BASELINE ASSESSMENT OF GHG EMISSIONS OF NEPAL'S HEALTH SECTOR

Government of Nepal
Ministry of Health and Population
Kathmandu

December 2024

Government of Nepal
Ministry of Health and Population
Kathmandu

BASELINE ASSESSMENT OF GHG EMISSIONS OF NEPAL'S HEALTH SECTOR

December 2024

Government of Nepal
Ministry of Health & Population
Phone : 4. 262987
262590
262802
262706
262935
262862
Ramshahpath, Kathmandu
Nepal

Ref: .....

Date : .....

Foreword

Climate change has significantly affected multiple sectors, including health, water, sanitation, hygiene, and others. Both Nepal's experiences and global evidence highlight climate change as the greatest threat to the health sector in the 21st century. Recognizing public health as one of the most vulnerable sectors, the Government of Nepal incorporated it into the development of the National Adaptation Plan (NAP). In alignment with this effort, the Ministry of Health and Population (MoHP) developed the Health National Adaptation Plan (H-NAP) to systematically tackle climate risks through targeted adaptation measures.

Nepal's contribution to global warming is negligible, with most emissions originating from sectors outside health. While the health sector does contribute emissions as part of delivering healthcare services, its impact has been considered relatively minor in the national emissions context. To generate evidence and proactively address mitigation alongside adaptation measures, the Ministry of Health and Population conducted a "Baseline Assessment of Greenhouse Gas (GHG) Emissions of Nepal's Health Sector" in 2023. This assessment, undertaken as part of Nepal's health commitments at COP 26, is the first of its kind in the country. It revealed that the health sector accounts for 4.1% of Nepal's total GHG emissions. The study encompassed a diverse range of healthcare facilities, including central, provincial, regional, district, community, and specialized hospitals, as well as private hospitals and health service centers.

I extend my heartfelt gratitude to the Director of the Management Division, for leading this important initiative. My sincere thanks go to all the officials and stakeholders who contributed to this effort, with special acknowledgment to Mr. Upendra Dhungana, Section Chief of the Environmental Health and Health Care Waste Management Section under the Management Division, for his invaluable support and coordination, which were instrumental in the successful completion of this assessment. I also deeply appreciate Dr. Samir Kumar Adhikari, Senior Health Administrator at the Ministry of Health and Population, for his valuable suggestions and coordination at various levels. Additionally, I am grateful to the Policy Planning and Monitoring Division team at MoHP for their support in facilitating the approval of this report.

I sincerely thank the World Health Organization, Country Office for Nepal for their technical and financial support to carry out this assessment. My heartfelt appreciation goes to Er. Raja Ram Pote Shrestha, National Professional Officer, for overall conceptualization, his technical guidance, coordination, review and valuable contributions at various stages of the assessment, as well as in finalizing the report. I also extend my gratitude to the WHO-Nepal office team, particularly Dr. Manish Baidya and Mr. Upendra K.C., for their dedicated technical inputs and facilitating coordination within and beyond the health sector.

I would like to express my gratitude to Dr. Bhupendra Das, Dr. Nawa Raj Bhattarai, and the entire study team from Nepal Energy and Environment Development Services for their technical support in successfully conducting this assessment. Furthermore, I extend my heartfelt appreciation to the experts from Healthcare Without Harm, including Ms. Sol Aliano, Ms. Antonella Risso, and Ms. Diana Picon Manyari, whose invaluable support, and suggestions significantly enhanced the coherence and structure of this report.

In conclusion, I hope this assessment will serve as a crucial foundation for developing evidence-based policies to reduce GHG emissions from Nepal's health sector. Additionally, I trust it will contribute to advancing measures aimed at building a sustainable, low-carbon health system in the country.

.....
(Dr. Roshan Pokhrel)
Secretary

GLOSSARY

Clinical mix heath care waste	**Wastes that contain both the biohazardous and hazardous waste from health sector**
Composting	Natural process of recycling organic matter into a valuable fertilizer that can enrich soil and plants
Cooling and fire suppression	Cooling refers to limiting temperature by increasing the rate at which heat is lost from the burning material and fire suppression refers to collective term for any engineering group of units that are designed to put out a fire
DPI	Dry powder inhaler which is a breath-actuated device and delivers the drug in the form of particles in a capsule or blister
Electricity transmission and distribution losses	Losses in transmission between sources of supply and points of distribution and in the distribution to consumers, including pilferage
Emission factor	An emission factor is a representative value that aims to connect the amount of a pollutant released into the atmosphere with a particular activity
Employee commuting	Travel of an employed person between his or her place of residence and his or her place of work
Extra supply chain	Emission emitted across the supply chain for a single unit of that product
Fugitive emission	Emissions from direct or indirect release of greenhouse gases to the atmosphere from various types of equipment and processes
Global Warming Potential	A greenhouse gas's global warming potential (GWP) is a measurement of how much infrared thermal radiation it would absorb over a specific period of time.
Greenhouse Gases	The gases that trap heat in the earth's atmosphere are referred to as greenhouse gases (GHGs).
Hazardous health care waste	Wastes with properties that make it potentially dangerous or harmful to human health or the environment from health sector
Incineration	Waste treatment process that involves the combustion of substances contained in waste materials
MDI	Metered dose inhaler which is a handheld aerosol device that uses a propellant to deliver medicine to the lungs

Medicinal/anesthetic gases	Inhaled anesthetics (nitrous oxide, volatile fluorinated liquids like isoflurane, desfluranes, sevoflurane) administered via specific vaporizers that transform the liquids into gases that diminish and, at higher doses, eradicate patient awareness
Mobile combustion	Emissions released from the direct burning of fossil fuel from mobile sources
Non-hazardous health care waste	Wastes that do not pose any particular biological, chemical, radioactive or physical hazard from health sector
Other manufactured product	It includes textiles, wearing apparel and leather products; rubber and plastic products; motor vehicles, trailers and semi-trailers; other transport equipment; machinery and equipment; electrical equipment; retail trade, except of motor vehicles and motorcycles.
Other procurement	It includes wholesale and retail trade and repair of motor vehicles and motorcycles, and wholesale trade, except of motor vehicles and motorcycles.
Patient commuting	Travel of patient between his or her place of residence and his or her health care facility
Purchased electricity	Electricity purchase means the transferring in quantity and time of electricity from electricity traders and/or energy exchanges, to the purchaser, upon the payment and other conditions defined in the relevant sale/purchase contract, and according to the procedures defined in this regulation. The activities that use purchased electricity indirectly cause emissions of greenhouse gases
Purchased steam, heat and cooling	Emission associated with purchased steam, heat and cooling
Solid waste disposal	Discharge, deposit, injection, dumping or placing of any solid waste into or on any land or water which does not include the transportation, storage or treatment of solid waste
Stationary combustion	Emissions released from the direct burning of fossil fuels from stationary sources on-site

ACRONYMS

AEPC	Alternative Energy Promotion Center
AFOLU	Agriculture, Forestry, and Other Land Use
CIC	Climate Impact Checkup
COP	Conference of the Parties
DG	Diesel Generator
DoHS	Department of Health Services
DoI	Department of Industry
DPI	Dry Powder Inhaler
EF	Emission Factor
EPA	Environment Protection Act
EV	Electric Vehicle
EWARS	Early Warning and Reporting System
FCDO	Foreign, Commonwealth & Development Office
GGHH	Global Green and Healthy Hospital
GHG	Greenhouse Gases
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GoN	Government of Nepal
GWP	Global Warming Potential
HCF	Health Care Facilities
HCWH	Health Care Without Harm
HFC	Hydro Fluorocarbons
HFO	Hydrofluoro-olefins
INC	Initial National Communication
IPP	Independent Power Producers
KfW	Kreditanstalt für Wiederaufbau
KII	Key Informant Interview
LAPA	Local Adaptation Program of Action
LPG	Liquefied Petroleum Gases
MDI	Metered Dose Inhaler
MoFE	Ministry of Forests and Environment
MoHP	Ministry of Health and Population

NAP	National Adaptation Plan
NEA	Nepal Electricity Authority
NEEDS	Nepal Energy and Environment Development Services Pvt. Ltd
NHEICC	National Health Education, Information and Communication Centre
PEP	Provincial Energy Planning
PIU	Programme Implementation Units
TUTH	Tribhuvan University Teaching Hospital
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization

EXECUTIVE SUMMARY

The Ministry of Health and Population (MoHP) of Nepal made health commitments on Climate Resilient and Sustainable Low Carbon Health Systems at the UNFCCC COP26. The commitments made at COP26 constitute a big step forward in the effort to reduce greenhouse gas emissions from healthcare systems. In light of this, the Ministry of Health and Population has been working with World Health Organization (WHO) to develop a sustainable, low-carbon health system. The GHG study considering health facilities is still in its early stages in around the world including in Nepal, hence it lacks a real-world data base. Realizing this fact, this study aimed to carry out baseline assessment of GHG emissions of Nepal's health sector. This study conducted baseline analysis of Nepal's health system's GHG emissions, including supplier chains, in consideration of its pressing requirements and support for MoHP.

The health care facilities (HCFs) taken into consideration for this study were selected based on several factors, including location, province, topography, HCFs type, and other inimitable characteristics. HCFs from the following categories were considered in this study: central hospital, regional health directorate, provincial/regional hospital, district hospital, community hospital, specialized hospital, private hospital, and health service center. The sample locations consist of three ecological zones and all seven provinces. Both the primary and secondary data collection method was carried out to collect the data. To gather the available data, the checklist/questionnaire, structural questionnaire, key informant interview, general group discussion, interaction and onsite physical observation were used. To estimate national activity data, each HCF category's total number was multiplied by the average activity data referring DoHS annual report of 2020/21 and onsite consultations. The GHG footprint from HCFs for the base year 2022 was calculated using the Climate Impact Checkup (CIC) tool, developed by Health Care Without Harm (HCWH), considering various activity data, variables, emission factors (EFs), and global warming potential (GWP) of various gases.

This study for the first-time estimated Nepal's GHG emissions from health sector, which is 0.002% of the global GHG emissions (i.e.1,164,719 tCO_2e); 4.1% of Nepal's GHGs emissions and 0.05% of global GHG emissions from health sector. The total contribution of GHG emissions was maximum from indirect sources i.e. 678,317 tCO_2e (58.2%) (i.e. business trips, employee computing, patient commuting, inhalers, extra supply chain, electricity transmission and distribution losses, and off-site waste) followed by direct emission i.e. 474,847 tCO_2e

(40.8%) (i.e. stationary combustion, mobile combustion, fugitive emission, and on-site waste) and purchased electricity i.e. 11,555 tCO_2e (1%). Under indirect emissions, the extra supply chain contributed the most to GHG emissions (50.4%), followed by patient commuting (4.8%), and other sources (business travel, employee commuting, inhalers, and garbage) contributed the final 3%. The largest portion of the total GHG emissions under direct emission was from fugitive emissions (28.1%) to which cooling, and fire suppression made the largest contributions (27.7%). Others (stationary combustion, mobile combustion, and waste) accounted for 12.6% of the total GHG emissions. The emissions were highest for the direct sources followed by indirect sources and purchased electricity in the scenario where the extra supply chain was excluded. DPI inhalers were utilized the most (75%) and MDI (25%), respectively, among all inhalers. The MDI (93%) contributed more to the overall GHG emissions, though. The top 5 emitter categories like other manufactured products (33%), construction (22%), business services (19%), medical instruments/equipment (9%) and paper products (8%) contributed to over 91% of the GHG emissions of the indirect emission - supply chain sub-category (i.e. production and distribution of a commodity). To our knowledge, this study is the first time in Nepal regarding GHG emission inventory for HCFs at national level, which could be a valuable references and guidance in the preparation of action plans for developing sustainable low carbon health system. Moreover, it provides actionable insights and recommendations for stakeholders to contribute to a greener and sustainable healthcare system especially through energy-efficient appliances, renewable energy technologies, low carbon transportation pathways, e-cooking, and advanced waste management technologies.

Key words: Health care facilities; Climate change; GHGs emission inventory; Action plans; Sustainable low carbon health system

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

1. INTRODUCTION

1.1 Background

Climate change is one of the burning issues not only limited to developing countries like Nepal but in global area. Nepal was considered as the fourth most vulnerable country in terms of exposure to climate change based on Climate Change Vulnerability Index (Maplecroft, 2010). Among 17 Sustainable Development Goals (SDGs) listed by United Nations, SDG Goal No. 13 is “Climate Action” (United Nations, 2018). SDG No. 13 highlights the significance of taking urgent action to combat climate change and its impacts (United Nations, 2018). Greenhouse gases (GHGs) is considered as the major force in accelerating the climate change. Both the natural events and anthropogenic activities are responsible for it. The anthropogenic activities like deforestation, burning of fossil fuels, waste burning, burning of agricultural residue contributes to the emission of GHGs.

