost and human excrement) (Ibid:27).

After 1980s/90s, the socio-economic context of Kathmandu valley has largely changed. Due to the rapid and unplanned expansion of urban settlements, the agricultural land has gradually been converted to the buildup area (Haack and Rafter, 2006). Thus, agricultural land has become limited and agricultural practices have decreased. Land use change is not only a cause of decreasing agriculture sector. It is also because of decreasing interest in agricultural activities of a new generation and increasing land fragmentation (Dixit et al., 2014). Although the agricultural practice has been reduced, the demand for food in urban and peri-urban areas of Kathmandu valley has increased. Because of increasing food demand agricultural production system has become more commercialized and intensified. Together with commercialization, many issues have emerged. For instance, overuse of pesticides, chemical fertilizer and other chemicals have directly affected to the food quality and created several threats to both human and environment (Pokhrel and Pant, 2008). It is also argued that the food has become unsafe due to pollution and unsafe use of river water which has been polluted and mixed with several harmful metals and chemicals (Rutkowski et al., 2007).

2.5 Waste and wastewater

In Kathmandu valley only 15 percent of the total people have access to managed sewerage facility, few people have built a septic tank and most of the domestic sewage is directly discharged into the rivers such as Bagmati River and its tributaries: Manohara, Hanumante, Godavari, Kodku, Dhobi Khola, Tukucha, Bisnumati, Balkhu, and Nakhu. (Rana et al., 2007). The industrial and agro-chemicals are mixed into the river water. The recent increment of industrial and commercial activities, as well as changing pattern of people's consumption, have caused a drastic rise in a municipal waste generation in the Kathmandu valley. In these ways, the natural bodies of water are being severely polluted that has affected the peri-urban farmers around the city.

Municipal waste comprises several organic and inorganic matters, which produced domestically, industrially and commercially. Many formal and informal efforts to manage urban waste and wastewater have been made and are continuously going on. Organizations such as Nepal Water Supply and Sanitation Cooperation (NWSC), Municipalities Department of Water supply and Sewerage (DWSS), local communities have been involving in managing the wastewater (Ibid:78). Practices of making compost in the household such as "Vermicomposting" have been promoted by different NGOs (Ibid:80). Nevertheless, due to weak governmental mechanisms and unstable political conditions, the wastewater management has not been effective and the problem of pollution remains unchanged.

2.6 Site 'A': Socio-economic-geographic overview

Fieldwork was conducted in two different sites of Kathmandu valley. One site is located in Madhyapur Thimi Municipality, which is drained by Manohara River (see in google earth image). This municipality consists of 17 wards and about 83,036 people are the total population (CBS, 2011). According to Aabadhik Nagar Parshochitra 2070 (Municipality profile-2013), the total area coverage of municipality is 1147.26 hectare. Most of the land is flat and fertile. Several vegetable farms are located in this area, mainly in Madhyapur Thimi (Manohara, Nagadesh, and Bode), Hanumanghat, Sipadol, Tathali, and Gundu. Vegetable cultivation is

Map 2:1 Google Earth image of Site 'A'

Until 2012, about 62 percent of the total land was covered by the agricultural land but since then different land integrations and town planning projects have been designed and implemented by both private and government sectors (Ibid:15). For instance, *Sintitar land*

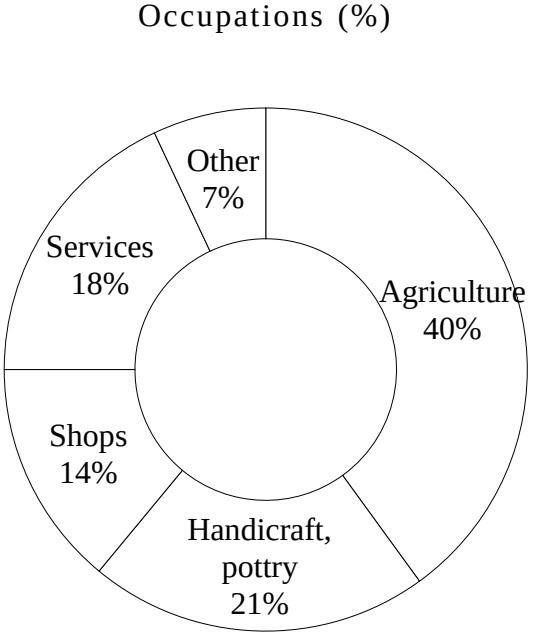


Figure 2.2 People employed by different sectors in Madhyapur Thimi

integration, Kamerotar Land integration, Manohara Phanta, Dibyswari Land integration projects have already started to work aiming to manage the unplanned expansion of urban settlement. However, the land use policies and its implementation has suffered from political and institutional failure. Several agricultural policies including a recent *Agricultural perspective plan (APP-1995-2015)* have been failed to conserve the fertile land and other agricultural issues (FAO, 2010). According to the municipal record of 2001, about 40 percent of the total employed population were engaged in agricultural activities. In addition, many employees involved in pottery, which is the traditional occupation. But these occupations have gradually been decreasing in this area primarily due to urban expansion (Thimi, 2013).

2.7 Site 'B': Socio-economic- geographic overview

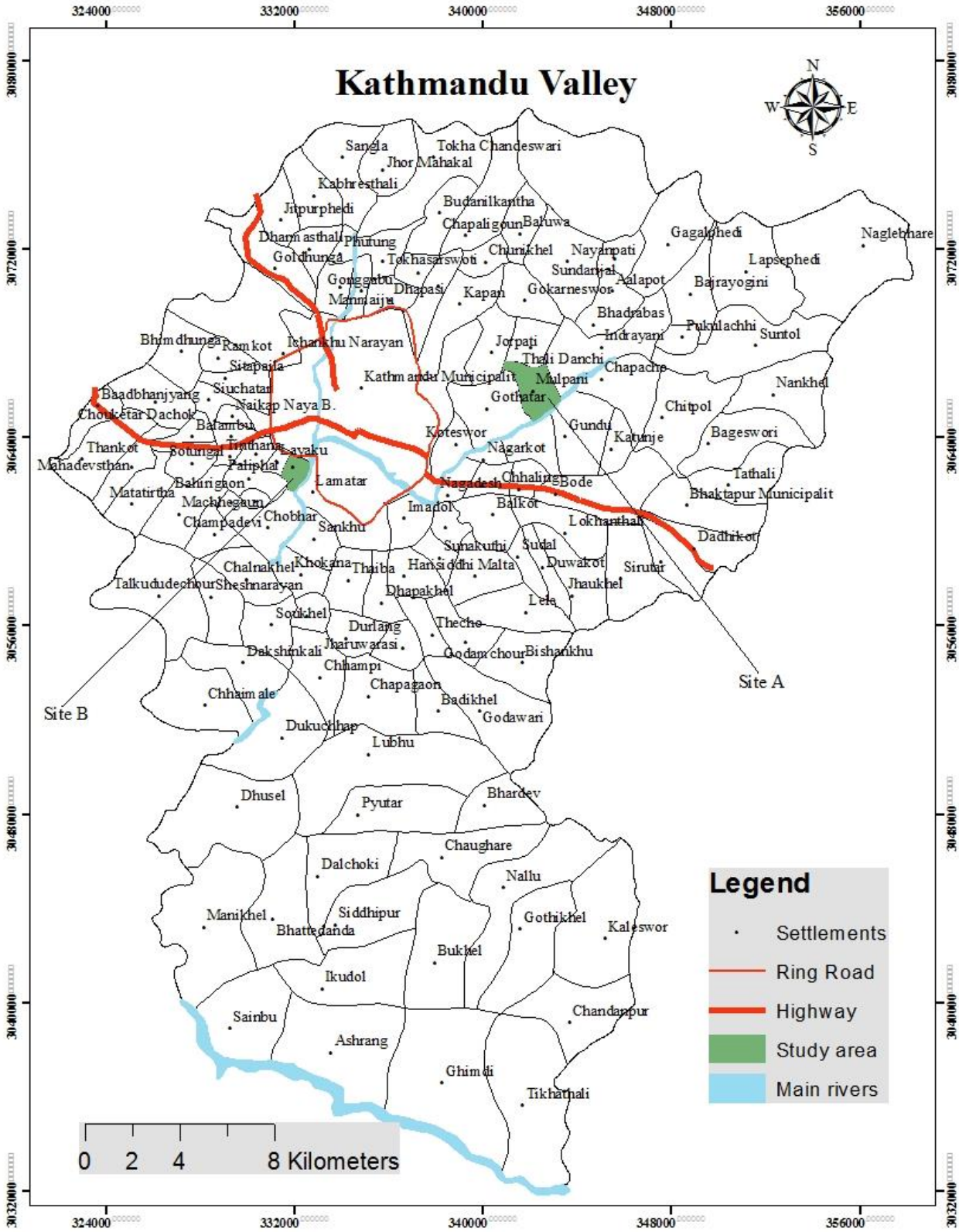
Another fieldwork site i.e. site 'B' is located in Kirtipur Municipality of the Kathmandu valley which is an old settlement situated at 27^0 38' to 27^0 42' N to 85^0 14' to 85^0 18' E in the southwest part of the valley (Shrestha et al., 2003). It is located about five kilometers away from the city center of Kathmandu bordering by Lalitpur Sub-metropolitan to the east,

Chandragiri municipality to the west, Kathmandu metropolitan to the north, and Dakshinkali municipality to the south. It is known as the city of glory[2]. Different caste people live in Kirtipur but the majority of them are *Newars*. It consists of 19 wards, and the total area coverage is 14.7 square kilometers with 65602 inhabitants (CBS, 2011). Historically Kirtipur municipality is an agricultural area. According to the recent record of municipality office (while fieldwork), about 6.6 square kilometers area is covered by agriculture land in which farmers are doing small-scale vegetable farming (see in map 2.2) and livestock which is mainly for commercial purpose. Farmers also cultivate paddy for household consumption. Recent years some farmers have started Kiwi farm in Khatrichap of Kirtipur which is close to this study site.

The agriculture sector is under pressure and productive land has been decreasing due to continuous urban expansion, land acquisition done by Tribhuvan University (T.U) and Kirtipur Horticulture Research Center. The land loss has also caused occupational change from agriculture to the non-agriculture sector of the local people (Manandhar and Shrestha, 1992).

Map 2:2 Google Earth image of Site 'B'

[2] http://kirtipurmun.gov.np/en/node/4



Map 2:3 The study area map

CHAPTER 3: THEORIES AND CONCEPTS

Geographic research is an effort of gaining a better understanding of the relationship between the human, place, and environment in which a researcher sensibly gather the information, put forward interpretation and reflects upon significant findings (Kitchin and Tate, 2000). The theory is an integral part of research that helps the researcher to provide a working framework which supports researcher to decide what to study, what to include, how to gather information and how to represent our research to other (Cresswell, 2013). This chapter comprises the multiple concepts and understandings of urban and/or peri-urban agriculture. It also presents the discourses of waste and wastewater use in urban and peri-urban agriculture.

3.1 The conceptual multiplicity of urban and/or peri-urban agriculture

Agricultural activities that are practiced in and within the urban area generally refers to urban and/or peri-urban agriculture. It has been diversely described in different academic contributions. One of the detail accounts can be found in Mougeot, 2000, Mougeot, 2006, Mougeot, 2010 . He has provided the multilayered concept of urban agriculture and he insists that agriculture as a significant strategy for livelihood. In elaborated form,

> *"...growing, processing and distribution of food and nonfood plant and tree crops and the raising of livestock, directly for the urban market, both within and on the fringe of an urban area. It does this through tapping on resources(unused or under-used space, organic waste), services (technical extension, financing, transportation) and products (agrochemicals, tools, vehicles) found in urban area and in turn, generate resources (green areas, microclimates, compost), services and products (dairy, poultry, flower) for urban area" (*Mougeot, 2010*)*

In his concepts, he reflects on external functionality in which understanding is relative to other concepts such as sustainable urban development, urban food supply system and advocates economic and environmental dimension of urban agriculture (Mougeot, 2000). He did not mention the locational factors of agricultural practices; however, concepts cover both geographical coverage of the urban and peri-urban area.

According to Game and Primus (2015), urban agriculture can be categorized into two spheres: Controlled Environment Agriculture (CEA) and Uncontrolled Environment

Agriculture (UEA). Producing food in an artificial environment where light, temperature, humidity and nutrition cycle etc. are controlled with the help of technology and infrastructures (e.g. greenhouses, vertical farming) is referred as CEA. Producing food in open spaces of city, gardens, and rooftop is called UEA.

Urban agriculture has also been understood as a broad spectrum of agricultural activities that can be performed within city building, yards, balconies, open space or in the form of gardens. Brown and Jameton (2000) mention "community gardens", "school gardens" and "entrepreneurial gardens" where green vegetables, herbs, flowers, and animals are raised for both consumption and selling. FAO (2001) has provided different concepts for urban and peri-urban agriculture. The "urban" agriculture is defined as growing crops and raising livestock within city areas such as vacant plots, gardens, verges, balconies, containers etc. The "Peri-urban" agriculture is defined as those farm units which are close to the city which is practiced as semi -/ fully commercial farms to grow vegetables, horticulture, poultry and other livestock to produce vegetables, milk, meat, eggs etc. for own-consumption and sale to the market. This thesis focuses on peri-urban agricultural activities.

3.2 The north-south divide in purpose and characteristics of urban and/or peri-urban agriculture

Concepts of urban agriculture vary throughout the world and with the social and environmental changes; it has been changing over the time. The conceptual variations of urban agriculture need to be taken into account while studying the issues of using waste and wastewater in it. Since this study is restricted in a small area of a developing country of Asia, the main interest here is about how urban agriculture is understood in Global South[3]. The widespread concept of urban agriculture found in Global South is not similar to the Global North. In the Global North (mainly in Europe), urban agriculture is advocated as a way of urban sustainability and

[3] The North–South divide is broadly considered a socio-economic and political divide. Generally, definitions of the Global North include the United States, Canada, Western Europe, and developed parts of Asia, as well as Australia and New Zealand, which are not actually located in the geographical North but share similar economic and cultural characteristics as other northern countries. The Global South is made up of Africa, Latin America, and developing Asia including the Middle East.
(https://en.wikipedia.org/wiki/North%E2%80%93South_divide)

economic resilience, though it embraces several challenges for urban planners (Morgan, 2015). It is also taken as an act to generate an environmentally friendly, resilient and productive city landscape (McClintock, 2010). In Global South, urban agriculture is mainly considered as a way of securing food, important sources employment, a way of utilizing urban waste etc. (Mougeot, 2006as cited in McClintock, 2010).

3.3 Concepts of waste and wastewater

Waste is any substance that is thrown away after primary use and wastewater is any water that is negatively impacted by human use[4]. In general, waste and wastewater are considered as useless and unwanted things. However, from the perspective of reuse, waste and wastewater are not necessarily recognized as useless.

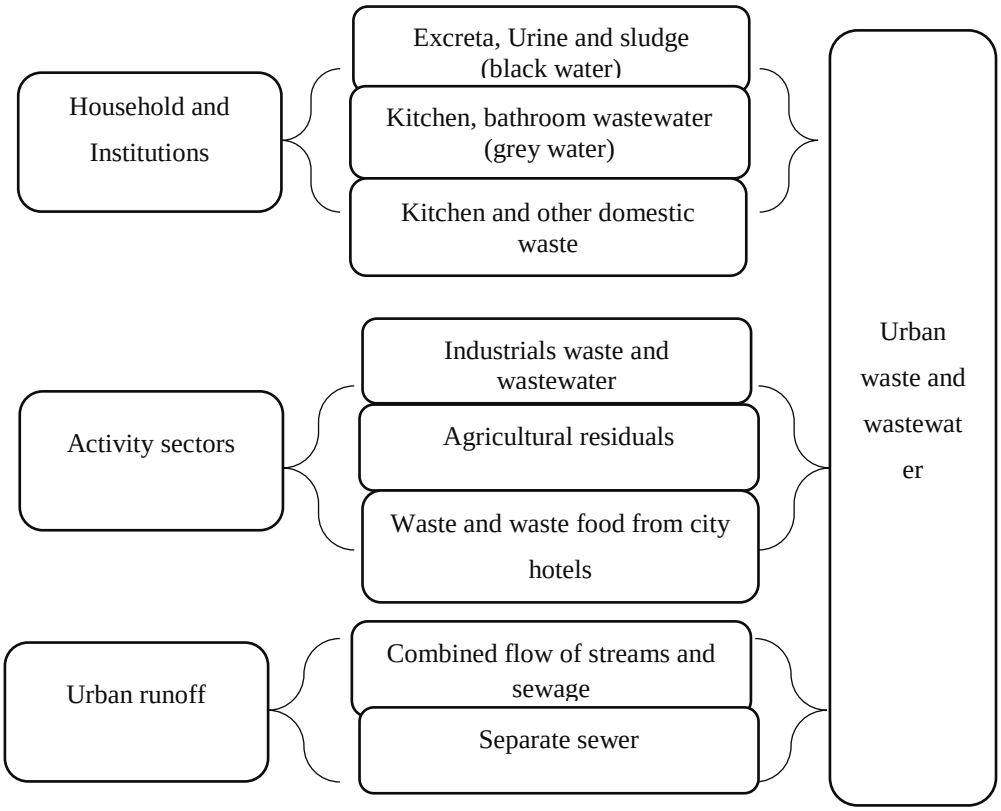


Figure 3.1 Types of waste and wastewater defined Van der Hoek (2004) and adjusted for the study

[4] https://en.wikipedia.org/wiki/Waste https://en.wikipedia.org/wiki/Wastewater

Concepts of waste and wastewater can be varied according to context of analysis, cultural and local understanding. The wastewater that is produced in the urban community is known as sewage. For, Mojid et al. (2010) wastewater refer to 'untreated sewage water. Based on sources of releasing, waste and wastewater also defined. In the way of presenting a framework to assess the urban wastewater, Van der Hoek (2004) has given conceptual definitions for different forms of wastewater.

