CAMPSITE GARBAGE, SITE SELECTION AND THEIR EFFECT ON HUMAN-WILDLIFE INTERACTIONS IN SIMIEN MOUNTAINS NATIONAL PARK, ETHIOPIA

BY

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DECLARATION

Declaration by Candidate

This thesis is my original work and has not been presented for a degree in any other University. No part of this thesis may be reproduced without prior written permission of the author and/or University of Eldoret.

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DEDICATION

This thesis is dedicated to my beloved family and friends for encouraging me throughout my studies in Kenya.

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ABSTRACT

Waste is one of the anthropogenic problems in most parts of the world's ecosystem. Likewise, waste (garbage) management is a perennial concern in SMNP, particularly in and around campsites. Currently, issues pertaining to campsite garbage, site selection and their effect on human-wildlife interactions in SMNP pose a major challenge to the management and conservation of wildlife in the park. This study was aimed at determining the current status of campsite garbage in SMNP; determining the conflicts between wildlife and campsite users; mapping suitable campsite garbage disposal sites, and assessing current and potential measures for mitigating the effects of campsite garbage on HWCs. Data were collected using questionnaires and field observation. Samples of garbage were collected, sorted and weighed to characterize it. GIS, remote sensing and multi-criteria evaluation techniques were used to collect and analyze geographical data for suitable garbage site selection. Garbage data were analyzed using ANOVA and Chi-square tests were used for socio economic data. Results showed that tourist campsites, staff residences and community lodges were the main sources of campsite garbage in SMNP. Tourist camps had the highest garbage generated (mean±SE=114.04±3.366kg), while community lodges had the least (mean±SE =18.18 ±1.068kg) generated. The daily mean garbage generated rate and compositions varied significantly ($F = 12.098$, $p < 0.001$) among the three campsites and garbage sources. Food waste had the highest (69%) composition percentage of campsite garbage, while glass had the least (1%). There was also a significant association ($\chi 2 = 73.932$, $df = 6$, $p = 0.0001$) between problematic animals and types of HWCs. Geladas and birds were the most problematic animals in SMNP. Poor waste disposal is the main cause of HWCs around campsites. Snatching food items from kitchens, tables, and people's hands were the main forms of HWC around campsites in SMNP. Garbage management practices had a significant relationship ($\chi 2 = 128.558$, $df = 12$, $p = 0.0001$) with the respondent's awareness and occupation. Slope, land use/land cover, distance from rivers, roads and buildings were listed as important criteria when selecting suitable garbage disposal sites in the park. The existing disposal sites are not suitable since they are located near buildings and surface water sources. Results further showed that 24% of the park is suitable for location of garbage disposal sites while 76% is not. In conclusion, a large quantity of garbage generated in SMNP is due to lack of environmental awareness and poor waste management practices. Campsites are the main hotspot places for human-wildlife conflicts. GIS and AHP methods were found to be the most suitable in locating sites for solid waste disposal. Awareness creation should be promoted among campsite users to have a sense of ownership of the park and engage in proper garbage management practices to reduce the quantity and effects of garbage. Finally further study on effects of campsite garbage on wild animal's health and behaviour is needed.

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LIST OF ACRONYMS

AHP	Analytical Hierarchy Process
DSS	Disposal Site Selection
EGSSAA	Environmental Guidelines for Small-Scale Activities in Africa
FAO	Food and Agriculture Organization
GIS	Geographical Information Systems
GPS	Global Position System
HWC	Human-Wildlife Conflict
WGEA	Working Group on Environmental Auditing
IUCN	International Union for Conservation of Nature
MDA	Multi-criteria Decision Analysis
SMCE	Spatial Multi-criteria Evaluation
SMNP	Simien Mountains National Park
SMNPGDP	Simien Mountains National Park General Management Plan
SPSS	Statistical Package for Social Sciences
SRTM	Shuttle Radar Topographic Mission
SWM	Solid Waste Management
UMGRP	University of Michigan Gelada Research Project
UNEP	United Nations Environmental Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
WHC	World Heritage Center

OPERATIONAL DEFINITTION OF TERMS

Campsite: a place usually away from urban areas where tents or simple buildings (such as cabins) are erected for shelter or for temporary residence (as for laborers, visitors, or vacationers. Downloaded from https://www.merriam-webster.com/dictionary/camp

Community lodge is a type of lodge which is owned by the ecotourism associations from local communities in SMNP.

Disposal: The discharge, deposit, dumping, spilling, leaking or placing of any solid waste into or in any land (UNEP, 2005).

Disposal site: A site where solid waste is finally discharged and deposited (UNEP, 2005).

Food wastes: are the organic residues, include uneaten portions of meals and trimmings from food preparation activities in kitchens, restaurants and cafeterias (UNEP, 2013).

Garbage: are wastes resulting from the growing, handling, processing, cooking and consumption of food and other materials.

Outpost or staff residence is a residence of staff members like rangers or scouts who are working in the SMNP.

Solid Waste; is the term used to describe non-liquid waste material arising from domestic, trade, commercial, agricultural and industrial activities, and from public services (Zerbock, 2003).

Waste; is a combination of various heterogeneous discarded materials. It is commonly known as garbage, refuse, rubbish or trash (Zerbock, 2003).

Waste sources: Agricultural, residential, commercial and industrial facilities, open areas and treatment plants where solid wastes are generated (Tchobanoglous *et al*, 1993).

CHAPTER ONE

INTRODUCTION

1.1 Background information

Over the past decades, transformation of landscapes, including habitat loss and alteration, has become the primary threat to biodiversity (Commission for Environmental Cooperation, 2001). Waste is one of the anthropogenic problems in most parts of the world's ecosystems (Khan, 2004). Waste was an early problem of mankind, and a growing one that is of major concern to every nation of the world (Allende, 2009). Every year, an estimated 1.3 billion tones of solid waste is collected worldwide and this figure is expected to increase to 2.2 billion tones by 2025, with almost all of the increase originating from developing countries (UNEP, 2013). An investigation into waste management is now becoming increasingly critical for these developing countries (Kyessi and Mwakalinga, 2009).

Thousands of tons of solid waste are generated daily in Africa. Most of it ends up in open dumps and wetlands. Throughout most of sub-Saharan Africa solid waste generation exceeds collection capacity (EGSSAA, 2009). Giessen (2011) stated that in various regions within Africa, severe pollution-related problems exist. These problems are generally caused by poor waste management. Public places, such as markets, recreation areas, and roadsides, are crowded with huge piles of waste. This is caused, amongst other factors, by inadequate facilities for disposal of solid waste in the areas.

In developing countries like Ethiopia, the forgoing problem is exacerbated by an influx of people moving to public centers (Montgomery, 2008). As in most developing nations, waste management in Ethiopia is an intractable problem. This problem also occurs in many national parks in the country. Visible human waste in national parks is problematic for at least two reasons – first, it detracts the tourist experience (reducing the number of visitors and income that the country depends upon), and second, it has the potential to harm the wildlife and the environment, which can exacerbate the reduction in number of tourists. Ethiopia has a number of protected areas among them national parks and sanctuaries that focus on the conservation of wild animals. These protected areas however, suffer many problems and waste is one of the common problems.

The Simien Mountains National Park (SMNP) is one of the oldest and best known national parks in Ethiopia. Like as with many national parks across Africa garbage management in SMNP is also a perennial concern, particularly in high-use camping sites where wildlife come into contact with humans is the most. The garbage disposal problem is especially salient in the high-mountain environment of the SMNP where because of the cold climate and low temperature, decomposition of waste material is a slow process. For this reason, even larger amounts of garbage remains in and around campsites have been observed for extended periods of time (Sunlu, 2003; Marion, 2003).

According to Lilieholm *et al.* (1998), improper waste management, food refuse, and the feeding of animals by campsite users are the primary causes of human-wildlife conflicts in protected areas. Careless dumping of human garbage in the open areas provides easy

food for the monkeys and other wild animals, which resulted in their frequent visit to the campsite premises (Fenta, 2014). Hence, poor waste disposal practices around campsites could exacerbate conflicts between campsite users and wild animals and also threaten wildlife resources as a whole.

1.2 Problem statement

The Simien Mountains National Park (SMNP) is home to critically endangered and protected species of the Ethiopian wolf (*Canis Simiensis*), Walia ibex (*Capra walie*), and the gelada monkey (*Theropithecus gelada*). It is also home to a number of other endemic fauna and flora (SMNP-GMP, 2009). SMNP has international significance due to its biodiversity, its high number of endemic species, and its outstanding bio-physical features. At present, however, the area is under heavy human pressure (Hurni and Ludi, 2000). Because of this human pressure and related problems, the World Heritage Committee designated the Park area on the List of World Heritage sites in Danger in 1996 (WHC, 2010).

To alleviate the challenges faced by human pressure, the government and the people have carried out different conservation measures; SMNP has continued to be subjected to various human induced problems among them human garbage. Despite this, the problem of human garbage has not been given much emphasis by concerned bodies, even though the threat is increasing. In Ethiopia many research works and projects regarding waste and related problems have been undertaken mainly in urban areas. Meanwhile wildlife areas are challenged by the same problems. And the campsites in the SMNP are some of these areas. In the SMNP, tourist campsites, community lodges, and ranger posts are all

situated in the same areas, causing campsite users (tourists and tourist service providers), lodge workers, and residential staff members live/stay together in a crowded manner in and around campsites, particularly during peak tourist seasons. Hence, currently significant numbers of people reside within and around campsites. Due to this situation, the generation rate of garbage at the campsite is growing rapidly and currently most of this garbage is disposed off in an inappropriate way.

Past studies conducted to assess the garbage situation and its effects on campsites and their surrounding areas are scarce and our understanding about the problem of garbage in protected areas, in general and SMNP in particular is very limited. Hence future understanding and knowledge on the current status of garbage management and the problems faced as well as the mitigation to be taken can be enhanced if this study is done with a view of designing better ways of garbage management in the campsites of SMNP. It is envisaged that this can be achieved if up-to-date information on the existing situation of garbage and its effects on human-wildlife conflicts in the park is availed through research. Currently, information on the current situation of garbage and its effects on human-wildlife conflicts around campsites in SMNP remain unknown and this situation is a major hindrance on how to manage wildlife in the study area.

1.3 Objectives of the study

1.3.1 General objective

To assess the status of campsite garbage, site selection and their effect on human-wildlife interactions in SMNP and provide information for sound planning and informed decision making on appropriate measures for sustainable wildlife management.

1.3.2 Specific objectives

1. To determine the sources, generation rate and composition of campsite garbage in SMNP.

2. To determine the conflicts arising from interactions between wildlife and campsite users in SMNP.

3. To map suitable campsite garbage disposal sites for appropriate wildlife management and planning in SMNP.

4. To Assess current and potential measures for mitigating effects of campsite garbage disposal in SMNP.

1.4 Research questions

1. What is the current status (sources, quantities, and composition) of garbage generated and disposed by campsites in Simien Mountains National Park?

2. What are the suitable criteria for selection of sites for campsite garbage in SMNP?

3. Are current campsite garbage sites located in suitable places or should they be shifted?

4. What measures are currently implemented to mitigate garbage disposal problems and HWC around campsites in SMNP?

5. What other potential measures can be implemented to mitigate garbage disposal problems and HWC around campsites in SMNP?

1.5 Hypotheses of the study

Ho_1: There is no significant difference in garbage generation rate and composition between campsites.

Ho_2: There is no significant difference in garbage generation rate and composition between garbage sources.

Ho_3: There are no major significant conflicts between campsite users and wild animals in SMNP

1.6 Justification and significance of the study

The SMNP is of global significance for biodiversity conservation because it is home to globally threatened species (WHC, 2010) and also has high economic value for the country through tourism development. Despite this, these spectacular landscapes and endangered wild animal species found in the park are being spoiled and threatened by improper garbage disposal around campsites (UMGRP, 2015).

Currently, human waste management problems are a growing public concern in many parts of Ethiopia including protected areas/ wildlife habitats like SMNP. Although human wastes in national parks have highly threatened wildlife species, most of the studies regarding wildlife and habitats undertaken by different researchers have focused on other problems. In order to successfully conserve biodiversity, it is necessary to mainstream biodiversity conservation in every aspect of human activities including waste management at campsite levels. As Friend *et al.* (2001) noted if the problems are not alleviated in a timely fashion, they can affect other wildlife conservation efforts.

To develop successful waste management strategies, baseline information is very important (Gidarakos *et al*., 2005; Kimani, 2007).Therefore, this study will provide

baseline information on the current situation of campsites garbage and its effects on human-wildlife in the study area. Findings of this study will help the park management, tourist service providers, campsite users, and other stakeholders to reflect on their contributions with regard to their role in wildlife conservation activities and how to reduce impacts. Findings of this study will also help in providing baseline information for future studies on the same or related issues and management interventions.

1.7 Scope of the study

Though there are other campsites around SMNP, because of time and financial constraints, this study was restricted to only three campsites namely Sankaber, Chenek and Gich that are located inside the park. These campsites are used for tourist purposes and location of staff residences and community lodges and are the most heavily impacted on by garbage generated from the three campsites. Additionally respondents interviewed were considered a representative of the local community and other stakeholders living in and around the park.

CHAPTER TWO

LITERATURE REVIEW

2.1 Characteristics of waste; waste sources, generation, and compositions

2.1.1 Characteristics of solid waste

Waste is a wide ranging term encompassing most unwanted materials. Many scholars have defined solid wastes in different ways, including the sources, composition and effects. According to Ajibuah and Terdoo (2013) waste is anything which people decide to or is required to be disposed off. It includes all items that people no longer have any use for and which they either intend to get rid of or have already discarded. Wastes are items which people are required to discard.

Ludwig *et al.* (2003) define waste as any unavoidable material resulting from domestic activity or industrial operations for which there is no economic demand and which must be disposed off. According to Kahl Consulting (2007) solid waste also commonly known as litter, trash, garbage, or refuse, is defined as durable goods, non-durable goods, containers and packaging, food wastes, yard wastes, and miscellaneous inorganic wastes from residential areas, commercial and institutional operations, and public areas.

According to Mantell (1975) solid wastes are those materials that result from man's activities and are not in the form of liquid or gas but are compacted and substantial substances which are thrown away for the fact that they are no longer in use, these materials are both organic and inorganic in form and differ in shapes, sizes, forms and compositions.

Generally, the term “solid waste” is used to describe an entire waste stream including all materials that will eventually be disposed in landfills or other facilities, as well as all materials which will be separated and recovered for reuse, recycling, or composting. Solid waste predominantly, is any garbage, refuse or rubbish that we make in our homes and other places. So according to the above definitions most of the garbage generated in campsites of national parks are referred to as solid wastes.

Solid waste generation rates and composition vary from country to country depending on the economic situation, industrial structure, waste management regulations and life styles. The availability and quality of data on solid waste generation as well as subsequent treatment also vary significantly from country to country (Pipatti *et al.,* 2006). Hence this study set out to assess waste generation and disposal in Ethiopia using SMNP as a case study.

2.1.2 Sources and generation rate of solid waste

Tchobanoglous *et al.* (1993) classified types of solid waste in relation to sources and generation facilities. According to the World Bank (1999) there are eight major classifications of solid waste generators: residential, industrial, commercial, institutional, construction and demolition, municipal services and agricultural. Hence, solid waste includes wastes generated from residential, commercial, industrial, institutional, construction, demolition, and municipal services.

Waste generation rates are affected by socio-economic development, degree of industrialization, and climate. Generally, the greater the economic prosperity and the higher percentage of urban population, the greater the amount of solid waste produced

(World Bank, 1999). The current waste generation rate of low income countries ranges between 0.4 to 0.9 kg per capita per day, whereas the high income countries show the greatest generation rates, which vary from 1.1 to 5.07 kg per capita per day (World Bank, 1999).

Thousands of tons of solid waste are generated daily in Africa. Most of this ends up in open dumps and wetlands, contaminating surface and ground water and posing major health hazards. Throughout most of sub-Saharan Africa solid waste generation exceeds collection capacity (EGSSAA, 2009). Waste generation in sub-Saharan Africa is approximately 62 million tons per year. Per capita waste generation is generally low in this region, but spans a wide range, from 0.09 to 3.0 kg per person per day, with an average of 0.65 kg/capita/day. High-income countries produce the most waste per capita, while low income countries produce the least solid waste per capita. Although the total waste generation for lower middle-income countries like Juba, in south Sudan is higher than that of upper middle income countries such as Thailand, the countries with the highest per capita rates are tourist destination areas, and this is likely due to waste generated by the tourism industry, giving a more complete accounting of all wastes generated (UNEP[2], 2013).

According to World Bank (2004) per capita amount of waste generated in Ethiopia ranged from 0.17 to 0.48 kg/capita/day for urban areas to about 0.11 to 0.35 kg/capita/day for rural areas. This range depends on several factors such as income and season. The total generation of municipal solid waste in Ethiopia in 2003 is estimated to be 2.8 to 8.8

million tones. This can be split to approximately 0.6 to 1.8 million tons from rural areas and 2.2 to 7 million tons from urban areas (World Bank, 2004).

According to other studies among them Afua (2015) it was noted that currently high amounts of solid waste produced per day are uncollected and dumped in unauthorized areas such as open fields, ditches, sewers, streets and many other available spaces in the urban and rural areas. Uncollected garbage is a serious environmental hazard for all, especially in areas where roads are not accessible to enable collection.

Solid waste streams should be characterized by their sources, types of wastes produced, as well as by generation rates and composition. Accurate information in these three areas is necessary in order to monitor and control existing waste management systems and to make regulatory, financial, and institutional decisions (World Bank, 1999). Knowledge of the sources and types of waste in an area is required in order to design and operate appropriate solid waste management systems.

2.1.3 Solid waste composition

Solid waste consists of many different materials some of which are combustible, non-combustible, recyclable, non-recyclable, biodegradable, and non-biodegradable. Essentially, a detailed documentation of the composition of solid waste will specify the management methods to be employed (Zerbock, 2003). The combustible materials that may be included in a waste stream include paper, plastics, yard debris, food waste, wood, textiles, disposable diapers, and other organics and the non-combustibles materials also include glass, metal, bones, leather and aluminum (Kreith, 1994 and Zerbock, 2003).

Generally, all low and middle income countries have a high percentage of compostable organic matter in the urban waste stream, ranging from 40 to 85 percent of the total (Zerbock, 2003).

Gupta *et al*. (1998) argue that the composition of waste depends on diverse factors among them food habits, cultural traditions, lifestyles, and climate and income. The variations are due to factors found across different countries as well as across different regions within one country. Waste composition is also influenced by external factors, such as geographical location, the population's standard of living, energy source, and weather. Although the definitions and methodologies for determining composition of waste were rarely discussed in waste studies, the compositions for municipal solid waste are assumed to be based on weight (World Bank, 1999).

In general, the composition of generated waste is extremely variable and is a consequence of seasonal, lifestyle, demographic, geographic, and legislation impacts. This variability makes defining and measuring the composition of waste more difficult and at the same time more essential (Gidarakos *et al*.., 2005).

2.2 Solid waste management practices

Solid waste management includes collection and disposal of garbage, as well as practices that reduce the amount of garbage disposed, such as source reduction, reuse, recycling, and composting (Kahl Consulting, 2007). Human waste management refers to the collection, transportation, processing, and disposal of human wastes (Pellikan and Robert, 2002). The World Bank (1999) states that waste management simply means the

collection, transport, processing or disposal, managing and monitoring of waste materials to minimize its consequences on humans and environment. There are several methods of managing the various types of waste. Some of these methods however cause additional harm to the environment, but not doing anything is not an option.

Every stage of waste handling should be addressed, from collection and transportation to disposal. Waste deposit systems that restrict wildlife access to garbage and good standards of waste management are important to avoid attracting wild animals to human settlements and to prevent wild populations from proliferating and becoming artificially sustained by the availability of human foods (Lamarque *et al.*, 2009). Despite this, most of the waste in Africa is disposed of in environmentally unsound open or controlled dumps.

Waste management methods cannot be uniform across regions and sectors because individual waste management methods cannot deal with all potential waste materials in a sustainable manner (Staniškis, 2005). Conditions vary; just as there is no individual waste management method which is suitable for processing all waste in a sustainable manner. According to Staniškis (2005) waste management is carried out by a number of processes, many of which are closely interrelated and therefore it is logical to design holistic waste management systems, rather than alternative and competing options. Although the differences in waste management strategies and definitions of waste are significantly different between countries, waste management remains to be a prominent issue with common methods of achieving certain goals and objectives (Sakai *et al.*, 1996). Proper waste management can be costly in terms of time and resources and so it is

important to understand what options exist for managing waste in an effective, safe and sustainable manner (El-Haggar, 2007).

According to various studies among them UNEP[1] (2013), the three Rs which are commonly used terms in waste management hierarchy stand for "reduce, reuse, and recycle". As waste generation rates have risen, processing costs increased, and available landfill space decreased, the three 'Rs' have become a central tenet in sustainable waste management efforts (Seadon, 2006; Suttibak and Nitivattananon, 2008). Despite this, human waste management is a growing public concern in many parts of Ethiopia and other countries including protected areas/ wildlife habitats.