Climate change has a significant impact on environment, human health, and national economies. The climate change affects many aspects of climate making rainfall less predictable, altering seasonal weather patterns and increasing the likelihood of extreme weather events like high intensity storms, droughts and hot and cold waves, sudden glacial lake outburst flood (GLOFs) and many more. The global temperature has been rising at the rate of 1.7^0C per century since 1970 (Marcott et al., 2013). The global mean temperature of the Earth was about 1.11 ± 0.13 °C above the pre-industrial level (from 1850 to 1900) in 2021 which is one of the highest one in between 2015 to 2021 (United Nations, 2022). In case of Nepal, the Global circulation model (GCM) projections indicate the increase in temperature between 0.5^0C and 2.0^0C with a multi-model mean of 1.4^0C by the 2030s (Sapkota and Rijal, 2016). By the 2090s, the temperature is predicted to increase between 3.0^0C and 6.3^0C with a multi-model mean of 4.7^0C (Sapkota and Rijal, 2016). It also projected an increase of up to 55% by the 2060s and up to 70% by the 2090s for extremely hot days and 77% by the 2060s and 93% by the 2090s for nights. In the case of precipitation, a

projection ranges from a decrease of 14% to an increase of 40% by the 2030s and from a decrease of 52% to an increase of 135% by the 2090s (Sapkota and Rijal, 2016).

Previous studies have provided strong evidence regarding the influence of climate change on human health (Dhimal et al., 2021; Mojahed et. al., 2022). The impact can be in the form of heat stress, loss of life due to natural disasters or vector-borne, water-borne or food-borne diseases. More than 50% of the known human pathogenic diseases can be exasperated by climate change (Mora et al., 2022). In Nepal, numerous instances of contagious illnesses, especially those transmitted by vectors, have been documented across various regions. These occurrences can be attributed to possible shifts in climatic conditions, which have led to the emergence of novel diseases, increased their severity, or expanded their geographical reach within the country. As a result, vector-borne diseases like dengue and malaria are likely to increase as an impact of climate change. Dengue has been recognized as a significant concern in Nepal in recent times. While it was initially recorded in 2004, the highest reported cases of dengue outbreak were 54784 witnessed in the year 2022 (EWARS, 2023).

Climate change can have significant impacts on the prevalence and transmission of communicable diseases too. Previous prior studies have shown how the variation in temperature, precipitation affect distribution and transmission of infectious diseases like vector-borne diseases (VBDs) (Anwar et al., 2019; Tuladhar et al., 2019a). About 5 VBDs viz. Malaria, Lymphatic filariasis, Japanese encephalitis, Visceral leishmaniasis and Dengue fever are found to be afflicted in Nepal (DoHS, 2014). Moreover, VBDs has been identified as one of the highest priority adaptation projects for the health sector in Nepal (MoE, 2010). Under the different climate change scenario, dengue is likely to shift towards higher elevation region and incidence rate ratio of dengue cases were found to rise by more than 1% for every 1^0C increase in minimum temperature (Acharya et al., 2018; Tuladhar et al., 2019b). There is a need to strengthen Nepal public health surveillance system, promote inter-sectoral collaboration, enhancing community engagement in disease surveillance. Moreover, prior study has emphasized on the benefits of climate-based early warning system in prediction of disease emergence to address the issue (Bhandari et al., 2020).

1.2 Rationale of the study

The main cause of the changing climate is the rise in greenhouse gas emissions (GHGs) linked to human activity. Climate change is having a variety of negative health effects on several nations, including Nepal. Populations can be protected from the detrimental effects of climate change by health systems that are robust to it and sustained low carbon health systems can significantly lower national and global emissions. One contributing factor in global warming is the health sector. The provision of healthcare and the acquisition of goods, energy use, transportation, services, and technological advancements from a carbon-intensive supply chain all contribute to the direct and indirect emission of greenhouse gases (GHGs) in every country. Prior research showcased the increase in GHG emissions by more than 5% between 2018 & 2019, ultimately accounting 5.2% of global GHG emissions from health sector (Romanello et al., 2022). Reducing national and global emissions can be significantly helped by a sustainable low carbon health system.

The UNFCCC COP26 Health Initiatives on Climate Resilient and Sustainable Low Carbon Health Systems have received the official support of Nepal's Ministry of Health and Population (MoHP). The pledges announced at COP26 represent a significant advancement in the fight against the greenhouse gases emission produced by healthcare systems. The primary goal of creating a sustainable, low-carbon health system is to decarbonize healthcare facilities, which can be accomplished by using low-carbon or net-zero emission technologies for care, low-carbon or energy-efficient building design, climate-smart cooling technologies, sustainable waste, water, and transport management, and reducing the use of anesthetic gases with a high potential for global warming, among other strategies. In light of this, the Ministry of Health and Population plans to create a sustainable, low-carbon health system with assistance from the WHO. The study on GHGs considering health care facilities is at the early stage in Nepal, and therefore lacks a real-world data base. This study has developed baseline of Nepal's health system's GHG emissions, including supplier chains for sustainable low-carbon health system. This is the first national level study in Nepal to assess the GHG emission from health sector. This study represents a pioneering effort in promoting a sustainable, low-carbon healthcare system. This groundbreaking initiative not only contributes to our understanding of GHG emissions in healthcare but also sets the stage for a significant learning and leadership opportunity within the region. It empowers leaders/decision-makers/policymakers with knowledge, evidence, and tools to address challenges, make informed decisions, and drive positive change for the benefit of their communities and the broader region.

1.3 Objective

The main objective of this study was to develop baseline of GHG emissions of Nepal's health sector for developing sustainable low carbon health system.

The specific objectives were following:

a. Carry out a baseline assessment of greenhouse gas emissions of country's health system and health care facilities, including supply chains.
b. Determine a carbon footprint or the total GHG emissions caused directly and indirectly by health sector at national level.

CHAPTER 2

2. Literature review

Climate change ranks among the most significant global challenges for human health and environment (Romanello et al., 2022; WHO, 2021). It is considered that the crisis in climate is also the health crisis. The increase in GHG emissions results various impacts on environment including rising temperatures, changing rainfall patterns, heat waves, floods, droughts and melting glaciers. The changing climate has an impact on human health too. It is projected that climate change will lead to approximately 250,000 additional annual deaths due to factors such as malnutrition, malaria, diarrhea, and heat-related stress (WHO, 2021). Additionally, extreme weather events can elevate the frequency of traumatic injuries (World Bank, 2023). Prior study has projected risks and found the increase in heat-related morbidity and mortality up to 16 times due to exposure to climate change (IPCC, 2018). Furthermore, the climate crisis is contributing to a threefold rise in the likelihood of another significant virus-related event, akin to the COVID-19 pandemic (World Bank, 2023). The extent of disease can be based on occurrence, distribution and severity of numerous diseases which is directly or indirectly impacted by climate change. Similarly, climate change is anticipated to exacerbate diseases like malaria and dengue (IPCC, 2018). In Nepal, Dengue outbreaks has been a serious concern in past few years. In 2022, about 54,784 cases were reported and 88 deaths linked to this disease which is three-fold higher than the previous largest outbreak in 2019 (DoHS, 2022).

GHG emissions from health sector have been increasing steadily in the recent years. Prior study estimated the significant increase in global emissions from healthcare from a 2014 baseline to more than triple by 2050 under a business-as-usual scenario if the climate actions are not taken both within and beyond the health sector (HCWH, 2021). Global health care facilities are responsible for 4.4 – 4.6% of global GHGs emissions (HCWH, 2019; The Commonwealth Fund, 2022). About 75% of the world's total health care climate footprint are contributed by top ten health care emitters such as United States, China, European Union, Japan, Russia, Brazil, India, South Korea, Canada, and Australia (HCWH, 2019). Prior study in Canada also reflected health care system as an important sector to national GHG emission (Eckelman et al., 2018). Among different health care facilities, studies suggest that hospitals contribute

substantially to GHG emissions in healthcare delivery, primarily through activities like transportation, waste management, and resource consumption (Schmidt & Bohnet-Joschko, 2022). Another study provided an insight regarding energy consumption as maximum parameter contributing more than 50% of health care's footprint (HCWH, 2019).

Chung and Meltzer (2009) assessed the carbon footprint of the American (USA) healthcare system. The study discovered that the health institutions produced 546 million metric tons of CO_2e, or 8% of all national GHG emissions, of which 39% were attributable to hospital operations and 14% to the use of prescription drugs. Economy-wide modeling in 2020 revealed that the US health system's GHG emissions were 1,692 kg CO_2e per capita in 2018 and had increased by 6% between 2010 and 2018 (Eckelman et al., 2018). 10% of all greenhouse gas emissions in the US are caused by activities in the health care industry, which has a negative impact on people's health. However, research on environmental sustainability in the healthcare industry is still lacking (Campion et al., 2015; McGain et al., 2010; Venkathesh et al., 2016). The operating room (OR) generates 650 to 1,200 kilograms of medical waste per day and more than 3 million kilos of greenhouse gas emissions per hospital annually, according to prior research (Stockert et al., 2014; Zygourakis et al., 2017) making it a significant source of spending and trash generation in a medical facility (MacNeill et al., 2017).

In context of Canada, hospitals and pharmaceutical companies contributed the most to the 33 million tonnes of CO_2e that the Canadian health system produced in 2014, accounting for 4.6% of all national emissions (Eckelman et al., 2016). Emissions of greenhouse gases and harmful air pollutants caused the loss of 388,000 disability-adjusted life years in 2018. State-level greenhouse gas emissions per person varied widely and did not significantly correspond with the effectiveness of the healthcare system (Eckelman, 2020). In context of Australian, the study evaluated the carbon footprint of the Australian health system during 2014 and 2015 and discovered that it generated 35,772 kilo-tonnes CO_2e, or 7% of the nation's overall emissions (Malik et al., 2018). The biggest sources of emissions were public hospitals and pharmacies. The authors stated that "the CO_2e emissions of health care were about half those of the construction of every single building, house, pipeline, dam, oil rig, road and rail line in Australia in 2014 to 2015" (Malik et al., 2018). In China, the study assessed the carbon footprint of the Chinese health system in 2012 and discovered that it generated 315 mega-tonnes of CO_2e, or 2.7% of China's overall emissions (Wu et al., 2019). Public hospitals (47%) and non-hospital pharmaceuticals (18%) were the main donors, same as in the earlier surveys. 55% of the entire carbon footprint was supplied overall by the pharmaceuticals. Japan is the most recent nation to have revealed the carbon footprint of its healthcare system. Japan's carbon footprint in 2011

was 62.5 million metric tonnes of CO_2e, or 4.6 percent of their whole national emissions. They showed that by 2015, total emissions will have increased by more than 15%, reaching 72.0 metric tonnes CO_2e (Nansai et al., 2020). Additionally, they discovered that the primary contributors are healthcare and medicines, with the prescription of wasted medication resulting in 1.24 metric tonnes CO_2e of preventable emissions (Nansai et al., 2020).

The CO_2e emissions of health systems in all OECD nations, China, and India between 2000 and 2012 revealed that China, the United States, Japan, India, and Germany were the top GHG emitters related to health systems in 2014, with their health systems accounting for 4% of worldwide GHG emissions (Pichler et al., 2019). The health sector was determined to be the highest contributor to national carbon footprints in most countries. If the Chinese and American health systems were ranked as countries, their carbon footprints would place them at 10th and 14th internationally, respectively. The health care sectors that contributed the most to GHG emissions were medical retail, hospitals, and ambulatory health services, with 38% of emissions coming from energy and water consumption, 22% from transportation, and 10% from the chemical and pharmaceutical industries. It is noteworthy that the UK, USA, Canada, Japan, China, and Australia's contributions to national carbon footprints varied between the separate research on these nations' health systems' carbon footprint and the carbon footprint were determined. This demonstrates the need of having access to enough data to allow for an accurate computation as well as the methodological variations in carbon footprint calculations (Pichler et al., 2019).

The resilience of health systems to climate change is now being improved, especially in developing countries (Biddle et al., 2020; Ebi et al., 2018; Keim et al., 2008). Although there has been emphasis paid to preparing health systems for climate change, the health sector's own role in climate change is frequently overlooked (Romm et al., 2018). The Paris Agreement calls for a drastic reduction in greenhouse gas (GHG) emissions to lessen the adverse (health) effects of climate change. The global health industry has a significant impact on climate change. It is in charge of 6.7% of the nation's GHG emissions in Germany. Understanding the volume and origins of GHG emissions in great detail is necessary for the transition to low-carbon hospitals (Quitmann et al., 2021).