He has distinguished household wastewater into two types: black and grey water. The "black water" refers to domestic effluents that may consist of urine and associated sludge and "the greywater" indicates kitchen as well as bathroom wastewater. However, the proportion of constituents can be varied in different place and time. The attention of this research is not only in wastewater but also the waste use in peri-urban agriculture. Thus, with the conceptual integration of these ideas, different types of waste are also included (see, fig 1.).

Figure 3.1 includes waste and wastewater produced from various small and large-scale manufacturing industries, agricultural residuals, waste food from nearby city hotels and restaurants. In addition to this, the urban-runoff "stormwater or other" is also mixed with the domestic and activity sectors of waste and wastewater. The combination of all or some of them is referred to urban waste and wastewater that have been using directly and indirectly in urban and peri-urban agriculture.

3.4 The cultural and local perspective of wastewater

Conceptual understanding from the cultural and local perspective of wastewater can be contrasted to scientific knowledge. Because of the cultural values, traditional practices and historical circumstances, the category of clean or dirty (wastewater) water can be ascribed differently in the local level that would not correspond with the reality. For instance, the distinction between physically pure and ritually pure water is one of the relevant examples in the context of Kathmandu valley. The water of Bagmati River of the valley (water near to Pashupati temple is believed as holy water) is considered as ritually pure water *(Sudhha Pani)* but in reality, it has been mixed with urban runoff, some sewage, and other pollutants. Similarly, in the area of Bhakatapur (where study site 'A' is located) quality of water is defined on the basis of how the clear water looks (see.Shaw, 2003:66). If the water looks transparent or with no visible particles, will be understood as clean water. The possibility of containing harmful bacteria and chemical on the local category of clean water is unknown. The perception of farmers towards wastewater, therefore, can be shaped by and embedded

with the local categories. It is important to reflect upon and get inside those categories to reach closer to the reality.

3.5 Typology of waste and wastewater use in peri-urban agriculture

The methods of waste and wastewater utilization in agricultural activities is a major concern as it linked with human and environmental influences. How different types of waste and wastewater are being used in urban and peri-urban agriculture can be associated and relied on plans and policies of a particular country as well as available technology. Therefore, dissimilarities in waste and wastewater use exist all over the world.

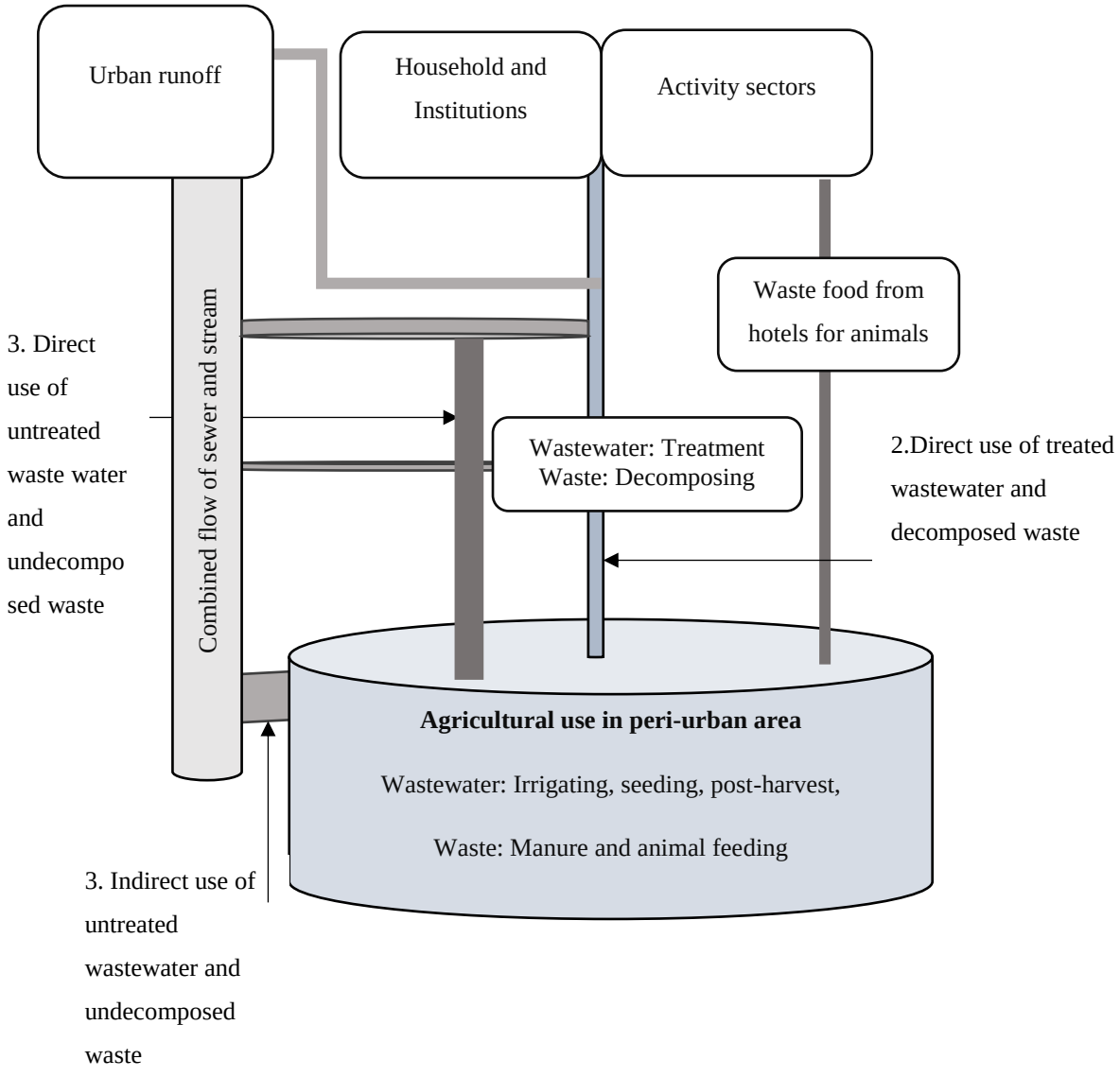


Figure 3.2 Pattern of waste and wastewater use in peri-urban agriculture based on Van der hoek et.al 2003

According to the Van der Hoek et al. (2002), the wastewater is used in three different ways; direct, untreated direct and treated direct, which are most relevant to study the pattern of waste and wastewater use.

i. *Direct use of untreated wastewater and undecomposed waste: directly from the sewerage system*
ii. *Direct use of treated wastewater: reclaimed water*
iii. *Indirect use of wastewater: combined with natural bodies of water*

The conceptual illustration (see. figure 2) shows that the possible ways of waste and wastewater use are borrowed from Van der Hoek et al. (2002) and modified for this study. The direct use of untreated wastewater and undecomposed waste is the use of raw wastewater and waste directly from the sewage outlet or directly placed on the crops (Jiménez et al., 2010). Indirect use of untreated wastewater and undecomposed waste refers to polluted stream water and waste mixed with stream water. In most of the developing countries, urban waste and wastewater are discharged without any treatment to the nearby river. Farmer located nearby that river use to irrigate their land. Van der Hoek et al. (2002) calls this "marginal quality water" as it believed to contain many unknown harmful substances. Another type of use; i.e. direct use of treated wastewater and decomposed waste tends to reflect on the situation of developed countries where the well-functioning treatment facilities exist. The "reclaimed water" has been termed for this type of use. With these supporting ideas, this research attempts to pursue empirically the patterns of waste and wastewater utilization in peri-urban farming activities.

3.6 The discourses on waste and wastewater use

According to Berge (2009), discourses are sets of ideas about a phenomenon. Sometimes contradictory discourses can be in circulation at any time. The global phenomenon of waste and wastewater use to fertilize the crops and feed the animals has been viewed from multiple viewpoints. On the one side, there are ideas, which focus on negative aspects of waste and wastewater use and some of the other ideas articulate the positivity of it. However, there is also a third set of ideas, which raised the issues of safe and harmless use of waste and wastewater use in agricultural activities. Here, I present those ideas and thoughts that will provide the analytical direction for the thesis.

3.6.1 The closed-loop discourses

The closed-loop discourse on waste and wastewater use, in this case, indicates those ideas or thoughts, which are articulated from the positive point of view. While theorizing the urban agriculture McClintock (2010) has used the Karl Marx's theory of metabolic rift. According to the theory, rapid urbanization and industrialization as a consequence of capitalism has separated humans from the natural environment and disrupted the 'traditional social metabolism'. As a result, a metabolic rift has been formed. That means the relationship between production and consumption is geographically separated. In this situation, it is argued that urban agriculture can even help to mend the metabolic rift and redress the social and ecological alienation by re-establishing the metabolic relationship between human and biophysical environment (McClintock, 2010, Sage and Dehaene, 2016). It is suggested that recycling the organic waste (human, animal and crop residues) through urban agriculture, the increasing dependency on petroleum-based food production can be reduced as a way to mitigate the metabolic rift (Ibid:p.194).

Smit and Nasr (1992) presented an influential idea of "closed loop system" in which they advocated waste as an efficient resource that can be utilized in agriculture as a way of recycling. This core view is that "agriculture in towns, cities, and metropolitan areas can convert urban waste into resources to grow agricultural products"(Ibid). This concept is closely associated with the sustainable urban environment and waste management. The speedy context of urbanization is predicted to reach the 66 percent urban inhabitants by 2050 if the current trend continues (UN, 2014). In this situation, attention has already given to the urban planning and development in which urban agriculture is seen as a vital way. The Brundtland Commission (1987) commission has postulated different dimensions of urban agriculture that helps to trap and utilize the urban unused and poorly used resources such as compostable waste, marginal land of the city, household waste and wastewater. Moreover, increase in food and oil price during the period of 2007/8 and a serious economic crisis have significantly raised the interest in urban agriculture throughout the world (McClintock, 2010).

Empirically and conceptually, the efficient role of waste and wastewater has been documented. For instance, Van der Hoek et al. (2002) deals direct and indirect benefits of using wastewater in peri-urban agriculture. Direct benefits as they listed are; conservation of fresh water, reduction of costs of fertilizer through recycling of nutrients of wastewater. The

wastewater is also considered as a reliable source of irrigation throughout the year whereas indirect benefits are, preventing pollution of urban waterbodies through agricultural use.

The wastewater generated from domestic processes or residential area possibly contain several plant nutrients. While dealing positive tradeoff of wastewater use, Qadir and Scott (2010) have listed possible positive implications. The soil nutrients such as Nitrogen (N), Phosphorous (P) and potassium (K) which are found in wastewater have an important role in crop growth and crop maturity. Therefore, the use of wastewater in agriculture reduces the need for these all nutrients. The soil organic matters can be added and the soil structure would be improved that resulted the gradual increment in soil nutrients for better crop yield. However, there would be time-place variation in nutrient supply capacity of wastewater (Ibid:106).

The positive impact of waste and wastewater use can be seen in the people's livelihood and urban food support system. The viability of waste and wastewater is believed as a driver of wastewater use in urban and peri-urban agriculture because of increasing scarcity of sources of water (Raschid-Sally and Jayakody, 2009). As it is economically viable to those who have low investment capacity in urban and peri-urban agriculture, can generate numbers of employment and efficient returns from this practice. Particularly, during the dry season people who don't have other access to irrigation may be unemployed. That may lead them to the food insecure condition. In this situation, they can adopt this alternative where they get the economically viable option. According to (Hoornweg and Munro-Faure, 2008), it can contribute to the food security and livelihood in different ways; for instance, urban agriculture provides the sources of income raises the family consumption capacity and it strengthens the economic base through the multiple chains of agricultural activities.

Food waste can be generated from different ways such as food production, processing, harvesting, distribution, and consumption. These food waste have been considered as possible alternative components of livestock input (Westendorf, 2000). Limited land availability, as well as the scarcity of fodder grass, always create obstacles to the livestock keeping in the urban and peri-urban area. In such situation, the common food waste such as vegetable or fruit waste from vegetable markets and farms, food waste from the food processor, bakery waste, food waste from restaurant and hotels may contain nutrients which can be used to feed urban livestock (Allison et al., 1998).

3.6.2 Public health (risk) discourse

Health implication to both human and environment from waste and wastewater use in urban and peri-urban agriculture has become a great matter of attention to the researchers and health organizations. In this case, the ideas, which are expressed from the perspective of risk regarding the use of waste and wastewater, are presented as risk discourse. Primarily, the guidelines for the safe use of wastewater, excreta, and greywater of WHO (2006a), raises various health implications and possible ways to mitigate. Particularly people in developing countries may not be aware of the proper sanitation and hygiene are in more vulnerable condition from the waste and wastewater induced diseases. Workers, local inhabitants, and consumer are at high risk of intestinal worms, excreta-related pathogens, diarrhea and other infectious diseases, for instance, typhoid and cholera from using excreta, waste and wastewater (Ibid:10).

Risks can be varied by type of waste and wastewater used as well as types of agricultural activities. For example, waste-fed aquaculture may pose skin infections to the farmers and to the consumers, pathogens can be transformed indirectly through the contaminated fishes. Similarly, the cross-contamination of urine and faeces causes health problem from the parasites. Greywater (bathroom, laundry, and kitchens) could have less health impact but the mix of other waste can generate pathogens (Ibid:11). Practices of livestock keeping in and around city area can be the cause of 'zoonotic diseases' i.e diseases that can be transmitted from livestock and poultry to the human beings (Mougeot, 2006). Such diseases can be spread more in the densely populated area.

The degree of health risk from waste and wastewater use in urban and peri-urban depend on how planned and safe techniques are adopted by the farmers as well as how consumers consume the food. People in developing countries have been suffering from poverty, malnutrition, and lack of education. They always face scarcity of basic needs. This forces them to use low costs input in farming activities. Moreover, people who use waste and wastewater are poorly informed about the health and environmental risk (Hussain et al., 2002) and mainly people those are out of easy access of fresh water, use wastewater for irrigation. According to (FAO, 2012b) wastewater, may contains salts, pathogens, heavy metals and pesticides that harm directly and indirectly to the public health and environment in various ways. Table 3.1 contains types of risks in human health, how they can be affected and who are more at risk.

Table 3.1 Major human health risks from irrigating vegetables with wastewater

Kind of risk	*Health risk*	*Who is at risk*	*How*
Occupational risks	• Parasitic worms such as *ascaris* and hookworm • *Diarrhoeal* diseases • Skin infections causing itching and blisters on the hand and feed • Nail problems such as *koilonychians*	• Farmers/ field workers	• Contact with irrigation water and contaminated soil
		• Children playing on the farm	• Contact with irrigation water and contaminated soil
		• Market vendors	• Exposed to contaminated soils while harvesting • Washing vegetables in wastewater
Consumption related risk	• Mainly bacterial and viral infection such as cholera, typhoid, hepatitis A • Parasitic worms	• Vegetable consumers	• Eating contaminated vegetable, especially those eaten raw
		• Children playing on the farm	• Licking soil

Source : FAO, 2012b

There would be a kind of link between the effect to the environment and human health from waste wastewater irrigation. For example, polluted (industrial) wastewater possibly contains different metals and other toxins directly harm the soil and causes to change soil structure (Qadir et al., 2007). Continuous accumulation of harmful metals and toxic substance in soil could raise the toxicity in crops and can have negative impacts. Eventually, it can affect whole food production and consumption chain from field to table (Ibid:11). An empirical study of Kayastha (2015) found an evidence of high concentration of heavy metals (Zinc, copper, lead, cadmium, arsenic, and mercury) in soil and vegetable crops of Bhaktapur district of Kathmandu valley. A potential reason they have mentioned is the use of polluted

water for irrigation. In this case, WHO, FAO and UNEP have promoted the safe wastewater irrigation methods and approach that is called “Multi-barrier approach” aiming to reduce health risks to the farmers and consumer.

3.7 Multi-barrier approach

Risk reduction and preventive measures of different health problems caused by waste and wastewater use in agricultural activities is a crucial issue. This is associated with the issue of food safety and safe use of waste and wastewater. Unsafe utilization of wastewater and waste causes microbial infections and different health problems to the people, as a result, many people die every year in developing countries (WHO, 2006a). WHO, FAO and various academic researchers have actively engaged to provide efficient guidelines to use wastewater in agricultural activities in the urban and peri-urban area (Ilic et al., 2010). The “multi-barrier approach” is a useful approach to deal the wastewater induced health risks and problems developed by WHO, FAO and UNEP (see, fig.3) integrating WHOs guidelines for safe wastewater irrigation (FAO, 2012b).