2.3 Contribution of garbage to HWCs around campsites

The main cause of human-wildlife conflict (HWC) worldwide is the competition between growing human populations and wildlife over the same declining living spaces and resources (Lamarque *et al.,* 2009). Another consequence of the opening of new lands and villages into areas that were once private wildlife refuges is the creation of new bush paths between these settlements. This generates a greater traffic of pedestrians, increasing the risk of contact with wild animals. Conflict between people and wildlife today undoubtedly ranks among the main threats to conservation in Africa (Muruthi, 2005).

According to Lamarque *et al.* (2009) baboons raid gardens and food in lodges and camping areas and can cause an immense nuisance in small urban settlements if left unchecked. On the Zimbabwean side of the Zambezi valley, baboons are a major menace in bush camps and small towns such as Chirundu and Victoria Falls, and in wildlife

camps and lodges where they are not actively controlled. They pull thatch from grass thatched roofed buildings and intimidate wide-eyed tourists in order to steal food directly from the tables they occupy (Gaynor, 2000; Kansky, 2002). The improper disposal of wastes also accounts for the prevailing human-monkey conflict in SMNP. Careless dumping of kitchen wastes and garbage in open areas provides easy food for monkeys and this has resulted in their frequent visits to the camp premises (Fenta, 2014).

While wild animals use campsite garbage, conflict may occur between campsite users and wild animals. Human infringement upon or presence in wildlife habitat may lead to wildlife harassment, in terms of conflict. As with user interactions with wildlife, there are also numerous problems associated with wildlife interactions with users. These usually attract the most attention as they incur economic costs. Such problems include the spread of disease, attacks on humans or their pets, or damage to private property (Seymour *et al*, 2006). Damage to private property caused by problematic wild animals is a vexing management issue. Wildlife, through behaviors such as foraging, nesting, and denning, harm or destroy private property. In general, poor waste disposal practices around campsites lead to exacerbated conflicts between campsite users and wild animals through increasing frequency of people and wild animal's interactions. Based on human-wildlife-garbage conflict information, this study set out to assess if garbage disposal around campsites has contributed to HWC in the park.

2.4 Factors that determine garbage disposal site selection

Waste disposal site selection is one of the major problems of waste management activities (Sener *et al.*, 2011). The disposal site must not damage the biophysical

environment and ecology of the surrounding area. There are also economic factors and geomorphologic features that must be considered during site selection for solid wastes. Several techniques have been used for selection of solid waste disposal site in literature. Site selection procedures can benefit from the appropriate use of GIS (Sener *et al.,* 2006).

Multi-criteria evaluation (MCE) is used to deal with difficulties that decision makers encounter in handling large amounts of complex information. The principle of the method is to divide decision problems into more smaller understandable parts, analyze each part separately, and then integrate the parts in a logical manner (Malczewski, 1997). The integration of GIS and MCE is a powerful tool to solve the landfill site selection problem because GIS provide efficient manipulation and presentation of the data and MCE supplies consistent ranking of the potential landfill areas based on a variety of criteria (Sener *et al.,* 2006). To determine the most proper disposal site for a region, many criteria should be considered. The multiple criteria decision analysis (MDA) is the most widely used method for site selection process. The main objective of MDA is to help the design of mathematical tools to support the subjective evaluation of a finite number of decision alternatives under a finite number of criteria in order to find the best choice (Sener *et al.,* 2011)

GIS combines spatial data shown on maps, aerial photographs, and satellite images with quantitative, qualitative and descriptive information (Kontos *et al.,* 2005). The overall GIS supported landfill site selection process contains two primary screening steps: (i) exclusion of areas unsuitable for landfill, also shown as the prescreening step or GIS step, and (ii) weighting (ranking) of remaining areas, also described as decision analyses step (Siddiqui *et al.,* 1996).

According to Sharifi and Retsios (2004), the site selection process is carried out in two phases: in phase one, spatial multiple criteria evaluation (SMCE) is applied in order to identify (design) potential areas, which are biophysically suitable for waste disposal. In the next phase, SMCE is applied to compare/evaluate potential sites considering their socio- economic and biophysical characteristics in order to make the final recommendation (choice of a solution). The socio- economic characteristics reflect the impact of a site on several spatial (and sometimes non-spatial) aspects. They can only be assessed for a potential site, which is why they cannot be used as a criterion in the design phase. In the choice phase of the site selection process, the suitability of each site, which is identified as a potential site in the first phase, will be assessed by means of SMCE, considering socio-economic factors (Sharifi and Retsios, 2004).

There are many criteria that are considered when selecting a landfill site based on a study area. The most common are environmental criteria, distance from settlements, distance from surface waters, distance from protected areas (ecologic, scientific or historic), geology/hydrogeology, land use/land cover, distance from roads, and slope. Each criterion is explained below in details.

2.4.1 Environmental criteria

Environmental selection criteria consider the ecological value of flora and fauna. The direct and indirect spatial use of a disposal site will destroy the actual vegetation and fauna. When making a decision, the ecological value of the actual vegetation and fauna should be evaluated carefully for the potential area. Ecological value is based on

diversity, naturalness and characteristic features (Fidèle, 2013). For example, Sener *et al*. (2011) used these ecological criteria for Lake Beysehir Catchment area, Konya, Turkey.

2.4.2 Distance from buildings

A new waste disposal site should not be located within a distance of a building area because of the dust and odour emissions. Depending on the local wind direction and speed, the safe distance necessary to locate disposal site should be determined to prevent sensing dust and odour (Hasan *et al.,* 2009). Many literatures among them, Sener *et al.* (2006) southwest of Ankara, Turkey considered it as one of the criteria in his study.

2.4.3 Distance from roads

Factors for the access of the disposal site depend on the condition and the presence of roads close to the site. If reconstruction of actual roads is needed, the costs will increase. Because of this road network is an important factor to locate the disposal site (Sener *et al*., 2011), he suggested that road network should be considered for landfill site selection criteria.

2.4.4 Hydrology criteria

The disposal site should not be placed within surface water or water resources protection areas to protect surface water from contamination by leachate (UNEP, 2005). Safe distances from meandering and non-meandering rivers should be made to prevent waste from eroding into rivers and major streams (Akbari, 2008). For example Hasan *et al*. (2009) applied in Dhaka, Bangladesh.

2.4.5 Topographical criteria

The topography of an area is an important factor on site selection, structural integrity, and the flow of fluids surrounding the disposal site because it has important implications for landfill capacity, drainage, ultimate land use, surface and groundwater pollution control, site access and related operations (Wilson, 1977). Deciding the type of landfill design (area, trench, and depression) is directly related to the topography of a site. The study by Sener *et al.* (2011) at Beysehir Lake Catchment area, Konya, Turkey considered topography, land use and land cover as an important criteria.

2.5 Measures for mitigating the effects of garbage disposal

The campsite users worldwide generate large quantities of solid waste beyond the management capabilities of the existing waste management system in the area (Posch, 2013). To mitigate the garbage disposal problems, during the last few years many good actions have been initiated by the park management among them employing permanent janitors for each campsite, preparing garbage pits and placing various types of rubbish bins around the campsite. According to SMNP (2015) office report the park management provides waste management services in SMNP with those employed janitors though unable to address the whole area properly.

According to Posch (2013) supervision of returned waste from expedition groups, the management of several clean-up campaigns, the construction of waste pits, the placement of rubbish bins along trekking routes, the employment of staff, the environmental education of youth, the publication of booklets and brochures, and the creation of tourist information centers are consistent activities of protected areas management.

The cleaning of campsites is carried out every day especially on the busiest day since the users generate garbage much higher than the usual day. The solid wastes generated within the campsite by users were stored in different containers including medium and small trash bins, trash sacks, and plastic bag among others. SMNP has also implemented various garbage disposal mechanisms around the campsites. Currently in SMNP, solid wastes are disposed from campsites by burning, burying, and dumping in garbage pits. Methods of solid waste management vary greatly with types of wastes and local conditions (UNEP[1], 2013). Like other protected areas, the existing garbage disposal mechanisms in SMNP are not enough to solve the problems that are faced. According to the World Bank (2004) waste management in most developing economies and countries involves overburdened waste collection services, and inadequately managed or even uncontrolled dumpsites where waste catches fire and burns. These problems are worsening most rapidly in low-income countries.

From the forgoing discussion, the current traditional approaches to solve waste management problems have proved to be ineffective and non-sustainable. Hence a new technical involvement and concerted efforts are needed for proper and scientific waste management programmes, such as selecting suitable garbage sites based on GIS methods.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study area

3.1.1 Location

Simien Mountains National Park (SMNP) was one of the first established national parks in Ethiopia, and is located in the North Gondar Zone of the Amhara Regional State, northwestern Ethiopia about 886 km from the capital Addis Ababa. According to SMNP-GMP (2009), the current Simien Mountains National park extends from $37^0$51'26.36"E to $38^0$29’27.59’’E longitude and from $13^0$6'44.09 " N to $13^0$23'07.85" N latitude at an altitude of between 1900m to 4300m *absl*. The total area of the park is about 412 km2 (Figure 3.1). SMNP was established in 1966 and gazetted in 1969 for its spectacular landscape, unique scenery and endemic wildlife species. The park was inscribed and listed as one of the World Heritage sites by UNESCO in 1978, making it the first natural World Heritage Site inscribed in Ethiopia (Debonnet *et al*., 2006). The park is surrounded by five districts (Woredas), namely, Janamora, Beyeda, Debark, Telemt, and Adi-Arkay, and borders 38 Kebeles (the smallest administrative units) of these Woredas (SMNP-GMP, 2009).

Because SMNP is such an important tourist attraction and destination site in Ethiopia, the accommodations and facilities within the park such as, community lodges and tourist campsites have increased inside the park thus posing a danger to the park and its wildlife particularly through poor garbage disposal.

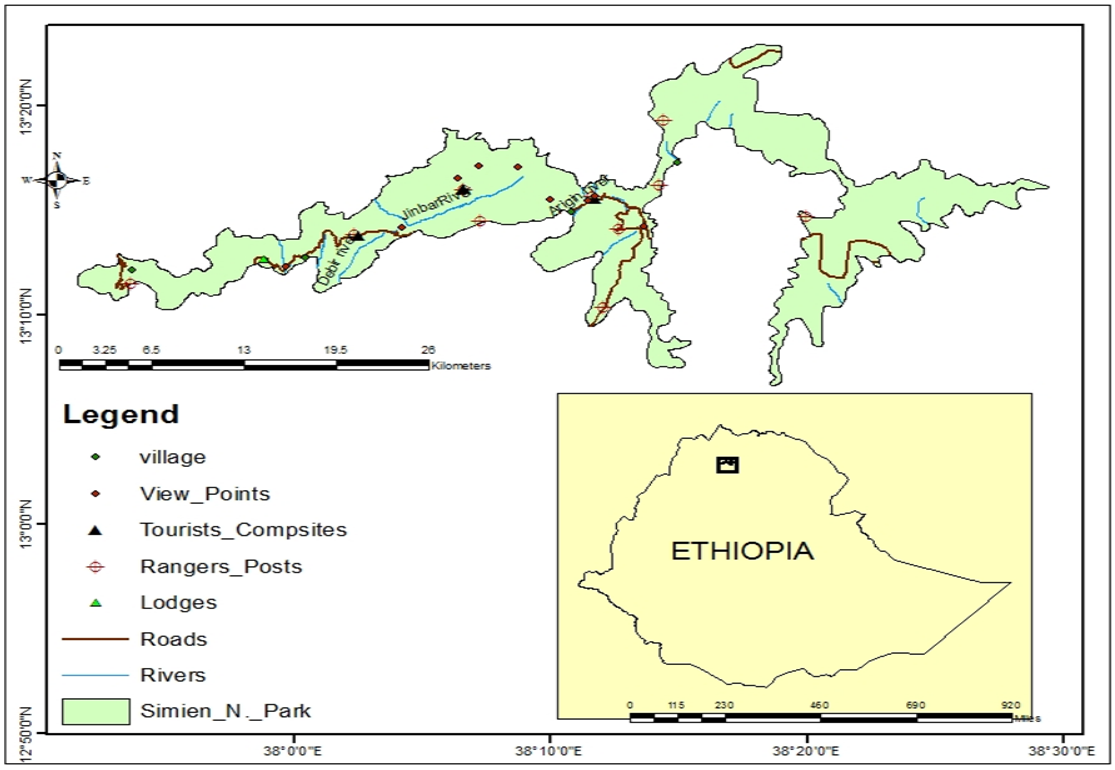

Figure 3.1: Location of the study area in Ethiopia

3.1.2 Climate

Simien Mountains have a wide range of altitudes and aspects making local climatic conditions quite variable. Temperatures are relatively uniform throughout the year but there is a high diurnal variation ranging from a minimum of -2.4-4.0°C at night to a maximum of 11.0-18.0°C during the day (Puff and Sileshi, 2005). The rainfall pattern is characterized by a single rainy season, whereby the highest amount of precipitation is between June and September with a mean annual rainfall ranges between 1350 - 1550mm and varies with altitudes (Hurni and Ludi, 2000).

3.1.3 Flora and fauna

There are three main vegetation zones in SMNP (SMNP- GMP, 2009); Montane forest (1,900 to 3,000m), Ericaceous belt (Sub-Afroalpine) (2,700 - 3,700m) and finally the Afroalpine zone (3,700 - 4,533m). The mountains are part of the Afro-alpine Centre of Plant Diversity, and form part of the Eastern Afromontane biodiversity hotspot with numerous endemic plant and animal species. There are over 1,200 species of plant in SMNP, of which three are found only in the Simien Mountains: *Festuca gilbertiana, Rosularia Simiensis* and *Dianthus longiglumi.* The vegetation of the park consists mainly of *Erica arborea, Lobelia rhynchopetallum, Hypericumrevolutum, Helichrysum* spp., *Rosa abyssinica* and *Solanum* spp. (Hurni, 1998).

The Simien Mountains are home to 21 large and seven small mammals that have been recorded in the Simien (UNESCO, 2001), including Walia ibex (*capra ibex walie*), which is a wild goat found nowhere else in the world, the Ethiopian wolf (*Canis Simiensis*), and Gelada monkey (*Theropithecus gelada*), though currently most are endangered due to habitat alteration caused by human impacts (agriculture, animal grazing, etc.

Since the SMNP is part of Central Ethiopian Highlands, which lies within one of the World's Endemic Bird Areas (Stattersfield *et al.,* 1998). There are more than 150 species of birds, about 10% of which are endemic to Ethiopia (Fishpool and Evans, 2001). The most spectacular and easily seen birds in the uplands are the Lammergeier (*Gypaetus barbatus*) and the endemic Thick-billed Raven (*Corvus crassirostris*).

3.1.4 Hydrology

The Simien Mountains are important not just for biodiversity, but also as a water catchment area. Several rivers rise in SMNP and form tributaries of Tekeze River, which provides a source of water for millions of users downstream in Ethiopia as well as Sudan and Egypt (SMNP-GMP, 2009). Most rivers in this area flow only after the rainy season, therefore the rivers that rise in SMNP have an important role in maintaining perennial river flow. Thus, conservation and management of this water catchment will maintain vital ecosystem processes that also contribute to ensuring food and livelihood security of the population residing in the catchment areas and beyond.

3.1.5 Geology and topography

The Simien Mountains are characterized by huge gorges and gullies, both of which carve out steep and jagged cliffs. The extreme escarpment in Simien appears to be a precondition for the formation of the extended uplift of the whole mountain massif 75 million years ago. Subsequently, extensive erosion (including the glaciations) of the basaltic layer for a millennia led to the formation of escarpments with its precipitous cliffs, deep gorges and the jagged mountain peaks that make up the spectacular landscape of Simien Mountains (Last, 2009). The dramatic views are due to this volcanic activity. This resulted in SMNP's steep escarpment extending in a southwest to northeast direction between 2,000 and 4,000 m *absl* (SMNP-GMP, 2009). The Simien was made up of thick basalt deposited on Mesozoic sandstone and limestone, Precambrian crystalline basement, and harder rocks on the foot of the escarpment (Hurni, 1998).

3.1.6 Socio-economic characteristics

The park is surrounded by smallholder agrarian communities residing in 38 kebeles (the smallest administrative unit), within six administrative Woredas (districts). Mixed farming dominates the highlands, with crop and livestock farming practiced in the same management unit (Bishaw, 2001). The production system is mainly rain fed, subsistence based and small holder oriented. The number of people living in the Park was estimated at 11,000, while the 1996 World Heritage Commission mission estimated that 4,500 people resided inside the park with another 30,000 living in the immediate vicinity that were dependent on its natural resources (SMNP-GMP, 2009).

Most of the population engages in subsistence farming, and the demand for natural products and land for farming is huge. Hence looking for benefit from the park revenue is expected by the local people. In SMNP, many people organized in different ecotourism activities like, guide, cook, mule rider, etc., which are involved as tourist service providers. According to SMNP office (2015) report more than 6000 people directly engaged and benefited from the parks through ecotourism activities.

3.2 Materials and equipment

During data collection, different materials were used such as; Plastic bags, plastic sheet, and spade were used to collect and sort sample garbage. Bucket and balance weighing scale were used to measure garbage. Gloves, nose masks, and brush were used to protect from any contamination of garbage. Garmin GPS 60 was used to measure altitude and coordinates of the study area.

3.3 Study design

The descriptive survey design was used to guide the study. This design assisted in describing various aspects of the study and to obtain qualitative and quantitative data pertaining to the existing status of garbage, human-wildlife conflict around campsites within the study area as well as soliciting for information on human experiences on various dimensions. The design guided in the collection of both quantitative and qualitative data. The descriptive survey design helped in collecting data on socio-economic characteristics of the respondents (e.g., gender, age, occupation, educational status and duration of stay in the park) and investigate solid waste generation by users and residents as well as its physical composition, and attitude of campsite users towards waste management practices in the park as well as human wildlife conflicts around campsites.

3.3.1 Target population

The target population for the study included tourist service providers such as cooks, guides, lodge workers, ecotourism associations involved in tourism who operate in and around campsites, tourists, residential staff living in the park, and park management and other stakeholders namely the tourism office and tour operators all of whom were considered as target population for this study.

3.3.2 Sample size and sampling techniques

There are three base camps in SMNP namely Chenek, Gich and Sankaber that comprise of tourist campsites, community lodges and staff residences. These three campsites were selected purposely, since they are located inside the National Park. To determine the

source of the garbage the study area was divided into three source points based on the demographic, location of the campsites, and lifestyle of the campsite users. To determine the generation rate and composition of waste all tourist campsites, staff residences and community lodges at each campsite were assessed through collecting garbage generated from each kitchen. For questionnaire survey, ninety three respondents were selected systematically from the list of tourist service provider associations who use the campsites in SMNP. According to SMNP office report (2015), the total number of target population who were directly involved in various activities in and around campsites in SMNP was 330 individuals. To determine the size and proportion of sample respondents from the target population a sample technique formula was used (Cochran, 1977), given by:

$$n = \frac{NZ^2PQ}{d^2(N-1) + Z^2PQ} \quad \text{---------- (3.1)}$$

Where;

P = Respondent unit variable (proportion of N); Q =1-P:

N =Total number of population units (330, SMNP, 2015); n = Sample size

Z =Standardized normal variable and valued that corresponds to 95% confidence interval equal to1.96; d =Allowable error (0.05)

Therefore, the result, n=93 was the sample size of the study (See Table 3.1).

Table 3.1: Distribution of target population

No.	Category of respondents	Total number	Sample size	Percentage
1	Cook	100	34	47.8
2	Guide	86	28	35.4
3	Residential staff	71	10	12.5
4	Tourist	-	8	-
5	Other stakeholders	73	13	13
	Total	330	93	28

3.4 Data collection

3.4.1 Data sources

Both primary and secondary data were collected. Primary data was collected using questionnaires and field observations, as well as garbage collection, sorting and weighing was employed to determine generation rate and composition of garbage. GIS and remote sensing techniques were used for objective three (suitable disposal site selection). Secondary data was obtained from published and unpublished sources like books, reports, journal articles, and the internet.

3.4.2 Questionnaires

Structured questionnaires were administered to 93 respondents drawn from tourist service providers, residential staff, community lodge workers and tourists visiting and/or residing around the campsites in the national park. The questionnaire was designed in English and translated and administered in Amharic (local) language with the help of translators (Appendix I). The questionnaire was used to get information relating to attitude of campsite users, park staff, tourists and tourist service providers in the campsite and surrounding areas. The aim was to assess respondents' knowledge of and views towards

the status of garbage generated, the conflict between wild animals and campsite users as well as the status of garbage management practices, and actual and potential mitigation measures put in place around the campsites in the park.

3.4.3 Field observations

Field observation was employed to help understand the existing situation and status of garbage generation and its handling practices, as well as issues of illegal dumping, waste collection and disposal site facilities in the national park. It was also employed to help understand and verify the current situation of human-wildlife conflicts in the study area. This method is important for gathering information on natural settings (Kothari, 2004). Photographs were taken during field observations to get a clear view of garbage management practices in the National Park (Appendix IV).