The NAP fulfills Nepal's obligation under the Paris Agreement of the UNFCCC, serving as a tool for adaptation. It aims to contribute to socio-economic prosperity by constructing a climate-resilient society, mitigating the impact of climate change on people and ecosystems. It also promotes electric modes of transport, ensures the use of sustainable energy (renewable) in

healthcare facilities, and enhances environmental health services, including air pollution monitoring and control. Furthermore, it entails establishing a climate change data management and monitoring system at the MoFE (NAP, 2021 – 2050). Simultaneously, Second Nationally Determined Contribution aims to prohibit the burning of healthcare waste in 1,400 healthcare facilities by 2030, achieved through the implementation of proper waste management utilizing non-burn technologies (Second Nationally Determined Contribution, 2020). In Nepal's Third National Communication, the comprehensive emission inventory encompasses sectors such as energy, industrial processes and product use, agriculture, forestry and other land use, and waste. Additionally, it incorporates a thorough vulnerability and impact assessment on human health resulting from the effects of climate change (Nepal's Third National Communication, 2021). Nepal is aspiring to attain a net-zero emission of greenhouse gases by the year 2045, with a strategic focus on maximizing clean energy, decarbonizing the transportation sector, promoting sustainable agriculture, increasing and maintaining forest cover, and fostering international cooperation on climate change mitigation and adaptation, among other key initiatives (Nepal's Long-term Strategy for Net- zero Emissions, 2021).

Though Nepal's contribution to global GHG emissions seems low in comparison to other countries. However, it is in increasing trend when compared with the previous studies conducted in 2004 and 2014. Nepal's contribution in the global GHG emissions was 0.025% and 0.027% as per Initial National Communication (INC) and Second National Communication (SNC) respectively (MoPE, 2004; MoSTE, 2014). There are various sectors in Nepal that contributes towards Nepal's GHG emissions viz energy, AFOLU, industrial processes and product use and waste which contributed 52.37%, 43.04%, 3.28% and 1.31% respectively of Nepal's total GHG emissions (MoFE, 2021).

CHAPTER 3

3. Process and methodology

3.1 Sample size and geographical distribution

Considering this as a pilot study and the first of its kind in Nepal, twelve healthcare facilities were selected. The study included all types of healthcare facilities (e.g., medical college & hospital, public hospital, private hospital, public health facilities/urban health centre/primary health centre/basic health service centre/health post/community health unit), as categorized in the annual report of Department of Health Services, Government of Nepal (2020/21).

The HCFs distributions are based on the following criteria:

i. Topography: Each region (Terai, Hill and Mountain) covers at one healthcare facility. For the pilot study, one complete region representing the Terai, Hill and Mountain was considered based on the highest number of HCFs, specialization/equipment, beds and population. Bagmati province was selected for it. The altitude is ranging from lowland (75.29 m) to highland (2,106.47 m) (Fig. 3.1, Table 3.1, Table 3.2).
ii. Region: The selection of sample sizes of the HCFs also considered regional balance (i.e., Eastern, Central and Western). Easter region covers two provinces (i.e. Koshi Province and Madhesh Province), central region covers one province (i.e. Bagmati Province), and the western region covers four provinces (i.e. Gandaki Province, Lumbini Province, Karnali Province, and Sudurpaschim Province) (Table 3.1, Table 3.2).
iii. Province: At least one sample of HCFs represents each province of Nepal (Fig. 3.2). HCFs located at provincial headquarter were given priority except in Madhesh and Karnali Provinces, where selection was based on specialization and services type, respectively.
iv. HCFs type: Each sample represented at least one category of HCFs such as central hospital, regional health directorate, provincial/regional hospital, district hospital, community hospital, specialized hospital, private hospital, and health center.

Based on the region, province, topography, type of HCF and its inimitability, TU Teaching hospital (TUTH) was selected among the central hospital with the capacity of over 700 beds. The Health Directorate of Lumbini Province (Bhaluwang) and Gandaki Province (Pokhara) were selected among the provinces considering the hub of fastest growing tourism and the rapid urbanization. Health management issues are also of a prime concern. Koshi hospital was selected among Provincial/Regional hospital as it is one of the oldest government hospitals with more than 13 different health services including ICU. Rasuwa district hospital was selected due to the highest altitude in the Bagamti Province. This added value in comparing the findings of energy consumption and GHGs emissions by altitude. The Salyan district hospital was selected from Karnali Province due to its accessibility and remoteness from the main market center and services type. Okhaldhunga hospital was considered as a community hospital run by the United Mission to Nepal. B.P. Koirala Memorial Cancer Hospital in Chitwan was selected for its specialization as well as a topography to represent one complete geographic region in the Bagmati province. Sagarmatha Choudhary Eye Hospital, the only specialized hospital in Madhesh Province, was considered. Considering the number of rural municipalities and municipalities and the population density, Gajendra Narayan Singh Sagarmatha Zonal Hospital of Madhesh Province was also considered. Moreover, Nisarga Hospital and Research Centre, the only private hospital in Sudurpaschim Province with more than 16 health services including an ICU and equipment facilities was included. An Urban Health Center was selected from Pokhara, Gandaki Province because it serves as both health post and urban health center (Table 3.1).

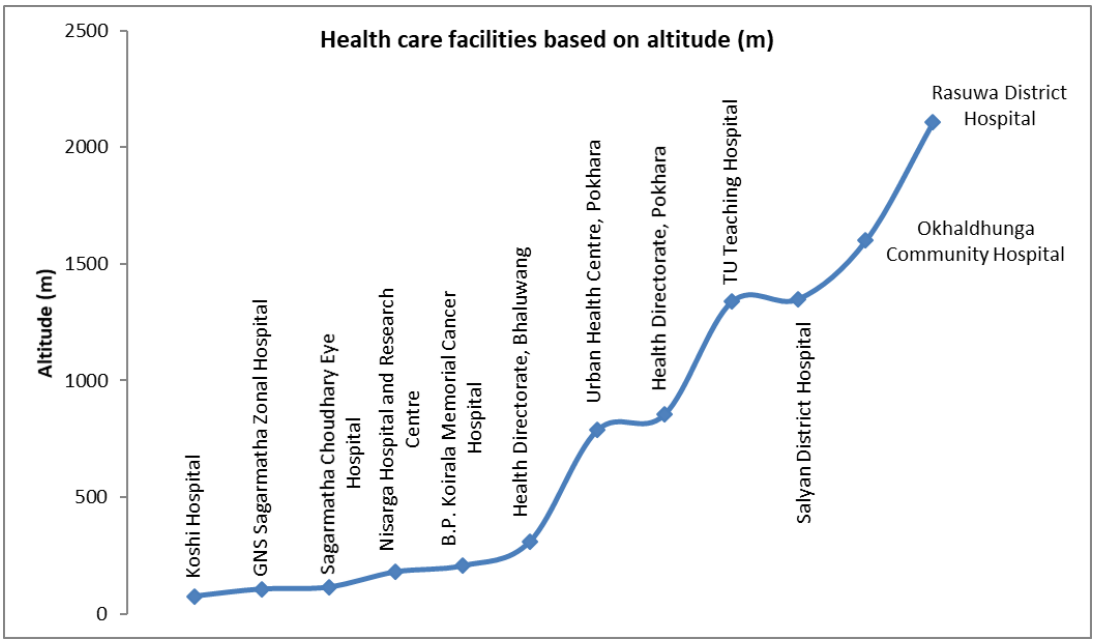


Fig. 3.1: Sample size and distribution

Table 3.1: Selected HCFs for the Study

	Name	Type of HCFs	Specialization	No. of bed	Patient/ year (Annual total)	Location	Province
1	Koshi Hospital	Provincial/ Regional Hospital	General/ICU	350	360000	Biratnagar	Koshi
2	Okhaldhunga Community Hospital	Community Hospital	Mission Hospital	50	96147	Okhaldhunga	Koshi
3	Sagarmatha Choudhary Eye Hospital	Specialization	Eye	450	214828	Lahan	Madhesh
4	Gajendra Narayan Singh Sagarmatha Zonal Hospital	Zonal Hospital	General	125	76912	Rajbiraj	Madhesh
5	Rasuwa District Hospital	District Hospital	General	15	9000	Dhunche	Bagmati
6	TU Teaching Hospital	Central Hospital	General/ICU & Research	700	782500	Kathmandu	Bagmati
7	B.P. Koirala Memorial Cancer Hospital	Specialization	Cancer	450	168000	Bharatpur	Bagmati
8	Urban Health Center	Health Center	Public Health Post	-	3985	Pokhara	Gandaki
9	Health Directorate Gandaki Province	Regional Health Directorate	Health Care System	-	-	Pokhara	Gandaki
10	Health Directorate Lumbini Province	Regional Health Directorate	Health Care System	-	-	Bhaluwang	Lumbini
11	Salyan District Hospital	District Hospital	Ayurvedic/ Allopathic	40	20000	Salyan	Karnali
12	Nisarga Hospital and Research Centre	Private	General/ICU	100	70000	Dhangadhi, Kailali	Sudurpaschim

Table 3.2: Geographical location of the HCFs

	Name	Latitude	Longitude	Altitude (m)	Topography	Province	Region
1	Koshi Hospital	26.45905	87.28519	75.3	Terai	Koshi	Eastern
2	Okhaldhunga Community Hospital	27.33094	86.50002	1599.6	Hill		
3	Sagarmatha Choudhary Eye Hospital	26.71024	86.4928	114.3	Terai	Madhesh	
4	Gajendra Narayan Singh Sagarmatha Zonal Hospital	26.53595	86.749947	106.4	Terai	Madhesh	
5	Rasuwa District Hospital	28.10995	85.29666	2106.5	Mountain	Bagmati	Central
6	TU Teaching Hospital	27.736	85.33026	1337.2	Hill		
7	B.P. Koirala Memorial Cancer Hospital	27.66668	84.41678	206.4	Terai		
8	Urban Health Centre, Pokhara	28.18345	83.98221	786.7	Hill	Gandaki	Western
9	Health Directorate, Pokhara	28.211867	83.999317	853.14	Hill	Gandaki	
10	Health Directorate, Bhaluwang	27.834125	84.750839	153	Terai	Lumbini	
11	Salyan District Hospital	28.37224	82.17239	1350	Hill	Karnali	
12	Nisarga Hospital and Research Centre	28.70805	80.58686	179.83	Terai	Sudurpaschim	

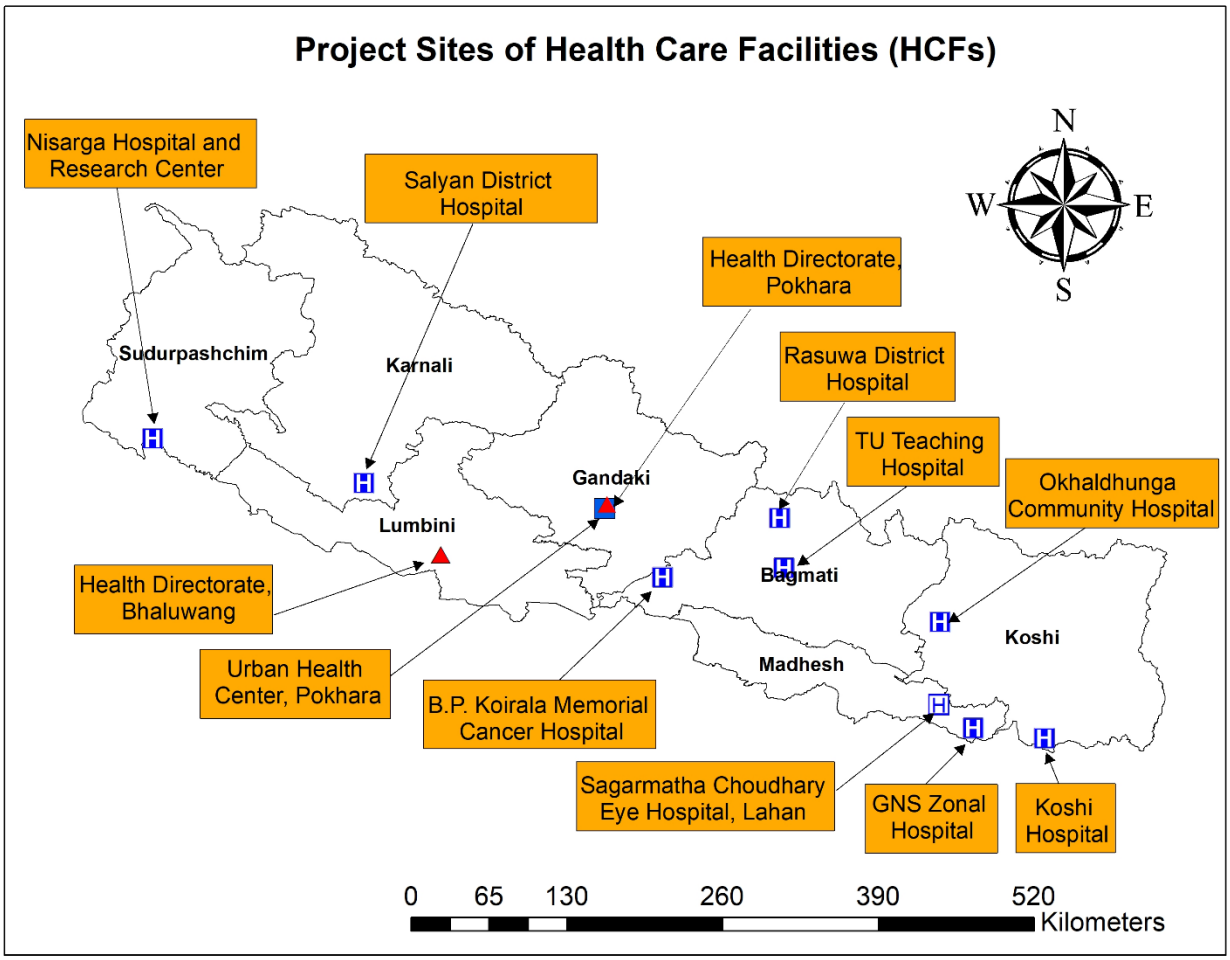


Fig. 3.2: Study sites

3.2 Process

3.2.1 Executive planning phase

In the executive planning phase, first of all team of experts were properly oriented by WHO Nepal and DoHS, Government of Nepal on the subject matter, sample size selection criteria, assessment tool, and their role/responsibilities for the successful completion of the project. A desk study was carried in which experts reviewed the information related to the assignment. After a thorough review of the documents, incisive analysis was conducted. The issues and challenges related to content of assessment, extent of coverage and limitation were also highlighted, discussed, and finalized. Before moving to the field, all the necessary arrangements were made in collaboration with WHO Nepal and DoHS. The checklist/questionnaire and rapid assessment sets were developed to collect the available data.