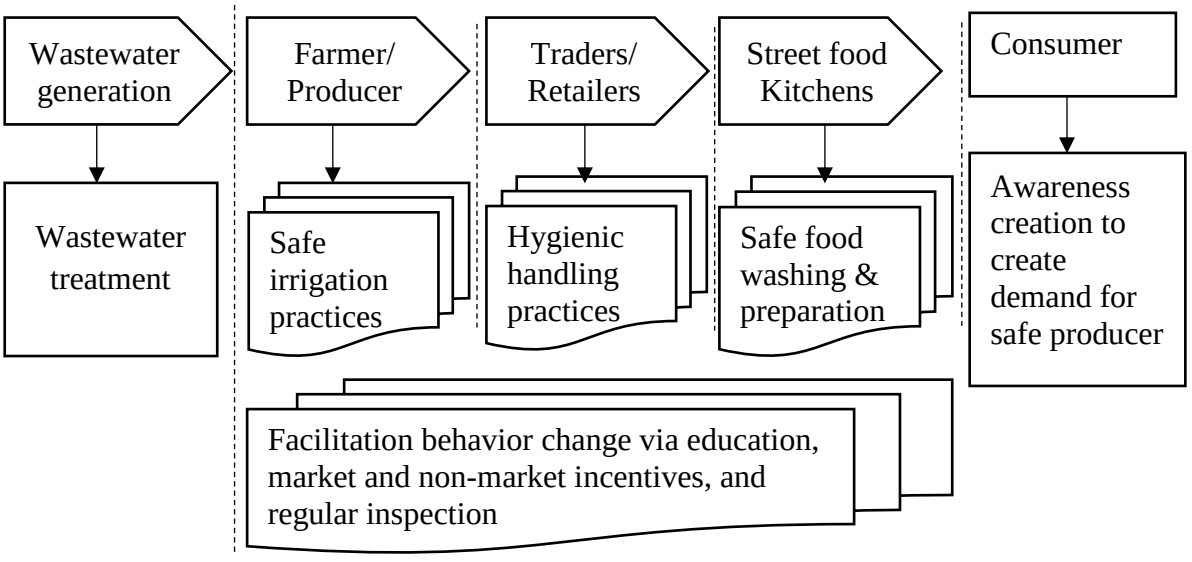


Figure 3.3 Multi-barrier approach to reduce health risks to farmers and consumers

Source:(WHO, 2006 cited in FAO, 2012b)

Conceptually multi-barrier approach catches the preventive way of risk reduction and considers that ‘food should be safe at the point of production and consumption’ (Ilic et al., 2010). The preventive way, in this case, indicates the risk prevention is targeted at numbers

of risk gateway before entering the stage of consumption (FAO, 2012b). This approach comprises ideas of hazard analysis and critical point (HACCP) approach. HACCP approach is widely recognized and used in the context of food safety risk reduction. According to Mortimore and Wallace, 2013 'HACCP identify the occurrence points of risk and hazard to prevent them. In a similar way, multi-barrier approach concern to all steps of the food chain such as food production, utilization, and consumption.

The facts and predictions produced through quantitative risk assessment and statistical measurement sometimes create more ambiguities and uncertainties. To neutralize those uncertainties, preventive approaches significantly works (Wynne, 1992). The multi-barrier approach is different from conventional risk assessment and wastewater treatment because it does not consider treatment as an ultimate solution but it also includes safety measures from farm-based via post-harvest and to consumption. This method seems more situation based in which "barriers are placed at critical control points along the food chain to reduce risks" (Keraita et al., 2010).

3.8 Analytical basis for the thesis

Academic and non-academic researchers, policymakers, have differently conceptualized the practice of waste and wastewater in urban and peri-urban agriculture. Since my focus is to explore the farmers' (who are the main actor in this practice) perspective and practice, it is important to listen and understand the farmers' storylines, their ideas, and expressions. Farmers' storylines and responses are the main analytical basis of this thesis, however, information collected from direct observation and secondary evidences will be considered. The conceptual and theoretical definitions presented above can represent the informants' responses and field evidences. Moreover, it is also important to consider pre-existed conceptual ideas and beliefs while investigating the farmers' perception. This is because sometimes researchers own perceptions could influence the analysis and outcomes of the research. It is also vital to make the reflection into those pre-existing ideas and beliefs that deal both positive and negative aspects of waste and wastewater use. For the reason that, waste and wastewater user farmers in the real field are likely to hold similar or contrasting perspective.

CHAPTER 4: METHODOLOGY

The choices we make about relevant ways of data gathering and forms of data analysis in research is referred as a methodology (Silverman, 2006). Careful selection of methodology helps the researcher to uncover the hidden truth about the given research problem. This chapter includes the detailed outline of research methods, techniques, and approaches to studying the issue of using waste and wastewater in urban agriculture. Presenting the reason for the selection of the particular research methods, it embraces the uses of different research technique to answering the research questions. This chapter also explains about the preliminary preparation before entering the field and discusses about my position during the fieldwork. At the end of the chapter, I will discuss an importance of the ethical issues, in which researcher has to be aware to maintain reliability and validity in the research.

4.1 Mixed method and triangulation as a methodological approach

Qualitative and quantitative researchs are considered as two major domains of research in geography. The quantitative method involves the explanation of phenomena through the collection and analysis of numerical data using mathematically based methods. The quantitative method is widely used by the natural scientists. It is about measuring and analyzing the relationships between and among the variables. Its paradigm is based on positivism or realism (Clifford et al., 2016). Positivists argue that there is only one truth or an objective reality that exists independent of human perception. It involves testing a theory or hypothesis using methods such as experimenting in laboratories and survey research. It usually involves large sample sizes. The qualitative methodology uses methods such as in-depth interviews, group interviews, and participant observation. This method helps us to increases the deep understanding of the cases. Qualitative studies generally use smaller sample sizes which can provide important information that might not be provided when dealing with a larger one (Bryman, 2012). It is said that these two methodologies do not oppose each other but they focus differently towards the same aspects of the phenomena of the world. The impression of using more than one technique for gathering, analyzing and representing of human or environmental phenomena will lead to improved understanding of the phenomena investigated (Greene, 2006).

The use of compound methods has been called as ‘methodological triangulation’ which is often advocated as a way of doing valid research (Jick, 1979). It is argued that the

convergence or agreement between two or more methods raises beliefs towards the research output (Bouchard, 1978: 302 cited in Ibid). In this study, data were produced using both qualitative and quantitative methods such as semi-structured questionnaire, observation, in-depth interview, participant observation and some informal discussion. The main aim of using multiple methods is to reach the depth of the reality. The issue of using waste and wastewater in agriculture is associated with the matter of social acceptance. The products that are known to be produced using waste and wastewater might be avoided in the market. Thus, there will be chances of getting pretended or no information from waste and wastewater user farmers. In such conditions, methodological triangulation provides the opportunities of crosschecking the information and getting actual information in the field. For instance, in the study site of Kirtipur, farmers did not provide any information about the use of human excreta to fertilize the crops but the field observation revealed some evidence.

4.2 Entering the field: some issues of informant consent

My fieldwork was started on 11th of May 2016 in site 'A'. Early morning of that day, I reached to the field with my field diary and camera. I saw that some people were washing carrots and leafy vegetable on the river water. I moved towards them and started a conversation asking about their actions but some of them hesitated to talk with me. It is because they thought me as a "news reporter" and were scared of being published in a newspaper. This time I failed to build a consent with the all informants in this site.

I realized that I should build a rapport with informants and make them convinced first. I started an informal conversation and I kindly requested for the help informing them about my actual purpose of visit. I explained in detail about the academic use of information that I have collected. I also informed them that my research report could not harm them and their everyday life. After few days of rapport building with informants, I went to the field with questionnaires but this time rainfall became my barrier because most of the farmer stayed at home during the rain. The farming system in this area is largely dominated by vegetable crops. Except few paddy cultivator farmers, nobody was in the field during the rainfall. While making some network with local people I kept some of the farmers' contact address. Now I started to call them first and then go to the field but it was difficult to find the actual house of each farmer in the city area. Some of them live in rented house. I could not meet informants regularly; however, I continued my field visit. Sometimes I met farmers in small

huts, which are built in the field to be saved from the rain and sun. They also prepared their vegetables for sale living at that hut.

After three weeks of fieldwork in site A, I started fieldwork in site B. This site was quite familiar to me, as I studied in the university located in this area. However, I have never been to the exact farm site. In this site, I also faced some challenges of informant consent. Since the farm is close to the Tribhuvan University, farmers had been interviewed or surveyed very often. Many graduate students from the University of Kirtipur used to go for their practical as well as academic reports. Farmers seemed more concerned with students and some of them responded me as:

> *"Lots of students come and go here but we don't get anything. So far, I gave information to more than a half of dozen students. It's just a waste of time"- a tomato farmer in Kirtipur*

Aiming to get familiar with informants as well as the issues, I participated with farmers work so that I could get more time to talk with them and they would be happy for my help in their work. The farmers in this site cultivate tomatoes in plastic tunnels which are similar to a greenhouse. The monsoon did not disturb more to my work in this site.

4.3 My status and role in the field

The status of a person is defined according to the position he or she occupies in a particular society or social setting. Status as the position an individual occupies in relation to the total society in which he or she lives. In addition, the role defines the way status is performed. A particular position of a person is connected to his rights and duties (Linton, 1936: 113). Generally, we confirm a particular status by acting according to our role expectations. This is because, without a certain degree of consensus about role expectations, our actions become unpredictable for others (Carling et al., 2014). Statuses are therefore contingent upon how the researcher and informants draw on their mental pools of social categories to establish the differences or similarities they hold in common (Ibid).

According to Mullings (1999), both the statuses as an insider and as an outsider have some advantages and disadvantages. As an insider, a researcher can study about his/her belonging group in which they get opportunities to use their own knowledge and understanding about the issues in their research. Outsider researchers are likely to have a greater objectivity and

observe meaning without personal influences since they are not the part of the studying group. She also decisively argues that the binary concept of insider/outsider is anticipated to hide the multiple positions and positional dynamism of researchers during actual fieldwork process (Ibid:340)

During my fieldwork, I occupied statues such as a Nepali young woman, a student researcher, and a farmer's friend. My statuses changed over time and in relation to different informants. Throughout the fieldwork, I was both the insider and outsider status depending on the place. As an insider, I was familiar with their official language (Nepali) but I did not understand Newari language. I was an outsider to them because I do not have experiences of agricultural work. It is said that being an outsider might have an advantage of getting a greater degree of objectivity (Fonow and Cook 1991 in Mullings, 1999)

As I explained above, I could not manage informants' impression in the beginning. When I opened up the conversation about the use of wastewater to wash vegetables, they tried to avoid answering it. The reason could be that the practice of using waste and wastewater is sensitive as it is associated with the issues of social acceptance. For instances, if consumers know about the practice, they might avoid buying vegetables in the market. At this point, the biggest challenge was to be familiar and acquire reliable answers from the informants. Firstly, I clearly explained them about my status (student researcher) and informed that the confidentiality of information as well as personal data will be maintained in a research report. Secondly, to be familiar I actively engaged in farm activities with the farmers. In this case, I was able to establish new status as a farmers' friend. Being a farmers' coworker, I get the opportunity to participate as well as experience the peri-urban farming activities. Progressively I ended up my fieldwork with important information.

4.4 Sampling Methods

In general, sampling is a process of collecting information about a part of whole or larger group. The process involves making generalizations from that part to the whole or group (Rice, 2010). Sampling involves acquiring information about a relatively smaller segment of a group under study (Clifford et al., 2010:230) in order to make useful conclusions about the larger group or population. According to Bryman (2012:187), a sample is a segment of the population that is selected for investigation. It is a necessary part of research because it provides guidelines for gathering information. There has been a debate for a long time about

the use of sampling between qualitative and quantitative researcher. The quantitative researchers often disagree with the qualitative sampling procedures. Gobo (2004) argues that only survey and poll researchers use these samples because they use probability sampling and its generalization. Qualitative researchers disagree with quantitative researcher because they argue that, sampling done by quantitative research do not have transferability of the findings. However, one of the mid-way has been made that claims about the qualitative sampling having more transferability.

In the data production process, sampling is necessary to address time, manpower and resource constraints. Therefore, considering these elements I have chosen the snowball sampling for this study. This allowed me to contact people easily in the peri-urban area. According to Shutt, 1996: 164 , snowball sampling is the process of identifying informants in which researcher find out one or few respondents of the study area first and communicate with them, then request them to indicate relevant others informants. This sampling process is also known as respondent-driven sampling (Heckathorn, 1997). In this way, I have chosen the informants for semi-structured questionnaire survey as well as for interviews. In the beginning, I have taken information from informant those were working on the farm and they introduced me to other farmers.

4.5 Methods

4.5.1 Questionnaire survey

The initial method used in the field was questionnaire survey that includes some closed and open-ended questions i.e. semi-structured questions. I have done 50 semi-structured questionnaires survey with respondents from two different sites (25 in each site). The aim of the semi-structured questionnaires survey was to get an understanding of the general characteristics and socio-economic data of the peri-urban farmers engaging in different farming activities. This tool was also used to gather information regarding current peri-urban farming practices, its major components such as land, labor, market, irrigation, types of production and recent changes. The information collected by this method were more quantitative which are presented in tables and diagrams.

Picture 4.1 Questionnaire survey with an informant (left) in Manohara, (right) in Kirtipur

4.5.2 **Interviews**

During my field study, I was involved in face-to-face communication with informants, talking with them in informal and formal conversations. That helped me to get familiar with many issues. According to Briggs, 1986 interview is a method of collecting data which occur in a face-to-face situation. In another way, Kitchin and Tate (2013) define interview allows a researcher to examine informants experiences, feelings or opinions which could be a rich source of information. The interview can broadly be based on two types of questions; one is open-ended and another is closed-ended.

For my research, I used open-ended questions with informant as one of the main data collection tools. Along with I also used voice recorder and field note to record interviews. During the conversation, I listen, to them carefully. Because interview helps me to understand the issue from the subjects' point of view and help to uncover the meaning of their experiences of the local people. It is an excellent way to get the real picture of the problem from the respondents. It also provides an easy situation for respondents to convey their problems. Most of my interviews were soft, informal, and conversational. Therefore, it helped participants to use their own words in the response and open interactions between the involved parts are prominent (Nicholas et al. 2010). During the interview, I introduced topics and objectives to the informants before agreeing to participate. I have conducted a total of fifteen interviews in each site with the farmers and livestock keepers. During interview majority of them want to speak in Nepali, except some of the old Newari farmer in Bhaktapur (Manohara). During the interview, many of the informants had a busy schedule, sometimes they left in the middle of an interview in such situation, and I requested them for their next free time to complete the interview.

Interviews help to fill the gaps in knowledge that other methods are unable to connect in the same extent, study motivations and behavior, collect a diversity of meaning, opinion, and experience (Dunn, 2010, p. 102). In my study, some farmers use agricultural waste in their farm and use wastewater for irrigation. Livestock keepers used urban food waste to feed the animals. Therefore, my different methods helped me to receive their unique opinion and experiences. By using this method, I also got a chance to understand how they perceived using waste and wastewater and what opportunity as well challenges they gain by using it. Since most of the farmers and livestock keeper have different opinions, it was good for me to use this method.

Picture 4.2 Interview with informants in Kirtipur

4.5.3 Observation

The research method observation is best to capture emotional experiences and non-human interactions in the field (Watson and Till, 2010). It involves our different senses such as touching, smelling and hearing the environment and making implicit or explicit comparisons with previous experience (Rodaway, 1994, in Kearns, 2010). Field observation has given me a worthy chance to obtain additional information that I could not get from other methods. By spending time in the field area, I was able to observe the daily activity of the farmers like irrigation, livestock keeping, washing vegetable in the river, slaughtering of animals in farms etc. These observations made it possible to look at the information that I had obtained from other methods.

I frequently visited the field aiming to get something new. Sometime, I walked around with my field diary just observing the phenomenon. For instance, I watched vegetable washing in polluted river water where some of the farmers and brokers usually come in the morning and

evening to wash their vegetables before taking to the market. Observation helped me to understand the ways of using waste and wastewater in farming practices. According to Silverman (2006) observation provide researcher to observe a real picture of society but it is important to recognize the local categories of a particular observation. In Kathmandu valley, there are traditional beliefs in which people perceived some sources of water as pure and clean. For, instance the water coming from (*dhunge dhara)* a water sprouting from a rock is believed to be naturally clean. Similarly, water is seen clean as it looks or the local categories of clean water is without any visible particle on it (Shaw, 2003).