3.4.4 Collection, sorting and quantifying of wastes

The study area has three base camps namely Chenek, Gich, and Sankaber. Each base camp contains three waste generating sites (users of kitchens) which include the tourist campsites, staff residences and community lodges.

Waste data were obtained using direct methods which include direct collection, sorting and weighing of the solid waste collected from each campsite kitchens, where it was generated throughout the day as reported by Hamid *et al.* (2015). Before the actual collection, sorting and measurement of solid wastes commenced, a one-day pretest was carried out to ensure quality of data. Hence actual collection and sorting of wastes from

the above three waste generating sites were conducted for seven consecutive days in line with what has been documented by the Forum for Environment (2010).

Each category of waste generator was given two plastic bags (labeled with their code number) using different colours for their daily food wastes (wet waste) and other (dry) wastes storage. A black plastic bag was used for their daily food waste generation and blue for daily dry waste generation storage. All the campsite kitchen users put the plastic bags at appropriate places to collect the daily waste properly as instructed to do. The collection period was done for seven successive days to give an average result of all the days of the week, and to determine differences in waste generation between and among the days. The waste was collected each morning from the kitchens and taken to selected sites for sorting and weighting.

3.4.5 Sorting and weighing of waste

Wastes were first placed on a blue plastic sheet stretched on the floor and sorted into different types of components. After sorting the wastes in to various components, the weight of the different wastes was measured with a weighing scale. Major waste components weighed included: food wastes, paper, plastic, metals, glass, and miscellaneous wastes, ash, dirt and dust/ sweepings. The total wet weight of each waste category was determined and expressed in kilograms, and the percentage of each constituent was calculated.

The collection was done by trained collectors using daily laborers, who carried the garbage to disposal pits every day after measuring, to dispose it. There were three

enumerators at each of the waste dumping sites giving a total of nine enumerators who sorted and recorded the required data. The whole process of sorting and weighing was carried for one week. Appendix II and III shows the tools that were used to collect garbage data for the study.

3.4.6 Garbage site suitability data collection

To determine and map the suitable site for campsite garbage sites, Garbage Site Suitability (GSS) data was collected in the study area using GIS/ remote sensing survey and Multi-criteria Decision Analysis (MDA) method (Sener *et al.*, 2011), and/ or a spatial multiple criteria evaluation (SMCE) method (Sharifi and Retsios, 2004). The satellite image was downloaded from land sat 8 satellite image using ArcGIS10.2 software. The suitability criteria were identified based on the biophysical characteristics of the study area (Sharifi and Retsios, 2004; Sener *et al.*, 2011).

Global Information System (GIS) combines spatial data (maps, aerial photographs, satellite images) with quantitative, qualitative and descriptive information databases (Kontos *et al*., 2005). The integration of GIS and Multi-criteria Decision Analysis (MDA) is a powerful tool to solve the landfill site selection problem, because GIS provides efficient manipulation and presentation of the data and MDA supplies consistent ranking of the potential landfill areas based on a variety of criteria (Sener *et al*., 2006). To identify the potential sites a number of techniques (direct and pair wise comparison) were used to evaluate the suitable criteria and ranking.

3.5 Data analyses

3.5.1 Statistical data analysis

The Statistical Package for Social Sciences (SPSS) version 21 and excel spread sheet were used to facilitate analysis of data One way ANOVA was employed to analyze the garbage generation rate and composition at three campsites, and to determine the significant difference of the mean garbage generation and composition between campsites and as well as between garbage sources in SMNP. All results for averages presented in either tables or figures were reported using mean ± SE.

Chi-square cross tabulation were used to determine the associations of demographic variables of respondents with HWCs and garbage management practices around campsites in SMNP.

3.5.2 Data analyses on selection of suitable disposal sites

Arc-GIS version 10.2 was used to generate suitability maps of garbage disposal sites. Multi-criteria evaluation technique (MCET) in GIS was used to generate suitability of garbage sites in SMNP. Data was presented in form of tables and maps.

3.5.2.1 Methods and procedures of data analysis on selection of suitable disposal sites

To achieve the objectives of the study primary and secondary data were used in analysis. Landsat 8 current land use/land cover map of the study area was downloaded from United States Geological Survey Global Visualization Viewer Website (USGS). A Land

use/Land cover map was prepared with the map of Google earth and GPS data for verification. Shuttle Radar Topographic Mission (SRTM) images derived from USGS with spatial resolution of (30 m * 30m) was used to extract Digital Elevation Model (DEM) of SMNP and it was used to derive slope of the study area. Road networks and buildings were developed from the GIS environment and structural plan of the study area. Secondary data were used from reliable internet sources, reports, journals, while SMNP office was used in general management plan. All the above data were collected, manipulated and analyzed in GIS environment to be used for further analysis.

To determine suitable disposal sites for campsites in SMNP five criteria were considered among them distance from buildings, distance from surface waters, distance from roads, Land use land cover (LU/LC), and slope. These basic criteria were selected after reviewing relevant literature, UNEP (2005) guidelines, and EPA (1996) regulations and taking them into consideration. ArcGIS 10.2 software was used for imaging and analysis of spatial data. GIS analyses such as buffer zoning, neighboring computation, and overlay analysis were used to determine constraint map.

In order to evaluate site selection criterion, Multi-criteria Decision Analysis (MDA) was used to measure the relative importance weighting for evaluation criteria. MDA divides the decision problems into smaller understandable parts, analyze each part separately, and then integrates the parts in a logical manner (Malczewski, 1997). The ranking and weight values were assigned to each criterion to determine Disposal Site Suitability Index (DSSI). DSSI was calculated by means of multiplication of each criteria weight with each sub-criteria weight.

Rankings varied between 0 (no constraint) and 10 (total constraint). Weights were generally assigned according to the relative importance of each criterion. The assigned weights were changed according to properties of the study area. The weights were assessed by considering the possibility of modifying the natural conditions of the sites. The map layers were formed in the GIS environment and final suitability map was created by overlay analyses of each criterion map. For the output map to be meaningful and consistent map weights had to add up to 100% and the attribute scores had to be chosen using a scheme that was the same for each map.

3.5.2.2 Determining constraint criteria /unsuitable areas for SMNP.

Suitable garbage disposal site for the study area was selected using GIS multi-criteria evaluation and overlay analysis. Site selection criteria that were considered for this research where evaluated individually and results were combined as overlay to produce map of a suitable disposal site. Although SMNP is a natural conservation area, core wildlife habitats considered as restricted areas that classified as unsuitable areas. To determine restricted areas, one should enter the collected data into the GIS environment and use geo-processing techniques like buffering. Based on results from various studies, buffer zones of different extent (Table 3.2) from each criterion were considered for this study too. The data were first digitized into vector format and thereafter introduced to the GIS platform. The unacceptable areas of different data layers are determined in GIS environment as following:

Table 3.2: Criteria and restriction parameters for siting disposal sites

Criterion	Restricted distance of buffer in meter (m)	Remark
Distance from water body	200 m buffer zone	
Distance from main road	100 m buffer zone	
Distance from building	300 m buffer zone	Campsite, outpost, lodges, etc

3.5.2.3 Criterion weighting

The purpose of criterion weighting is to express the importance of each criterion relative to other criteria. A number of criterion-weighting procedures based on the judgments of decision makers have been proposed in the multi-criteria decision literature (Aden, 2016). After determining where restricted areas are, the remaining areas are classified into classes of "high suitability" and "low suitability" to be used as waste disposal sites. This was done through a two steps of weighting process. In the first step, each layer was internally weighted based on minimum and maximum distances. In the second step, each layer is externally weighted based on how critical and important the data layer was to the waste disposal problem (Vassiloglou, 2001). Each map layer was both internally weighted based on their direct distance to features and environmental judgment and externally weighted using Analytical Hierarchy Process (AHP), based on the relative importance of the criterion.

i. Internal weighting: In this step, each data layer is studied individually. The locations of each data layer are assigned a weight from 0 - 9 based on their direct distance to the features, implementation as well as other skill judgment. For example, considering the road facilities, locations which are close to the roads have higher weight than the ones far away from the road network. Similarly, for the rivers locations which are far from them

have a higher weight and vice versa. For building areas the locations are weighted based on their distance to these centers (Table 3.3).

Table 3.3: Scale for pair wise comparison

Value	Definition
1	Equal importance
2	Equal to moderately importance
3	Moderate importance
4	Moderate to strong importance
5	Strong importance
6	Strong to very strong importance
7	Very strong importance
8	Very strong to extremely strong importance
9	Extremely strong importance

Source: (Saaty, 1980)

ii. External weighting: As indicated in the previous sub-section locations are weighted within each data layer internally. However, the data layers themselves are not necessarily of equal weight for the problem at hand. To obtain external weights, the method described by Saaty (1980) was used (Table 3.4).

Table 3.4: External weighting representations of factors used to determine site selection

Factor map	Weight	% Influence
Distances of point map (villages, ranger posts, socio institutions, lodges, campsites)	0.16	16
Reclassified slope	0.25	25
Reclassified vegetation map	0.25	25
Restricted areas	0.01	1
River	0.13	13
Road network	0.2	20
	Total	**100**

CHAPTER FOUR

RESULTS

4.0 Introduction

In this chapter, results are grouped into four sections guided by objectives namely: Sources, composition and generation rate of campsite garbage, existing situation and measures to mitigate human-wildlife conflict, waste management practices and mitigating measures in SMNP, and the suitability map of garbage sites.

4.1 Waste sources, generation rate and composition

4.1.1 Garbage sources in SMNP

There were three main garbage sources around campsites in SMNP and this included the tourist campsites, staff residences and community lodges (Figure 4.1). From the findings, the tourist campsites had the highest mean generation rate of garbage (114.042 ±3.366), followed by staff residences (22.585 ± 0.474), while the community lodges had the least (18.185 ±1.068).

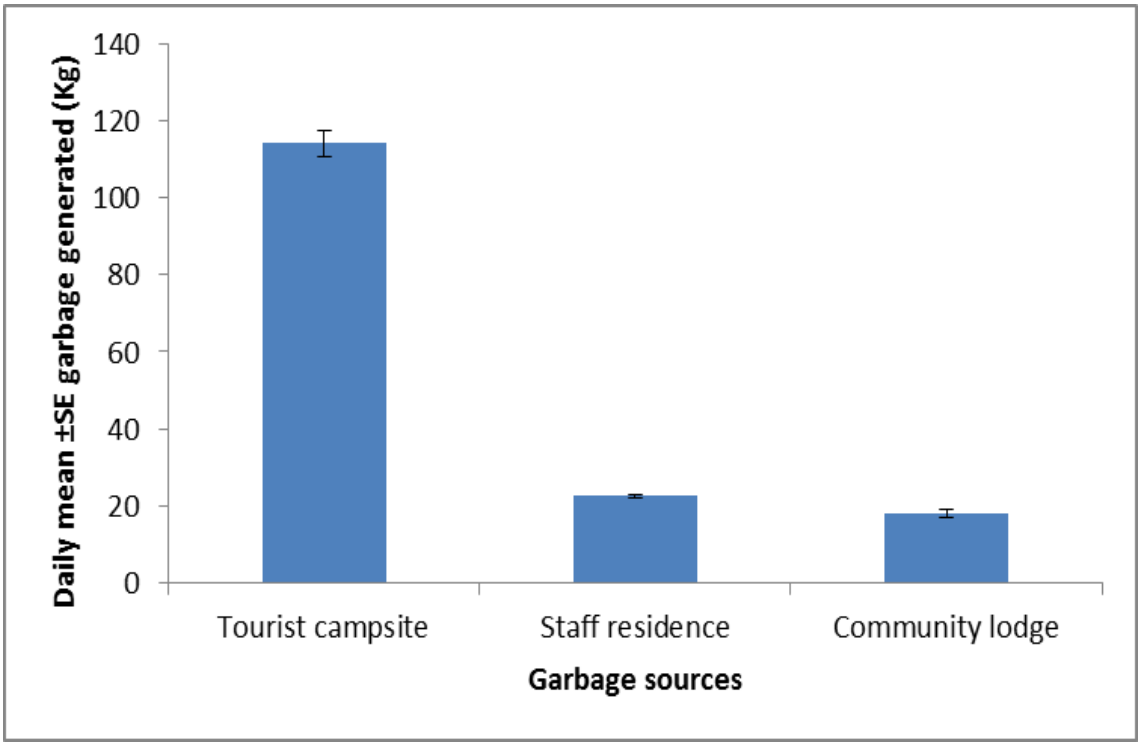

Figure 4.1: Daily mean ±SE garbage generated by sources (kg)

The sources of solid waste generation in Chenek and Gich Campsites are tourist campsites, staff residences and community lodges while in Sankaber the tourist campsite and staff residences are the main sources of waste (Figure 4.2). Results showed that Sankaber generated the highest daily mean garbage of 45.671± 1.661 kg most of (80.2%) which was from the tourist campsite, followed by Chenek (36.900± 1.516) and Gich (31.514± 2.320). Further, waste from Chenek (11.014± 0.842) and Gich (7.171± 0.469) was generated from the community lodges. Sankaber campsite had none from a lodge, since there was no community lodge in Sankaber campsite (Figure 4.2).

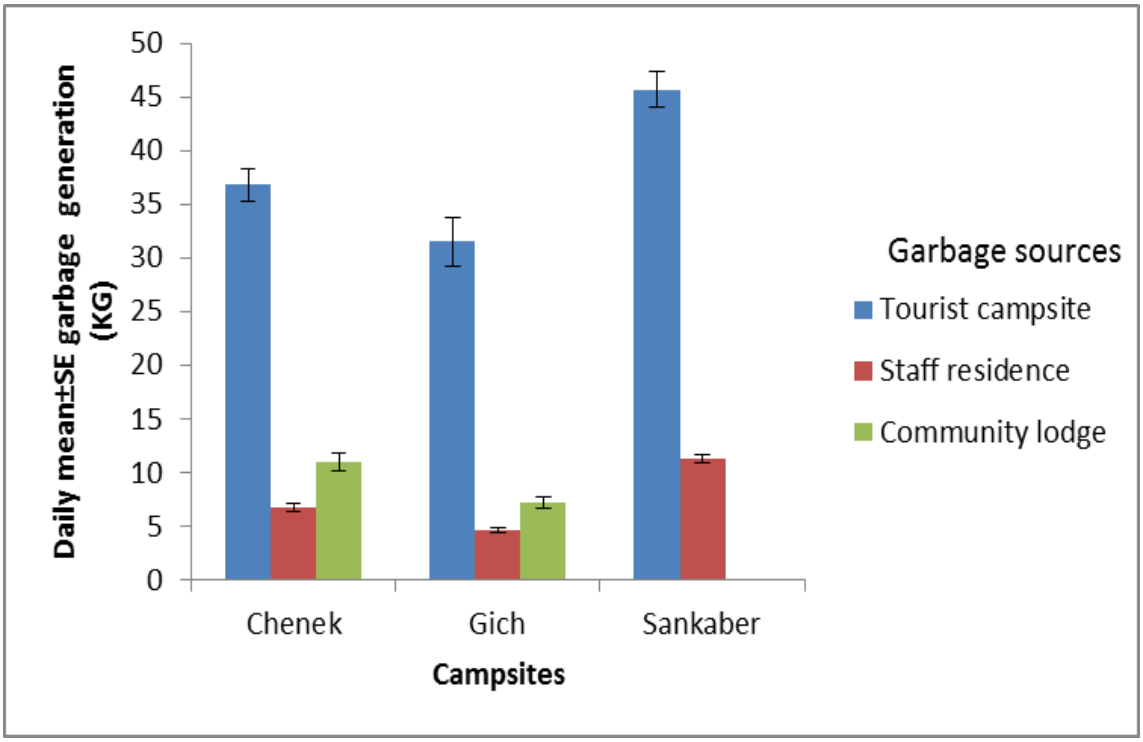

Figure 4.2: Waste sources and daily mean generation rate by campsites

4.1.2 Garbage generation rate by source

To determine if there was a significant difference between garbage generated in tourist campsites, staff residences and community lodges, a one-way analysis of variance (ANOVA) was performed. Results showed that there was a significant difference between the three garbage sources among the three campsites in SMNP ($F = 691.91$, $df = 2, 18$, $p < 0.0001$).

A Tukey's post-hoc test was carrying out to separate the means and results showed that there was no significant difference between staff residences and the community lodges ($P = 0.309$). However, tourist campsites had significantly higher mean than community lodges ($p < 0.0001$), and staff residences ($p < 0.0001$) (Table 4.1).

Table 4.1: Multiple comparisons results of garbage generation rate by source

		Subset for alpha = 0.05	
Source name	**N**	**1**	**2**
Community lodge	7	18.185	
Staff residence	7	22.585	
Tourist camp	7		114.042

Means for groups in homogeneous subsets are displayed.

Results in Table 4.2 show the per capita waste generation rate by waste sources in SMNP. Among the waste sources cited the tourist campsite generated more waste per person per day than other sources and this accounted for a mean of 0.82kg±0.011/person/day, while staff residences and community lodges generated a mean 0.42kg±0.009/person/day and 0.53kg±0.016/person/day waste, respectively. When computed per month, tourist campsites produced the highest waste of 3.420 tones, followed by Staff residences (0.678 tones), and Community lodges (0.546 tones).Therefore, tourists and their service providers produced more waste per person per day at the campsites than residential staffs and community lodge workers.

Table 4.2: Solid waste generation rate per person per day by source

Waste sources	**Av. guests/day**	**kg/person/day**	**Mean Waste kg/source/day**	**Mean Waste kg/source/month**
Tourist campsite	138±4.1	0.82±0.011	114	3420
Staff residence	53±0.25	0.42±0.009	22.6	678
Community lodge	34±1.93	0.53±0.016	18.2	546
Total	225±31.9	0.69±0.01	154.8	4644

4.1.3 Generation rate of garbage by campsite

The total solid waste generated at Chenek, Gich and Sankaber during a one-week sampling was 381.4kg, 303.4kg and 398.9kg respectively. The total waste generated from the three campsites sums up to 1083.7kg. Figure 4.3 shows results on garbage generation rate per day from Chenek, Gich and Sankaber respectively. From the results, the garbage from Sankaber campsite had a numerically higher mean (56.985± 1.435kg) compared to the garbage generated in Chenek (54.485± 2.324kg) and Gich campsite (43.342±2.370kg) (Figure 4.3).

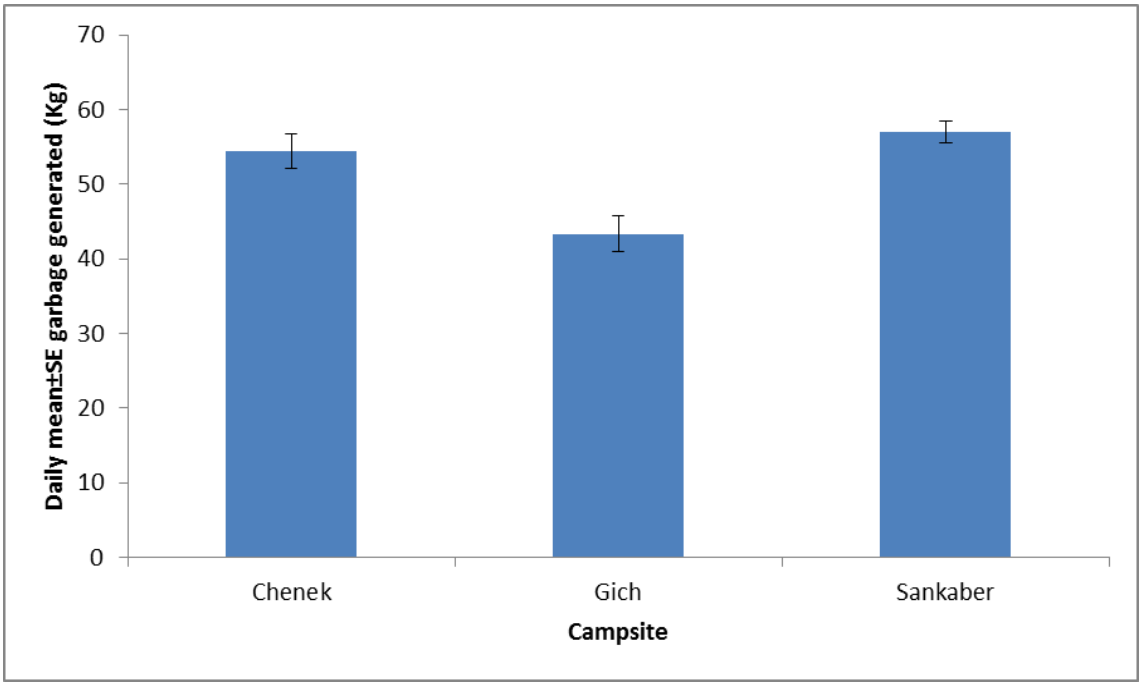

Figure 4.3: Daily mean ± SE waste generated in kg by campsites

To determine if there was a difference between the garbage generated in the three campsites, a one-way ANOVA was performed. Results showed that there was a significant difference in the effects of garbage generated across the three campsites (F =

12.098, df = 2, 18, p < 0.0001). To establish the nature of the difference between the means of the waste generated in the three campsites, ANOVA test was followed-up with Tukey post-hoc tests where the means were tested. The multiple comparisons results showed that there was no significant difference between the mean of garbage generated at Chenek and Sankaber (P = 0.680). However, the mean of Gich campsite showed a significantly smaller figure than that of Sankaber (p = 0.001) and Chenek campsite (p = 0.004) (Table 4.3).