3.2.2 Review, design and reporting Phase

In this phase, data/information, reports, and activity plans were finalized. The main elements of this phase were the findings/results, discussion, conclusions and recommendations.

3.3 Data and methods

3.3.1 Published literature

An extensive analysis of available data, current policies, plans, research, and pertinent sectoral documents on climate change and health, a sustainable low-carbon health system, energy, greenhouse gas emissions, and current information on Nepal's HCFs was conducted.

Study planning, approach, methodologies, and incisive analysis of GHGs were carried out referring various published sources of emission inventory of Nepal (e.g. Das et al., 2022; Das et al., 2020; Das et al., 2018; IPCC, 2006 (default); Mool et al., 2020; Sadavarte et al., 2019; Shrestha, 2018; Stockwell et al., 2016; etc.). Likewise, other published reports were considered (e.g., provincial energy plans, district climate and energy plans from AEPC/NEEDS, WHO, DoHS, MoFE, and other related development partners. The information on health institutes/hospitals were gathered from the annual health reports.

The technical team received training on the Climate Impact Checkup (CIC) tool on May 3 and May 4, 2023, from an international team of expert from HCWH. The technical details of CIC are highlighted in the section below (3.3.4.2).

3.3.2 Field work

Field visits were conducted from 20th May 2023 until 16th July 2023 to gather information from HCFs. Sets of structure questionnaire, checklists, observation sheet, and Key Informant Interview (KII) guidelines were developed. Depending upon the nature and topic of the subject, interviews regarding the use of energy at hospital/health institution were conducted, sites were assessed through direct observation, and suggestions/comments for the improvement of energy technology were gathered through KII. KII was conducted at the health institution. Structure questionnaire and KIIs were utilized along with the tools outlined in the guidelines to collate primary data. For both, the key participants such as professionals/doctors, academicians, government organizations, manager/directors of health institutions were invited. The entire questionnaire aligned with the WHO scope/TOR (e.g. energy consumption pattern, GHGs emission, technological development and choices, resource utilization).

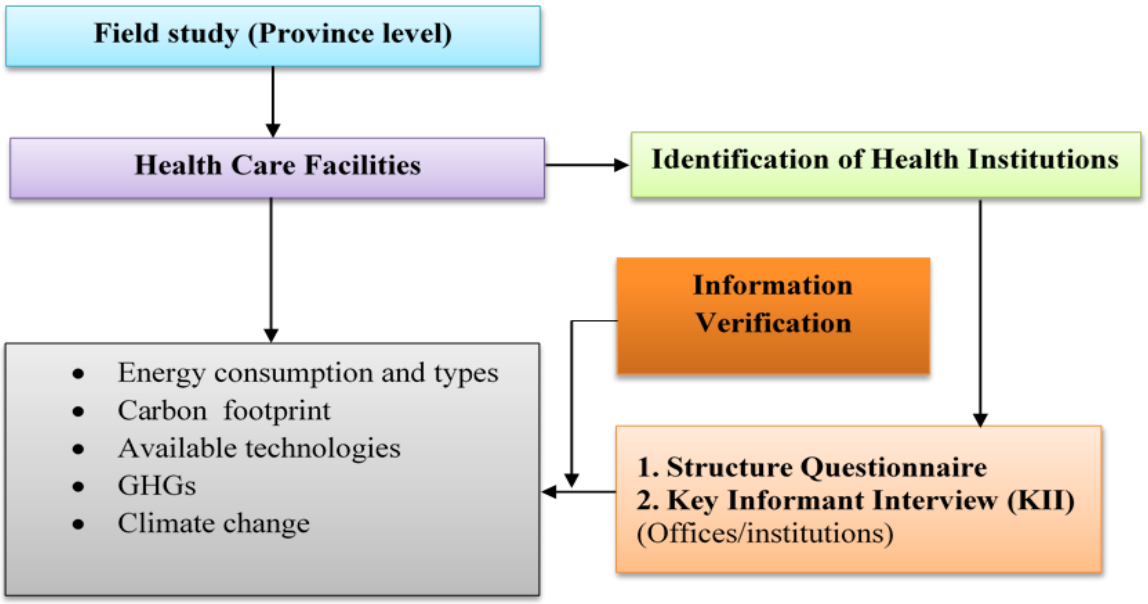


Fig. 3.3: Data collection process

3.3.3 Activity data

The collected data focused on fossil fuels; purchased energy; transportation of goods and services including the full supply chain; travel and transport; infrastructure, technologies, and products; supply chain and food; water sanitation, hygiene and healthcare waste, etc. (Fig. 3.4). It also included the health workforce (staff active travel, meetings, tele-health, digital health, energy use by staff actions, staff commuting, business travel, etc.); water, sanitation and health care waste (water use, water heating & cooling, wastewater management, healthcare waste management including waste generation, processing, recycling, waste incineration, waste disposal); energy (fossil fuel use, electricity, space heating and cooling, transport); supply chain (medical equipment, non-medical equipment, anesthetic products, IT equipment, construction, business services, other procurement, food supplies, refrigerant gases for cooling systems, fuel & lubricants, generator diesel, gas etc.), which are assembled through the structured questionnaire as well as secondary sources.

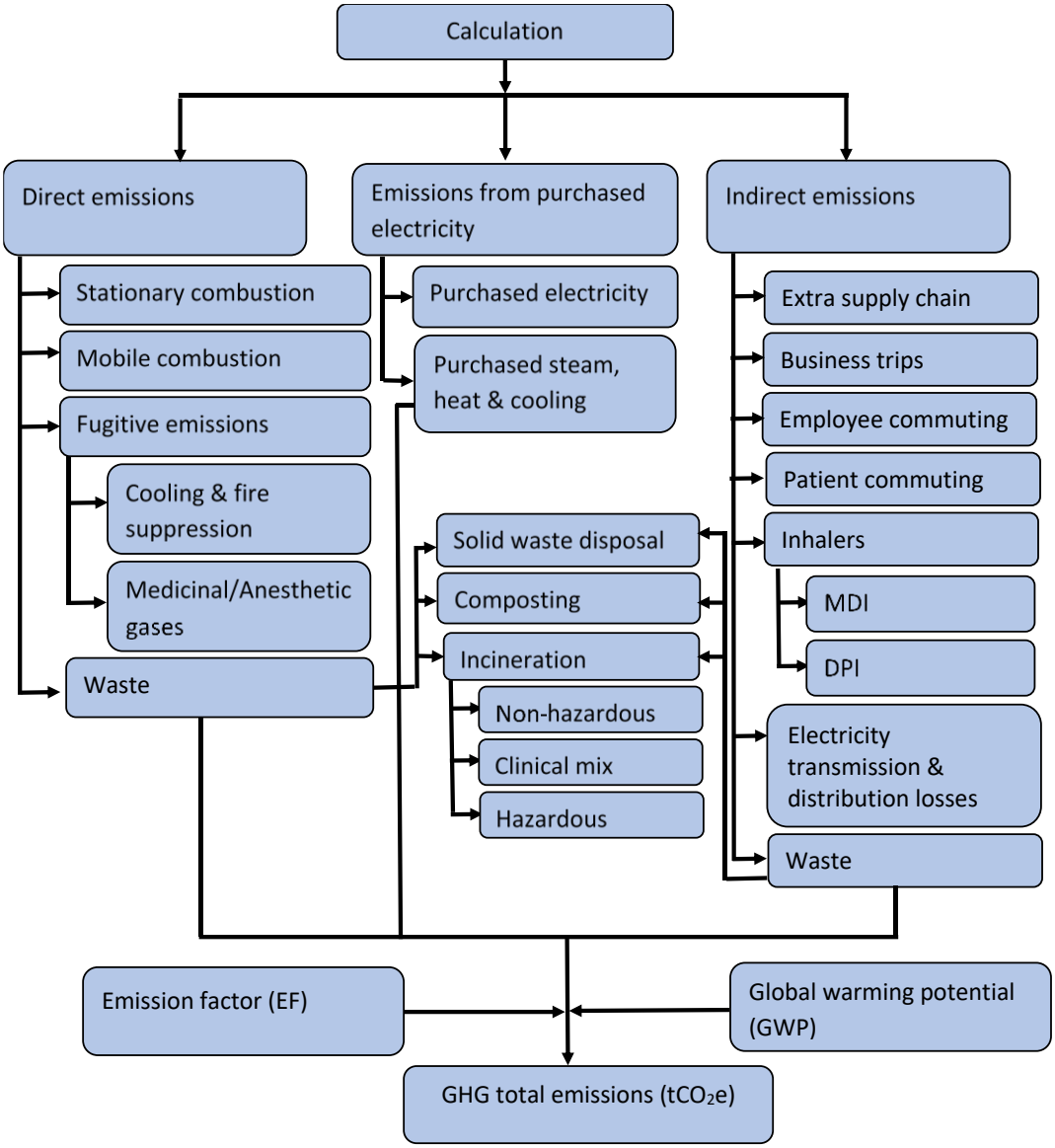


Fig. 3.4: GHGs estimation process
(Source: Health Care Without Ham (2019)

3.3.3.1 Scaling-up activity data to national level

Altogether, 12 HCFs were selected: one teaching hospital, three general hospitals, one provincial hospital, two non-public hospitals, two specialized hospitals, one health post/health center, and two health directorates. The samples of similar categories of facilities were averaged in line with HCF category of DoHS (2020/21). The average activity data was then multiplied by the total number of each HCFs category, as outlined in Table 3.3 to estimate the national activity data.

Each HCF category highlighted in table 3.3 is similar in structure, facilities, and functions in terms of selected study samples. According to medical council standards, all teaching hospitals in Nepal are alike in terms of physical facilities and services (e.g. OD, ICU, CCU, NICU, dialysis, anesthesia), human resources, facilities, equipment, accessories, etc. Likewise, according to Health Institution Guidelines (2016) of Nepal, structure, facilities, service type, and functions are similar for each general hospital, specialized hospital, provincial hospital, non-public hospital, health posts/urban center, and health service centers. These are well supported by Health Facility Operation Standards (2020), Public Health Service Regulations (2020), Health Infrastructure Development Standards (2017), and Operation Guideline for Provincial, District and Local Level of MoHP.

Table 3.3: HCFs of Nepal

HCFs	Number
Teaching Hospital	5**
General Hospital	136**
Specialized Hospital	54**
Provincial Hospital	6**
Non-public Hospital	470*
HP/UHC/CHU/BHSC/Others	6,955**
Basic Health Services	1,136*
Total	**8762***

Source: *DoHS, 2020/21
**Observation, Expert's consultation and estimation based on DoHS, 2020/21

The full-time employees, annual total patients, total number of occupied beds (annual average), and reason of hospitals visit were reported in National Economic Survey (2021/22), Government of Nepal. These values were considered to calculate GHG emissions per bed, patients, and employees.

3.3.4 Emission factors and emission estimation

3.3.4.1 Global warming potential and emission factors

The study considered the best available global warming potential (GWP) (Table 3.4) and emission factors (EFs) (Table 3.5) from the literature, as well as climate impact checkup tool, developed by health care without harm (HCWH). The EFs were also tallied with the country specific EFs from various literature (Das et al., 2022; Sadavarte et al., 2019; Stockwell et al., 2019; Mool et a., 2019; etc.).