Picture 4.3 Observation of the field area (left) Kirtipur and (right) Manohara

4.5.4 **Participant Observation**

Participant observation involves the researcher's involvement in a variety of activities over an extended period that enables him/her to observe the people in their daily lives and to participate with them in their daily activities to facilitate them a better understanding of these behaviors and activities. It helps to understand the phenomena in a natural setting through observing and participating in those activities. Observation enables the researcher to see events occurring in their natural environment and participant observation as involving the engagement of the observer (researcher), in the social setting they want to observe (Bryman, 2008:256). Participant observation helped me to get firsthand information. This method enabled me to talk with them in the natural setting while doing their daily activities, like binding leaf vegetable for them, help to carry their load, to pluck grass etc. This method helped me to enhance my contextual understanding of the real situation of farmers growing vegetables and livestock keeping in urban and peri-urban areas.

Picture 4.4 Participant observation in the study area (Manohara)

4.6 Ethical Issues in Research

Ethical behavior in geographical research indicates acting in accordance with notions of right and wrong (Mitchell & Draper, 1982, in Hay, 2010: 35). Research ethics is concern about to what extent our research process addresses the social justice and be sincere to the informants. According to Silverman, 2006:271 , researchers have to obtain the informed consent of informants before carrying the research. Ethical issues arise at various stages of the research and we have to give attention to these ethical issues. Particularly, ethical consideration lies in interpersonal relationships, communication, interpretations, experiences of people, analyzing, even while writing the issue. Research processes possibly involve invading informant's privacy; thus, it must be conducted within the ethical boundary. Research ethics entails providing relevant information to enable informants to decide whether to participate in the research. Ryen (2011) also noted that it ensures the confidentiality of the informants. Therefore, informants must also understand what their information would be used for and their participation should be voluntary. According to Bryman (2012), informed-consent is an important ethical consideration that means prospective research participants should be given as much information as might be needed to make an informed decision about whether or not they wish to participate in the study.

In my case, maintaining ethical issues is also crucial. Therefore, I have attempted to maintain ethical concerns in the field as well as during presenting the data in the report. Most

essentially the informed consent with the informant was maintained before of questionnaire surveys and in-depth interviews. I have only use the recording device with the full agreement of informants. I have taken notes in a conversation with informants who felt uneasy or refused the recording device. The photographs (for instance, washing vegetables in polluted water) presented in this study were taken with the permission of the informants. Informants who rejected to be exposed thought that their regular business might be down. Concerning to maintain the privacy of personal information, informants' names, age, sex etc. have not been exposed in the report. Instead, I have given the serial numbers for all informants, for instance from one to fifteen and while presenting individual comments on the report I have cited only informant's serial numbers and the farm site (e.g. Informant 1, site A).

Establishing research ethics is associated with ensuring informants rights and freedoms (Hay, 2010: 35). Thus, as a researcher, my responsibility was to avoid or minimize any kind of harms to the informants. During fieldwork, I was concerned about informant's time that I took for interviews and questionnaire survey.

4.7 Reliability and Validity

Research is a systematic process of knowledge production. Qualitative research in social science always aims to produce knowledge that can reliably and validly describe the reality. What counts as reliable and valid processes of research is crucial because the knowledge, which produced through the certain research process, is associated with the public and academic concern. Reliability and validity are ways to explain and measure the rigor of particular research so that knowledge can be publicly and academically accepted (Bloor and Wood, 2006). These concepts were originated in quantitative research but have been brought into the qualitative research paradigm (Long and Johnson, 2000).

According to Kirk and Miller (1986) validity' indicates " to what extent research gives correct answer " or it is about the accuracy of the findings to be matched with reality. Validity in qualitative research can be defined as establishing truthfulness and authenticity of research. Kapborg and Berterö (2002) discussed validity in two ways; internal validity and external validity. In qualitative research, establishing internal validity is significant, in which it can be achieved through the constant lines and quotation of informant's responses. In this research, the internal validity is established through the direct quotation of what responded said during the field. Whereas, external validity defined as the transferability of finding to another situation.

‘Reliability’ refers “extent to which a measurement procedure yields the same answer however and whenever it is carried out” that indicates the methodological consistency in particular research (Kirk and Miller, 1986). It means, whether those methodologies and processes of measurement used in fieldwork and data analysis produces the similar result or not if they are used in other place and time. This is about the dependency of consistency of research result on “measuring instruments” (Long and Johnson, 2000). Reliability in this sense holds the position what Guba, 1985 see.in Kapborg and Berterö (2002) said about transferability. The knowledge which produced in one setting can be transferred to the other is known as “transferability”.

As research process possibly guided by different theoretical approaches, the explanations of reliable and valid knowledge can be varied. However, the establishment of reliability and validity crucial part of all research. One of the widely recognized ways of establishing validity and reliability through the idea of ‘triangulation’ (Flick, 1992, Mays and Pope, 1995, Jick, 1979). The concept of “triangulation” notify that the complementary conception of both qualitative and quantitative or mix of both methods possibly generate validation in research (Jick, 1979). In triangulation data can be collected from a wide range of different, independent sources through different methodological tools; that a good way of ‘safeguarding validity’ (Mays and Pope, 1995).

This research has many concerns about reliability and validity since the issues of using waste and wastewater in agriculture is directly related to the informant’s legality and the exposer of information can affect their markets. Facing some ethical issues and considering the view of triangulation, I have employed different tools and techniques for data collection and I have collected data from various sources. For example, the semi-structured questionnaires used for collecting information about the nature of pattern of waste and wastewater use in agriculture activities. That has been cross-validated through the participant observation and observation. An in-depth interview with informants has provided the ‘thick description’ about the issues, which clarifies the conceptual interpretation of informants about the waste and wastewater.

4.8 Data analysis

So far, I have outlined the fieldwork methods, fieldwork challenges, and ethical issues. After collecting data from the field, one of the important parts of a research is to analyze and present it in a research report. Since the fieldwork methods used in this research belong to both qualitative and quantitative research which is known as mixed research (Johnson and Onwuegbuzie, 2004), the nature of data collected is also mixed. According to Onwuegbuzie and Combs (2011), the analysis in mixed research is the use of both qualitative and quantitative analytical techniques within the same research framework which is based on the analytical decision that occurs prior to or during the study. The main purpose of the mixed method is to establish methodological triangulation and complementarity (Creswell and Clark, 2007). In this research, data regarding the peri-urban farming system and socio-demographic characteristics of the farmer are mainly collected from questionnaire survey which is presented in a numerical form in tables and diagrams. I have done data tabulation and drawn frequencies using statistical tools such as Excel and SPSS. But analysis of farmers' perceptions knowledge concerning to waste and wastewater use in peri-urban farming activities is based on qualitative analysis. Information collected from the interview, participant observation and observation was in the form of field diary, photos, and audio recording. Qualitative analysis began with transcription of field diary and interview data. After that comparative case analysis of the data of two different sites has been done.

CHAPTER 5: PERI-URBAN AGRICULTURE, WASTE, AND WASTEWATER

Peri-urban farming activities are the main sources of livelihood for a certain group of people in Kathmandu valley in which farmers have been using waste and wastewaters directly and indirectly. Farmers practice of using wastewater, organic waste, and food waste as a farm input in two peri-urban sites of the valley is the important attention of this thesis. Thus, in this chapter, I will present existing situation of waste and wastewater use in the study area. The chapter begins presenting general characteristics of peri-urban farmers as well as their farming practices. It provides an overview of different sub-sectors of peri-urban agriculture of the study area. Then the chapter emphasizes on how and in what ways farmers utilize the different type of waste as well as wastewater in different sub-sector of peri-urban agriculture.

5.1 A general overview of peri-urban agriculture

It is crucial to understand the overview of peri-urban agricultural practices before analyzing the existing situation of waste and wastewater use in two research sites located in Kathmandu valley. As I explained in chapter two the research site located in Madhyapur Thimi municipality has been referred as site 'A' and research site located in Kirtipur municipality has been referred as site 'B' in this thesis[5]. A descriptive overview of peri-urban agriculture is presented here in the comparative form of both research sites. While presenting the overview, I will follow the conceptual understanding about peri-urban agriculture given by FAO (2001) in which peri-urban agriculture has been conceptualized as a distinct phenomenon than urban agriculture. The overview covers key components of the peri-urban farming system such as crops, livestock, land, labor, fertilizer, market etc.

There are some commonalities and differences in components of the peri-urban farming system in the two study sites. Similarities, for instance, both peri-urban sites are characterized by fully or semi commercialized and market-oriented production system. As my own field survey data, average 97 percent products in research site of 'A' and 92 percent in research 'B' are sold in market and rest of the products are used for household consumption. They consume an only small proportion of total production because they only produce few items such as vegetables, meat, and milk that cannot fulfill the complete daily

[5] The research sites are anonymized considering ethical issues and challenges.

consumption requirement of the family. In both sites, farmers relied on fragmented and small land size (mostly below 0.1 hectares) and they mostly reported the problem of insufficient land for farming. Increasing trend of in-migration and rapidly growing buildup area has resulted in the high rate of agricultural land encroachment and gradually decreasing the agricultural practices. Moreover, utilization of hybridized seeds, use of a higher amount of chemical fertilizer and pesticides are other common characteristics of peri-urban farming activities of both research sites.

Agriculture sector occupies a small area in both municipalities. However, it has an important role in supplying of urban food to city people. Especially, vegetable, meat, and milk are produced, processed/packed, transferred and marketed. Besides some, large-scale (which are operated in partnership) farms, most of the farms are small, individually owned and operated. Farmers are doing different kinds of sub-sectors of peri-urban farming activities in both research sites such as vegetable, poultry, dairy cow, pig, fish, and dog farms (see. table 5.1) among them vegetable production is dominant in both sites.

Picture 5.1 Tunnel-based tomato cultivation site 'B'

In site 'B', about 17 out of 25 surveyed farmers are engaging in vegetable cultivation. As you can see in the picture, 5.1 most of them cultivate tunnel-based hybrid tomatoes. Farmers have been cultivating tomatoes under the tunnels, which are made up of bamboo and plastic. Tomato seeds are sown during January/February and its seedlings are transplanted during March/April of the year but it also varies due to the availability of water resource. An informant said, "*This year we planted tomato seedlings two months later (in May) than last year because the water in the well was dried up and we had to wait for winter rainfall" (Informant 7, site-B, 2016).* Normally after two months of the plantation, tomato harvest starts. Farmers can harvest tomatoes twice a week up to five to six months continuously but regular watering and weeding are required. According to an interviewee from site 'B', the initial investment for tomato cultivation is higher than other vegetables because of the higher costs of tunnel building materials but the profitability is also high. Apart from tomato, farmers also cultivate other vegetables such as cauliflower, cabbage, beans, carrot etc. Another important sub-sector in the site 'B' is pig farm that is especially for meat. Farmers

are either raising pigs only or combine of pig farm as well as vegetable cultivation. Few poultry[6] and cow farms have been operated for milk, meat (cow is not for meat) and eggs in this area. Two farmers have kept different types of improved varieties of dogs for the sale.

Table 5.1 Different sub-sectors of peri-urban farming

Sub-sector peri-urban farming	Site A (n=25)	Site B (n=25)
Vegetable farms	19	17
Vegetable + Pig farms	7	5
Poultry farm	4	3
Cows farm	2	3
Dog farm	0	2
Fish	0	2

Fieldwork 2016

Picture 5.2 Varieties of leafy vegetables in site 'A'

In site 'A' 19 out of 25, farmers are cultivating varieties of vegetable crops. The crop diversity and higher crop intensity exist in this site. According to an interviewee, traditional/local crops varieties have almost disappeared because of the introduction of hybrid varieties. As site 'B', tunnel-based tomato production is not found in the site 'A'. Farmers produce other kinds of vegetable crops: green leafy vegetables such as spinach, coriander, fennel, cress, fenugreek, celery etc. are produced. Farmers also produce chili, carrot, radish, turnip, cauliflower etc. The traditional practice of paddy cultivation has become less in this site. Farmers only cultivate paddy in the low-lying land because rainwater is stored during rainy season so that vegetables cannot be grown. The cropping pattern and cropping calendar seem quite dynamic and complex in this site because farmers cultivate various types of vegetable which are grown in different seasons. Some farmers are also raising cows, pigs, ducks, and chickens.

Table 5.1 depicts the farmers' socio-demographic attributes of peri-urban that includes the evidence about the ethnic composition, farmers' land ownership, and their main occupation.

[6] Here, the poultry include hybrid chickens and ducks

The evidences are the outcomes of a semi-structured questionnaire survey. It shows that *Newar* caste is predominated and they have been engaging in agricultural activities for generations. The evidence of land ownership of research site 'A' shows that about 84% farmers have their own land and they mostly belong to the native *Newar* caste of the Kathmandu valley (see table 7.1). The case of gendered difference in this site shows that more i.e. about 87 percent of the male farmer act as a household's farm operator. Farm operator here indicates the agricultural decision-makers in the household. As a farm operator male decides all farming activities such as selection of crops, amount and time of pesticides, fertilizer use etc.

Table 5.2 Socio-demographic attributes of peri-urban farmers

Attributes	**Sub-category**	**Site A (n =25 %)**	**Site B (n=25 %)**
Gender (Farm operator)	Male	87	59
	Female	13	41
Caste group	Newar	91	52
	Other[7]	9	48
Land ownership	Own	84	57
	Leased	16	43
Main Occupation	Agriculture	78	63
	Non-agriculture	22	34

Fieldwork, 2016

In research site 'B', considerable numbers of *non-Newars* farmers' involvement has been found where more women are the farm operators than site 'A'. Many farmers of this site are migrated from another part of countries so that the percentage of the rented land user farmers is higher in comparison to site 'A'. Especially women whose husbands involved in service sector such as military, teaching, private job etc. have rented the land from locals on a contract basis in which they generally make the contract for minimum 3 years to 10 years. The costs for land rent ranges from 10,000 to 20,000 Nepalese rupees per year for per *ropani*[8]. Rented land user farmers have built a small cottage in farmland for a living. This

[7] Here other castes include all castes except *Newar*. The sub-categorization is made only into two groups because in both sites *Newar* is the dominant caste.

[8] 19.65 ropani = 1 hectare

has reduced the ordinary costs of living and provided close caring of their farm. One of the respondents said, *"The numbers of farmers cultivating crops in the rented land have increased after the earthquake of 2015 because numbers of middle-class people (who were living in a rented apartment) lost their apartment in an earthquake so that they started to rent land. They have built a small cottage (which is believed to be safe) in a land so that they can live as well as do farming." (Informant, 1 site B)*

Both sites have good access to wholesale and retail markets. Balkhu Vegetable Market is very close to the site 'B', which is recently opened large-scale wholesale market. Nagadesh Vegetable Market is located close to site 'A'. In addition, Kalimati Fruits and Vegetable Market, as well as Tukucha Vegetable Market, are the other large wholesale markets in Kathmandu valley. Both 'A' and 'B' site have relatively equal distance from these large-scale marketplace. However, only a few farmers go to sell their products in the wholesale market. Mostly retailers and brokers go to the field and collect vegetables. During off-season time, some agents also transfer vegetables to Hetauda, Narayanghat, and Pokhara.

5.2 Nature and typology of waste and wastewater: Analysis of existing situation

Formation of waste and wastewater is directly and indirectly associated with the entire city population and all types of activities such as domestic, business, industries, services etc. High population density and manifold city activities are continuously producing a large volume of waste and wastewater in Kathmandu valley. From the managerial perspective, increasingly growing municipal waste and wastewater has become one of the greatest problems of sustainable city management. On the other side, waste and wastewater have been utilized as resources for peri-urban agriculture.

Peri-urban farmers of both research sites have been utilizing different forms of wastewater for a different purpose. In addition to wastewater, farmers also utilize human excreta, agricultural residual and food waste. At this point, I will discuss different forms (composition and nature) of waste and wastewater that are being produced and how peri-urban farmers are utilizing these as the farming inputs in both research sites. I will follow the concept of waste and wastewater and typology of waste and wastewater use given by Van der Hoek (2004) that I have presented in theory chapter.

The nature of waste and wastewater here indicates the types, composition or features of urban waste and wastewater that can be generated differently in one place to other. For

example, the waste and wastewater generated from domestic activities are different from waste and wastewater generated in industrial and commercial sectors. In Kathmandu valley, a considerable proportion of waste and wastewater is being generated from a residential area. Some previous studies documented the information about domestic contribution in generating municipal solid waste in Kathmandu valley. Manandhar (2005) stated that about two-thirds percentage of waste is generated from the households of Kathmandu valley. The report of Asian Development Bank (2006) reported more than 80 percent of municipal waste is generated from the household. Over the time, the composition of municipal waste and wastewater has been changing, commercial and business activities have been increased, and the use of plastic, paper, and textile has increased. As the consequences of these changes, the composition of waste and wastewater has also changed. A recent study by Dangi et al. (2011) found a decreasing trend of organic waste and increasing trend of plastic, paper, and electronic waste is the composition of municipal waste in Kathmandu.