Table 4.3: Results of comparisons of mean garbage generation rate by campsite

		Subset for alpha = 0.05	
Campsite name	**N**	**1**	**2**
Gich	7	43.342	
Chenek	7		54.485
Sankaber	7		56.985

Means for groups in homogeneous subsets are displayed.

The waste generation rate per person per day of the entire study area by campsite is highlighted in Table 4.4. From the results, Sankaber has the highest generation rate per person per day accounting for a mean of 0.72 ± 0.011 kg/person/day, while Gich and Chenek campsites generated 0.69 ± 0.013 kg and 0.65 ± 0.014kg of garbage per person per day, respectively. When further computed the generation rate per month showed Sankaber produced the highest waste of 1.71 tones, followed by Chenek (1.63 tones), and Gich (1.29 tones).

Table 4.4: Solid waste generation rate per person per day by campsite

Campsite	Av. Guest/day ±SE	kg/person/day ±SE	Waste kg/day/camp	Waste kg/camp/month
Chenek	83 ±3.7	0.65 ± 0.014	54.5	1635
Gich	63 ±2.7	0.69 ± 0.013	43.3	1299
Sankaber	79 ± 1.3	0.72 ± 0.011	57	1710
Total	225±6.03	0.69± 0.013	154.8	4664

4.1.4 Solid waste compositions in SMNP

Results showed that the composition of waste was almost the same in nature across the study site. From samples of solid wastes collected and analysed from the three campsites in the park, six different types of wastes were identified and categorized. This mainly comprised of foodstuffs, plastics, papers, metals, glasses and other miscellaneous materials like ash and dust. Foodstuffs included leftover food residues, vegetable waste, leaves and decayed vegetables. Plastics included; disposable bottles, polythene bags, chips packets, small sashays, milk and juice packs. Paper products included; biscuit packs, cottons, cigarette packs, tea packs, disposable caps and plates. Metals included; cold drink bottles, toothpastes and shaving cream packs. From field observations, most of the waste generated was biodegradable and this accounted for 72.9% (112.9kg) of the total campsite garbage collected during the study time. On the other hand the non-biodegradable and miscellaneous waste accounted for 13.4% (20.8kg) and 13.7% (21.1kg) respectively.

The above results clearly indicate that the composition of biodegradable waste is dominated by food wastes which accounted for 69% (106.6kg) per day while papers

account for 4.1% (6.3kg). Of the non-biodegradable wastes, plastic had the greatest percentage amounting to 12.6% while percentage composition for metals and glasses accounted for 4.1% (6.4kg) and 1% (1.6kg) respectively. The third category of waste, that was miscellaneous also accounted for 13.7% (21.1kg); and mainly included ash, dirt and other fine materials. Results of garbage composition are presented in Table 4.5. Over all, food waste was associated with the highest numerical mean of 106.686±3.490kg in all the three campsites followed by miscellaneous (21.114±1.011kg), while glasses had the lowest numerical mean (1.614±0.455kg).

Table 4.5: Results of total garbage composition by campsite (kg)

	Campsite			
	Chenek campsite	**Gich campsite**	**Sankaber campsite**	**Total**
Garbage type	**Mean ±SE**	**Mean ±SE**	**Mean ±SE**	**Mean ±SE**
Food waste	36.342 ±1.766	29.714 ±2.074	40.628 ±1.669	106.686 ±3.49
Plastics	3.771 ±0.187	4.757 ±0.203	4.042 ±0.456	12.571 ±0.455
Paper	2.1 ±0.148	1.951 ±0.155	2.314 ±0.18	6.371 ±0.306
Glasses	0.414 ±0.241	0.671 ±0.2	0.528 ±0.172	1.614 ±0.455
Metals	2.085 ±0.118	2.014 ±0.186	2.371 ±0.068	6.471 ±0.242
Miscellaneous	9.771 ±0.782	4.242 ±0.209	7.1 ±0.322	21.114 ±1.011

A one-way analysis of variance was conducted to compare differences between the compositions of campsite garbage in the sampled campsites. Results showed that there was a statistically significant difference in food wastes ($F = 8.882$, $df = 2, 18$, $p = 0.002$) and miscellaneous wastes ($F = 30.163$, $df = 2, 18$, $p < 0.0001$) between the three campsites. However, no statistically significant difference was exhibited between plastics, papers, glasses and metals in the three campsites sampled in SMNP ($p > 0.05$ for

all). A Tukey's post-hoc test was carrying out to separate the means and results showed that there was no significant difference between food waste in Sankaber and Chenek, ($p = 0.251$), as well as between Chenek and Gich. ($p = 0.51$), however the difference between food waste in Sankaber and Gich was statistically significant ($p = 0.002$). Miscellaneous waste was significantly different between three campsites ($p < 0.05$), although the mean of miscellaneous waste in Sankaber was significantly higher than that of Chanek and Gich (Table 4.6).

Table 4.6: Multiple comparison results of garbage composition between campsites

	Food waste			**Miscellaneous waste**			
	N	**Subset for alpha = 0.05**		**N**	**Subset for alpha = 0.05**		
Campsite name		**1**	**2**		**1**	**2**	**3**
Gich	7	29.7143		7	4.243		
Chenek	7	36.3429	36.3429	7		7.1	
Sankaber	7		40.6286	7			9.771
Sig.		0.051	0.254		1	1	1

Means for groups in homogeneous subsets are displayed.

Results associated with garbage composition across the different sources are reported in Table 4.7. Glass waste was associated with the numerically smallest mean (1.614±0.455kg), while food waste was associated with the numerically highest mean (88.271±3.432kg) level at tourist campsite. On the contrary staff residences had the highest mean value of miscellaneous waste mean (11.628±0.580kg), while tourist campsite had the least (3.042± 0.351kg).

Table 4.7: Results on composition of garbage by sources (kg)

	Garbage sources			
	Tourist campsite	Staff residence	Community lodge	Total
Garbage type	**Mean ±SE**	**Mean ±SE**	**Mean ±SE**	**Mean ±SE**
Food waste	88.271 ±3.432	10.071 ±0.363	8.342 ±0.548	106.686 ±3.49
Plastics	9.942 ±0.496	0.357 ±0.071	2.271 ±0.153	12.571 ±0.455
Paper	5.485 ±0.257	0.3 ±0.037	0.585 ±0.076	6.371 ±0.306
Glasses	1.114 ±0.32	0.171 ±0.128	0.328 ±0.099	1.614 ±0.455
Metals	6.185 ±0.279	0.071 ±0.047	0.214 ±0.128	6.471 ±0.242
Miscellaneous	3.042 ±0.351	11.628 ±0.58	6.442 ±0.57	21.114 ±1.011

To establish whether there was a difference between garbage composition in tourist campsites, staff residences and community lodges, a one-way analysis of variance was performed. The independence between ANOVA groups yielded a statistically significant difference between food wastes ($F= 514.463$, $df = 2,18$, $p < 0.0001$); plastics, ($F= 280.279$, $df = 2,18$, $p < 0.0001$); paper, ($F = 345.689$, $df = 2,18$, $p < 0\ 0001$); glasses, ($F = 5.935$, $df = 2,18$, $p < 0.01$); metals, ($F = 376.851$, $df = 2,18$, $p < 0.0001$) and miscellaneous wastes ($F = 71.36$, $df = 2,18$, $p < 0.0001$) among the three garbage sources. From the results it can be inferred that, a difference exists in composition between all six categories of garbage in terms of composition among them food wastes, plastics, papers, glasses, metals and miscellaneous waste in tourist campsites, staff residences and community lodges.

To further establish the nature of the differences in composition of garbage between the three waste sources, the ANOVA was followed-up with Tukey post-hoc tests (Table 4.8). The difference between food waste in tourist camps and staff residences was statistically significant as was the case with that of tourist campsites and community lodges ($p <$

0.0001). The difference between plastics and miscellaneous wastes was also statistically different in the three sources ($p < 0.0001$) (Table 4.8).

Table 4.8: Multiple comparison results of garbage composition by garbage sources

		Food waste			Miscellaneous waste				
Sources of Garbage	N	Subset for alpha = 0.05			Sources of Garbage	N	Subset for alpha = 0.05		
		1	2				1	2	3
Community lodge	7	8.3429			Tourist camp	7	3.043		
Staff residences	7	10.071			Community lodge	7		6.44	
Tourist camp	7		88.23		Staff residences	7			11.6
Sig.		0.818	1		Sig.		1	1	1

Means for groups in homogeneous subsets are displayed.

Finally, the mean difference for paper waste, glasses and metal waste was significant between tourist camps and staff residences as well as tourist camps and community lodges. However, there was no statistically significant difference between food waste, paper, glasses and metals between staff residences and community lodges (all $p>0.05$) (Table 4.9).

Table 4.9: Multiple comparison results of garbage composition by garbage sources

		Plastics			Papers		Glass		Metals	
Sources of Garbage	N	Subset for alpha = 0.05			Subset for alpha = 0.05		Subset for alpha = 0.05		Subset for alpha = 0.05	
		1	2	3	1	2	1	2	1	2
Staff residences	7	0.357			0.3		0.17		0.071	
Community lodge	7		2.271		0.585		0.33		0.214	
Tourist camp	7			9.942		5.486		1.11		6.185
Sig.		1	1	1	0.419	1	0.86	1	0.842	1

Means for groups in homogeneous subsets are displayed.

4.2 Human-wildlife conflicts between campsite users and wild animals around campsites in SMNP

4.2.1 Demographic characteristics of respondents

Demographic characteristics of the respondents assessed included gender, age, educational level, occupation status, duration of service and location. Results are shown in Table 4.10.

Results on gender showed that male respondents (82.8%) were more than female respondents (17.2%). This implied that most of the campsite users and service providers were mostly men. Further, majority of the respondents (84.9%) were aged between 18 and 40 years, while 3.2% of the respondents were over 50 years of age. This shows that activities undertaken by campsite users were mainly by youths. From the results, there were varied views received on HWC and waste management across age categories in the study area. Out of 93 respondents interviewed, over forty percent (48.4%) of the respondents had attained a degree, while 4.3% had attained elementary level of education. This shows that majority of the respondents had knowledge about the surrounding environments where they live. With regards to occupational status of the respondents, 36.6% were cooks, 30.1% were guides, 10.7% were resident staff, 8.6% were tourists and 14% were community leaders and stakeholders.

With reference to duration of service, majority of the respondents (77.4%) had served three years and above in the park, while 22.6% of the respondents had less than three years of service in the park. This indicates that majority of the respondents had knowledge about wildlife resources in SMNP. Finally, 35.5% of the respondents

currently resided inside the park, 54.8% near the park and the remaining (9.7%) lived far away from the park. Table 4.10 gives a summary of the results on demographic characteristics of the respondents.

Table 4.10: Demographic characteristics of respondents

Variables	Category	Frequency	Percent
Sex	Male	77	82.8
	Female	16	17.2
	Total	**93**	**100**
Age in years	18-30 years	40	43
	31-40 years	39	41.9
	41-50 years	11	11.8
	Above 50 years	3	3.2
	Total	**93**	**100**
Education status	Elementary	4	4.3
	High school	27	29
	Diploma	45	48.4
	Degree and above	17	18.3
	Total	**93**	**100**
Occupation	Cook	34	36.6
	Guide	28	30.1
	Staff resident	10	10.8
	Tourist	8	8.6
	Other Stakeholders	13	14
	Total	**93**	**100**
Duration of service	1-3 years	21	22.6
	Between 3 and 5 years	40	43
	Above 5 years	32	34.4
	Total	**93**	**100**
Permanent location of residence	Inside the park	33	35.5
	Near the park	51	54.8
	Far away from park	9	9.7
	Total	**93**	**100**

4.2.2 Knowledge about wildlife resources and HWC in SMNP

Table 4.11 summarizes the respondents who reported on their knowledge about wildlife resources and HWC in SMNP. From the findings, majority (71%) of respondents were

aware of the conflicts that exist between humans and wild animals, while 29% were unaware. To determine the relationship between demographic variables and awareness on human-wildlife conflicts, a chi-square test was performed. In general, our results showed that the individuals with the most awareness of HWC were those who were: men, older in age, higher in education, spend more time in the park, and/or those who have direct contact with the animals. Results showed that there was no significant relationship between marital status and awareness on human-wildlife conflicts ($\chi 2 = 2.516$, df =1, $p = 0.113$). However, there was a significant relationship between sex of respondents and awareness on human-wildlife conflicts ($\chi 2 = 4.124$, df = 1, $p = 0.042$) and age ($\chi 2 = 12.297$, df = 3, $p = 0.006$). Over 75% of male respondents were aware of HWC. Similarly, majority (90.9%) of the older individuals were more aware of HWC than those that were younger.

Also, the education level of respondents had a significant relationship with awareness on human-wildlife conflicts ($\chi 2 = 37.215$, df = 3, $p < 0.0001$). Majority of the respondents (71%) who were educated individuals were aware of the conflicts that exist between humans and wild animals. Moreover, chi-square results showed a statistically significant relationship between the occupation of respondents and the awareness on human-wildlife conflicts ($\chi 2 = 24.559$, df = 4; $p < 0.0001$). This is especially the case for guides and cooks who have direct contact with animals. For instance, gelada monkeys were noted to snatch food from the kitchen, tables and people's hands. There was also a significant relationship between duration of services ($\chi 2 = 8.394$, df = 2; $p = 0.015$), locations of respondents ($\chi 2 = 11.121$, df = 2; $P = 0.004$) and awareness on HWC. Majority of the respondents (72.5%) who had three years or more of service in the park were aware of

the existence of HWC compared to those who had only worked for a few years, while 78.4% of respondents of those who are living near and far from the park were aware of HWCs (Table 4.11).

Table 4.11: Knowledge of respondents about wildlife resources and HWC in SMNP

		Awareness in HWC			
		Yes		**No**	
Demographic variables	**Category**	**Frequency**	**%**	**Frequency**	**%**
Sex of respondents	Male	58	75.3	19	24.7
	Female	8	50	8	50
	Total	**66**	**71**	**27**	**29**
Age of respondents	18-30years	21	52.5	19	47.5
	31-40years	32	82.1	7	17.9
	41-50years	10	90.9	1	9.1
	Above 50years	3	100	0	0
	Total	**66**	**71**	**27**	**29**
Education level	Elementary	0	0	4	100
	High school	10	37	17	63
	Diploma	39	86.7	6	13.3
	Degree & above	17	100	0	0
	Total	**66**	**71**	**27**	**29**
Occupation status	Cook	18	52.9	16	47.1
	Guide	28	100	0	0
	Residential staff	6	60	4	40
	Tourist	8	100	0	0
	Others (stakeholders)	6	46.2	7	53.8
	Total	**66**	**71**	**27**	**29**
Duration of service	1-3 years	10	47.6	11	52.4
	Between 3&5 years	29	72.5	11	27.5
	Above 5 years	27	84.4	5	15.6
	Total	**66**	**71**	**27**	**29**
Location of residences	Inside the park	17	51.5	16	48.5
	Near the park	40	78.4	11	21.6
	Far away from park	9	100	0	0
	Total	**66**	**71**	**27**	**29**

4.2.3 Status and extent of HWCs around campsites in SMNP

Table 4.12 highlights results on the status and extent of HWC around campsites in SMNP. From the results, majority of the respondents (80.6%) reported that they experienced (or witnessed) a HWCs around campsites in SMNP while only 19.4% did not experience any HWCs. Furthermore, to determine the degree of association between demographic characteristics of respondents and whether they experienced a HWC around campsites in SMNP, a chi-square test for contingency tables was conducted. Results showed that location did not affect the likelihood of experiencing a HWC ($\chi 2 = 3.961$, df = 2; p = 0.138). However, there was a significant association between occupation status ($\chi 2 = 12.207$, df = 4; p = 0.016) and encounter with HWCs in SMNP, with all guides (100%) reported some form of HWCs occurred unlike the other groups (Table 4.12). There was also a significant association between duration of services ($\chi 2 = 13.999$, df = 2; p = 0.001) and encounters with HWCs, those having shorter service duration (1-3 years) reported less HWC (52.4%) than those with long service duration (above 3 years).

Table 4.12: Respondents' encounters with HWCs around campsites in SMNP

		Encounter with HWCs			
		Yes		**No**	
Demographic variables	**Category**	**Frequency**	**%**	**Frequency**	**%**
Occupation status	Cook	24	70.6	10	29.4
	Guide	28	100	0	0
	Residential staff	8	80	2	20
	Tourist	7	87.5	1	12.5
	Others (stakeholders)	8	61.5	5	38.5
	Total	**75**	**80.6**	**18**	**19.4**
Duration of service	1-3 years	11	52.4	10	47.6
	Between 3 and 5 years	35	87.5	5	12.5
	Above 5 years	29	90.6	3	9.4
	Total	**75**	**80.6**	**18**	**19.4**

The study sought to establish the relationship between the season with more human-wildlife conflicts and problematic wild animal involved. Table 4.13 illustrates the results. From the findings, majority (75.3%) of the respondents reported that HWCs were high whenever there were many people residing in and around campsites. A cross tabulation test undertaken to determine the relationship between the season with most human-wildlife conflicts and the problematic wild animal showed that there was a significant relationship between the season with more human-wildlife conflicts and problematic wild animals ($\chi 2 = 18.176$, df = 4, p = 0.001). Over 87.1% of the respondents reported getting into conflict with the geladas. Results further showed that whenever there were high number of people visiting SMNP, conflicts arose between humans and the geladas as well as birds.

Table 4.13: Relationship between season with more HWCs and problematic wild animals (**NB**: Sep. to Feb. = high season; Mar. to Aug. = low season)

	Season when more HWCs occurrence					
	Time with high number of people		**Time with low number of people**		**Throughout All seasons**	
Wild Animals	Frequency	%	Frequency	%	Frequency	%
Geladas	54	87.1	0	0	8	12.9
Ethiopian Wolves	1	33.3	0	0	2	66.7
Birds	15	53.6	3	10.7	10	35.7
Total	70	75.3	3	3.2	20	21.5

4.2.4 Respondents opinion on HWC hotspot campsites and problematic animals

Table 4.14 highlights results on respondents' opinion on HWCs hotspot campsites. From the results, 73.1% of the respondents reported that Chenek campsite had more HWC incidences followed by Sankaber (21.5%). Chi-square results showed that there was no

significant association between duration of services ($\chi 2 = 8.035$, df = 4, p = 0.090). However, there was a significant relationship between locations ($\chi 2 = 0.202$, df = 4, p = 0.037), occupation status of respondents and campsites with most incidences of HWCs ($\chi 2 = 19.602$, df = 8, p = 0.012), with majority of residential staff (80%), noting that Chenek was a HWC hotspot campsite unlike others respondents (Table 4.14).

Table 4.14: Respondents opinion on HWC hotspot campsites

	Campsites with most incidences on HWCs					
	Chenek		**Gich**		**Sankaber**	
Occupation status	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Cook	27	79.4	1	2.9	6	17.6
Guide	22	78.6	0	0	6	21.4
Residential staff	8	80	1	10	1	10
Tourist	3	37.5	0	0	5	62.5
Others (Stakeholders)	8	61.5	3	23.1	2	15.4
Total	68	73.1	5	5.4	20	21.5

Three common problematic wild animals were reported to be the cause of conflicts with campsite users. These animals were geladas, the Ethiopian wolf, and birds. Among the listed problematic wild animals, geladas were reported to be the most problematic animals (66.7%), followed by birds (30.1%) and the Ethiopian wolf (3.2%). Chi-square results showed that there was a significant relationship between the campsite with more incidences of HWCs and the problematic wild animals ($\chi 2 = 55.747$, df = 4, $p < 0.0001$). Chenek camp had the most (85.3%) incidences of HWCs with the most problematic animal being the geladas, while Sankaber had least (5%) (See Table 4.15).

Table 4.15: Relationship between campsites and problematic wildlife

	Most problematic wildlife in SMNP					
	Geladas		Ethiopian Wolf		Birds	
Campsites	Frequency	%	Frequency	%	Frequency	%
Chenek	58	85.3	2	2.9	8	11.8
Gich	3	60	1	20	1	20
Sankaber	1	5	0	0	19	95
Total	62	66.7	3	3.2	28	30.1

4.2.5 Causes of HWCs around campsites in SMNP

From the findings, the main causes of human-wildlife conflict around campsites in SMNP were poor waste disposal, human pressure, lack of food and too many wild animals around campsites among others. Majority (83.9%) of the respondents believed that poor waste disposal was the main cause of conflict between campsite users and wild animals, while 8.6% of respondents believed that too many wild animals around campsites as well as human pressure was the cause of conflicts (4.3%). A chi-square test carried out to determine the degree of association between campsites and cause of HWCs at SMNP showed that there was a significant association between campsites and cases of HWC in SMNP ($\chi 2 = 13.508$, df = 6, $P < 0.036$). Among the listed causes of HWCs were poor waste disposal around campsites which was rated as the main cause at Chenek campsite (88.2%), followed by Sankaber (80%) (Table 4.16).