Table 3.4: Sources of global warming potential of GHGs

GWP	Sources
CH_4, N_2O, CO_2	IPCC Fourth Assessment Report, 2007
Isoflurane, Sevoflurane	Atmospheric Chemistry of Isoflurane, Desflurane, and Sevoflurane: Kinetics and Mechanisms of Reactions with Chlorine Atoms and OH Radicals and Global Warming Potentials, 2011
CCL_2F_2	https://ieeexplore.ieee.org/document/8685961, 2023
R-12, R-22, R-410A, R-22, R-123, R-404A, R-508A, R-600, R-410B	IPCC Fourth Assessment Report, 2007; Green House Gas Protocol
R-600a, C_4H_{10}	UN Environment, GWP-ODP Calculator

Table 3.5: Sources of emission factors

EFs	Sources
Natural gas; Liquefied Petroleum Gases (LPG); Gasoline; Gas/Diesel Oil; Fuel oil/Bunker; Kerosene; Coal; Wood; Biodiesel; Biogas/Bioethanol	• IPCC, 2006 Guidelines • Secretaría de Energía (actualmente Ministerio de Energía y Minería) Resolución 6/2010 - Establécense las especificaciones de calidad que deberá cumplir el biodiesel. • Green House Gas Protocol Global Warming Potential Values • UN Environment GWP-ODP Calculator
Transport sector	• Das et al., 2022; ARAI, 2007
Grid emission factor	• IFIs - Harmonization of Standards for GHG accounting, 2019
Waste	• IPCC, 2006 Guidelines
Air trips; Composting; Cooling & fire suppression; Electricity transmission and distribution losses; Extra Supply Chain; Incineration; Inhalers	• World Resources Institute / GHG Protocol • EPA, 2018

3.3.4.2 Climate Impact Checkup and GHGs estimation

Climate Impact Checkup (CIC) is a tool which enables medical facilities anywhere in the world to calculate their GHGs footprint. It gives the access to a peer network where members may exchange experiences and ideas through discussion forums and a global community of practice, in addition to providing carbon footprint data and defining a mitigation starting point. Climate Impact Checkup includes GHG sources for which representative and accurate data are available, as well as those that are peculiar to the health care industry (such as fugitive medicinal gases). Over time, further improvements will be made by HCWH based on the

feedback from its consumers. The sources of emissions by scope are listed in the table 3.6. It offers a place to start when trying to monitor, manage, and support mitigation goals and action planning. Checkup tool, which is accessible online and as a downloadable spreadsheet, makes it easier to combine these acts with additional environmental tactics like sustainable purchasing. CIC calculates the footprint using national or local EFs after entering facility-level data about energy use, transportation, waste management, and gases important to the healthcare industry. CIC estimates GHGs emission from healthcare institutions. It makes possible for health systems and facilities to compare their footprint to that of other facilities of a similar nature in their nation, region, and the world. CIC also gives the access to a peer network where users can interact in forums and a worldwide community of practice to exchange experiences and advice.

Based on activity data, all estimates for Scopes 1, 2, and 3 were generated. Using emission factors for 43 countries and average emission factors for the rest of the world, scope 3 extra supply chain estimates were based on spend data and employ a different technique (Table 3.6).

Table 3.6: Scopes and the activity data

Scope 1	Scope 2	Scope 3	Scope 3 extra supply chain
Stationary combustion **Mobile combustion** **Fugitive emissions (cooling and medicinal/anesthetic gases)** **Waste: on-site final disposal, composting, incineration**	Purchased electricity Heat and steam purchase	Business travel Employee commuting Patient commuting Electricity transmission and distribution losses Inhalers Waste: off-site final disposal, composting, incineration	Business services Construction Food and catering Information and communication technologies Manufactured fuels, chemicals, and gases Medical Instruments/ equipment Other manufactured products Paper products Pharmaceuticals Water and sanitation Other procurement

The activity data, EFs and GWP were used for calculating the GHGs emissions. GHGs emission 'E' for pollutant type 'i' and fuel type 'l' were estimated using the eq. (1) and eq. (2), where 'M_1, quantity of fuel' multiplied with emission factor '$EF_{i,l}$' specific to GHG type 'i' from fuel type 'l'

(Das et al., 2020; Das et al., 2022; Kanabkaew and Oanh, 2011; Shrestha et al., 2013; Shrestha, 2018; IPCC, 2006) and $GWP_{i,l}$ specific to GHG type 'i' from fuel type 'l' where possible.

$$E_{I,l} = \sum_l M_l \times EF_{I,l} \quad (1)$$

$$E_{I,l} = \sum_l M_l \times GWP_{I,l} \quad (2)$$

3.4 Limitation of Study

As this study of health sector is first of its kind in Nepal, it considered only twelve healthcare facilities for sample field data collection due to resource limitation and time constraints among others. Although, the data collection covered nationwide all types of healthcare facilities (e.g. medical college & hospital, public hospital, private hospital, public health facilities/urban health centre/primary health centre/basic health service centre/health post/community health unit).

The GHG footprint from HCFs for the base year 2022 was calculated using the Climate Impact Checkup (CIC) tool of Health Care Without Harm (HCWH). To gather the available data, the checklist/questionnaire, structural questionnaire, key informant interview, general group discussion, and interaction were used based on the scope of the tool. Both the primary and secondary data collection method was carried out to collect the data considering various activity data, variables, emission factors (EFs), and global warming potential (GWP) of various gases.

To estimate national activity data, each HCF category's total number was multiplied by the average activity data referring DoHS annual report of 2020/21. As this study considers scale-up activity data and most of the EFs are global-based (Table 3.5), there might be some uncertainties which could be a scope for future study.

The supply chain data of B.P. Koirala Memorial Cancer Hospital and Inhalers data (MDI and DPI) were not available. The scaling factor referring another similar hospital i.e., Sagarmatha Choudhary eye hospital and Rasuwa district hospital, respectively considering annual average occupied beds was considered for this. The scaling factor was multiplied by total annual average beds of B.P. Koirala Memorial Cancer Hospital and Salyan hospital to get its yearly estimate of supply chain, and MDI and DPI respectively.

CHAPTER 4

4. Findings and discussion

4.1 Data analysis

4.1.1 Stationary combustion

Nationally, the highest consumption of fuel in stationary combustion in the year 2022 from HCFs is from gas/diesel oil, followed by gasoline, LPG, and so forth (Table 4.1). LPG, natural gas and woods are highly used in quarter and canteen, whereas diesel, gasoline and kerosene in generator sets during the power cutoff. Little amount of fuel oil is used to run the engines.

Table 4.1: Stationary Combustion

Type of fuel	Amount Consumed	Unit
Natural Gas	6,955	m^3
Liquefied Petroleum Gases (LPG)	1,593,091	kg
Gasoline	5,225,600	liter
Gas/Diesel Oil	32,409,655	liter
Fuel oil/Bunker	19,880	liter
Kerosene	3,600	liter
Wood	835,720	kg

4.1.2 Mobile combustion

In Nepal, in the year 2022, the highest consumption of fuel in mobile combustion in HCFs was from gasoline, followed by gas/diesel oil (Table 4.2).

Table 4.2: Mobile Combustion

Type of fuel	Amount Consumed	Unit
Gasoline	10,776,479	liter
Gas/Diesel Oil	5,392,456	liter

4.1.3 Cooling & fire suppression

Nationally, in the year 2022, the highest consumption of gas by HCFs in cooling & fire suppression was from refrigerator, followed by refrigerator/vaccines, central equipment, multi split, and so forth (Table 4.3).

Table 4.3: Cooling & fire suppression

Sources	Gas	Quantity	Unit
Centralized equipment	R-12	17	kg
Centralized equipment	R-22	17	kg
Centralized equipment	R-410A	1,724	kg
Centralized equipment	R-22	68	kg
Centralized equipment	R-123	512	kg
Centralized equipment	C_4H_{10}	243	kg
Freezer	R-404A	48	kg
Freezer	R-508A	48	kg
Freezer	R-600	24	kg
Freezer	R-12	205	kg
Freezer	R-22	205	kg
Freezer	CCL_2F_2	838	kg
Refrigerator	CCL_2F_2	8,754	kg
Refrigerator / Vaccines	CCL_2F_2	3,502	kg
Mini split	R-404A	294	kg
Multi Split	R-410B	1,188	kg

4.1.4 Anesthetic gases

The highest consumed anesthetic gases was Isoflurane, followed by Sevoflurane in the year 2022 in Nepal (Table 4.4).

Table 4.4: Anesthetic gases

Anesthetic Agent	Bottle Size (ml)	Number of Bottles
Isoflurane		
Bottle Size 1	192	30,036
Bottle Size 2	35	6,870
	Bottle Size (ml)	Number of Bottles
Sevoflurane		
Bottle Size 1	175	8176

4.1.5 Purchased electricity

The total quantity of grid electricity consumption was estimated to be 268.73 million kWh from HCFs in the year 2022 in Nepal (Table 4.5). Moreover, purchased steam, heat and cooling was negligible in HCFs in Nepal, therefore, it had not been considered for this study.

Table 4.5: Purchased electricity

Electricity type	Estimated consumed quantity	Unit
Grid electricity	268,730,288	kWh

4.1.6 Transport sector

The highest mode of transportation by HCFs for business trips were by plane, whereas in employee commuting and patient commuting, motorbike was the highest in the year 2022 in Nepal (Table 4.6).

Table 4.6: Transport sector

Transport categories	Business trips	Employee commuting	Patient commuting	Unit
Private car (diesel)	3,342,240	2,836,720	6,368,427	km
Private car (gasoline)	8,745,000	24,853,596	8,055,396	km
Plane	16,673,146	-	-	km
Bus	6,409,500	8,614,703	929,640	km
SUV or Light Goods Vehicle (diesel)	10,633,120	344,533	57,613,815	km
SUV or Light Goods Vehicle (gasoline)	2,705,709	-	1,723,441	km
SUV or Light Goods Vehicle (CNG)	-	-	50,000	km
Motorbike	3,159,320	182,853,874	113,753,964	km

4.1.7 Inhalers

Nationally in the year 2022, the total consumption of inhalers was estimated to be 859,000. DPI consumption was around three folds of MDI in that year (Table 4.7).

Table 4.7: Number of inhalers

Type of inhaler	Dispensed at the institution	Sold or delivered in the central pharmacy	Prescribed by doctors	Total
Total	320,458	280,945	257,971	859,374
MDI	78,762	55,091	84,391	218,244
DPI	241,696	225,853	173,581	641,130

4.1.8 Supply chain

A supply chain comprises businesses and individuals engaged in the manufacturing and distribution of goods or services. Producers, suppliers, distributors, transportation firms, warehouses, and retailers are the elements that make up a supply chain.

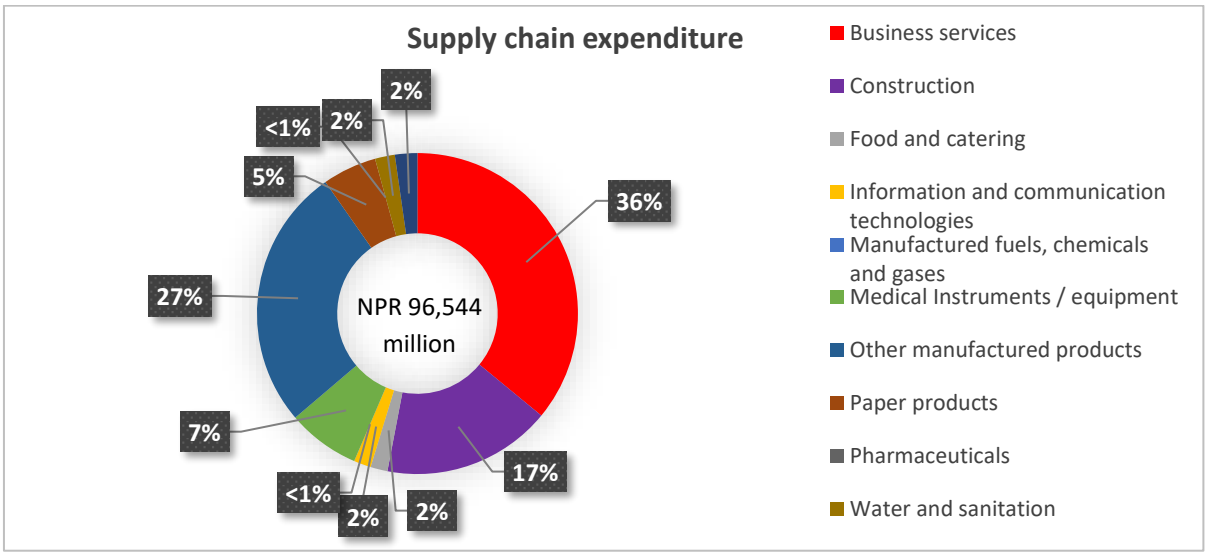


Fig. 4.1: Supply chain

Other manufactured product includes textiles, wearing apparel and leather products; rubber and plastic products; motor vehicles, trailers and semi-trailers; other transport equipment; machinery and equipment; electrical equipment; retail trade, except of motor vehicles and motorcycles. Other procurement includes wholesale and retail trade and repair of motor vehicles and motorcycles, and wholesale trade, except of motor vehicles and motorcycles. The

expenditure from the supply chain from the HCFs of Nepal in the year 2022 was estimated to be 96,544 million rupees. The highest share was from business service, followed by other manufactured products, construction, medical instruments/equipment, paper products, and so forth (Fig. 4.1).