According to Asian Development Bank (2013), the composition of different types of solid waste generated in the household, institutional as well as industrial sector is different in Kathmandu valley. The household waste is highly dominated by organic waste i.e. about 66 percent of the total waste, followed by plastic with 12 percent and paper product with 9 percent. Besides solid waste, a significant amount of wastewater is generated through the domestic water use. Domestic wastewater may consist of excreta, urine, fecal sludge, bathroom wastewater, kitchen wastewater etc. While institutional, commercial and industrial sector generates more inorganic solid waste materials such as paper, plastic, glasses, textiles, metals, rubbers etc. and heavy metals and chemicals contained in wastewater. According to ADB report, only about 22 percent of organic waste and about 45 percent paper waste are generated by institutions[9] (Ibid:11).

Typology, in this case, indicates the ways and patterns of waste and wastewater use in different sectors of peri-urban agriculture. Peri-urban farmers from both research sites are facing scarcity of fresh and clean water resources for irrigation as well as post-harvest activities. During the winter season, they face water shortage because of the insignificant of winter rainfall, drying up the artificial wells and limited as well as polluted water flow in the rivers. The study of Karn and Harada (2001) about water discharge in rivers of Kathmandu valley found low water discharge i.e. below 2 m^3/sec during the winter season. To cope with

[9] Offices, schools, and colleges were categorized in institutions.

such problem farmers in both research sites utilize different types of wastewater directly and indirectly. Farmers also utilize the decomposable organic waste as a fertilizer for crops and waste foods as fodder to the animals.

5.3 Nature of waste and wastewater of site 'A':

Peri-urban agriculture research site 'A' is located on the eastern bank of Manohara River in Madhyapur Timi municipality of Bhaktapur district. The surrounding lands are mostly covered by buildup area with high population density. Densely populated human settlements, several schools, hotels-restaurants, shopping centers and some industries are the main waste and wastewater generators. The country's main airport, Tribhuvan International Airport, and a Coca-Cola manufacturing industry are located near to this area. A squatter community *(sukumbasi basti)* is also settled on the bank of Manohara River. In addition, among the three industrial estates of Kathmandu valley, the Bhaktapur Industrial Estate is also located. This industrial estate includes brick factories, leather tanning, and some food processing industries. These sectors also produce different kinds of waste and wastewater of which some are possibly harmful to the farmers.

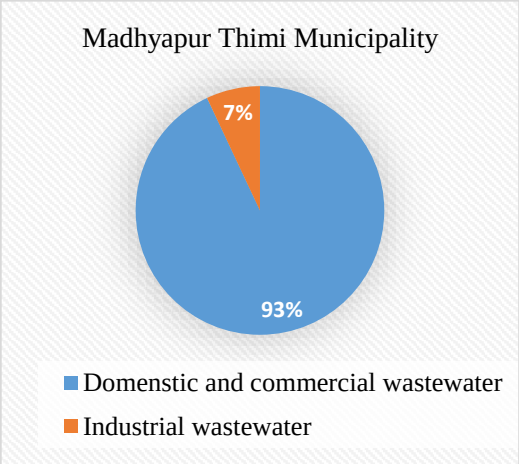


Figure 5.1 Composition of wastewater in Madhyapur Thimi

(Source: Municipal record of Madhyapur Thimi, 2015)

Figure 5.1 shows that approximately 93 percent of the total wastewater is generated from the household and commercial sector and rest of the percentage is generated from the industrial sector. According to municipal record, the composition of municipal waste in of Madhyapur Thimi municipality shows about 70 percent of organic waste and other 30 percent waste consists of paper, rubber, leather, wood, plastic textile, metal, inert, medicinal waste etc.

The managerial infrastructures of waste and wastewater such as managing mechanisms, treatment plants, compost making and reusing techniques have been found very insignificant. Most of the households do not have a septic tank. Households' bathroom wastewater flow as well as toilet's outflow have been joint and connected with the urban sewers system. Recently a policy about housing development in which septic tank is mandatory has been launched but people do not want to make. A municipal officer said, *"In*

new urban planning policy the septic tank is mandatory for new house construction however, people tend to avoid it. Recently we have also prepared a plan to construct sewer inspectors in different places of the municipality. Most of the sewers are being directly discharged into the Manohara River. The wastewater generated in the industrial and commercial sector is also discharged in Manohara River. There is no any separated discharging system of municipal runoff and it directly flows into the river. This indicates that nowadays Manohara River is carrying household and industrial wastewater as well as urban runoff then naturally comes clean water.

5.4 Use of waste and wastewater in peri-urban agriculture of site 'A':

Peri-urban farmers in research site 'A' have been using waste and wastewater for a long time. However, the ways of using waste and wastewater have been changed over the time. As I presented in the theory chapter, waste and wastewater can be used in three different ways: direct use of untreated wastewater and non-composted waste, direct use of treated wastewater and composted waste and it can also be used indirectly to the farm (can unknowingly be used e.g. if river water is contaminated by pollutants).

Since the population of the valley is quite large, the human excreta (faeces) is one of the main urban waste. It has been used in vegetable farming from the historical time in site 'A'. Farmers (local *Newars*) of this area used to use human excreta without making compost until the decade of the 80s and 90s (Duncker et al., 2007:p.15). They collected and used directly in the farm but over the time scenario has been changed. Now the direct use of human excreta in site 'A' is very rare. However, still there is an indirect connection with human excreta and agricultural activities. Most of the household's toilets are discharged into the Manohara River and the river water is highly contaminated with human excreta and other pollutants. A few farmers, whose farms are located close to the river use river water for irrigation. According to an informant of site 'A', the use of polluted water from the river to irrigate crops has become less since the beginning of the use of underground water through the deep borehole. I have found evidence of washing vegetable in polluted river water. As reported by local farmers, mainly the vegetable brokers wash vegetables in river water, which has already been polluted. The brokers buy vegetables from farmers at the wholesale price before harvest. They mostly wash green leafy vegetable that is sold with their roots and carrots. In this way, human excreta and other industrial pollutants indirectly contaminated with agricultural products.

Picture 5.3 Evidences of washing vegetables in Manohara river water

Vegetable/crop residue and grass that collected during crops weeding are other types of waste that have been used as an important fertilizer in site 'A'. Normally farmers collect it in one place from their farm and mix it with chicken manure. The commonly used crops residues are leaves of vegetable and rice husk. Farmers buy chicken manure from a poultry farm. They leave it on the land until it starts to decay. Few farmers also dig pits and make compost in it. Making compost from vegetable residue and weed grass is one of the organic practice in agriculture (Bàrberi, 2002).

While asking farmers in site 'A' if they segregate household organic waste and make compost to use in peri-urban agriculture, one example of answer - "*we use household organic waste, but it is difficult to make compost as we have limited area here at around home and its bit long to take waste every day to the farm" (Informant 12, site A).* They do not make compost of household organic waste because they live in a compact settlement where they do not have space to make it and there is longer distance between household and farm. Another possible reason for not using organic household waste is the lack of proper knowledge to utilize it.

Besides crop related farming, there is also the practice of livestock keeping that utilizes urban food waste. Even though it is an ancient practice, the use of waste food to feed animal has become more common in the peri-urban area of Kathmandu valley. Different livestock species were reared in site 'A' such as dairy cattle, chickens, ducks, and pigs. Not all of them utilize the food waste. The ducks and pigs are the most commonly reared livestock species in site 'A' which have been feeding with food waste collected from nearby hotels and restaurants. Seven out of twenty-five surveyed household have kept pigs and four of them also have kept ducks. Farmers have made a certain agreement with nearby hotels and restaurants (mainly located at Pepsi Cola and around Airport area). They go with their bicycle to the hotels and restaurants in the early morning of the day to collect food remnants. Farmers themselves have put plastic food container in the hotels where they have made an agreement to bring waste food. Farmers get this waste food without cost. As shown below in pictures a,b,c, and d, they collected and store waste food in the big plastic container. For pigs, they cook and feed but for ducks, they feed without cooking. Some farmers use burning rubber and plastics as fuel to cook waste food.

Picture 5.4 Cooking and feeding of food waste to the pigs and ducks in site 'A'

5.5 Nature of waste and wastewater in site 'B':

Kirtipur is a residential city with high population density. The Center Campus, the Tribhuvan University is located at this place so that this place is inhabited by immigrants mainly academic personal i.e. students and teachers coming from other part of countries. In a single house, many families have been living where they have kitchens for each family. This

indicates that the rate of waste and wastewater generation in the household seems high. Waste and wastewater consist of matter that is more organic. One previous record of Ministry of Local Development (2004) about the average waste generation rate in Kirtipur stated that 0.34 kg/person/day waste was generated. This rate was higher than the other part of Kathmandu valley. About 95 percent of the waste was of organic nature. My concern here is to present the typology of waste and wastewater use in peri-urban agriculture in research site 'B' located in Kirtipur municipality.

5.6 Use of waste and wastewater in peri-urban agriculture of site 'B':

Farmers of site 'B' also use waste and wastewater in peri-urban farming. During fieldwork, I have found different ways of utilization of waste and wastewater. In this site, more than seventy percent of surveyed cultivars live in close to the farm or in the farmland. Since they live in farmland, direct use of household uncomposted waste and untreated wastewater in their farm is more. Commonly farmers who live in farmland utilize the decomposable kitchen waste as crop fertilizer. Some farmers mix the crop residuals with kitchen waste and make compost fertilizer.

The practice of direct use of human excreta and urine has been found widespread in site 'B' in compare to the site 'A'. The open sewer is one of the main reasons of using more. In this site, one sewer is being flown just from the channel (i.e open) that mainly brings wastewater including human excreta and urine of a slum settlement[10]. Farmers whose farms are near to this open sewage use wastewater. Seventeen out of twenty-five surveyed household have responded that they use the water from Balkhu Khola, however, they only use it to irrigate the crops. They pump the river water and use for the crops. Since most of the city sewage water are discharged to the river, the river water is contaminated with human excreta, urine, bathroom water and industrial chemicals. There is no any practice of treating wastewater. Farmers are using wastewater mainly for the tunnel based tomato cultivation, cabbage, and cauliflower but they do not use it for tomato's nursery plants. This is because farmers have experienced the incidence of dying nursery plants after using river water.

Few tomato farmers (two out of twenty-five) have installed new irrigation system i.e. drip irrigation. They have built a pipe connection to collect the household wastewater and store it

[10] In 2003, Urban Community Support Fund (UCSF) Kathmandu has built couple of dozens houses in Kirtipur that were given mainly for the people who are poor and landless people from the Kirtipur city itself.

in a large plastic tank (Hill Tank). Farmers also store the tap water that is left after using from household in that plastic tank. A network of pipes has been built in the farm that allows water to drip very slowly to the roots of tomato plants. A farmer says this way of irrigation is very appropriate to utilize the wastewater as well as to save the water. "Drip irrigation helped to cope with water scarcity during the winter season. Moreover, after installing this irrigation system the production has increased (Informant 8, site B) Despite of having more benefits most of the farmers do not have drip irrigation because of the high installing cost. The majority of farmers in this area are doing farming in the rented land which has short (3-4 years) period agreement. Thus, farmers do not want to invest more money for short period.

Picture 5.5 Pipe network on the surface for drip irrigation

Farmers in site 'B' also collect waste food from the hotels, restaurants and private hostels. However, it is less compared to site 'A'. Waste food is mainly fed after cooking to the pigs. Pigs' meat is sold in different meat shops of Kirtipur. They slaughter pig themselves and prepare meat to deliver to the meat shops. The meat waste such as bones, non-eaten body parts is also utilized in this site. Two farmers have kept some improved breed of dog as commercial dog farms. The main food for the dogs is meat by-products which is collected from pig farms and some of the butchers of Kirtipur market.

5.7 Summary

As I discussed above, both research sites of Kathmandu valley include multiple sub-sectors of peri-urban farming: vegetable, poultry, dairy cow, pig, fish and dog farms. The vegetable farming is dominated in both sites but high crop diversity in site 'A' and single crop (i.e. tunnel based tomato) domination in site 'B' has been found. While considering the question of how farmers utilizes waste and wastewater in those sub-sectors, it has been understood that in site 'A', the wastewater is indirectly used through the polluted river water. A few farmers and vegetable brokers in this site use wastewater to wash vegetables. Only few farmers (whose farms are located near to river) use for wastewater to irrigate. In the other

site, farmers use wastewater both directly and indirectly. Directly they use from the open sewers and household discharges. Indirectly they use pumping the river water that flows through the urban sewers. Farmers of both sites use the crop residue to fertilize the soil and some farmers of site 'B' also mix organic waste of household. Moreover, the practice of collecting of waste food from nearby hotels and restaurants to feed pigs and ducks has been found in both sites. Most of them feed waste food to pig after cooking. A few farmers use plastic, rubber, and wood waste to cook the food. Whereas in site 'A' farmers give waste food to the ducks without cooking.

In this chapter, I have presented evidences about peri-urban farming practices and the practices of using waste and wastewater in it. The following chapter will deal about how farmers perceived the benefits of using waste and wastewater.

CHAPTER 6: FARMERS' PERCEPTIONS AND KNOWLEDGE ON WASTE AND WASTEWATER USAGES IN PERI-URBAN AGRICULTURE

6.1 Introduction

Different people have different perceptions about the same subject, situation or phenomenon. Perception depends on the complex function of nervous system. With experience, socio-cultural and historical context people make perceptual categorization of the real world (Rehder, 1999). Farmers are the main actor of peri-urban farming activities. In my study site, where farms are small and individually owned, each farming activities are under the control of the farmer. The fundamental concern of this thesis is to assess the farmers' perceptions towards waste and wastewater use in agricultural practices. This chapter of the thesis is dedicated to analyzing the empirical evidences about farmers' perception that includes; motivation of waste and wastewater use, farmers' views/knowledge about the quality of wastewater and waste food, perceived benefits of using waste and wastewater and farmers' risks perceptions.

6.2 Motives (reported by farmers) of using wastewater and waste in crops

Underlying motives are important to understand farmers' perception of waste and wastewater. As I discussed in chapter five peri-urban farmers utilize both waste and wastewater in different ways in their farming activities. During fieldwork, farmers have given varied explanations and reasons for using waste and wastewater. Wastewater (mainly from polluted Balku Khola and open sewer) user farmers of site 'B' more frequently reported that the main reason of using wastewater is lack of alternative sources (cheaper and reliable) of water for irrigation.

> *"What to do sister, it is hard to get clean water even to drink, how to get clean water for irrigation?" (Informant 3, site-B, 2016).*

From this quotation, it can be understood that the scarce water condition and lack of irrigation facility is one of the main drivers of wastewater use. In Kirtipur, many local people use water from dug well *(Inar)* for household purposes. These dug wells are built close to residential area. Normally the dug wells are 20-25 meters deep and 1.5- 2 meters diameter but it is varied by location. However, most of the farmers do not have such dug wells so they

do not have groundwater access. As I discussed in chapter five, farmers in this site are cultivating in rented land and they have short-term (3-4 years) contract with the landowner. They do not want to invest money in it for such a short period. The contract extension is always uncertain. *"Forty-fifty thousand rupees is not a small amount to build a well and I have only three years' contract for this land so I don't want to take a risk." (Informant 9, site-B, 2016).* A few farmers (those who have own land) have the wells to extract groundwater but during the dry season, they do not get enough water to irrigate in this site. Thus, they only have options, for instance, the contaminated river water, water from open sewage, household wash water (i.e. wash water form dishes and laundries, from vegetable washings etc.).

Farmers stopped using Manohara river water for irrigation has become less in site 'A'. When I asked to local farmers about the practice of vegetable wash, they often refused it *"I stopped to (use river water) wash vegetable after the Pepsi-cola town planning was built. When I was child we used to bath in this water and caught the fishes, now it is very sludgy and dirty to touch (Informant 5, site-A, 2016).* Most of the local farmers in site 'A' get underground water from the deep borehole. The underground water is almost enough for the whole year. They referred that only *Tarkari Byapari or* some mobile traders[11] wash leafy vegetables, carrot, and radish in this river water. To get more profit the brokers buy such vegetables at wholesale rate from the field from local farmers before harvest and they collect vegetables when the market price in the city goes higher. "*The vegetable brokers do not want to pay for groundwater so that they wash their vegetables in the river water" (Informant 5, site-A, 2016).*

Weak institutional arrangements, the current state of policy, lack of proper urban planning and management practices have resulted in increasing pollution in the river water. It has been affecting directly to the local farmers' water demand for irrigation. Most of the farmers' matter of choice of wastewater irrigation in this situation is directed by their necessity not by the intention. It seems, if they had alternatives of fresh water sources, they would not have preferred to use wastewater.

In case of using vegetable/crops residues and grasses, I have found two specific motives. Firstly, farmers are aware that it can be used as a compost to fertilize the crops. According to

[11] Those traders who carries vegetables on locally made load carriers *Doko* and *Kharpan*. *Doko* is cone shape basket made from bamboo and *Kharpan* looks like a Libra with two baskets on each side and a bamboo stick that is kept on shoulder.

a farmer of site 'A' when the green grasses and some crop's residues mixed with chicken manure, a good compost is made. Second, it helps farmers to control the weed problem in crops that is important to prevent losses in gross yield. As farmers reported, some troublesome weeds are difficult to destroy. If they leave it somewhere in the land, it will grow again. Thus, they dig the pits and put for a month or more. Doing this the weeds will be destroyed and converted into organic fertilizer. In both study sites, weed control is done through manual weeding by hand and no chemicals are used for it.