Table 4.16: Relationship between campsites and causes of HWCs in SMNP

	Causes of HWCs at Campsite in SMNP							
	Lack of food		Human move to habitats		Too many wild animals		Poor waste disposal around campsites	
Campsites	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Chenek	2	2.9	1	1.5	5	7.4	60	88.2
Gich	0	0	1	20	2	40	2	40
Sankaber	1	5	2	10	1	5	16	80
Total	3	3.2	4	4.3	8	8.6	78	83.9

4.2.6 Types of HWCs around campsites in SMNP

Study results showed that the main forms of conflicts around campsites in SMNP were manifested through snatching of food from kitchens, tables and people's hands, besides destruction of property, disruption of human activity and human threat at night among others were also reported (Table 4.17). About 75.3% respondents stated that the type of HWCs experienced was food items being snatched from kitchens, tables and people's hands in the campsite, followed by disruption of human activity (like reading, feeding and cooking) (12.9%), and destruction of property (7.5%).

A chi-square test carried out to determine the degree of association between the campsites and the type of human-wildlife conflicts at SMNP revealed that there was a statistically significant relationship between campsites and the type of HWCs at SMNP ($\chi 2 = 14.057$, df = 6, p = 0.029). Among the types of conflicts, snatching food from kitchens and people's' hand occur at Chenek (80.9%), while 20% occur at Gich campsite.

Table 4.17: Relationship between campsites and types of HWCs in SMNP

	Types of HWC at campsite in SMNP							
	Snatch food from kitchens, tables & people's hands		Destruction of property		Disruption of human activity		Human threat at night	
Campsite	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Chenek	55	80.9	5	7.4	5	7.4	3	4.4
Gich	1	20	1	20	2	40	1	20
Sankaber	14	70	1	5	5	25	0	0
Total	70	75.3	7	7.5	12	12.9	4	4.3

A chi-square test carried out to determine the degree of association between problematic animals and the type of HWCs at SMNP showed a statistically significant relationships between type of human-wildlife conflicts and problematic wild animals ($\chi 2 = 73.932$, df = 6, $p < 0.0001$). The geladas snatching food items from kitchens, tables and people's hands' was ranked first by majority of respondents (82.3%), while the Ethiopian wolf threatened humans at night time (Figure 4.4).

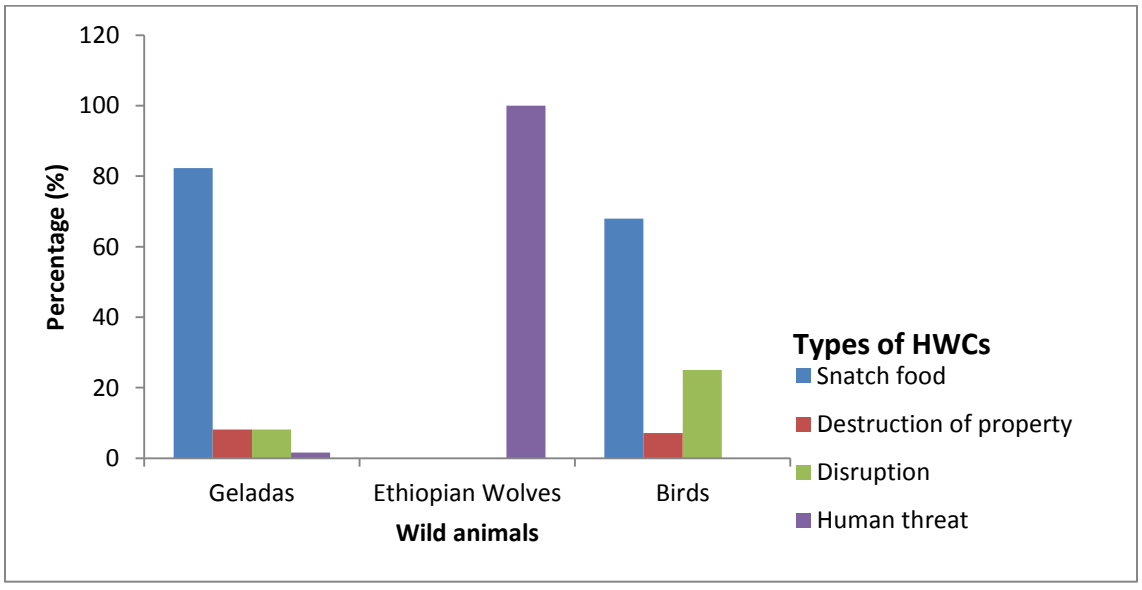

Figure 4.4: Relationship between problematic animals and types of HWCs in SMNP

4.2.7 Trends in HWCs around campsite in SMNP

Findings showed that majority of the respondents (82.6%) reported that trends in HWCs in SMNP had increased through time, while 14.1% reported that the situation had remained as it was. A chi-square test carried out to determine the degree of association between the occupation status and location of respondents, and the trends in HWCs in the last few years around campsites in SMNP revealed that there was no significant relationship between occupation status of respondents and the trends in HWCs ($\chi 2$ = 11.944, df = 8; P = 0.154). Despite this, there was a significant relationship between location of respondents' residences and trends in HWCs ($\chi 2$ = 10.090, df = 4, P = 0.039). Majority of the respondents (75.8%) living inside the park and 90.2% from near the park noted that HWC in SMNP had increased, while 37.5% respondents drawn away from the park reported the situation had remained as it was (See Table 4.18).

Table 4.18: Respondents opinion on trends in HWC around campsites in SMNP

		Trends in HWCs in the last 5 years around campsites in SMNP					
		Increased		Decreased		Remained as it was	
Demographic variables		Frequency	%	Frequency	%	Frequency	%
Location	Inside the park	25	75.8	3	9.1	5	15.2
	Near the park	46	90.2	0	0	5	9.8
	Far away from park	5	62.5	0	0	3	37.5
	Total	76	82.6	3	3.3	13	14.1

Table 4.19 shows that majority (94.1%) of the respondents reported that the trend in HWCs were on the increase at Chenek campsite, at Sankaber it remained as it was (47.4%), whereas 60% respondents from Gich indicated that the situation had decreased.

Consequently, there was a significant relationship between the campsites and trends in HWCs ($\chi 2 = 75.291$, df = 4, $P < 0.0001$).

Table 4.19: Relationship between campsites and trends in HWC

	Trends in HWCs around campsites in SMNP in the last 5 years					
	Increase		Decrease		Remained as it was	
Campsite	Frequency	%	Frequency	%	Frequency	%
Chenek	64	94.1	0	0	4	5.9
Gich	2	40	3	60	0	0
Sankaber	10	52.6	0	0	9	47.4
Total	76	82.6	3	3.3	13	14.1

From the results in Table 4.20 on the relationship between the type of HWCs and the trends in HWCs. Based on the results, majority of the respondents (84.1%) noted that trends in HWC manifested in terms of snatching food items from kitchens and people's hand, while 75% reported about disruption of human activities around campsites. Cross tabulations done to test the relationship between the type of HWC and trends in HWCs showed that the type of HWC had a significant relationship with trends in HWC in the park ($\chi 2 = 16.027$, df = 6, $p = 0.014$). The implication of this is that HWCs increases whenever wild animals snatch food from kitchens, tables and people's hand (84.3%), when there is disruption of human activity and the destruction of property.

Table 4.20: Relationship between the type of HWC and trends in HWC

	Trends in HWC in the last 5 years around campsites in SMNP					
	Increase		Decrease		Remained as it was	
Type of HWC at campsite	Frequency	%	Frequency	%	Frequency	%
Snatch food from kitchens, tables and people's hands	59	84.3	0	0	11	15.7
Destruction of property	5	83.3	0	0	1	16.7
Disruption of human activity	9	75	2	16.7	1	8.3
Human threat at night	3	75	1	25	0	0
Total	76	82.6	3	3.3	13	14.1

4.2.8 Impacts of HWC in SMNP

Table 4.21 shows results on impacts of HWC in SMNP. Majority of respondents (88.2%) reported that HWCs impacted on wild animals while 11.8% did not respond. Chi-square test carried out to determine the relationship between demographic variables and whether they observed any negative impact of HWCs on wild animals around campsites showed no relationship between location ($\chi 2 = 2.058$, df = 2, p = 0.357) and occupation ($\chi 2 = 9.592$, df = 4, p = 0.054). However, a significant relationship was shown with duration of service of the respondents ($\chi 2 = 18.006$, df = 2; $P < 0.0001$). Majority of respondents (95%) who had served for over 3 years reported having observed negative impacts of HWCs on wild animals around campsites among them wild animals preferring human food than wild food (64.5%) and the animals had lost fear for humans (16.1%).

Table 4.21: Respondents opinion on impacts of HWCs on wild animals in SMNP

	Do you observe any negative impact s of HWCs on wild animals around campsites in this park?			
	Yes		No	
Duration of service	**Frequency**	**%**	**Frequency**	**%**
1-3 years	13	61.9	8	38.1
Between 3 and 5 years	38	95	2	5
Above 5 years	31	96.9	1	3.1
Total	82	88.2	11	11.8

4.2.9 Measures used to mitigate HWCs around campsites in SMNP

Results on traditional measures used to mitigate HWCs around campsites in SMNP are shown in Table 4.22, those interviewed, (100%) reported that they use traditional means to protect themselves from wild animal conflicts in the last few years during their stay around campsites. Traditional methods used included chasing (62.4%), noise-making (9.7%) and scarecrow (10.8%). Furthermore, a chi-square test performed to test the association between demographic characteristics of respondents and the current mitigating measures of HWCs showed that there were significant associations between occupation ($\chi 2 = 27.178$, df = 12; P = 0.007), duration of service ($\chi 2 = 32.639$, df = 6; P < 0.0001) and the current mitigating measures of HWCs, with staff residents (80%), guides (78.6%), and cooks (64.7%), reporting using chasing methods while 50% of the tourists did not.

Table 4.22: Respondent's opinion on current measures used to mitigate HWC

	Current measures taken by campsite users							
	Chasing		Noise-making		Scarecrows		Leave them	
Occupation	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Cook	22	64.7	1	2.9	5	14.7	6	17.6
Guide	22	78.6	3	10.7	3	10.7	0	0
Residential staff	8	80	0	0	0	0	2	20
Tourist	2	25	1	12.5	1	12.5	4	50
Others(Stakeholders)	4	30.8	4	30.8	1	7.7	4	30.8
Total	58	62.4	9	9.7	10	10.8	16	17.2
Duration of services								
1-3 years	4	19	2	9.5	4	19	11	52.4
Between 3&5 years	32	80	4	10	1	2.5	3	7.5
Above 5 years	22	68.8	3	9.4	5	15.6	2	6.3
Total	58	62.4	9	9.7	10	10.8	16	17.2

Further, chi-square test performed to determine relationship between animal species, campsites and current measures taken by campsite users to mitigate HWCs showed there were significant relationships with campsites ($\chi 2$ =19.636, df = 6; P = 0.003) and animal species ($\chi 2$ = 33.255, df = 6; P < 0.0001) Most of the respondents (71%) noted that they used the chasing method for the geladas, while only 6.5% used noise-making for geladas (Table 4.23).

Table 4.23: Relationship between wild animals and current measures to mitigate HWC

	Current measures taken by campsite users to mitigate HWCs							
	Chasing		**Noise-making**		**Scarecrows**		**Leave them**	
Problematic wild animals	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Geladas	44	71	4	6.5	5	8.0	9	14.5
Ethiopian wolf	0	0	3	100	0	0	0	0
Birds	14	50	2	7.1	5	17.9	7	25
Total	58	62.4	9	9.7	10	10.8	16	17.2

4.2.10 Potential measures used to mitigate HWCs in SMNP

Study results showed that there were various potential measures that can be used to mitigate HWC in SMNP. Among these are appropriate waste disposal mechanisms (68.8%), guarding (20.4%), and relocation of campsites (10.8%). Table 4.24 highlights the results.

Pearson chi-square test of association was used to determine the relationship between campsites and the opinions of respondents in mitigating HWCs. A statistical significant relationship was established between the campsites and the opinions in mitigating HWCs ($\chi 2 = 15.382$, df = 4, p = 0.004). Among the respondents who suggested garbage management, 70.6% indicated proper waste management is the best solution for Chenek campsite, and 60% of the respondents suggested that relocation will solve HWC at Gich campsite.

Table 4.24: Relationships between campsites and potential measures to mitigate HWC in SMNP

	Potential measures to mitigate HWCs					
	Guarding campsite property		Keep SMNP clean from garbage		Relocate campsites to suitable places	
Campsite	Frequency	%	Frequency	%	Frequency	%
Chenek	16	23.5	48	70.6	4	5.9
Gich	0	0	2	40	3	60
Sankaber	3	15	14	70	3	15
Total	19	20.4	64	68.8	10	10.8

4.3 Selection of suitable sites for garbage disposal in SMNP

In this section the results of factor maps, constraint map and final suitability maps were presented with four classes of suitability levels.

4.3.1 Results of factor maps

4.3.1.1 Road network

The study area included two main roads that pass through the park to neighboring districts. The waste disposal sites should not be too close to the roads and not far away from transport routes in order to facilitate transportation and to reduce the relative cost of transportation. But it is also important to consider the aesthetic values and wildlife resources. So, the minimum distance from the road network is important in order to avoid negative impacts and other nuisances. According to Leao *et al*. (2001), roads plus 100 m around them should be designated as a buffer zone. Therefore, a 100-m buffer zone is applied to these roads (Table 4.25 and Figure 4.5).

Table 4.25: Suitability criteria for roads

Factor	Criteria value	Suitability/classification
Road network	0-100m	Unsuitable
	100-500m	Highly Suitable
	500-1000m	Moderately suitable
	>1000m	Marginally suitable

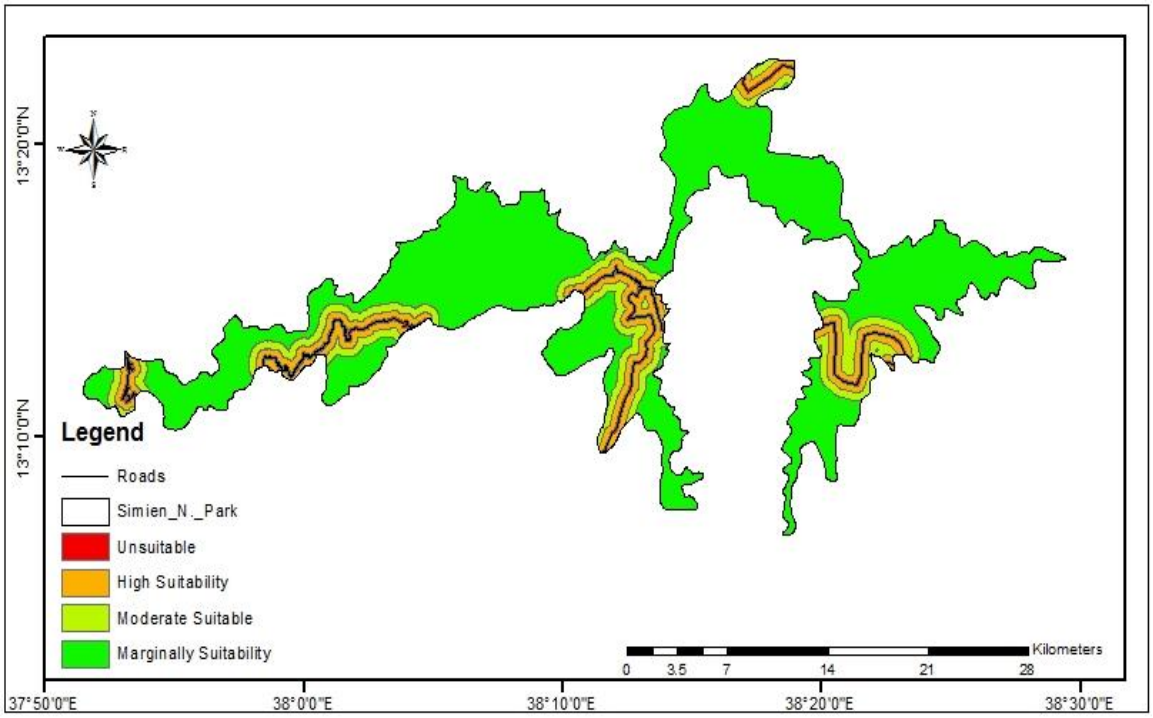

Figure 4.5: Road suitability map for SMNP

4.3.1.2 Surface water and rivers

SMNP is a source of several major rivers and tributaries that flow to downstream users. The waste disposal areas should not be in the vicinity of rivers, tributaries, springs, and other water sources to minimize water pollution by campsite garbage. Therefore, according to Akbari *et al* (2008) 200 m and Hasan *et al* (2009) 100 m buffer distances should be used respectively. Hence, buffers of 200 m rivers were applied in the current study (Table 4.26 and Figure 4.6).

Table 4.26: Suitability criteria for rivers

Factor	Criteria value	Suitability/classification
Surface water	0 – 200m	Unsuitable
	200-350m	Marginally Suitable
	350-800m	Moderately Suitable
	>800m	Highly suitable

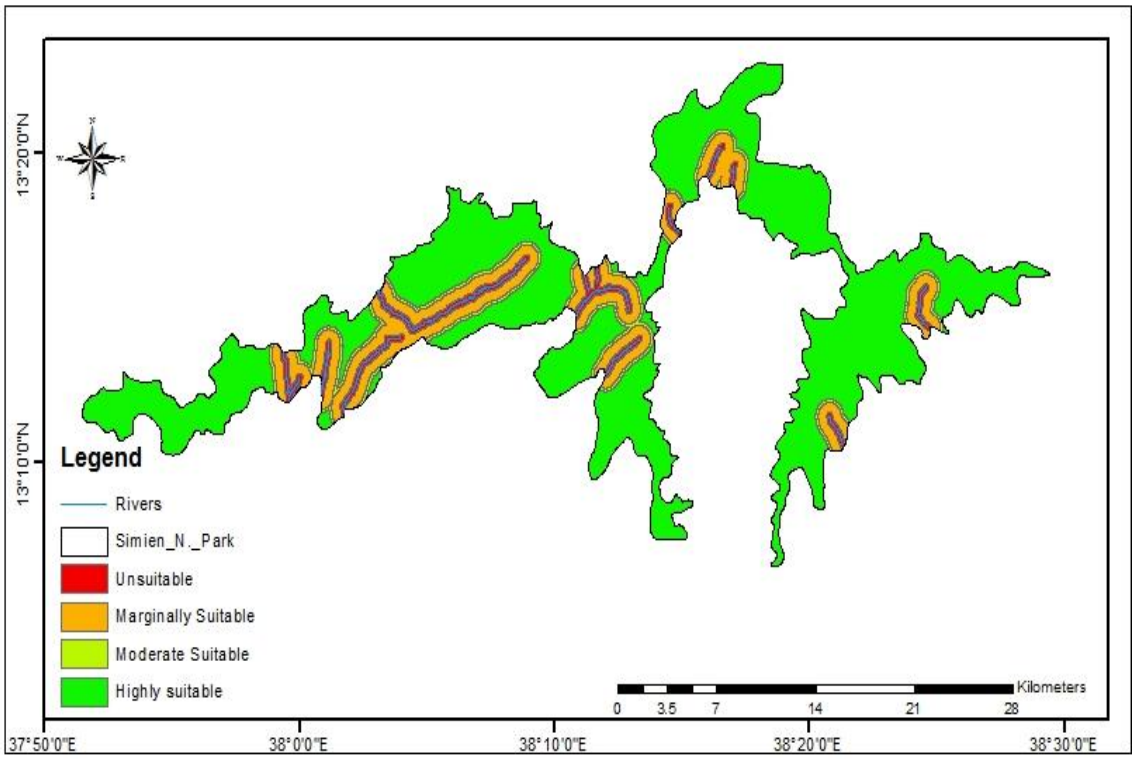

Figure 4.6: River suitability map for SMNP

4.3.1.3 Building areas

Tourist campsites, ranger outposts, community lodges and other buildings that existed in and around SMNP were considered as buildings. The waste disposal areas should not be near residential (building) areas to reduce air pollution. According to Cantwell (1999),

the buffer distances for villages and buildings should be determined to be between 250m to 500m. In the current study, a buffer zone of 300 m from all buildings was applied to determine unacceptable areas (Table 4.27 and Figure 4.7).