4.1.9 Waste sector

The highest amount of waste is sent to final disposal site/landfill by HCFs. Waste burning practices at HCFs are very common. The maximum amount of non-hazardous/general health care waste, and other types like clinical mix (biohazardous & hazardous) and hazardous were also burnt in 2022. Only little amount of waste is used for compost making (Table 4.8).

Table 4.8: Waste handling/management

Waste handling/management	Quantity	Unit
Amount of waste that is sent annually to final disposal/burial	14,225,279	kg
Amount of waste to be composted	578,090	kg
Amount of waste being incinerated		
Non-hazardous/general health care waste	5,190,040	kg
Clinical mix (biohazardous & hazardous)	430,399	kg
Hazardous	801,070	kg

4.2 GHG emissions from 12 HCFs samples

The direct emission purchased electricity and indirect emission of the 12 HCFs in the year 2022 can be found in Table S1 and Figure S1 (Annex). The direct and indirect emission of TU Teaching Hospital were found to be highest and least for Urban Health Center, Pokhara. Similarly, the purchased electricity was highest for B.P. Koirala Memorial Cancer Hospital and least for Urban Health Center, Pokhara.

Table 4.9: GHG emissions from selected HCFs

S.N.	Name of HCFs	Direct emission (tCO_2e)	Purchased electricity (tCO_2e)	Indirect emission (tCO_2e)	Total (tCO_2e)
1	TU Teaching Hospital, Kathmandu	2,575.06	63.47	5,417.92	8,056.45
2	Rasuwa District Hospital, Rasuwa	471.22	3.34	48.85	523.41
3	Gajendra Narayan Singh Sagarmatha Zonal Hospital, Saptari	21.08	18.83	320.91	360.82
4	Salyan District Hospital, Salyan	23.94	2.73	49.56	76.23
5	Koshi Hospital, Morang	46.64	10.02	58.37	115.03
6	Okhaldhunga Community Hospital, Okhaldhunga	124.06	3.87	367.59	495.52
7	Nisarga Hospital and Research Centre, Kailali	1,341.51	18.06	1,878.70	3,238.27
8	B.P. Koirala Memorial Cancer Hospital, Chitwan	362.89	95.36	3,180.50	3,638.75
9	Sagarmatha Choudhary Eye Hospital, Siraha	91.45	14.89	1,605.80	1,712.14
10	Urban Health Center, Pokhara, Kaski	0.97	0.02	1.39	2.38
11	Health Directorate Pokhara, Kaski	175.49	0.77	5.69	181.95
12	Health Directorate Lumbini, Dang	3.39	0.06	69.16	72.61
Total		**5,237.70**	**231.42**	**13,004.44**	**18,473.56**

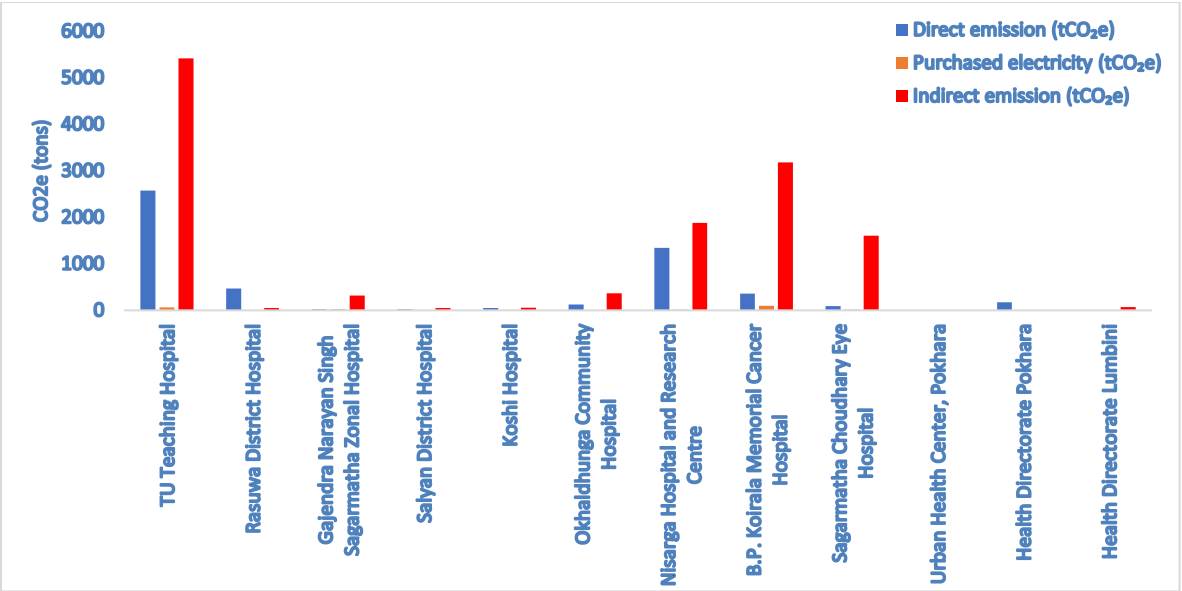


Fig. 4.2: Comparative emissions from HCFs

The total emission in terms of per employee, per patient and per occupied bed are presented in Table S1 (Annex). The total emission in terms of per employee, per patient and per occupied bed were found to be highest for Rasuwa district hospital which was 14,146 kg CO_2e/employee, 58 kg CO_2e/patient (Fig. 4.3) and 214 kg CO_2e/occupied bed (Fig. 4.4) respectively followed by Nisarga Hospital and Research Centre as 12,953 kg CO_2e/employee, 46 kg CO_2e/patient (Fig. 4.3) and 197 kg CO_2e/occupied bed (Fig. 4.4) respectively and found to be minimum for Urban Health Centre, Pokhara as 475 kg CO_2e/employee, 1 kg CO_2e/patient and negligible per occupied bed respectively.

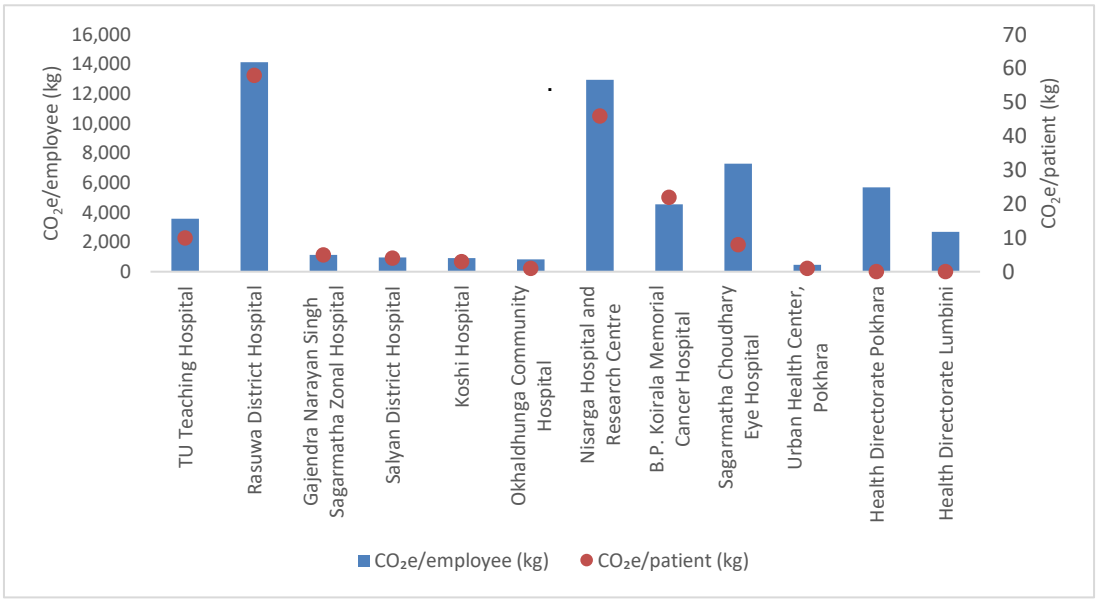


Fig. 4.3: Total emission per employee and per patient from HCFs (year 2022)

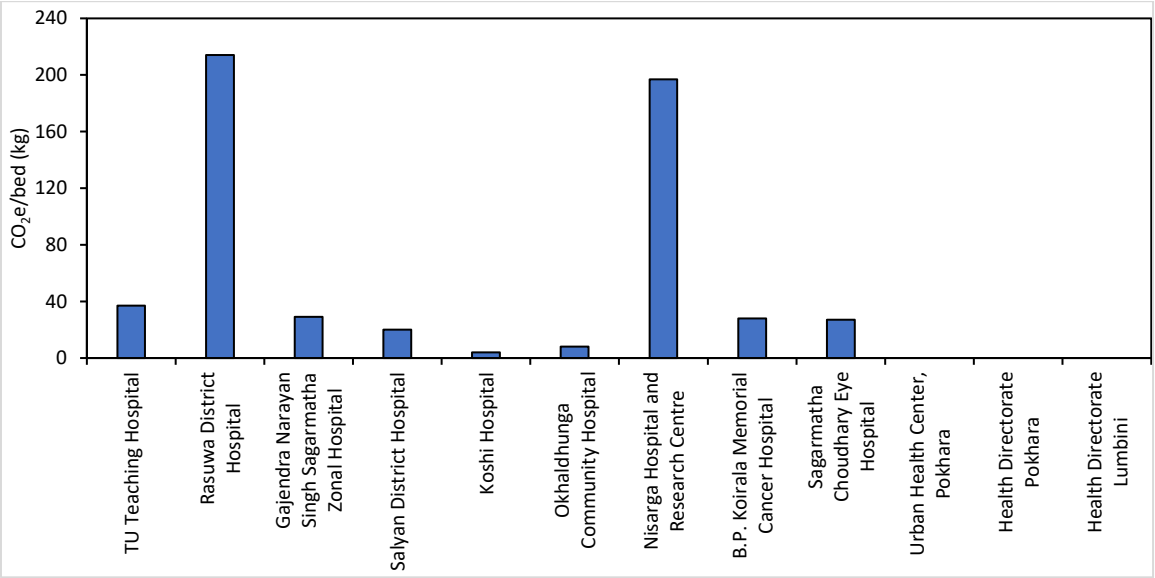


Fig. 4.4: Total emission per occupied bed from HCFs (year 2022)

4.3 National GHG emissions

The GHG emissions consist of scope 1 (direct emissions), scope 2 (emissions from purchased electricity), and scope 3 (indirect emissions). Direct emissions comprise of stationary combustion, mobile combustion, fugitive emission (i.e. emissions from direct or indirect release of GHG from various types of equipment and processes), and waste. For the fugitive emission, it further consists of cooling and fire suppression and medicinal/anesthetic gases. Furthermore, under waste, it consists of solid waste disposal, composting and on-site incineration in the HCFs. The types of waste for the incineration comprises of non-hazardous/general health care waste, clinical mix (biohazardous and hazardous) and hazardous. Emissions from purchased electricity mainly consist of two items viz. purchased electricity and purchased steam, heat and cooling. Purchased steam, heat and cooling are negligible in Nepal, therefore, emissions from these sources were not considered. Indirect emissions contain business trips, employee commuting, patient commuting, inhalers, extra supply chain, electricity transmission and distribution losses and off-site waste. Under inhalers, it consists of MDI and DPI and waste comprises of solid waste disposal, composting, incineration which takes outside HCFs. Under incineration, the items are same as mentioned in direct emissions.

Extra supply chain includes GHG emissions from operation related to business services; construction; food and catering; information and communication technologies; manufactured

fuels, chemicals and gases; medical instruments/equipment; other manufactured products; paper products; pharmaceuticals; water and sanitation; and other procurement.

In the year 2022, the total contribution of GHG emissions was maximum from indirect emissions i.e. 678,317 tCO_2e (58.2%) followed by direct emissions of 474,847 tCO_2e (40.8%) and emissions from purchased electricity of 11,555 tCO_2e (1%) (Figure 4.5 & Table 4.10). Under direct emissions, the GHG total emission was highest from fugitive emissions (28.1%) on which cooling, and fire suppression contributed the maximum (27.7%). The total GHG emission was 12.6% for others (stationary combustion, mobile combustion, and waste).