6.3 Motives (reported by farmers) of using waste food to feed the animal

Feeding animal with household's food waste is one of the traditional practices, however, in recent years, it has increased in both study sites. Nowadays farmers are feeding food waste to the animal in small-scale commercial livestock farm not only in the household. There are many small-scale livestock farms but those farms which have pigs and ducks mainly use food waste as feed. Asking farmers why they feed pigs and ducks with waste food, the usual answer was, ''…it is easy to get and no cost to pay''. This indicated that the matter of choice of using waste food to feed pigs and ducks is directly associated with convenience and profit in the context of fodder scarcity as well as high fodder price in the city area.

In southeast and south Asian countries the preparation of feed to their pigs and ducks has been attached with socio-cultural practices (Deka et al., 2014). In both study site, local people believe that pigs and ducks can eat waste food and can stay in dirtier places than the other animals. "*Pigs and ducks are such kinds of animal which love to eat mud, stay and wallow in muddy place" (Informant 9, site-A, 2016).* Here I mean to say is that the practice of giving food waste to some particular animals (pigs and ducks) is historical.

6.4 Farmers' views Vs scientific views in wastewater/water quality

In geographic research, it is often argued that knowledge is always bounded with particular time and space (Aitken and Valentine, 2014). It is challenging to understand everything from single viewpoints. Therefore, different types and sources of knowledge are important to take into consideration while dealing a particular issue (Kindon et al., 2007). In this case, it is relevant to set a discussion about how local farmers' views are different or in what ways their views are similar with a scientific view about the quality of untreated wastewater.

Many scientific studies have been conducted about the quality of wastewater in different developing countries of the world but in Nepal, studies are limited. A study conducted by

Kathmandu Upatyaka Khanepani Limited, Ministry of Urban Development, and Government of Nepal has evaluated the water quality of river of Kathmandu valley in 2013. The BOD[12] level measured in different sites of the rivers of the valley and sample were taken in different seasons of the year shows a high level of water pollution. The observed BOD levels range from 1.7 to 239.4 mg/l in the pre-monsoon, 2.1 to 84.7 mg/l in the monsoon and 2.3 to 119.4 mg/l in the post-monsoon season (KUKL, 2013 p.22). The quality of water can be highly varied by both spatial and temporal factors. River water before entering the city might be good in quality and after crossing the city or in the core of city area; the water could be highly contaminated. Water quality during the rainy season and the dry season can be also different. Such evidence has been found by the study of (Shrestha et al., 2015). The study states that water quality of rivers of Kathmandu valley, mainly Bagmati River was good enough for drinking, aquatic lives and agricultural use at its area of origin (i.e. Sundarijal) as recommended quality by BBWMSIP-1994[13]. However, at the core city area and at the exit point of the city the river water was found anoxic which is poisonous for aquatic lives as well as agricultural use. A similar study of Regmi et al. (2014) states that the BOD in rivers of the valley increases as the river flows to the core city from its origin and the river water is extremely poor quality as well as not suitable for the agricultural purpose.

To understand farmers views, I asked wastewater user farmers about the quality of wastewater which they are using. Farmers' views were gathered during the interview as well as semi-structured questionnaire survey. As you see in figure 6.1 majority of the farmers in both sites agreed that wastewater should be treated before use. Most of the groundwater user farmers in site 'A' even referred to wastewater as 'dirty water'. For groundwater user farmers, the groundwater is clean and good to use for the agricultural purpose. 19 percent of the total surveyed farmers' in site A and 23 percent in site B responded as 'do not know' and only a few farmers did not give concern about wastewater treatment. According to a farmer of site B, they often need to combat with bad smells from wastewater, while they irrigate. If they use it during the sunny day, the bad smell does not go away for 3-5 days of use.

[12] Biochemical Oxygen Demand (BOD) is the amount of dissolved oxygen needed by aerobic biological organism to break down organic material present in a given water sample. BOD is internationally recognized indicators for water quality.

[13] Bagmati Basin Water Management Strategy and Investment Program-1994, Government of Nepal

Moreover, during the pumping time, farmers usually get small pieces of plastic, rubbers and oily substances.

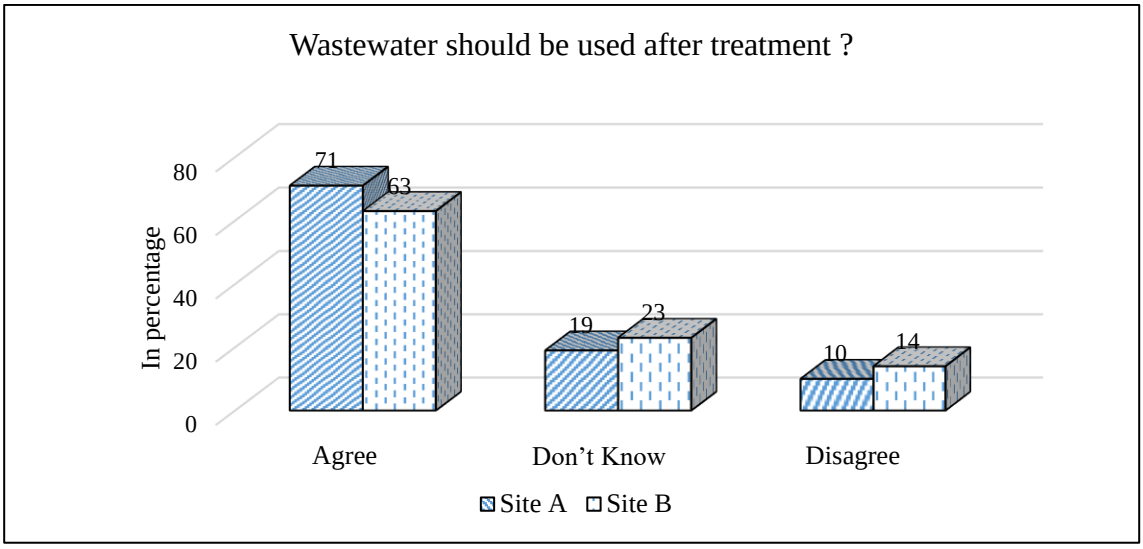


Figure 6.1 Farmers' view about quality of wastewater

This indicates that the wastewater user farmers, in general, are aware of the bad quality although they are still using it. Famers view here corresponds with the scientific studies mentioned above which have already revealed extremely poor water quality in valleys river water mainly in the core city area of Kathmandu. Those studies were conducted in general covering all the rivers of Kathmandu, which also includes the rivers of my study sites. If farmers agree with the bad quality of wastewater, do they consider wastewater as assets for their farming or not; if they do, to what extent and in what ways they get benefits? I will go through these questions in the following session.

6.5 Perceived benefits of using wastewater

The closed-loop discourse of wastewater use advocates wastewater as a resource that can be water, fertilizer and energy saving. It is argued that the resources embedded in wastewater would be enough to irrigate and fertilize large area of crops worldwide (Hernández-Sancho et al., 2015). However, I argue that this assertion can only be logical if it fulfills the conditional requirement i.e. proper management of wastewater. My concern here is to assess empirically the farmers' views about the positive aspects of wastewater use.

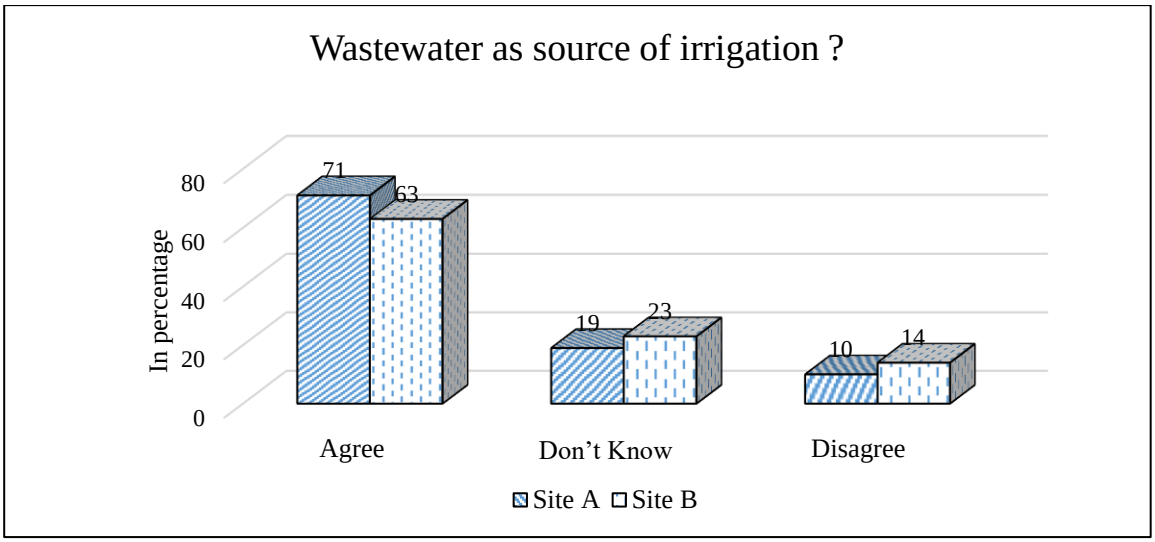


Figure 6.2 Farmers' agreement on wastewater as a source of irrigation

Figure 6.2 shows farmers agreement on the matter that wastewater as a source for irrigation. In site B, more than half i.e. 51 percent of the total surveyed farmers agreed that wastewater could be taken as an irrigation source. About 28 percent farmers, answered as do not know or do not want to speak about this matter and 21 percent of the total surveyed farmers in this site disagreed that wastewater can be a source for irrigation. An opposite condition has been found in site A. In this site, more farmers i.e. 60 percent farmers disagreed that wastewater can be source for them and only 23 percent farmers agreed on this matter.

One of the reasons for getting a different figure in site A and site B is differences of water source they are currently using for irrigation. As I discussed in the previous session, in site A, 80 percent of the farmers have access to groundwater. The local farmers thought that groundwater is good enough for irrigation and washing vegetables although, they do not know the quality of groundwater. Farmers referred to wastewater as dirty water so that it cannot be a source of irrigation. They repeatedly mentioned that mainly vegetable brokers use polluted river water to wash vegetable washing. The WHO's guideline of using wastewater mentioned that the use of wastewater for vegetable washing is riskier to the public health than the use of wastewater for irrigation (WHO, 2006b).

6.6 Perceived benefits of using crop residue, weed, and household organic waste

Recycling of crop residues, crops weed and household organic waste is said to be a cost-effective and environmentally safe way of transferring biomass into new crops (Pane et al., 2015). Rice husks and straw, leaves of vegetable (mainly: carrot, cauliflower, and cabbage)

and tomato residue are the major crop residues in both study sites which have been used to fertilize new crops. Different types of weed grasses and organic waste produced in kitchens are also used.

Farmers of site 'A' have their own practices of on-farm composting of agricultural residues. In this practice, usually, farmers collect crop residue and weed in the farmyards or at the farm edge. They buy chicken manure (or they can have chicken manure if they have their own) and they mix with those collected residues and cover with plastic or sacks (see in the pic. 6.1) they leave it to be decomposed for a couple of months. After that, they use it for the vegetable cultivation.

Picture 6.1 Making on-farm compost from crop residues and weed grasses

In recent year, numbers of commercial compost producers have started to deliver compost to the farmers' farm. One of the popular commercial compost delivered in both sites is called '*Kisan Mal'.* The company is in Lalitpur district. This private company mainly use agricultural residues such as rice husk, rice straw, and oilseed cake. The company buys these residues with farmers as well as local food processing centers and mix with animal manure such as chicken, goat, and cow. Farmers in site A are aware that the use of agricultural residues and household organic waste can contribute to raising soil fertility, though they are not reusing their own household organic waste because of the long distance between farm and household. According to an informant of site A', if they make composts from weeds, vegetable residues, they do not need to buy such amount of fertilizers (animal manure as well as chemical fertilizers) which is required in absence of composts. *This year, I brought six bags (50 kg inside) of chicken manure to cultivate leafy vegetables (sag) and mixed with weed grasses, leaves of carrots but if I had not mixed it, I would have brought nine or ten bags of manure (Informant 3, site-A, 2016).*

Farmers of site 'B' have not given the significant interest in on-farm composting of weeds grass, agricultural residues and household organic waste in comparison to farmers of site 'A'. They just throw in the land or burn during the dry season. However, as they mentioned that in *Karesa Bari* (Land located very close to the house or house yard) they do not need to put extra fertilizer. Because they throw most of the decomposable household waste on that land. According to an informant, they get more production in *Karesa Bari* than other land.

6.7 Benefits of using food waste as animal feed

Use food waste as animal feed in Nepal is not new. In rural agriculture, farmers have been feeding waste food and agricultural residues to their animal for the centuries but in a recent practice, it has become common in the small-scale animal farm which is located near to the city. Growing population and increasing business of hospitality in the Kathmandu valley generates a substantial amount of food waste. A large part of the food waste is dumped in nearby landfill sites. However, some farmers of both study areas have started to collect food waste to feed their animal mainly to pigs and ducks. Farmers of site A, have enough access to food waste collection than site B since it is located close to the core city and international airport where a lot of hotels and restaurants are opened. Except for festival time such as in *Dashain,* they get food waste (e.g. cooked rice, vegetables, pulses etc.). Farmers of site B have less access to hotels and restaurant but they also collect from private student hostels and private apartments of Kirtipur. Some farmer fulfills their animal feed requirement from brewing waste.

The amount of feed that is required depends on the types of animal they keep. For instance, farmers who have only ducks need less feed than farmers who have pigs. Therefore, for the duck farmers, food waste collection would be easy and might get enough amount what they need but for the pig farmers, food waste collection can be difficult as they need more or may not be enough all the time. As farmers referred, they are getting less or more returns from the ducks and pigs rearing which consumed food waste. The gross return fluctuates and varies every year since animal often suffers from different types of disease.

> *I have 34 adult ducks, which are almost ready to sell and 70 ducklings. Most of the time we feed food waste to the adult ducks. But when ducks are very young (duckling) an intensive care is needed and they can't eat food waste. For them, we need to buy special duckling feed from the poultry suppliers. ..... If ducks remain healthy*

until they are adult, gives a good profit. We normally buy ducklings from a hatchery in 25-35 NPR and after 10-12 weeks it can be sold in 7-800 NPR and the cost for feed is minimal (Informant 7, site-A, 2016).

Picture 6.2 Waste feed to adult ducks and duckling feed for baby ducks

Pigs in both study sites consume a large amount of food waste. Since pigs need more feed than ducks, the collected food waste is not enough for all the times. According to an informant, about fifty percent of the total required feed for his eight pigs is covered by collected food waste from hotels and restaurants. They also need to buy some supplementation mainly dry feeds, such as bran (rice polish) and forages. Making a mix of some of these dry feeds with the food waste they cook and feed to the pigs. Some pig farmers are also doing brewing as an alternative livelihood. They mainly use millet and rice to make local alcohol. From that brewer's waste/brewer's grains (*Jand cut*) is produced. Farmers also feed that waste grains for the pigs. One of the farmers says while feeding food waste and brewing waste grains, about seventy-five percent of the feeding cost is reduced.

It indicates that the cost of input for the duck and pigs keeping has been reduced or minimized due to using food waste. Thus, from the economical point of view, food waste as animal feed is one of the low-cost peri-urban farming practices that provide self-employment for the pro-poor urban people. For small-scale farmers, who have less investment capacity can be obtained.

6.8 Risk perceptions of using waste and wastewater

The use of waste and wastewater in agriculture is directly linked with the issue of food hygiene. According to the World Health Organization, the use of untreated wastewater and waste such as human excreta possibly causes diarrheal diseases and helminth infection in

both farmers and consumers (WHO, 2006b). The risk of such diseases is found to be higher in developing countries where the governmental mechanisms and awareness about food hygiene management is not enough (Antwi-Agyei et al., 2016). The Kathmandu valley of Nepal is also a city with a high risk of diarrheal diseases and parasitic infection. For instance, Tandukar et al. (2013) studied intestinal parasitic infection among school going children of Lalitpur area of Kathmandu valley. The study found that about 16.7 percent of the total 1392 sampled children were infected by intestinal parasitic infection and the evidence shows that the children ones belonging to the family of agriculture workers were found to be commonly infected. Similarly, Bhandari et al. (2015) found a higher prevalence of Cryptosporidium (i.e. a coccidian protozoan genus is an important cause of parasitic diarrhea) among the school going children in the Kathmandu valley. They stated that livestock presence at home, consumption of untreated drinking water and raw vegetables are found to be the major causes.

WHO has developed detailed guidelines of using wastewater and waste in agriculture in series of documents in which the multi-barrier approach (I have presented the details about the multi-barrier approach in theory chapter) has also been suggested to maintain the possible human health risks. For health risk reduction, every element of the food system (from farm to plate) should be taken into consideration. However, it is argued that farm and farmers are the most important in this case (Keraita et al., 2008) therefore, the study of farmers perception about health risk could contribute to seeking options for health risk reduction.