Table 4.27: Suitability criteria for building areas

Factor	Criteria value	Suitability/classification
Buildings	0 – 300m	Unsuitable
	300 – 700m	Marginally Suitable
	700 – 1000m	Moderately Suitable
	>1000m	Highly suitable

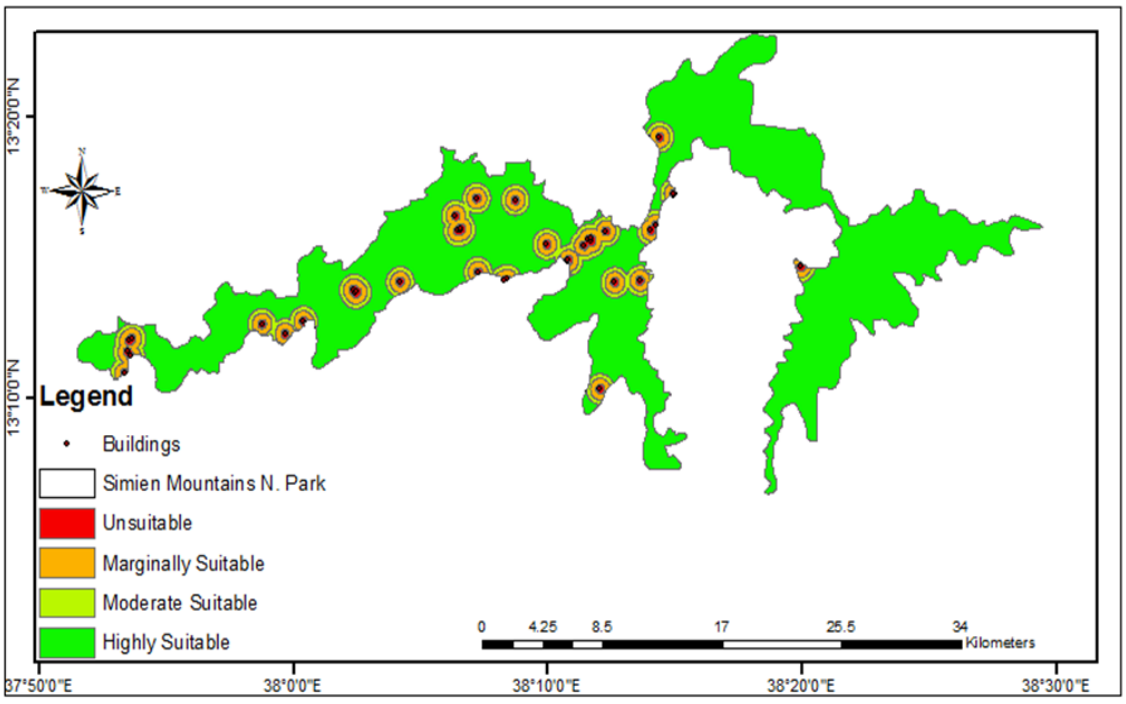

Figure 4.7: Building areas suitability map for SMNP

4.3.1.4 Slope

Slope is one of the key criteria to be considered in solid waste disposal site selection. Slope of the study area was developed from DEM 30*30 m resolutions and used in GIS environment which is shown in Figure 4.8. As stated by Allen (2002) areas with steep slopes should be avoided for a landfill site for allow easy access and avoid garbage being carried downstream by water.. Therefore, for this study the slope was reclassified into four classes (Table 4.28 and Figure 4, 8).

Table 4.28: Suitability criteria for slope

Factor (Slope %)	Representation	Suitability/classification
32-100	very steep	unsuitable
26-32	steep	marginally suitable
13-26	moderately steep	moderately suitable
0-13	marginally flat	highly suitable

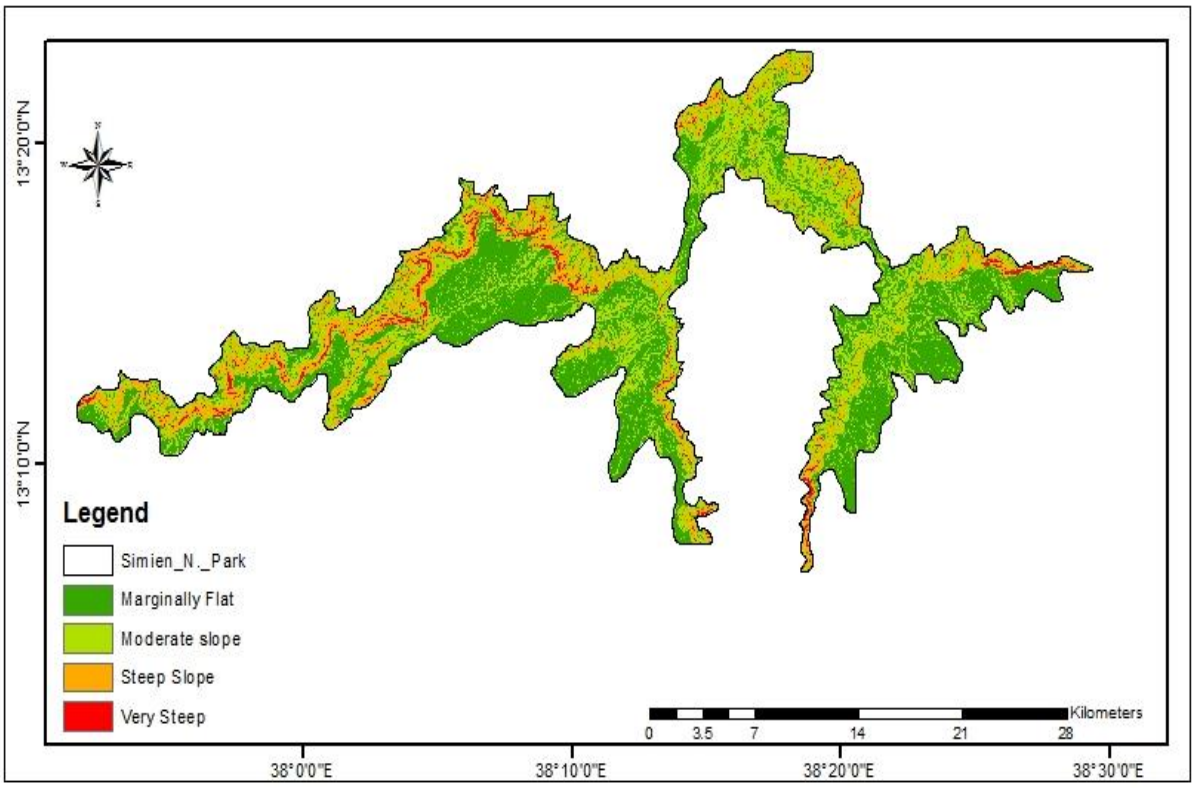

Figure 4.8: Slope suitability map of the study area

4.3.1.5 Land use/Land cover

Land use/Land cover map for a study area is one of the criteria used to select potential sites for solid waste disposal. Direct and indirect spatial use of a disposal site will destroy the actual vegetation and fauna (Fidèle, 2013). When deciding the ecological value of an area, the actual vegetation and fauna for the candidate site should be evaluated carefully. Ecological value is based on diversity, naturalness and characteristic features. Since SMNP is a natural conservation area, core wildlife habitats (wood land areas) considered as restricted areas were classified as unsuitable areas (Fidèle, 2013). The LU/LC of the study area was classified into five classes as shown in Table 4.29 and Figure 4.9.

Table 4.29: Suitability criteria for LU/LC

Factor	Criteria value	Suitability/classification
LC/LU	Woodland/forest	Unsuitable
	Open woodland	Unsuitable
	Shrub land	Marginal suitable
	Open shrub land	Moderately suitable
	Grassland	Suitable

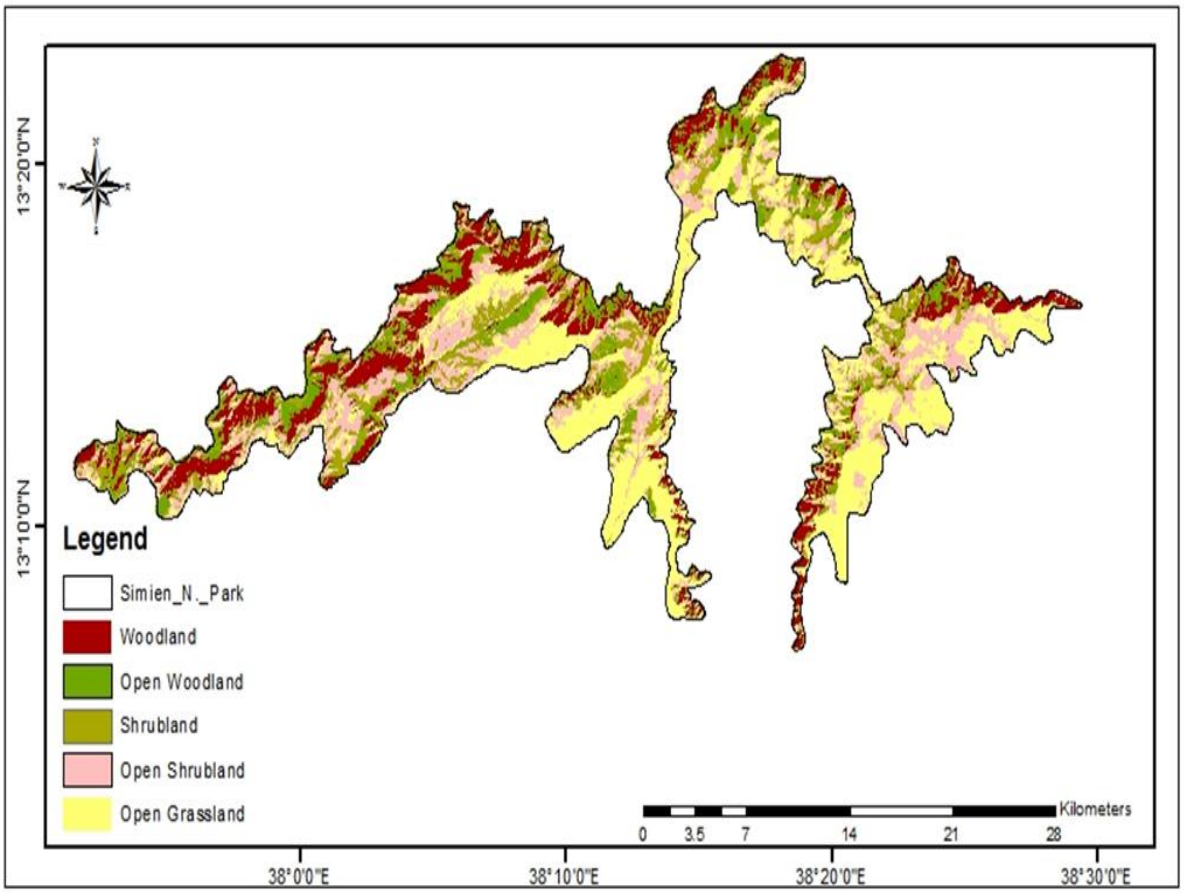

Figure 4.9: LU/LC suitability map for SMNP

4.3.2 Results of the constraint map

The constraint map was then produced by merging each individual theme within the study area. This procedure created a constraint map for each theme identifying areas in a binomial way as suitable or unsuitable areas. Hence, a general suitability map was created by combining potential landfill site maps and different constraint layers (Figure 4.10).

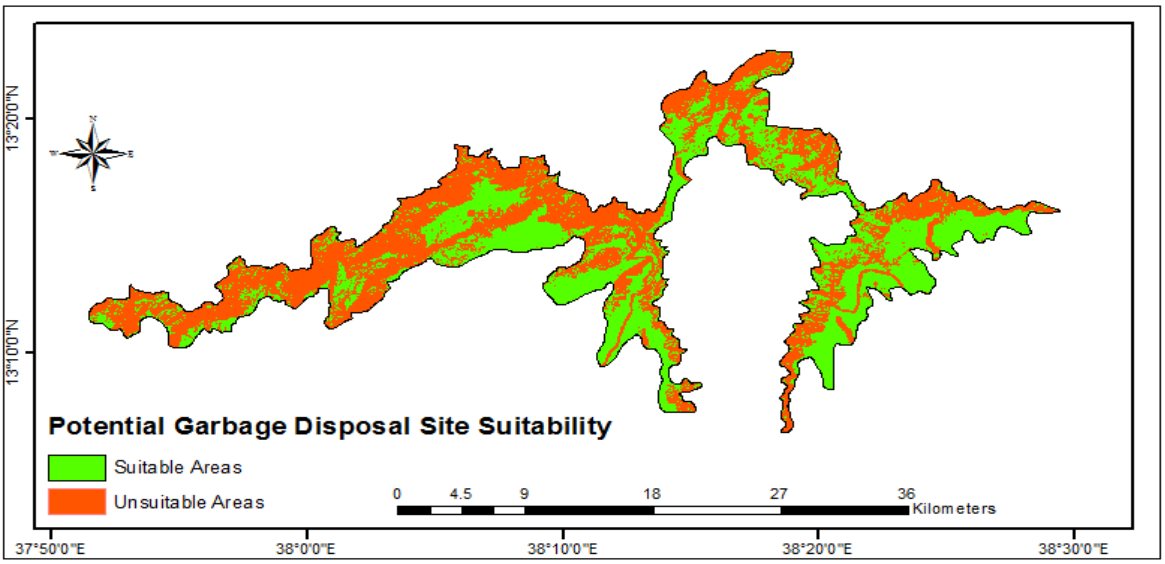

Figure 4.10: Potential disposal site suitability map of the study area

4.3.3 Existing garbage disposal sites versus suitability map

Currently there are three garbage disposal sites around the campsites in the study area although these sites are not suitable for location of a garbage disposal site. Based on results, the existing three disposal sites were located in unsuitable area, since they did not fulfill the disposal site suitability criteria (Figure 4.11).

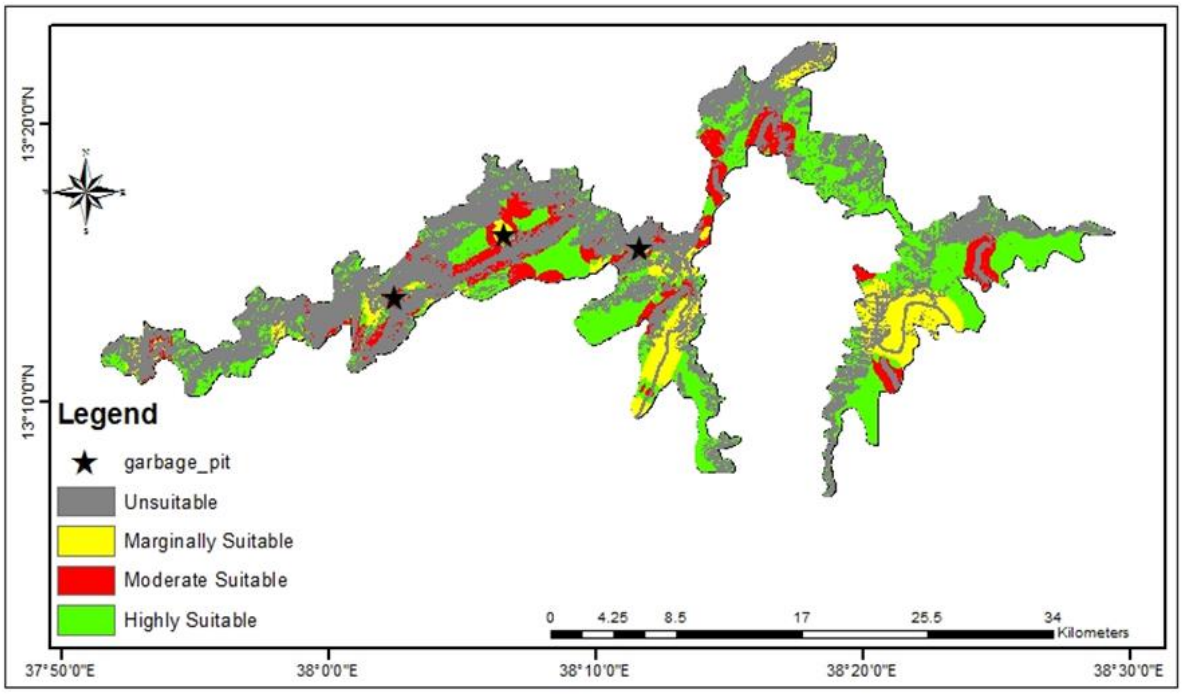

Figure 4.11: Suitability map versus existing garbage disposal sites

4.3.4 Disposal site suitability evaluation

With different degrees of importance, both environmental and socio-economic factors such as surface water or rivers, roads, buildings, slope, land use/land cover, and wildlife habitats were considered in determining garbage disposal sites. The evaluation of the weight overlay analysis showed that with slight differences, all factor maps (data layers) were equally influential as they are very important to protect wildlife resources from poor garbage disposal problems. Results from the weighted linear combination assessment in the ArcGIS software, revealed three indices of site suitability for the campsite garbage disposal of SMNP. These are marginally suitable, moderately suitable and highly suitable sites (Figure 4.12).

The area coverage of each suitability class of the sites was calculated in an ArcGIS algorithm after converting the raster map into vector. Results showed that 31,263.12 hectare (76%) of the total study area is unacceptable for siting garbage disposal site as the areas are environmentally unfriendly, socially unacceptable and economically impracticable to be proposed as a solid waste disposal site. The unacceptable areas included forest areas, steep slopes, buildings, areas closer to major roads and water sources. The main purpose of restriction of these areas was to protect wildlife resources and the environment from potential negative effects of improper waste disposal sites. However, the remaining areas of about 9,500 hectare (24%) of the park satisfied the environmental, social and economic criteria set for selection and location of disposal site. This was supported with different suitability indices (Table 4.30 and Figure 4.12).

Table 4.30: Solid waste disposal site suitability indices and their areas

Suitability class	Area (ha)	Area (%)
unsuitable	31263.12	76
Marginally suitable	4538.97	11
Moderate suitable	1658.88	4
Highly suitable	3686.4	9
Total	41147.37	100

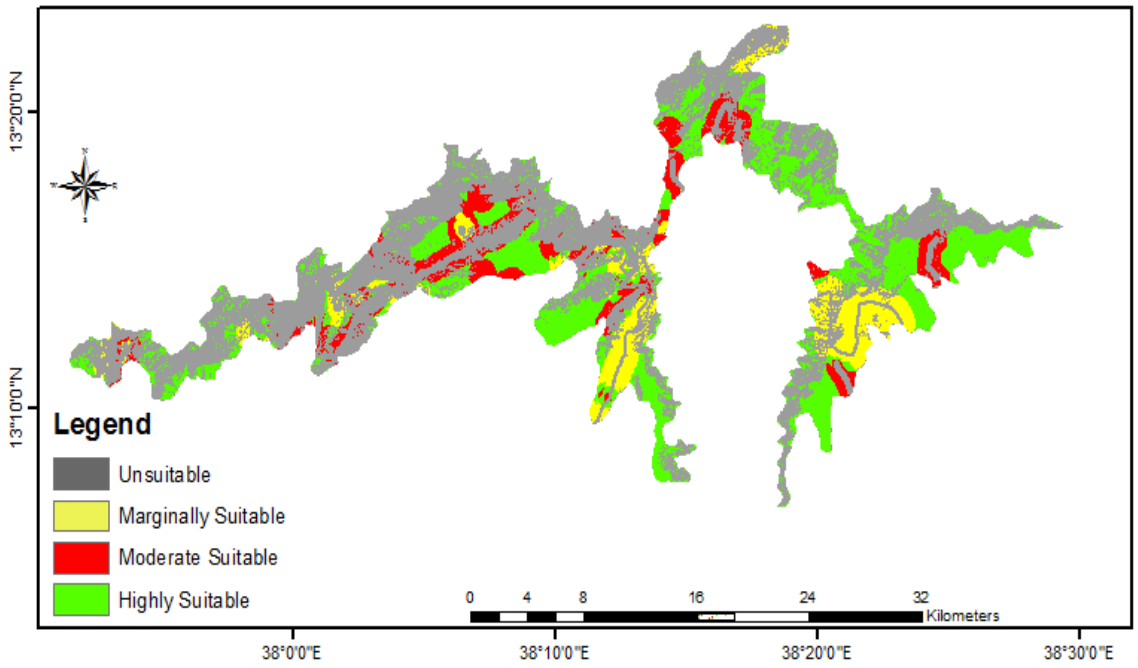

Figure 4.12: Final disposal site map based on suitability levels

4.4 Status of campsite garbage management practices in SMNP

This section of the analysis highlights the results on the respondents' views on the current situation of campsites garbage and its management practices in SMNP.

4.4.1 Respondents' awareness about campsite garbage

Findings on respondents' awareness on existence of campsite garbage are presented in Table 4.31. From the results more than half (58.1%) of the respondents were aware of the campsite garbage problem, whereas the remaining 41.9 % were unaware of the garbage situation. Cross tabulation test results on the relationship between demographic characteristics of respondents and awareness on campsite garbage showed there was a significant relationship between the education level of respondents and awareness on campsite garbage ($\chi 2 = 24.946$, $df = 3$, $p < 0.0001$). Apparently, respondents with

Diploma level of education (66.7%) and those with a Bachelor's degree (94.1%) were aware of campsite garbage although 70.4% of those with high school level of education were unaware. This implies that the level of education has a bearing on the level of awareness on campsite garbage.