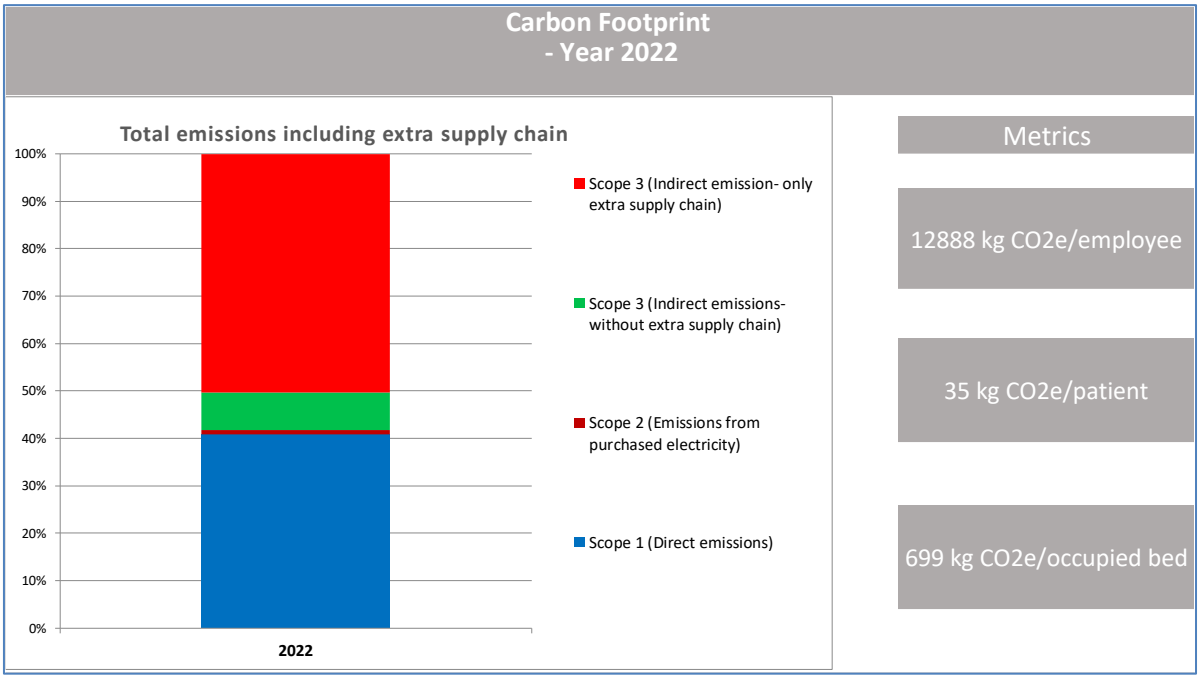


Fig. 4.5: GHGs emissions from various sources of HCFs in Nepal

Table 4.10: Direct GHGs emissions from various sources of HCFs in Nepal

	GHG total emissions (tCO2e)	**1,164,718.91**	**100%**
	Scope 1 (Direct emissions)	474,846.93	40.77%
1.1	Stationary Combustion	104,151.89	8.94%
1.2	Mobile combustion	39,788.49	3.42%
1.3	Fugitive Emissions	327,674.74	28.13%
1.3.1	Cooling & fire suppression	322,816.24	27.72%
1.3.2	Medicinal / Anesthetic gases	4,858.51	0.42%
1.4	Waste	3,231.82	0.28%
1.4.1	Solid waste disposal	Estimated in indirect emissions	0.00%
1.4.2	Composting	Estimated in indirect emissions	0.00%
1.4.3	Incineration	3,231.8	0.28%
	Non-hazardous/general health care waste	2,783.7	0.24%
	Clinical mix (biohazardous & hazardous)	246.2	0.02%
	Hazardous	201.9	0.02%

Under emissions from purchased electricity, the total GHG emission was contributed only from purchased electricity (1%). Under indirect emissions, the maximum contribution of GHG emissions was from extra supply chain (50.4%) followed by patient commuting (4.8%) and remaining was from others contributing 3% (business trips, employee commuting, inhalers and waste). The total GHG emissions excluding the extra supply chain was 7.8% (Fig. 4.5 & Table 4.11).

Table 4.11: GHGs emissions from Scope 2 & 3 of HCFs in Nepal

	Scope 2 (Emissions from purchased electricity)	11,555.40	0.99%
2.1	Purchased electricity	11,555.40	0.99%
2.2	Purchased steam, heat and cooling	Not Ocurring	0.00%
	Scope 3 (Indirect emissions)	678,316.57	58.24%
3.S	Extra Supply Chain	587,102.03	50.41%
3.1	Business trips	11,076.83	0.95%
3.2	Employee commuting	12,413.72	1.07%
3.3	Patient commuting	55,343.18	4.75%
3.4	Inhalers	5,652.19	0.49%
3.4.1	MDI	5,248.89	0.45%
3.4.2	DPI	403.30	0.03%
3.5	Electricity transmission and distribution losses	372.20	0.03%
3.6	Waste	6,356.42	0.55%
3.6.1	Solid waste disposal	6,246.93	0.54%
3.6.2	Composting	109.5	0.01%
3.6.3	Incineration	-	0.00%
	Non-hazardous/general health care waste	Estimated in direct emissions	0.00%
	Clinical mix (biohazardous & hazardous)	Estimated in direct emissions	0.00%
	Hazardous	Estimated in direct emissions	0.00%

4.3.1 Emissions from sources with extra supply chain

The highest contributor of GHG emissions per source was contributed by extra supply chain (50%) followed by cooling and fire suppression (28%), stationary combustion (9%), and others (13%). Out of 13%, 5% of the GHG emissions was contributed by patient commuting followed by mobile combustion (3%), and 5% was contributed by other remaining sources (Fig. 4.6).

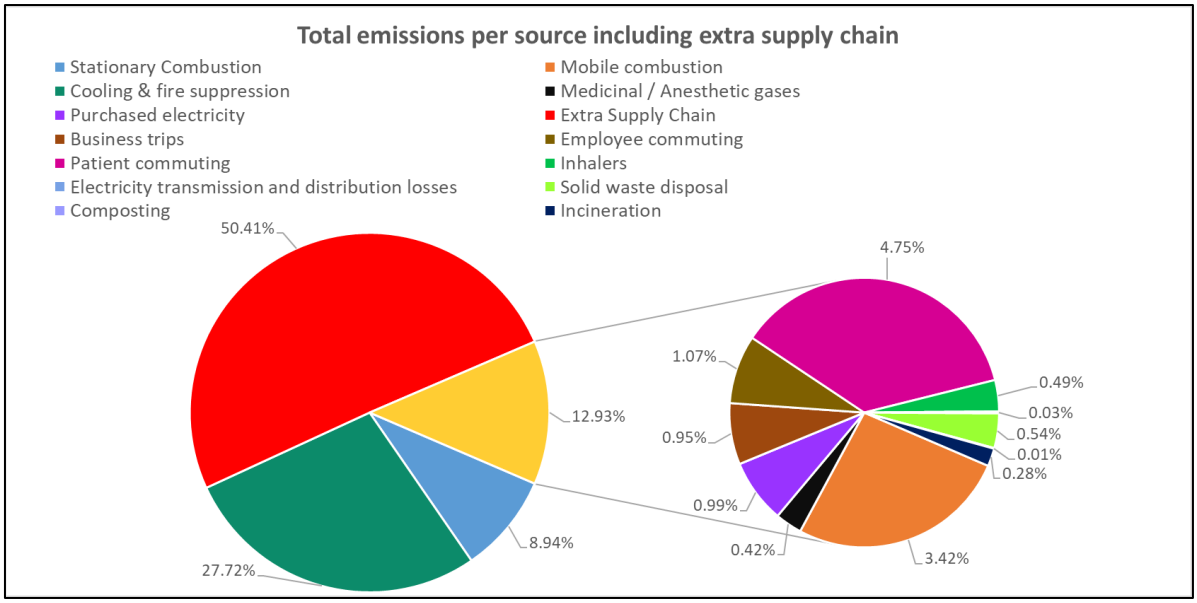


Fig. 4.6: Total emissions per source including extra supply chain of HCFs in Nepal

4.3.2 Emissions from sources excluding extra supply chain

About 50% of the total GHG emissions was contributed by cooling and fire suppression followed by stationary combustion that contributed approximately 17% of the total GHG emissions. The remaining 33% was contributed by other sources that includes GHG emissions from patient commuting, mobile combustion, medicinal/anesthetic gases, purchased electricity, business trips, employee commuting, inhalers and solid waste disposal (Fig. 4.7).

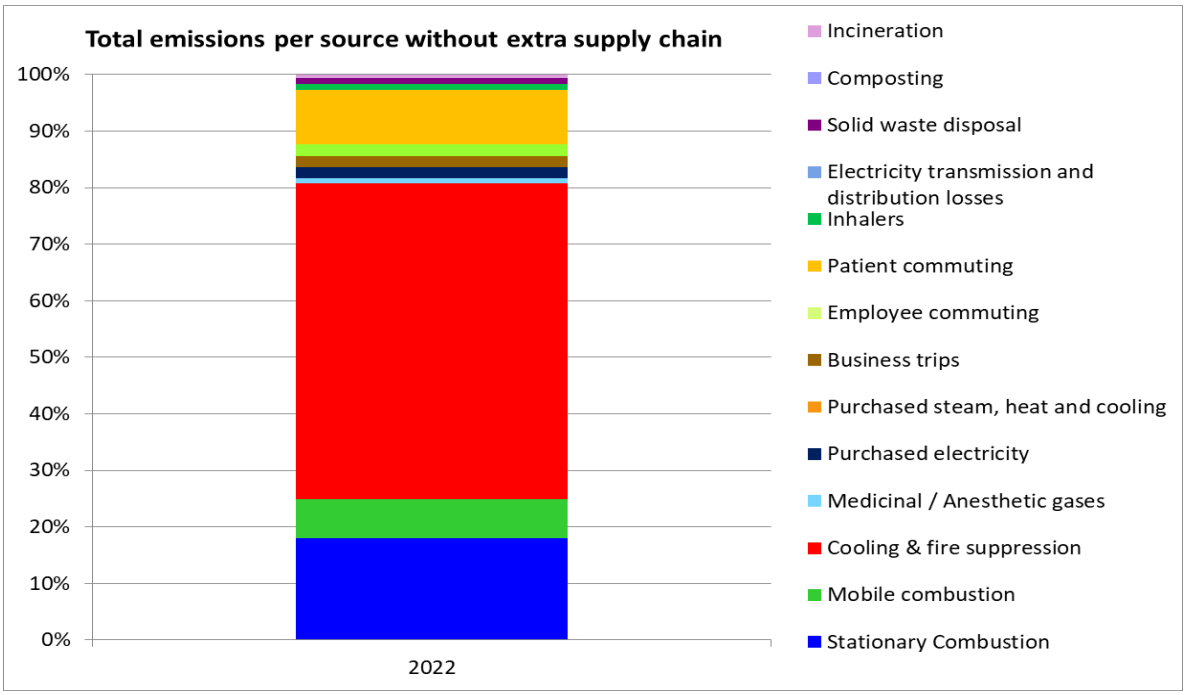


Fig. 4.7: Total emissions per source without extra supply chain of HCFs in Nepal

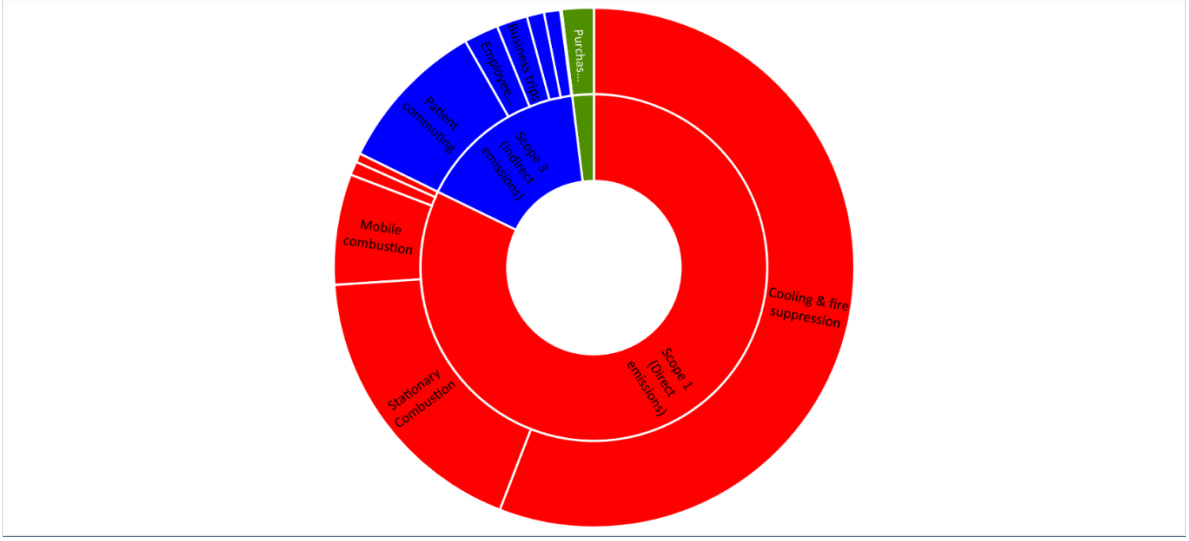


Fig. 4.8: Total emissions per scope & source without extra supply chain of HCFs in Nepal

Figure 4.8 reflects the total emissions per scope & sources without extra supply chain. The GHG emissions was highest for the direct emissions followed by indirect emissions and emissions from purchased electricity in the scenario where the extra supply chain was excluded. Under direct emissions, cooling and fire suppression was the major contributing factor and under indirect emissions, patient commuting was the major one contributing GHG emissions.