Interviews with each farmer in both sites started with a general opening question, "What do you think about the risks of using waste and wastewater on your farm?" The intention of asking such question was to reveal farmers state of mind about the risks of waste and wastewater. In site 'A' (of Bhaktapur) about more than half percent of the total surveyed farmers perceived that wastewater is 'dirty water'. Recently they have invested in the deep borehole and started to use borehole water (groundwater) for irrigation as well as to wash vegetable. Farmers said that a reason they stopped the use of polluted river water is bad smell and frequent experiences of skin infection. *The river has been polluted, the water smells very bad, and even we cannot go around. It has been almost seven years that I have stopped to use this water (Informant 11, site-A, 2016).* However, they are not using wastewater; the odd smell even comes to their farm during the daytime from the polluted river. When I asked some other farmers of the same site those who are still using

contaminated river water, reported that these days the river water is only being used for rice cultivation in which they spend less time for work. Nonetheless, during the weeding time, they often face a problem of skin itching in their hands and legs. The itching problems mainly occur in the skin of gaps between fingers because the area between the fingers is relatively delicate as it does not endure the same frictions as does the other part of hand and legs[14].

Table 6.1 Frequently faced problems related to farmers' health

Problems	**Site A (n=25) %**	**Site B (n=25) %**
Itching and skin infection	35	64
Odd smell	48	54
Mosquito nuisance	13	72

Fieldwork 2016

In site B, more farmers reported such occupational health problems i.e. skin infection (64% of sample) odd smell (54%) and mosquito nuisance (72%) (See. table 6.1) than the site A. This is because most of the farmers in this site have been directly and indirectly exposed to wastewater. Farmers who have been using direct wastewater from sewage commonly reported the problems. During the irrigation time, farmers need to touch wastewater more often so that the frequencies of health problem happens more. According to an informant at least once a year he has to face the problem of skin ailments in his hands or legs. Besides the skin infection, farmers of this site also facing the problem of an odd smell and the prevalence of mosquitos during the summer time both in the field and in the home. Concerning protective measures, famers do not use protective gloves and masks while using waste and wastewater but they use working shoes during the working time. They also use mosquito nets in home that might help them to protect from malarias and other mosquito infected diseases.

The majority of farmers in both sites experienced that the wastewater causes health-related problems. However, informants had only the information about disease or problems which they can feel or experience themselves without any medical test. There could be other diseases, which would require medical tests. For instance, the information about a widely recognized health problem caused by wastewater use; intestinal parasite infection or helminth infection (WHO, 2006b, Trang et al., 2007, Antwi-Agyei et al., 2016) is unknown

[14] https://www.healthhype.com/itching-and-rash-between-fingers-causes-treatments.html

here. According to a farmer, he and his family members suffer quite a few times in a year by diarrheal diseases, headache, and fever but it is difficult to say that it is caused by a wastewater.

Wastewater exposer may also cause to local environment dilapidation and damage of cultivated crops. Table 6.2 summarizes some perceived negative impacts of wastewater to the crops and local environment. In site A, farmers referred that they occasionally face a problem of excessive growth of rice *(Hausine). If rice gets excessive growth, the rice plant would not give any production. Plant just grows higher than its normal height (Informant 7, site-A, 2016).* Farmers also said that they used to find fishes in Manohara river water until two to three decades before but now it's become impossible.

Table 6.2 Perceived negative impact on their crops and local environment due to wastewater use

Study sites	Problem to crops	Impact on local environment	Other problems
Site A	Excessive growth of rice	Extinction of fishes in Manohara river	No
Site B	Damage to tomato seedling, excessive growth of vegetables	Suspended solid waste on soil: small pieces of plastics, rubber etc.	Damage to pump

Source: Fieldwork 2016

In the other site, farmers also mentioned some negative impact of wastewater on their crops and local environment. Farmers in this site usually do not use wastewater in tomato nursery but they start to use right after when they transfer nursery seedlings to the field. This time the possibility of tomato seedlings dying would be high and farmers need to do replantation. In addition to this, the problem of excessive growth of the plant is also said to be happened in this site. According to the informant, while pumping wastewater to the field, it also brings many suspended solids such as small pieces of plastics and rubber that damages the soil fertility. Sometimes those suspended solids block the water pump and damage it.

Reuse of food waste as animal feed could pose animal health problems. Some developed countries of the world (e.g. Japan, UK) have been using waste food as animal feed but they have strong regulatory legislation for the treatment, storage and transfer of food waste feeds (Salemdeeb et al., 2017). In my both study site, farmers are feeding food waste to their animal without any regulatory guidelines for treatment, storage, and transfer. Farmers either

feed food waste after cooking (i.e. heat-treated) or feed without treatment. I have asked the farmers of both sites about the problems related to their animals and huge loss due to food waste feeding. Most of the pig farmers said that they have not faced any noticeable lost due to food waste feeding. One of the possible reason of not facing animal disease could be the strategy of feeding food waste after cooking. However, farmers did not respond that they feed waste food because of this reason. Famers said that if waste food is cooked by mixing some rice bran on it, pigs eat it nicely. According to Westendorf (2000), feeding waste food after cooking can reduce the animal diseases. Some farmers (whose pig farms are located close to the private housings) reported that they have been warned a couple of time from the local municipal authorities to transfer their farm to another place. It is because the residents often made the complaints to the municipal authorities that their farm spreads odd smells.

6.9 Summary

The analysis of farmers' motives, perceived benefits, and risk of using waste and wastewater in the peri-urban farm has revealed some important points. The practice of using wastewater in both sites is typically directed by the scarcity of fresh water sources. Thus, it has been understood that most of the farmers of site B, a few farmers and vegetable brokers in site 'A' have chosen wastewater for irrigation and vegetable wash because of their need of water, not for the purpose of fertilizer. In site 'A', the majority of farmers perceived that the untreated wastewater (in this case, the Manohara river water) is dirty and can not be used in agricultural purpose. For them, the groundwater (i.e. water from deep borehole) is clean and good for agricultural uses. Concerning that whether farmers consider wastewater as a source for irrigation or not, it has been found that more farmer in site 'B' (i.e about 51%) agreed on it and 23 percent farmers agreed in site 'A'. Farmers perception towards the use of waste (here mainly indicated to the agricultural residues, weed grasses and kitchen organic waste) for crops and food waste for animals in both sites seems more positive. In general, it can be said that farmers motive of using such waste and food waste as animal feed is to get more inputs with less investment. The use of weed grass to make compost has also contributed to troublesome weed control.

Itching and skin infection, odd smell and mosquito nuisance have been found as the main recognized problems related to the farmers' health caused by the use of waste and wastewater on their farm. More farmers of site 'B' indicated these problems in comparison to site 'A'. The reason could be higher numbers of wastewater user of site 'B'. The health

problems that can only be detected after lab test remains unknown here. Neither the farmers have kept information about this nor my study included the lab test information. Farmers also mentioned some problems related to the crops due to wastewater use, for instance, excessive growth of the plant, dying of crop seedlings. Farmers do not use any protective measures, except regular plastic shoes and mosquito net in the home.

CHAPTER 7: FARMERS PRACTICES AND DISCOURSES OF WASTE AND WASTEWATER USE

7.1 Introduction

The demand for food and water in the urban areas of developing countries is increasingly going up because of the rapid growth of urban population (Connor et al., 2017). The release of wastewater and food waste is also continuously increasing (Weerasekara, 2017). Thus, on the one hand, there is a pressing need of fulfilling the demand of food and water and on the other hand, appropriate handling of waste and wastewater and proper reuse should be done. Therefore, the practice of using waste and wastewater in agricultural activities in the urban area is increasingly brought up in academic and non-academic platforms. Since the practice intersects with both problems as well as opportunities, it has become a burning issue of exploration, discussion, and symposium. I have discussed the farmers' practices of waste and wastewater use and their perceptions on problems and opportunities of it in the previous chapters. In this chapter, I will discuss the issue like to what extent the farmers' practices and their perceptions reflect the discourses of waste and wastewater use which are presented in theory chapter.

7.2 Farmers practices and the closed loop discourse

The general idea of the closed loop discourse is that the agricultural activities conducted in the urban/peri-urban area can be an appropriate approach to recycle waste and wastewater that offers social, environmental and economic returns to individual, society and the world. As I discussed in chapter three, researchers have articulated such ideas in different ways, however, the fundamental concept behind it seems similar. For instance, Smit and Nasr (1992) advocated the concept of 'closed loop system' in which they explicitly stated that waste and wastewater need to be seen as a resource for sustainable development not as a serious problem of the growing cities that is possible through urban agriculture. They have argued that cities of developing countries generate more nutrient-rich wastewater that can contribute to lowering the chemical fertilizer use. However, if we see evidence of local level from developing country (i.e. my own field), farmers' practice of wastewater use in both sites was not driven by the purpose of fertilizing the farmland. I have found that the farmers of both sites have not considered the nutrient value of wastewater, which they have been using. They might avoid using wastewater for fertilizing the crops to reduce the risk of

excessive plant growth. It seems that the use of wastewater has substituted farmers' freshwater requirement and farmers' decision of using it is largely determined by the situation of freshwater insufficiency. Therefore, the farmers' practice of wastewater uses in both study sites is not associated with the idea of closed loop system. However, the requirement of water supply for irrigation is partially fulfilled with wastewater so that the cultivation of crops is still going on.

Conceptually the closed loop system gives the ideal impression and more positive perspective on recycling the urban waste through agricultural use. While considering the field evidence of waste use in agriculture, it can be understood that the farmers' practice of using organic waste such as agricultural residues, weed grasses and kitchen waste possibly gives some effective returns to the farmers. Farmers have reported more positively about such waste to be used as fertilizer. Nonetheless, the degree of effectiveness of its use can be determined by farmers' local knowledge or indigenous practice of making compost and the distance between farm and farmers household. For example, farmers of both sites have been utilizing such waste as an organic fertilizer. But in site 'A', farmers have applied local knowledge (see in chapter 5) of making compost from agricultural residues and weed grasses so that it has contributed to reduce the total cost of fertilizer whereas farmers of site 'B' have not used properly as farmers of site A. In another case, the use of household organic waste such as kitchen waste, ashes have been used more commonly in site 'B' since their houses are located close to the farmland in compare to site A in which farm and household are located bit away.

The use of food waste as animal feed has been extensively suggested in recent years. (Papargyropoulou et al., 2014) have recommended a food waste hierarchy as a sustainable and holistic approach to food waste control and disposal. According to them, fundamentally priority should be given to reduce the food waste. Second, food waste should be redistributed to homeless or people who do not have access to food. After that, the framework recommends recycling of food waste into animal feed. Both developed and developing countries in the world have been utilizing food waste as animal feed but the ways of utilization are different. Some developed countries have adopted advanced technologies for hygienic reuse of food waste (zu Ermgassen et al., 2016). For example, about 3 million tons of food waste is recycled with heat-treatment techniques as animal feed in the UK. Similarly, 35.9 percent of the total food waste in Japan is recycled as animal feed (Salemdeeb et al., 2017).

According to FAO (2011), globally, more than 1.3 billion tons per year food is wasted. The quantity of food waste is almost equal in developed and developing countries but the legislation and mechanism of food waste reuse as livestock feed are different. A study of Deka et al. (2014) documented that small-scale farmers in the peri-urban area of Southeast and South Asia are feeding their pigs mainly with kitchen waste, vegetable peels, food leftover, rice bran with limited supplements of purchased feeds. Use of food waste to pig and duck in peri-urban area of Kathmandu valley has also become cheap and easy means of livelihood to the low or middle-income urban farmers. We can relate such farmers practice with the idea of the closing nutrient loop. While dealing the concept of closing nutrient loop, Nelson (1996) has stated that organic waste and food waste contains bulk of the nutrients which need to be recognized as an economic asset. Taking into consideration the farmers practices of food waste use in both study sites, it can be said that it has noticeably supported them to be self-employed in the competitive urban job market. That has raised household income as well as contributed to the urban food system. Thus, in this case, it can be said that farmers practice of feeding food waste to some extent replicates the closed loop views of waste and wastewater use in agricultural practice.

7.3 Farmers practice and public health risk discourse

It is apparent that the use of waste and wastewater offers agronomic and economic benefits but the major challenge is how to manage, prevent and reduce the possible risks to the farmers, crops, animals and local environment. It has been documented that the application of wastewater, human excreta and other waste in agricultural activities causes multiple health hazards. For example, WHO (2006b) stated that intestinal worm infection is one of the commonly identified health problems in the developing countries where untreated wastewater is used in agriculture. FAO (2012a) has also listed the occupational and consumption related health risks that I have presented in chapter three. Farmers are supposed to be on the top of the list of sufferers from the occupational health problems such as parasitic worms, skin infections, diarrheal disease etc. and consumers are at risk of bacterial and viral infections such as, cholera, typhoid, and hepatitis.

The issue of public health risk posed by the practice of waste and wastewater use in agriculture has become a part of risk discourse. The concept of ‘risk’ was introduced in the 17th century in the western world with the development of probability theory in which risk was understood as the mathematical likelihood of event occurring (Dake, 1992). It was used

in both positive and negative senses. Over the time the concept of risk and its uses have evolved and the meaning of risk has been started to see only from negative perspective (Gabe, 1995). In public health discourse, the concept of risk has thought to be embedded with the idea of danger. According to Lupton (1993) in public health risk discourse, the idea of risk can be conceptualized in two separate ways. The first risk is a kind of high-level health danger that is posed by external causes, for instance, environmental hazards, nuclear waste, industrial toxic chemicals in which people might have less control. But people react to this kind of risk expressing anger or/and feeling of powerlessness towards public authorities and the failure of their system. It is because the weak legislation and unregulated system usually create such situation of risk. Another risk is considered as outcomes or consequences of people's everyday activities or lifestyle choices they make. In this kind of risk, people might have self-controlling options through changing their behavior (Ibid: p.427).

In this case, the risk poses by waste and wastewater use in agricultural practice can be empirically conceptualized in both ways. The high contamination of irrigation sources (mainly river water) of Kathmandu valley is the results of unplanned and haphazard urbanization. Due to lack of proper municipal plans, policy or it's implementation, the private and public sewerage have been discharged into the river. People have been making their houses without systematic housing policies so that toilets and bathrooms of each household are directly discharged to the river water. Farmers are not the causes of creating such situation and they do not have the controlling capacity but they have been victims of the situation. For this, Lupton explained it as public health risk with a high level of danger.

The risk posed by everyday practice of waste and wastewater use in their agricultural practice to the farmers can be related to another concept of risk. We know that farmers do not have alternative sources of water but the choices of utilizing waste and wastewater have been made by themselves. In this sense, if farmers became aware of potential threats, they could reduce the level of risk. For instance, wearing the protecting gloves while working with the waste and wastewater might reduce the danger of potential disease such as skin infection. According to Lupton (1993), health promotion authorities can warn or spread awareness to the individual so that their behavior may be modified. It can be said that in both study sites the waste and wastewater user farmers need to be given health promotion awareness and ways of mitigating potential risks.

7.4 Local food production chain and farmers role in food safety (Farm to Fork)

The journey of food indicates how food grows, what inputs are used, from where our food comes, how it travels to our home and then to our plate. The matter of food safety has become a global concern in which the attention is given to prepare safe and healthy food to avoid foodborne disease outbreak (Wilcock et al., 2004). The concern of discussion here is whether food is grown, packed, transferred, stored and prepared safely as well as in a right way before we eat or not. In this case, it is important to relate the practice of using waste and wastewater for food production and the issue of safe and healthy local food journey.