Result also showed a statistically significant relationship between location and awareness on campsite garbage ($\chi 2 = 26.397$, df = 2, $p < 0.0001$). All respondents who resided far (100%) and near the park (72.5%) were more aware of campsite garbage compared to those who resided inside the park. These results suggest that proximity to the park in terms of location of residence decreases the likelihood of awareness on garbage by respondents.

Finally, there was a significant relationship between occupation and awareness on campsite garbage ($\chi 2 = 44.171$, df = 4, $p < 0.0001$). Result showed that all the tourists and guides (100%) were aware of the campsite garbage in SMNP, while cooks (70.6%) and residential staff (80%) were unaware. Although most of the respondents resided around the campsites, they were unaware of the garbage problem in SMNP. This implies the respondents who are residing in the park were unable to get access for education and awareness about campsite garbage problems.

Table 4.31: Relationship between demographic characteristics of respondents and their awareness about garbage problems in SMNP

		Are you aware of any campsite garbage in this park?					
		Yes		No		Total	
Variables	**Category**	Frequency	%	Frequency	%	Frequency	%
Education level	Elementary	0	0	4	100	4	100
	High school	8	29.6	19	70.4	26	100
	Diploma	30	66.7	15	33.3	45	100
	Degree and above	16	94.1	1	5.9	17	100
	Total	54	58.1	39	41.9	93	100
Occupation status	Cook	10	29.4	24	70.6	34	100
	Guide	28	100	0	0	28	100
	Residential staff	2	20	8	80	10	100
	Tourist	8	100	0	0	8	100
	Others (Stakeholders)	6	46.2	7	53.8	13	100
	Total	**54**	**58.1**	**39**	**41.9**	**93**	**100**
Location of residence	Inside the park	8	24.2	25	75.8	33	100
	Near the park	37	72.5	14	27.5	51	100
	Far away from park	9	100	0	0	9	100
	Total	**54**	**58.1**	**39**	**41.9**	**93**	**100**

4.4.2 Current situation of garbage management in SMNP

Results on respondents' views on the current situation of garbage management in SMNP are presented in Table 4.32. Results revealed that nearly half of the respondents (46.2%) considered the current status of garbage in SMNP to be in a bad state, 34.2% perceived it as serious while 18.3% stated that garbage management in SMNP was in good condition.

Further, chi-square test results on the degree of association between demographic characteristics of respondents and their views towards current garbage management status showed that there was no statistically significant relationship between sex, marital status,

and duration of services and their views on the current status of garbage management around campsites (all p>0.05). However, there was a statistically significant relationship between the occupation of respondents ($\chi 2$ = 78.219, df = 12, p < 0.0001), location of respondents ($\chi 2$ = 23.275, df = 6, p = 0.001) and the current garbage management. Most of the cooks (73.5%) noted that the current garbage management status is bad while 87.5% of the tourists and 82.1% of the guides stated it was the worst.

From the results, there was a significant relationship between the education level of respondents and their views on the current garbage management status ($\chi 2$ = 27.664, df = 9, p < 0.001). Most of the educated respondents, particularly those with a degree and above (70.6%) affirmed that the current garbage management status is the worst, while those with elementary education (50%) indicated it was good.

Additionally, the chi-square test of independence established that there was a significant relationship between the occupation status of the respondents and their concern about garbage problems at SMNP ($\chi 2$ = 100.271, df = 8, p < 0.0001). This implies that respondents that were directly affected by the wastes such as guides (100%) and tourists (87.5%) were more concerned about garbage problems in SMNP. Table 4.32 gives a summary of the results described above.

Table 4.32: Respondents opinion on current status of campsite garbage problems

	The current status of campsite garbage problems in SMNP							
Variables	**Serious/worst**		**Bad**		**Good**		**Better**	
Education level	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Elementary	0	0	2	50	2	50	0	0
High school	1	3.7	18	66.7	7	25.9	1	3.7
Diploma	19	42.2	19	42.2	7	15.6	0	0
Degree and above	12	70.6	4	23.5	1	5.9	0	0
Total	**32**	**34.4**	**43**	**46.2**	**17**	**18.3**	**1**	**1.1**
Occupation status								
Cook	1	2.9	25	73.5	7	20.6	1	2.9
Guide	23	82.1	5	17.9	0	0	0	0
Residential staff	0	0	8	80	2	20	0	0
Tourist	7	87.5	1	12.5	0	0	0	0
Others (Stakeholders)	1	7.7	4	30.8	8	61.5	0	0
Total	**32**	**34.4**	**43**	**46.2**	**17**	**18.3**	**1**	**1.1**
Location of the residence								
Inside the park	2	6.1	21	63.6	9	27.3	1	3
Near the park	23	45.1	21	41.2	7	13.7	0	0
Far away from park	7	77.8	1	11.1	1	11.1	0	0
Total	**32**	**34.4**	**43**	**46.2**	**17**	**18.3**	**1**	**1.1**

4.4.3 Onsite handling, sorting and reuse trends in garbage at SMNP

Proper waste handling practices at kitchen level has positive implications on waste management. As a result, the study deemed it important to establish trends in onsite handling, sorting and reuse in garbage at SMNP. About 41.9% of the respondents reported they clean their kitchen at campsite daily, 16.1% after two days, 11.8% clean after three days and 30.1% reported that they clean based on their interest. Moreover, 91.4% of the respondents have temporary storage materials like trash bin, sack and plastic bag, while 8.6% of the respondents had no temporary storage facility at the kitchen (Table 4.33).

Chi-square test of independence results to show the relationship between demographic variables and garbage handling practices of the respondents showed that there was no relationship between sex ($\chi 2 = 0.779$, df = 1, p = 0.377) and marital status ($\chi 2 = 1.229$, df = 1, p = 0.255) and waste collection practices. However, there were significant relationships between occupation ($\chi 2 = 53.864$, df = 4, p < 0.0001), duration of services ($\chi 2 = 7.434$, df = 2, p = 0.024) and garbage storage facilities around campsites in SMNP. Among the respondents' categories all cooks, guides, residential staff and tourists had temporary storage materials during their stay in the park, whereas only 61.5% of stake holders and others had no temporary storage materials.

Table 4.33: Relationship between demographic variables and garbage storage facilities

		Do you have any temporary garbage storage materials?			
		Yes		**No**	
Variables	**Category**	**Frequency**	**%**	**Frequency**	**%**
Occupation status	Cook	34	100	0	0
	Guide	28	100	0	0
	Residential staff	10	100	0	0
	Tourist	8	100	0	0
	Others (Stakeholders)	5	38.5	8	61.5
	Total	**85**	**91.4**	**8**	**8.6**
Duration of service	1-3 years	20	95.2	1	4.8
	Between 3 and 5 years	33	82.5	7	17.5
	Above 5 years	32	100	0	0
	Total	**85**	**91.4**	**8**	**8.6**

Table 4.34 shows results about the relationship between demographic variables and the separation of wastes. As evidenced in the table, more than half of the respondents (53.8%) reported that they separated garbage before disposal, while 46.2% did not. A chi-

square test of independence further revealed that the relationship between demographic variables and the separation of store wastes showed a significant relationship between education level ($\chi 2 = 29.043$, df = 3, $p < 0.0001$), and occupation status ($\chi 2 = 51.618$, df = 4, $p < 0.0001$) of respondents and the separation of stored wastes. Majority of those with a degree and above (94.1%) and almost all (100%) the guides and tourists reported sorting their wastes before disposal. This implies that educated individuals have knowledge on how to separate store wastes produced in the kitchen.

Besides, there was a significant relationship between duration of service ($\chi 2 = 31.384$, df = 2, $p < 0.0001$), location of the respondents residence ($\chi 2 = 21.766$, df = 2, $p < 0.0001$) and the separation of stored wastes produced in the kitchen. Since individuals living inside the park were unaware of wastes, they had no knowledge on how to separate stored wastes produced in the kitchen. In terms of length of service, the implication is that individuals that have stayed longer at SMNP (93.8%) are aware of the benefits of separating store wastes produced in the kitchen (Table 4.34).

Table 4.34: Relationship between demographic variables and separation of wastes

	Do you sort the garbage while generating it?			
Variables	**Yes**		**No**	
Occupation status	**Frequency**	**%**	**Frequency**	**%**
Cook	9	26.5	25	73.5
Guide	28	100	0	0
Staff resident	1	10	9	90
Tourist	8	100	0	0
Others (Stakeholders)	4	30.8	9	69.2
Total	**50**	**53.8**	**43**	**46.2**
Duration of service				
1-3 years	7	33.3	14	66.7
Between 3and 5 years	13	32.5	27	67.5
Above 5 years	30	93.8	2	6.3
Total	**50**	**53.8**	**43**	**46.2**
Location of residence				
Inside the park	8	24.2	25	75.8
Near the park	33	64.7	18	35.3
Far away from park	9	100	0	0
Total	**50**	**53.8**	**43**	**46.2**

From the findings in the table 4.35, only 25.8% of the respondents reported they reused solid waste while the majority (74.2%) had no experience with waste reuse. A chi-square test carried out to determine the degree of association between occupation status, education level, location of residence, duration of service and garbage reuse trend in SMNP showed that there was no statistically significant relationship between duration of services and garbage reuse practices ($\chi 2 = 1.812$, df = 4, $p = 0.404$). However, there was a statistically significant relationship between occupation status and reuse of waste ($\chi 2 = 47.093$, df = 4, $p < 0.0001$).

Results also revealed that the occupation of an individual influences whether they reuse waste. All the residential staff (100%) reused waste whereas all tourists (100%) did not

reuse waste, since tourists come from far away from park and left the garbage after used it. There was a significant relationship between the education level of respondents and reuse of waste ($\chi 2$ = 10.325, df = 3, p = 0.016). The implication is that the lower level class individuals (50%) have a higher likelihood of reusing waste particularly plastics and metals for extra purpose.

Additionally, there was a significant relationship between location of the respondents and reuse of waste ($\chi 2$ = 13.767, df = 2, p = 0.001). For individuals that reside inside the park (48.5%), they reused the waste since they are directly affected by the increase in the generation of wastes, whereas 88.9% of respondents that resided far from the park and 86.3% of respondents near the park had no reuse experience (Table 4.35).

Table 4.35: Relationship between demographic variables of respondents and waste reuse practices

Demographic Variables	Category	Do you reuse the waste?			
		Yes		No	
		Frequency	%	Frequency	%
Occupation status	Cook	7	20.6	27	79.4
	Guide	0	0	28	100
	Staff resident	10	100	0	0
	Tourist	0	0	8	100
	Others (Stakeholders)	7	53.8	6	46.2
	Total	**24**	**25.8**	**69**	**74.2**
Location of residence	Inside the park	16	48.5	17	51.5
	Near the park	7	13.7	44	86.3
	Far away from park	1	11.1	8	88.9
	Total	**24**	**25.8**	**69**	**74.2**

4.4.4 Opinion on willingness to engage in waste management campaign in SMNP

Table 4.36 illustrates respondents' opinion about their willingness to engage in waste management campaign at SMNP. Results showed that majority of the respondents (65.6%) did not involve themselves in garbage cleanup campaign, while only 34.4% of the respondents participated in garbage cleanup campaign in the campsites. However, during the time of this study 89.2% of the respondents showed willingness to support future garbage management campaigns through participation.

To determine the relationship between occupation status, education level, permanent location, and duration of service in the park and willingness to engage in campsites waste management campaign, a chi-square goodness of fit test was performed. Results showed that there was no significant relationship between occupation status ($\chi 2 = 6.882$, df = 4, p = 0.142) and location of respondents ($\chi 2 = 5.612$, df = 2, p = 0.06) and willingness on campsite garbage management campaign. However, there was a significant relationship between education level and participation in waste management campaign ($\chi 2 = 7.978$, df = 3, p = 0.046). With increase in the level of education, there was also a significant increase in participation in waste management campaigns. As such, the level of education plays a key role in promoting participation in waste management campaigns.

There was also a significant relationship between duration of service or stay in the park and participation in waste management campaign ($\chi 2 = 38.417$, df = 2, $p < 0.0001$). All (100%) respondents that had served for longer periods of time at the park showed willingness to support future campsite garbage management campaigns. The implication

is that, individuals that have stayed longer at SMNP are aware of the benefits of waste management at the park (Table.36).

Table 4.36: Respondents' opinion about willingness to engage in waste management campaign at SMNP

		Would you like to support future garbage management campaigns?			
		Yes		**No**	
Variables	**Category**	**Frequency**	**%**	**Frequency**	**%**
Education level	Elementary	3	75	1	25
	High school	21	77.8	6	22.2
	Diploma	44	97.8	1	2.2
	Degree and above	15	88.2	2	11.8
	Total	**83**	**89.2**	**10**	**10.8**
Duration of service at SMNP	1-3 years	11	52.4	10	47.6
	Between 3 and 5 years	40	100	0	0
	Above 5 years	32	100	0	0
	Total	**83**	**89.2**	**10**	**10.8**

4.4.5 Opinion on potential measures for mitigating garbage management at SMNP

Table 4.37 illustrates results on the potential measures for mitigating garbage management at SMNP. Based on the results in the table, 39.8% of the respondents suggested that burying garbage in pits is the most appropriate waste disposal method for SMNP, while 11.8% stated that transportation of waste outside the park is a viable option for waste disposal.

Chi-square test results on the degree of association between occupation status, duration of service, location and potential garbage management practices showed there was a significant relationship between occupation ($\chi 2 = 104.991$, df = 12, $p < 0.0001$), duration

of services ($\chi 2 = 19.087$, df = 8, p = 0.014), location ($\chi 2 = 83.897$, df = 6, p < 0.0001) and potential garbage management options. Specifically, 58.8% of cooks suggested the burn method, whereas majority of tourists (87.5%) suggested transporting the garbage to areas outside the park (Table 4.37).

Table 4.37: Potential measures to mitigate campsite garbage management problems

	Appropriate waste management system for SMNP							
Variables	**Burn**		**Bury**		**Dispose in garbage pit**		**Transport to other places**	
Occupation status	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Cook	20	58.8	4	11.8	9	26.5	1	2.9
Guide	3	10.7	0	0	25	89.3	0	0
Staff resident	4	40	3	30	2	20	1	10
Tourist	0	0	0	0	1	12.5	7	87.5
Others (stakeholders)	10	76.9	0	0	0	0	2	15.4
Total	37	39.8	7	7.5	37	39.8	11	11.8
Duration of services								
1-3 years	8	38.1	2	9.5	4	19	7	33.3
Between 3 and 5 years	18	45	4	10	15	37.5	3	7.5
Above 5 years	11	34.4	1	3.1	18	56.3	1	3.1
Total	37	39.8	7	7.5	37	39.8	11	11.8
Location of residence								
Inside the park	20	60.6	7	21.2	5	15.2	1	3
Near the park	17	33.3	0	0	31	60.8	2	3.9
Far away from park	0	0	0	0	1	11.1	8	88.9
Total	37	39.8	7	7.5	37	39.8	11	11.8

CHAPTER FIVE

DISCUSSION

5.1 Introduction

This chapter discusses key findings of the research. The findings focus on garbage generation rate and composition, status of human-wildlife conflicts around campsites, suitable garbage site selection, and garbage management practices and potential mitigating measures.

5.2 Garbage sources, generation rate and composition in SMNP

The sources, generation rate and compositions of garbage were examined with a view of generating knowledge on the sources and types of waste generated to guide in the design and adaption of an appropriate solid waste management system within the park. The study showed that the main sources of garbage in SMNP were tourist campsites, staff residences and community lodges. These findings are in line with those of Wseem *et al.* (2004) who argued that hotels, restaurants and staff residences were the main source of waste in Ayubia National Park, Pakistan. According to the current study findings tourist campsites were the highest garbage sources in SMNP as compared to staff residences and community lodges. Similarly, a study from Nepal by Basnet (1993) showed tourist and tourist association activities as the main sources of garbage in Sagarmatha National Park followed by lodge workers and hotels while local residences were minor polluters.

Findings also showed that the mean garbage generation rate between tourist campsites, community lodges and staff residences were significantly different with tourist campsites

having the highest proportion of garbage generated. The implication is that the tourist campsites had a higher generation rate of garbage since the lifestyles of the tourists were better than those of residential staff and community lodges. These results concurred with those of Wells (1996) who suggested that there is a direct relationship between individuals' life standards and waste generation rates. People who have a better life standard tend to consume more than low income communities hence they generate more wastes. Waste quantities are inextricably linked to economic activity and resource consumption (World Bank, 1999). Additionally, tourist campsites had a relatively high percentage of foreigner tourists and their economic backgrounds might have influenced their purchasing power and probably translated to the relatively high waste generation rates. Similar assertions were also made by Bartelings and Sterner (1999) who alluded that increasing population levels, rapid economic growth and a rise in community living standards accelerate the generation rate of solid waste.

Findings showed that there was a significant difference in garbage generated between the three campsites. Sankaber had the highest generation rate followed by Chenek campsite, while Gich had the lowest garbage generation. Sankaber and Chenek campsites are located along the main road. Likewise Sankaber campsite is near Debark town, while Gich campsite is located far from the main road. Due to this easy access, most campsite users used Sankaber and Chenek campsites as opposed to Gich, resulting to a high garbage generation rate compared to Gich. The study revealed that geographical locations affected waste generation of the different communities residing around them. Similar

observations were made by Otoo (2013) who carried out a study in Ejisu, Kwamo and Fumesua towns in Ghana.

Based on the study findings the average per capita garbage generation rate in SMNP was much higher than the national level waste generated profile range study by (World Bank, 2004) which established that the per capita amount of waste generated in Ethiopia ranged from of 0.23-0.5 kg/capita/day. Hence compared to the national level the outcome from campsite waste generation exercise is somewhat is puzzling, indicating an average campsite user's waste generation rate of 0.69 kg/person/day in SMNP. However, it was also much lower compared to other studies conducted in Pakistan's Ayubia National Park by Wseem *et al.* (2004) where tourists generated wastes ranging from 3.38 to 3.84 kg/capita/day. This result could be due to variations in the life standards of campsite users among other factors around SMNP.

Based on the findings six different types of wastes were identified and categorized. This comprised of foodstuff, plastics, papers, metals, glasses, and other miscellaneous materials like ash and dirt. Findings showed that food waste had the highest composition while glasses had the lowest composition across the three campsites. Hence the findings on the nature of garbage composition in SMNP were similar with those of other studies conducted in different countries among them Mohan *et al.* (2011) in Kathmandu, Nepal and Hamid *et al.* (2015) in Malaysia. Most of these studies have shown that organic waste dominates the waste stream. For instance, a waste generation and composition study at an Administrative Building Café in University of Putra, Malaysia by Hamid *et*

al. (2015) found that organic waste had the highest percentage (81%), followed by plastic (8%), while glass had the least (1%). Previous studies had also reported that a large a portion of solid wastes in developing countries is food waste (Wakjira, 2007). These findings show that most of the waste generated in protected areas such SMNP and their surroundings is solid waste.

The study showed that the composition of garbage was not significantly different across the three campsites. However, food waste and miscellaneous wastes were statistically significant between Sankaber and Gich and between Chenek and Gich .campsites. The study also showed that composition of garbage was significantly different between garbage sources in SMNP. This implies differences of location (access by road) between campsites and other factors like feeding culture and economy between tourists and local residents influenced variations in consumption as well as waste composition percentage. Similar trends were observed in Ayubia National Park, Pakistan (Wseem *et al*., 2004), and at three villages in Ghana (Ansah, 2014). Physical composition of solid waste is also extremely variable as a consequence of different factors such as economic, demographic, locations and season (Yohanis and Genemo, 2015).

5.3 Human-wildlife conflicts around campsites in SMNP

In this objective, various factors were identified as being potentially important when assessing the perception of campsite users in SMNP towards wildlife resources and HWC. Survey result showed respondents were aware of HWC in and around the campsites of the SMNP. Moreover, the demographic characteristics such as age, education level, and occupation status, duration of service and location of the respondents

had a significant association with awareness on HWC. Although marital status had no significant association, men and educated individuals were aware of HWC. Similar observations were made by Mir *et al.* (2015) in Kashmir valley, India where findings indicated that gender and education played an important role in determining awareness about HWC rather than marital status.

Majority of the respondents encountered at least one conflicts with wild animals during their stay in the park. The implication is that human-wildlife conflicts remain a critical issue for park management in the SMNP. Specifically results revealed that there was a significant association between encounter with HWC and occupation status and length of services. Not surprisingly, those who were most likely to come into contact with the animals in a feeding situation, that are cooks and those workers who spend the most time in the park, reported higher levels of HWC than other respondents. In a study by Yihune *et al*. (2009), and Mamo (2015) in SMNP and Bale Mountains National Park, respectively established that senior residents were more affected by HWC than residents that were recent settlers around the park. Incidences of HWC significantly differed across the different campsites and animal species. For example, Chenek campsite was a hotspot for HWC as compared to Sankaber and Gich campsites. Incidence of HWC had a significant association with campsites and problematic animals with the geladas being cited as the most problematic animals at Chenek campsite. Similar trends were reported in studies conducted in Limpopo Province, South Africa by Findlay (2016) where incidences of HWCs were varied between and among problematic animals and hotspot areas.

During this study, various causes of HWC were identified among the once cited were poor waste disposal, human activities around campsites, lack of food for wild animals and too many wild animals among others. Moreover, these causes of HWCs varied by season and animal species. For example, conflicts with geladas and birds were severe during peak periods of tourism related activities in the park since poor waste disposal is increased. Similar trends were observed in the Middle East, Israel where increased food availability from agricultural production and illegal refuse dumps disturbed ecological equilibriums and encouraged conflicts (Distefano, 2005). This implies that the conflict is expected to escalate if illegal and poor waste dumping is not prohibited (Yom-Tom *et al.*, 1995). The study found that increased in human activities around campsites cause HWC. Similar observations were made by Lamarque *et al.* (2009).who argued that growing interest in ecotourism and the increasing presence of humans in protected areas across Africa were exacerbating conflict between humans and wildlife.

Various types of HWC were reported by respondents among them snatching food from human hands and tables, the destruction of campsites properties, the disruption of human activities and human threats among others. The types of HWC were significantly associated with particular animal species and trends of conflicts. Apparently the geladas were the most likely to snatched food from their hands and tables, besides some properties were destroyed and human activities disrupted by these problematic animals around campsites. Similar observations were made by Fenta (2014) in a study conducted in Wondogenet district, Ethiopia. According to that study findings, baboons and monkeys snatched food items, destruction of property, human disruption (especially when they

were sleeping), and threats of humans with nocturnal carnivores such as spotted hyenas when walking at night from their offices to homes. The foregoing trends were observed in Zambezi valley, Zimbabwe (Lamarque *et al.*, 2009), whereby baboons (*Papio spp*.) raided gardens and food in lodges and camping areas and caused immense nuisance in small urban settlements. Baboons have been reported to be a major menace in bush camps and small towns such as Chirundu and Victoria Falls, Zimbabwe and in wildlife camps and lodges where they are not actively controlled. They pulled thatch grass from roofs of buildings and even intimidated tourists in an attempt to steal food directly from the tables they occupy (Gaynor, 2000; Kansky, 2002).

Counter-measures such as chasing wild animals, noise-making and scarecrows were used by campsite users to mitigate conflicts with wild animals in SMNP. Elsner (2008) reported that guarding methods currently used against primates involve chasing animals until they leave the immediate vicinity of an area and then ceasing to chase. These measures are, however, not sustainable since wild animals can be habituated over time. Likewise some species such as baboons show less fear and simple vigilance does not yield effective results (Lamarque *et al.*, 2009).

Potential mitigating measures were identified by respondents among them keeping campsites clean, guarding campsite properties and relocating the camping sites. This study showing that keeping SMNP clean could mitigate the problem in to the long term. Also, improving garbage disposal system will be a key component in reducing HWC. In line with the study findings, Distefano (2005) suggested that good standards of waste

management are important to avoid attracting wild animals to human settlements and could restrict wildlife access to garbage.

5.4 Suitable site selection for campsite garbage disposal sites

Although SMNP is a pristine wildlife area, it is losing its attractiveness due to garbage left behind by tourists as well as improper disposal of solid waste by residential staff and community lodges. Collection and disposal of waste are the major challenges in SMNP. A considerable quantity of waste which is generated and collected is disposed directly into open areas and garbage pit without any technical determination. This affects the whole park environment in general and the wildlife resource in particular.

Although national parks and natural conservation areas such as SMNP are not suitable for the location of disposal sites, proper siting around campsites and lodges is possible to prevent unmanageable garbage. Hence the ecological value of flora and fauna could be considered of high priority on a study area. The major goal of the disposal site selection process is to ensure that the disposal facility is located at the best location possible with little negative impact on the environment or wildlife resources. To determine a suitable garbage site for campsites in SMNP, the GIS based suitable site selection method is very important (Lunkapis, 2004). The role of GIS in solid waste management is widely recognized as many aspects of its planning and operations are highly dependent on spatial data. The multi criteria decision analysis is widely used for site selection process (Pournamdarian, 2010). Identification of the suitability of potential disposal sites, and modifications to existing facilities, requires a comprehensive assessment of site conditions and potential impacts on the environment.

To determine the most suitable garbage disposal site for SMNP, different criteria were identified to assist in selecting a suitable garbage sites such as slope, land use/land cover, distance from rivers, distance from roads and distance from building areas. Similarly Sener *et al.* (2011) applied those criteria at Lake Beysehir catchment area, Konya, Turkey used for siting disposal site.

The study showed that the existing disposal sites are all located in unsuitable areas, since they are near water sources and building areas. Hence they did not fulfill the disposal site suitability criteria. The areas in the park with open grass lands and gentle slopes are suitable areas for disposal. The most suitable areas are found around the buffer zone of the park and far away from the water sources and buildings with low impacts on ecological, economic and social aspects. Similar observations were made by Nwosu and Pepple (2016) in Ile-Ife, Nigeria. According to his study by applying those selection criteria the existed disposal sites shifted to suitable sites.

5.5 Campsite waste management practices and potential mitigating measures

The status of campsite waste management practices and potential measures were examined in the study area. Findings showed that demographic characteristics such as education level and duration of services of the respondents and waste management practices in SMNP were significantly associated. However, there was no significant relationship between sex and marital status of respondents with awareness on garbage management practices. Similar observations were made by Lutui (2001) in a study conducted in the Kingdom of Tongan in which sex and marital status had no significant

relationships with awareness on waste and waste management practices, however others (education level and occupation status) were significantly associated.

The study showed that most respondents were aware of campsite garbage problem in SMNP. This finding contradicts with those of Kumar and Nandini (2013) in Karnataka, India, where most of the households were not aware about solid waste generation and its impacts. However, garbage management practices around campsites in SMNP were still at rudimentary stage because majority of the respondents reported that garbage management status around campsites was not very effective. This means that onsite` handling, sorting and reuse practices of garbage are not practiced consistently by majority of campsite users.

Source sorting is the basic and most important factor for improved waste management since mixed waste offers largely limited possibilities for effective disposal methods. The present solid waste generated in SMNP is however not separated but virtually collected as a mixed waste. The study showed that majority of respondents had no knowledge about the sorting practice at kitchen level in SMNP. Similar trends were reported in Karnataka, India by Kumar and Nandini (2013) and in Jijga town by Yohanis and Genemo (2015) who concluded that large portion of the households did not separate waste while a small fraction practiced separation. Similarly in Karnataka, India, most of the households are directly disposing into the community bins without segregation. Reuse is an important factor in reducing the amount of waste to be dumped at the final disposal site. The study showed that few respondents reported those who had reused their waste

for further services such as plastic bottles used for refilling gas and other liquids. In conformity with the results, a study conducted by Kumar and Nandini (2013) indicated that there is little practice of waste reuse for different purposes for example industrial waste or can for sale. This reaffirms that source separation was totally absent in solid waste management practices of most developing countries (UNEP, 2000).

With regards to on site handling in SMNP, garbage generated by the users was stored in different containers including plastic bags, metal bins, and sacks among others. The receptacles used for waste storage in the study areas were similar to those reported by Freduah (2004) in Nima, a suburb in Accra. Other respondents including tourists in SMNP used communal trash containers and garbage pit for refuse disposal. In SMNP, majority of campsite users depended on the communal containers as their means of garbage storage, while few users threw their refuse in open areas at their kitchen sides, as their temporary waste storage.

At the time of this study, solid wastes were disposed from campsites by burning, burying and disposed in garbage pits. However, the current traditional approaches to solve these problems have proved to be ineffective and non-sustainable. In this study, various suggestions have been provided for garbage disposal including combustion by open burning, burying, disposal in garbage pits and transport to other places outside the park among others. Organizing of several clean-up campaigns, the construction of garbage pits at suitable sites, the placement of rubbish bins around campsites, the employment of staff, the environmental education of youth, and the creation of tourist information centers are

needed in SMNP. According to Posch (2013) in Sagarmatha National Park, Nepal those activities have been implemented to mitigate the garbage problems in the national park.

Majority of the respondents reported their willingness to participate in garbage management practices in the future if the conditions are favorable and involve campaigns by the park management. Similar observations were made by Kumar and Nandini (2013) in a study conducted in Karnataka, India, where an average 63% of the households were willing to participate in garbage management campaigns for better management of waste.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Findings on the sources, quantities and composition of garbage at SMNP showed that the principal sources of garbage in SMNP are tourist campsites, staff residences, and community lodges. A considerable amount of garbage in the park is however, generated from tourist campsites. Among the three campsites Sankaber had the highest mean of garbage generated in SMNP, while Gich had the least. The average waste generation rate in SMNP is considerably above the level of national waste profile. Food waste had the highest composition of garbage (69%) around campsites in the park followed by miscellaneous waste (13.7%), while glasses were the least (1%). Generally the mean garbage generation rate and composition was significantly different across the three campsites and garbage sources.

Findings on human-wildlife conflict around campsites in SMNP showed that human-wildlife conflicts are a common occurrence around campsites in the park. Campsites are the main hotspot places for human-wildlife conflicts. Hence, conflicts between campsite users and wild animals could be a big threat to people residing around campsites and wild animals themselves. The geladas and birds are the main problematic wildlife around campsites in the study area. Poor garbage disposal practices by campsite users as well as increasing human activities around campsites were the main causes of conflicts in the study area. Snatching foods from human hands and tables as well as disruption of human activities such as reading, cooking and eating and destruction of campsite properties were

the main forms of HWC around campsites in the park. Trends in conflicts showed an increase through time with increasing poor garbage disposal activities.

Findings showed that the application of GIS and AHP methods were found to be the most suitable in locating sites for solid waste disposal. Use of these GIS multi-criteria analysis methods took into consideration land use/land cover, slope, surface water or rivers, roads, and building areas as determining factors used to find appropriate sites for waste disposal. Results also showed that 76% of the area covered by the park is not suitable for location of garbage disposal sites, while 24% of the area is suitable for disposal with different suitability indices. Areas composed of high wood land or forest areas, steep slopes, near surface water, and roads were found unsuitable for siting disposal sites since they are critical sites for wildlife conservations and other economic values. Results also showed that the existing garbage disposal sites are not suitable for disposal since they did not fulfill the siting criteria.

Findings also revealed that current garbage collection, handling, separation, reuse and disposal methods in SMNP were not effective. From the analysis, it is clear that a large quantity of garbage generated in SMNP is due to lack of environmental awareness and improper waste management practices. A considerable quantity of waste which is generated and collected is disposed directly into the open areas and garbage pit without any waste separation and treatment methods. This affects the whole environment of the park in general and the wildlife resource in particular.

6.2 Recommendations

6.2.1 Waste management recommendations

- From the study findings, poor garbage disposal practices are the main challenges faced around campsites in SMNP while the resulting outcome is that the geladas and birds have lost their wariness for humans and get into conflict with campsite users in their search for food. Therefore, efforts should be made to store wastes at the park in wildlife-proof containers and trashcans to reduce the reliance of wild animals and birds on garbage feeding.

- To address the problems of perpetual human garbage in SMNP the park management should implement a bucket system for the removal of garbage at all campsites in SMNP. This means that with campsite users should be required to provide buckets in which garbage will be collected and be brought out from the park area and dumped in to the pre-designated area. Moreover, since the existed disposal sites are not located in suitable area for disposal, they should be shifted to the recommended suitable areas.

- Finally, there is need for stakeholders to raise awareness on the importance of proper waste disposal at SMNP since human garbage is the main cause of HWC in the study area. In addition, in order to improve the sense of ownership of wildlife resources, workshops should be held to sensitize staff and other people on improving their management practices.

6.2.2 Recommendations for further studies

- Because of time and budget constraint the study was conducted only during the dry season. However, in compliance with international best practice, a second waste generation and composition study should be conducted during the wet season to determine any seasonal variations.

- The study was restricted only effects of garbage on human-wildlife conflicts, however further study on effects of campsite garbage on wild animal's health and behaviour is needed.

- Likewise, this study only considered five social, economic and environmental criteria in the selection of potential solid waste disposal sites. However, other factors that have an influence on solid waste disposal site selection should be included among them the number of users, ecological aspect, geological factors and others. Further studies should fill this research gap by including these layers in the evaluation criteria.

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APPENDICES

APPENDIX I: QUESTIONNAIRE FOR COLLECTION OF INFORMATION ON CAMPSITE GARBAGE AND ITS EFFECTS ON HUMAN-WILDLIFE INTERACTIONS IN SMNP

Hello, good morning/afternoon.

My name is **Abebaw Azanaw Haile** I am a student at the University of Eldoret, Kenya, undertaking an MSc in Wildlife Management. I have come here to collect data. The purpose of this questionnaire is to collect relevant information needed for only academic purpose and on the campsite garbage and its effects on human-wildlife conflicts in Simien Mountains National Park. I am kindly requesting you to take a few minutes and give me your answers and opinions on the questions indicated below.

Thank you very much for your time and cooperation.

SECTION A: GENERAL INFORMATION ON RESPONDENT

Date_____

1. Age in years: 18 - 30 [ ] 31-40[ ] 41 -50[ ] Above 50 [ ]

2. Sex: Male [ ] Female [ ]

3. Education level (Tick one): [ ] Primary [ ] Secondary [ ] Diploma [ ] University [ ]

4. Marital status single [ ] married [ ]

5. Occupation (Major source of livelihood): Cook [ ] Guide [ ] Staff member [ ] Tourist [ ] Others (Stakeholders, drivers) [ ]

6a. Do you have any additional job: Yes [ ] No [ ]

b. If yes, state the other job you have ……..

7. For how long have you been staying at this campsite or your duration in the service is? 1-3 years [ ] 3-5 years [ ] Above 5 years [ ]

8. Location of permanent residence: Inside the park [ ] Near the park [ ] Far away from the park [ ]

SECTION B. KNOWLEDGE, ATTITUDES AND OPINION OF RESPONDENTS TOWARDS EXTENT OF HWC IN SMNP

9. Are you aware of HWC in this park? Yes [ ] No [ ]

10 a. Have you seen wild animals near campsites in this park? Yes [ ] No [ ]

b. If you have seen the three major campsites in this park, in your opinion, which campsite is more prone to HWC/ Incidence of HWC by campsite? Chenek [ ] Gich [ ] Sankaber [ ]

11. In your opinion, what are the reasons behind your answer in question 14 above? Location of the campsite [ ] Poor waste disposal [ ] Near to human settlement [ ]

12. Do you think HWC exist around campsites in SMNP? Yes [ ] No [ ]

13. Which time or season do more HWC occur at the campsite?----------

14. In your opinion, which animals are more problematic in SMNP? Gelada baboon [ ] Ethiopian wolf [ ] Bush buck [ ] Walia ibex [ ] Birds [ ]

SECTION C. RESPONDENTS' OPINION ON CAUSES, TYPES AND TRENDS OF HWC AROUND CAMPSITES IN SMNP

15. What are the main causes of HWC at campsite in SMNP? Lack of food for them [ ] Human move to habitat [ ] Too many wild animals [ ] Poor waste disposal [ ]

16. What are the types of HWC that exist at campsites in SMNP?

Snatching food items from kitchens, tables and people's hands [ ] Destruction of property [ ] Disruption of human activity [ ] Threat to human walking at night [ ]

17. Do you encounter any wildlife conflicts at campsite in SMNP? Yes [ ] No [ ]

b. If yes, how often do you encounter conflict from wild animals during your stay in SMNP?

Always [ ] Often [ ] Once in a while [ ] Rarely [ ]

18. Measures taken by campsite users to mitigate the problem of wild animals that coming to the campsite Chasing [ ] Noise-making [ ] Scarecrows [ ] Far away from wild animals [ ]

19. In your opinion, what are the trends in HWC around campsites in the last 5 years in SMNP? Increased [ ]. Decreased [ ]. Has remained as it was [ ]

20. If your answer is increase, what is the reason for increase in conflicts? Animal population has increased [ ] Scarcity of wild food [ ] Animals have lost fear for humans [ ] Lack of protective measures [ ] Animals prefer food remains than wild food [ ]

21. Have you observe any negative impacts of HWC on wild animals? Yes [ ] No [ ].

22. What changes have you observed with regard to Wild animals?----------

23. How concerned are people about HWCs in this Park? Very concerned [ ] Concerned [ ] Not concerned [ ]

24. In your opinion, what are the mitigating measures of HWC in SMNP? Kill wild animals [ ]

Guarding [ ] Keeping SMNP clean/ improve garbage management system [ ] Relocate the campsite [ ]

SECTION D. RESPONDENTS' OPINION ON THE CURRENT SITUATION OF CAMPSITE GARBAGE IN SMNP

25. Are you aware of Campsite garbage in this park? Yes [ ] No [ ]

26a. Did you generate any garbage during your stay at the campsite? Yes [ ] No [ ]

b. If yes, what is your measure on garbage found in the park? Pick and take it to garbage pit [ ] Burn it 3[ ] Bury it [ ] I leave or throw it away [ ]

c. If you collect garbage, where do you store it? Trash bin/can [ ] Plastic bag [ ] Trash sack [ ] Other (Specify) [ ]

27. In your opinion, what is the current status of campsite garbage problem in SMNP?

Serious [ ] bad [ ] good [ ] Better [ ]

28. In your opinion, how about the current situation of campsite garbage management?

Better [ ] Good [ ] Bad [ ] Worst [ ]

SECTION E. RESPONDENT'S OPINION ON CURRENT GARBAGE HANDLING, SORTING, REUSE AND OTHER MANAGEMENT PRACTICES IN SMNP

29a. Have you ever seen any garbage collection materials at a campsite in SMNP? Yes [ ] No [ ]

b. If yes, what type of collection materials have you been used at the campsite? Trash bin [ ] Plastic bag [ ] Trash sack [ ] Others (Specify) [ ]

b. How often do clean your kitchen? Every day [ ] After two days [ ] After three days [ ] Others (it depends)[ ]

30. Do you sort out your waste before disposal? Yes [ ] No [ ]

31. Do you have any temporary garbage storage materials? Yes [ ] No [ ]

32. Which type of collection materials are used?. Trash bin or can [ ] Plastic bag [ ] Trash sack [ ] Others (Specify) [ ]

33. Do you reuse the waste you generate? Yes [ ] No [ ]

34. In your opinion, is the collected material placed at an appropriate site? Yes [ ] No [ ]

35. Are the garbage collection materials enough for disposal of all garbage? Yes [ ].No [ ]

SECTION F. RESPONDENTS' OPINION ON WILLINGNESS TO SUPPORT GARBAGE MANAGEMENT CAMPAIGN

36. How concerned are you about the garbage problem in this Park? Very concerned [ ] Concerned [ ] Not concerned [ ]

37. Do you think garbage pose a problem for the SMNP? Yes [ ] No [ ]

38. In your opinion, whom do you think is mainly responsible for waste management in SMNP? Park office [ ] Tour association [ ] Other partners (NGO's) [ ] All [ ]

39. Have you ever participated in waste management campaign before? Yes [ ]. No [ ]

40a.Would you like to support any future campaign on garbage management? Yes [ ] No [ ]

b. If yes, in what way can you make your contribution? Providing labour [ ] Providing money [ ] Material support [ ] All the above mentioned contributions [ ]

41. What is your view on the appropriate waste management system for SMNP? Burning or combustion [ ] Bury [ ] Disposal in garbage pit [ ] Transport of garbage to other places [ ]

APPENDIX II: GARBAGE COLLECTION DATA SHEET

1. Data sheet for daily generation rate of garbage

Campsite name (site name) ---------- Date----------

Sources of garbage	Family size/	Days of generations of garbage							Total (kg)
		Day1 (kg)	Day2 (kg)	Day3 (kg)	Day4 (kg)	Day5 (kg)	Day6 (kg)	Day7 (kg)	
Tourist camp									
Staff residence									
Community lodges									
Total									

2. Data sheet for number of guest and daily generation rate of garbage

Campsite name (site name) ---------- Date----------

Sources of garbage	Days of generations of garbage (kg) and number of guests															
	Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 7		Total	
	Garbage	Guest	Garbage	Guest	Garbage	Guest	Garbage	Guest	Garbage	Guest	Garbage	Guest	Garbage	Guest	Garbage	Guest
Tourist camp																
Staff residence																
Community lodges																
Total																

APPENDIX III: DATA SHEET FOR GARBAGE COMPOSITION

Campsite name ----------, Garbage source name ----------

Ser/no	Type of garbage	Days of generation (kg)							Total	%
		1	2	3	4	5	6	7		
1	Plastic									
2	Food									
3	Paper									
4	Metals									
5	Glass									
6	Miscellaneous									
7	-									
	Total									

APPENDIX IV: PLATES

Plate 1: Gelada baboon scavenging human garbage

Source: UMGRP, 2013

Plate 2: Garbage pit around a campsite without cover

Plate 3: Newly installed metal trash bin at campsite