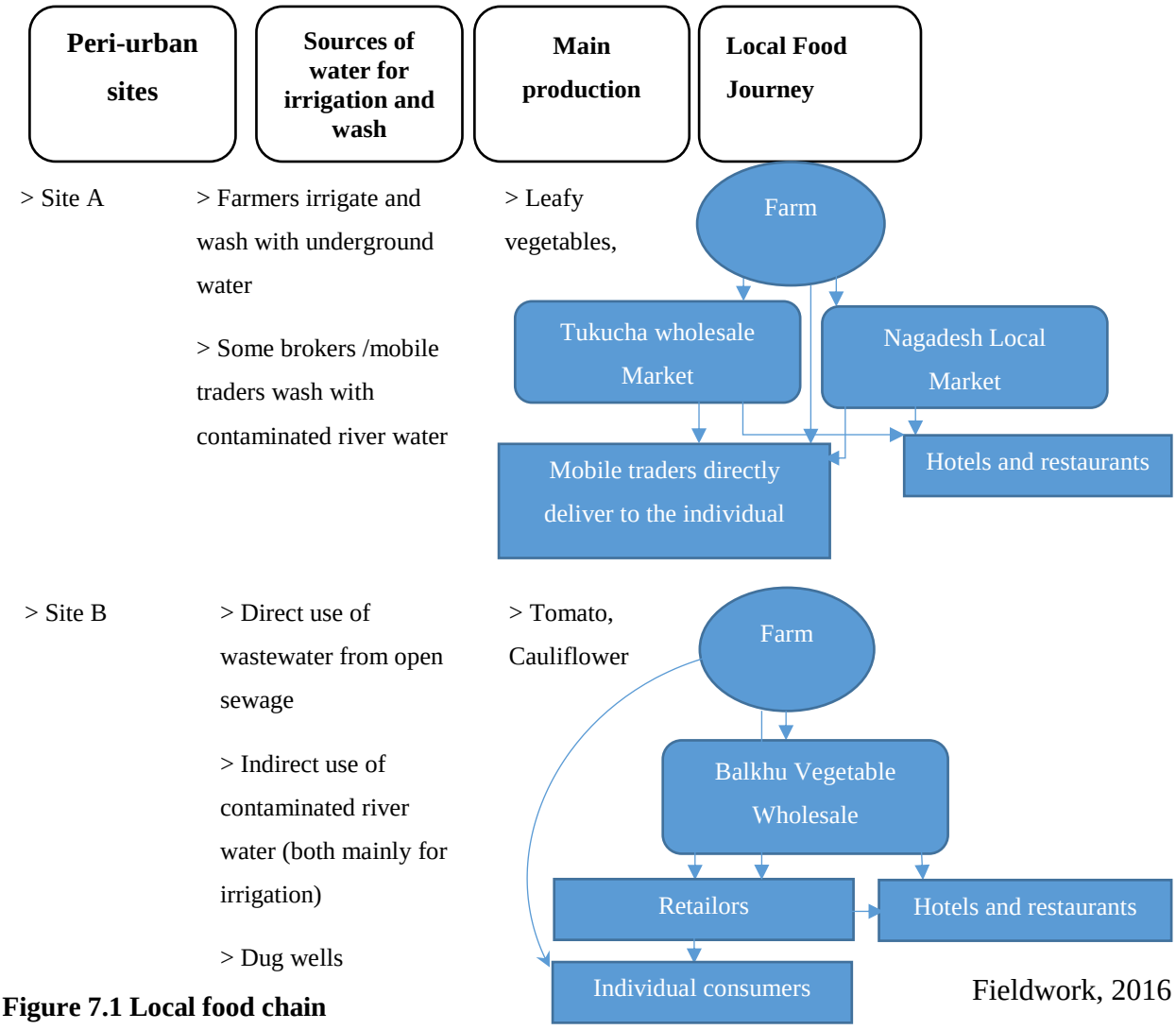


Figure 7.1 Local food chain

Figure 7.1 demonstrates the general ideas about how food is produced and reached to the consumers in two peri-urban study sites of Kathmandu valley. In site A, the leafy vegetables and carrot are delivered to the consumers through three channels. From this site, some amount of vegetable goes to the Tukucha wholesale market, which is in the core city.

Farmers mainly sell their products in the Nagadesh local market, which is close to the farm site. The mobile traders/vegetable brokers deliver themselves to the individual consumers (carrying in *Kharpan*). Some vegetable brokers also sell in temporary markets, which do not have specified place and permanent market infrastructure. Such kind of market open in the morning and/or evening of the day occupying some open street or pavements. In the other site, tomato and cauliflower are mainly produced. These vegetables go to the Balkhu vegetable and fruit wholesale market. From that, retailers and individual consumers buy and take to their home. In this site, some farmers also sell vegetable themselves in Kirtipur open market held in the evening time of the day.

One thing is that food is produced using waste and wastewater (either less or more) in both sites and another thing is that the journey of food is not as safe as it should be. Most of the structures of vegetable wholesale markets are not properly managed. There is no system of packaging, storing in the right temperature and regular monitoring of food quality. This lowers the quality of food that possibly poses the risks to the consumer. Visual inspection is the only one way of judging the quality of vegetable because consumers rarely get the chance to see when the vegetables would be expired. The vegetables which are sold in temporary markets (evening or morning) held in the side of the road might be contaminated more with the pollutants coming from the busy traffic street. These are the countless issues of food safety in the local food journey, which are the concerns beyond the farmers.

The responsibility of producing safe and hygienic food before reaching to market (include: cultivation, fertilization, harvest, and post-harvest) goes to the farmers. Farmers' role in food safety is important and it is essential for reducing the risks. FAO (2012b) has suggested some low-cost methods to make waste and wastewater use as safe as possible which are useful in developing countries. First, methods such as drip irrigation, furrow irrigation can be applied to reduce direct contact of wastewater with edible parts of vegetables, which minimizes the contamination in crops. Next, it is better to stop to irrigate with wastewater to the crops that are ready to be harvested. Making sedimentation ponds is another way that reduces the contamination. It helps to settle down the harmful organisms and worm's eggs at the bottom of the pond. These are some suitable options for farmers to contribute to food safety but none of the ways has been applied in the study sites except two evidences of drip irrigation in site B.

7.5 Summary

Aiming to seek an empirical association between the local practices of waste and wastewater use and the general discourses of waste and wastewater use, in this chapter I have attempted to assimilate some evidence from the real field with some documented ideas. As advocated by closed loop discourse, farmers have not expressed a positive attitude towards the practice of wastewater usages but in case of using waste as fertilizer and waste food as animal feed, the concept of closed loop discourse can be reflected. The risk of waste and wastewater is conceptualized in two separate ways under the public health risk discourse. Unmanaged urban waste and unregulated sewers are the causes of river water pollution that has created the condition to the farmer to use wastewater. The continuous increase of pollution has posed the risks to farmers and consumers that is a high-level risk. Farmers' role to normalize this kind of risk is less but local authority should take an action. The risks posed by farmer's choice of irrigating wastewater and brokers' practice of washing vegetable in it are another type of risks that can be controlled by farmers and brokers own effort but they should be given awareness and knowledge giving programs. Taking into consideration the issue of food safety, I have observed the local food journey of the study site. From the observation, it can be said that the local journey of the food itself might pose the public health risks, however, the potentials of posing risks on public health are higher in the practice of vegetable washing (WHO, 2006b). Thus, the multi-barrier approach needs to be implemented in the journey of food to make it safe. Nonetheless, the prime point of making safe food journey is a farm so that farmers' knowledge and awareness about safe use of waste and wastewater is crucial.

CHAPTER 8: CONCLUSIONS

8.1 Conclusions

Intending to assess the farmers' perception and knowledge of using waste and wastewater in two peri-urban agricultural sites of the Kathmandu valley, in this study I have analyzed the empirical data in three successive chapters. Each analytical chapter has focused on answering subsidiary questions and interlink with the chapters has been established to achieve the main study goal. I have used the concepts of waste and wastewater and its typology of usages given by Van der Hoek (2004) while dealing the existing situation of waste and wastewater use. Then I analyzed farmers' perceived benefits and perceived risks of waste and wastewater use in their farming practices. In the third analytical chapter, I endeavored to conceptualize the farmers' real practices with pre-documented discourses on waste and wastewater use in agriculture. Finally, this chapter briefly wraps up the whole study with some important concluding remarks.

The analysis of the existing situation of waste and wastewater uses in two peri-urban farming sites of Kathmandu valley revealed that farmers are notably using waste and wastewater as the inputs for farming. The polluted river water is used to irrigate their crops in both peri-urban sites; however, the practice is more common in the site 'B'. Some of the farmers in site 'B' also uses wastewater directly from open sewage which is defined as a direct pattern of wastewater use by Van der Hoek. The contaminated river water is also used to clean the dirt and plant debris of vegetable crops such as leafy green vegetables and carrot but only in site 'A'. The vegetable brokers/ mobile traders were found as the main users of such water to wash the vegetables. The organic waste produced in the household, agricultural residues and weed grasses have been found to be used to fertilize the crops but the ways of uses are found to be more effective in site 'A'. The evidence of utilizing the food waste as animal feed have been also found in both peri-urban agricultural farm sites.

Based on farmers/respondents' statements, I have assessed the perceived benefits and risks of using waste and wastewater in farming activities. Shortage of clean irrigation sources is found as a strong driver of farmers' state of mind towards the wastewater use. In addition, since most users of the wastewater did not have cognizance of fertility value, it can be realized that the farmers' decision of using wastewater is driven by necessity, not by the fertility value. In case of using household organic waste, agricultural residues, and weed

grasses, I have found a strong awareness of fertility value of such waste among the users in both sites. In this sense, the key motive of using such kind of waste is the agronomic and economic value. Reuse of food waste as animal feed is also found as an important benefactor of low-income livestock farmers mainly those who have kept pigs and ducks. It seems that this practice has offered self-employment opportunities to them. Regarding the perceived risks, it has been found that farmers of both sites were concerned about negative impacts of wastewater. Itching and skin infection, odd smelling and mosquito nuisance were responded as common health-related problems but the number of respondents is higher in site 'B'. Most farmers of site 'A' perceived the wastewater as 'dirty water' and the well water (underground) as a clean water so that they have shifted their source of irrigation from polluted river water to underground water. It is to be noted that farmers of both sites generally viewed household organic waste, agricultural residues and weed grasses and waste food favorably to be used in farming practices since they have not faced any noticeable problems.

At a conceptual level, I have endeavored to integrate empirical data with the discourses of waste and wastewater use. In the case of wastewater, the field data have not substantiated the closed loop discourse since farmers have a negative perception of wastewater. This is because none of the farmers has considered the nutrient value of wastewater and most of them have expressed undesirable impression towards it. However, the farmers' practice of using agricultural residues, weed grasses, and kitchen waste to fertilize their crops and utilization of food waste as animal feed is closer to the idea of closed loop discourse. Thus, it is concluded that the current use of wastewater in agriculture is found to be a response to handle and cope with clean water scarcity whereas the waste and waste food use is to obtain agronomic and economic values. Relating to the public health discourse, it is said that farmers are not responsible for generating urban waste and wastewater but they are facing the problems that should be taken care by the local authorities. High risks to consumers' health can be associated with washing vegetable in contaminated river water. Besides the practice of wastewater use, the unsafe local journey of food possibly poses the health risks to the public. Therefore, it is to be noted that the adoption of multi-barrier approach might be a possible way forward to reduce the public health risks. Nonetheless, the risks related to farmers health posed by farmers practice can be controlled by farmers efforts. For this, safe and low-cost options of utilizing waste and wastewater should be applied that reduce the potential contamination on food and health.

8.2 Recommendations to policymakers

The issues of waste and wastewater usages that are raised and discussed in the thesis are directly associated with existing problems of the society in which policymakers and the local government are the main responsible actors to draw the solutions. Therefore, policy recommendations serve to inform policymakers about the issues, help to explore the possible alternatives and make the best decision. Although different international organizations that are working in public health and agricultural sector such as WHO, FAO have released the various suggestions and guidelines of using waste and wastewater in agricultural practices, the case-specific recommendations might be valuable for local government and policymakers. Based on my own research I have put forward some policy recommendations.

- It is realized that the choice of using wastewater is driven by freshwater scarcity. Therefore, an immediate action needed in Kathmandu valley is to control and manage the urban sewage that are being discharged into the rivers so that the farmers those are really suffering from lack of irrigation sources might get relief.

- A high priority needs to be given to the farmers who are farming in rented land while providing governmental supports concerning to irrigation. Since they have not been able to invest in deep boreholes or dug well to use groundwater, their problem of water scarcity seems critical.

- Another fundamental action is to make aware of the waste and wastewater users about the safety measures, such as masks, protected gloves, safety shoes etc.

- As pointed out by (FAO, 2012b) simple and low-cost on-farm wastewater handling options are very relevant in this case that can save farmers from occupational health risks. For instance, storing wastewater in sedimentation ponds before using it can minimize the diseases that caused by organisms. It helps to settle down worm eggs to the bottom of the pond. Similarly, setting up drip irrigation in vegetable farm reduce the contamination since the wastewater drops directly go to roots of crops in this irrigation system.

- The fertility value of organic waste (household organic waste and farm residues) and the value of food waste as animal feed are commonly understood. However, to raise

its effectiveness and to minimize the possible health risks, training about compost making, safe handling of food waste is required to the farmers.

- The local food chain (that include: post-harvest cleaning, processing, transferring, storing) of the Kathmandu valley seems unsafe. Lack of adequate local food infrastructures such appropriate packaging, cooling, and continuous quality checking mechanism might be the major causes of making food chain unsafe. Therefore, the emergence attention needs to be given toward on these problems.

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APPENDIX I: ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
BOD	Biochemical Oxygen Demand
CBS	Central Bureau of Statistics
CEA	Controlled Environment Agriculture
DWSS	Department of Water supply and Sewerage
FAO	Food and Agriculture Organization
ICIMOD	International Centre for Integrated Mountain Development
IPCC	Intergovernmental Panel on Climate Change
NGO	Non-governmental organizations
NPR	Nepalese rupee
NWSC	Nepal Water Supply and Sanitation Cooperation
UCSF	Urban Community Support Fund
UEA	Uncontrolled Environment Agriculture
UNEP	United Nations Environment Programme
VDC	Village Development Committee
WHO	World Health Organization

APPENDIX II: GLOSSARY

Bad	seedbed
Baise rajya	a group of 22 principalities existed before of unification of Nepal
Bari	unirrigated land
Choubise rajya	a group of 24 principalities existed before of unification of Nepal
Darbar	old royal palace
Dashain	one of the biggest festival of the Hindus
Gopalas	first ruling dynasty of Kathmandu
Inar	locally made dug well to extract groundwater
Jand cut	food waste after making local alcoholic drink '*Jand'*
Karesa Bari	land located very close to the house or house yard
Khet	irrigated paddy field
Kisan Mal	a kind of organic fertilizer
Malla	ruling dynasty of Kathmandu who came to power in around 1200
Nepalbhasa	*a language spoken by Newars*
Newars	historical inhabitants of the Kathmandu valley
Rajkulo	historical and indigenous water supply canals of Kathmandu valley
Sudhha	clean or pure
Tarkari Byapari	vegetable traders

APPENDIX III

Semi-structured questionnaires used in the field

The information will be used for academic purposes and will be kept confidential

Household Head.....

Name of Site: ……. Municipality:……..

Ward no.....

Socio-Demographic Information

1. Household Composition

S.N.	Age	Sex	Education	Occupation	Migration	Remarks
1						
2						
3						
4						
5						

2. Present overview of urban and peri-urban farming system

1. What type of farming activities are you engaged in?
    a. Crop and Vegetable farming b. Livestock farming c. Other.....
2. Where is the farm located? If, outside how far is it?
    a. Within settlement b. Outside settlement (…….)
3. Does the available land size is enough for your peri-urban agriculture?
    a. Yes b. No
4. Production type
    a. Commercial b. Subsistence/only for consumption
5. Land holdings and ownership

Type	Size in ropani	Price of rent
Cultivated land		
Own land		
Rented land		

6. Crops Production

Crops	Yearly production in kg	Remarks

7. Are there any specific reasons why you grow/keep above-mentioned crops/ animals?

.....

8. What is your cropping pattern according to seasons?

……

……

9. What proportion of household food do you obtain from the farm?

None (0 – 10%) …….
Little (10 – 20% ……
Some (20 – 40%) …….
Half (40 – 60%) …….
Much (60 – 80%) …….
Most (Over 80%) ……

10. Livestock

Type	Number	Purpose

11. How much percent of total production do you sell? .....% (estimated)

12. In which market do you sell products?.....

13. What was the source of initial capital? a. Own income, b. Loan from micro-c. Finance lender d. Remittance

14. Do you receive any support from government or other institutions?

    a. Yes b. No if yes which type?.....

15. How many days in a week do you engage in farming?

……

16. Perceptions towards waste and wastewater

Statement	Agree	Don't know	Disagree
Waste and wastewater are resources for Irrigation			
Use of waste and wastewater in agriculture is a great health risk			
Growing food in the city are is not hygienic			

17. Knowledge on utilization of waste and wastewater

Statement	Agree	Don't know	Disagree
Waste and waste water should be sanitized			
Use of waste and waste water effect on food qualities			

APPENDIX IV INTERVIEW GUIDE

Waste and wastewater use: Practices, Knowledge, and Perceptions

1. What are the sources of water for irrigation? .....
2. Do you have enough irrigation facility? .....
3. Do you use wastewater/polluted river water on your farm? If yes, for which purpose do you use it? (Fertilize, irrigate washing vegetable)

   ...……
4. Do you use water from open swear in your farm? If yes, for which purpose do you use it? (Fertilize, irrigate) ...……
5. In your opinion, do you think it is useful/harmful to your crops? If it is useful, how? Or if it is harmful, what kind of harms have you identified? .....
6. What kind of health-related problems do you face while using wastewater? .....
7. What safety method do you use while using wastewater? .....
8. Do you make compost from household organic waste and use on the farm? .....
9. Do you make compost from farm residues, grasses, and weed, use in the farm? .....
10. Do you think, use of such organic waste can reduce the cost of fertilizer input?
11. What do you feed to your livestock? Do you collect food waste from hotels and restaurant?

    ……..
12. In your opinion, is it good to feed waste food to livestock health?

    .....
13. Do you think use of food waste reduces the cost of feed? .....