4.3.3 Fugitive emissions & inhalers

Fugitive emissions refer to emissions from direct or indirect release of GHGs to the atmosphere from various types of equipment and processes.

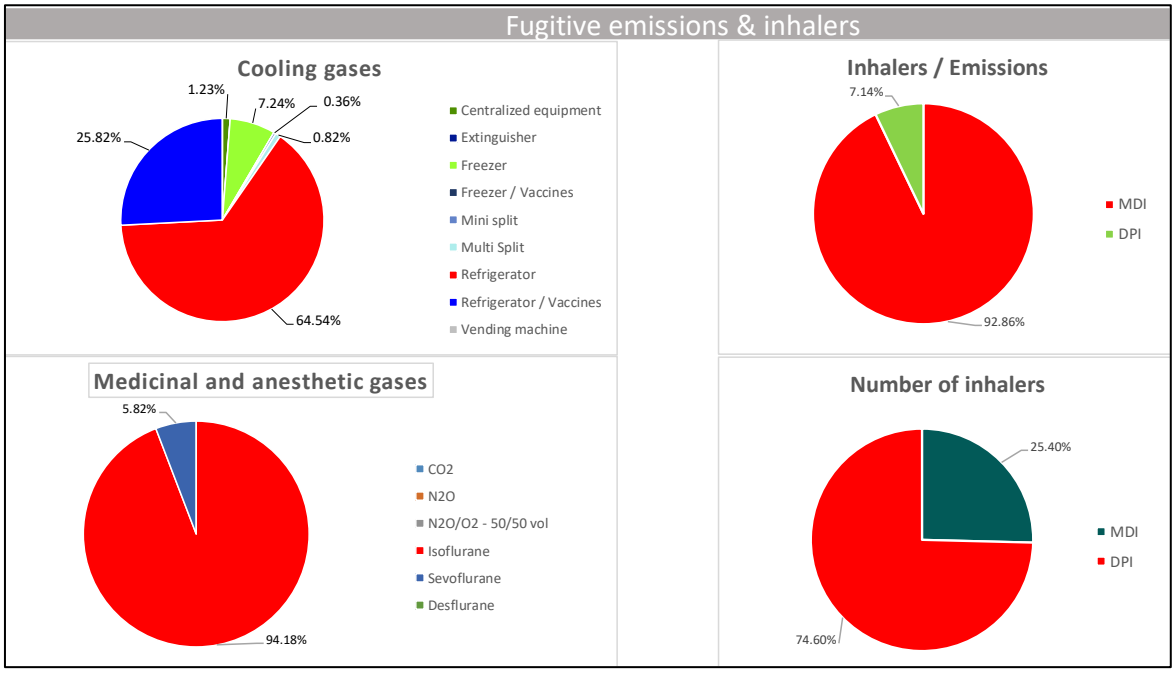


Fig. 4.9: Fugitive emissions & inhalers of HCFs in Nepal

Figure 4.9 provides the emissions contributed from fugitive sources and inhalers. Among the cooling gases, the highest GHG emissions was contributed from refrigerator (65%) followed by refrigerator/ vaccines (26%) and others (9%). Under medicinal and anesthetic gases, isoflurane (94%) was the highest contributing gas followed by sevoflurane that contributed 6%. Among inhalers, the highest no. of inhalers used was of DPI (75%) and the remaining was MDI (25%). However, the total GHG emissions was contributed more by MDI (93%).

4.3.4 Indirect emissions with extra supply chain

The graphical representation of the indirect emissions including the extra supply chain can be found in figure 4.10. The highest contributor of GHG emissions under indirect emissions was contributed from extra supply chain (Approx. 11%) followed by patient commuting (Approx. 8%), and employee commuting and business trips (Approx. 4%).

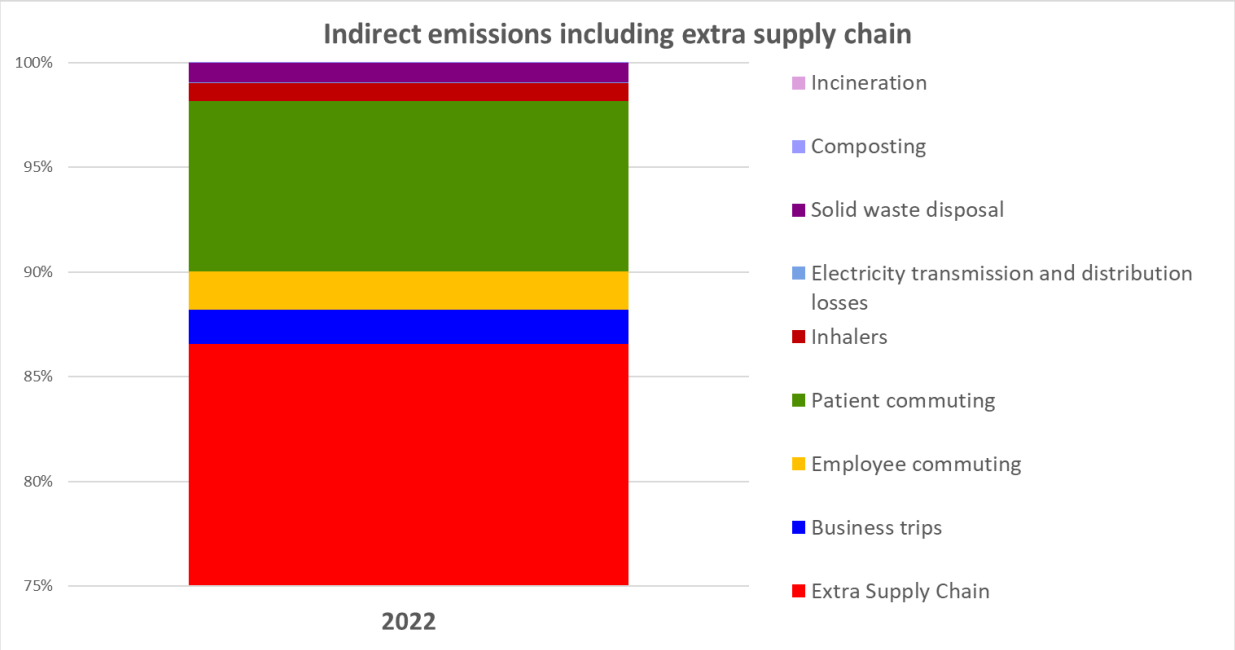


Fig. 4.10: Total emissions per scope & source without extra supply chain of HCFs in Nepal

4.3.5 Transport related categories

Figure 4.11 reflects the transport related categories that was included under indirect emissions. Under patients commuting category, the most preferred type of vehicle by patient was SUV or light goods vehicle (diesel) which was 76% followed by motorbike (13%). The main reason behind visiting the HCFs was for medical consultations and outpatient procedures, emergencies, and hospital visits. Similarly, majority of the employee of HCFs used motorbike (46%) as a mode of transportation followed by diesel light good vehicles (26%). For business

trips, the employee mostly used diesel light good vehicles (35%). Similarly, 29%, 13%, 9%, 8%, 5% and 1% of the employee used bus, plane, private car (petrol), SUV or light goods vehicle (gasoline), diesel powered private car, and motorbike respectively for business trips.

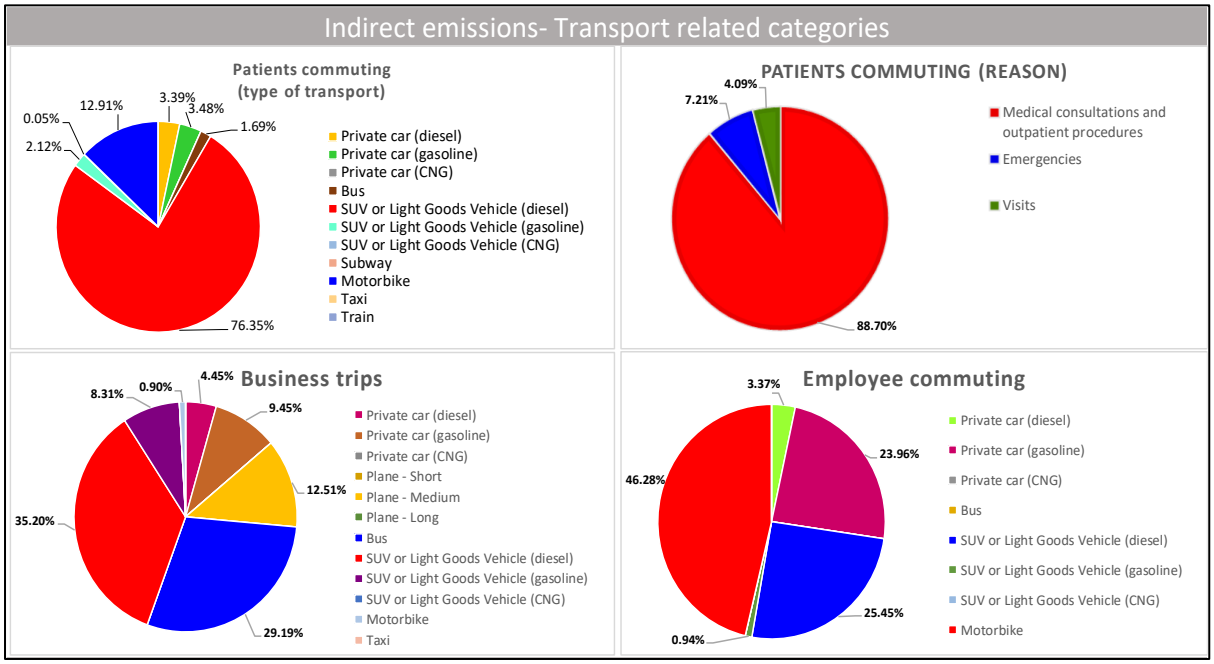
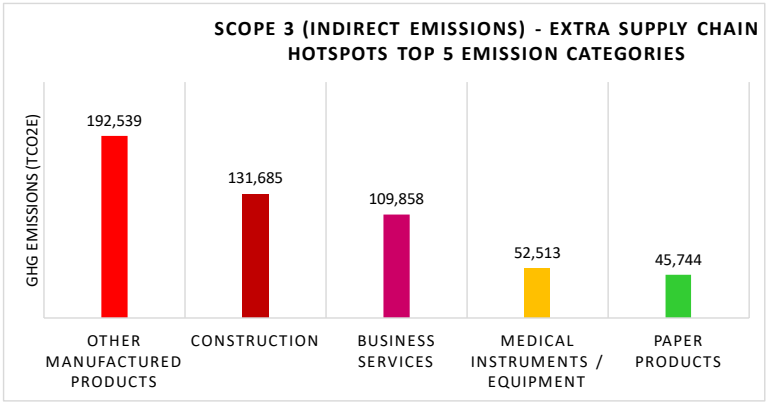


Fig. 4.11: Transport related categories of HCFs in Nepal

4.3.6 Indirect emissions - extra supply chain

The extra supply chain hotspots under scope 3 is represented in figure 4.12. About 91% of the GHG emissions of scope 3 – supply chain sub-category was contributed by top 5 emitter categories which included other manufactured products (textiles; wearing apparel and leather products; rubber and plastic products; motor vehicles, trailers and semi-trailers; other transport equipment; machinery and equipment; electrical equipment; retail trade, except of motor vehicles and motorcycles) as 33%, construction as 22%, business services 19%, medical instruments/equipment 9%, and paper products as 8%. The remaining 9% of the total GHG emissions was contributed by water and sanitation, food and catering, other procurement (including pharmaceuticals), and information and communication technologies as 4%, 3%, 1% and 1% respectively. Since most pharmaceutical activities were run by private retailers outside the boundaries of hospitals, they were not considered for this study.

Scope 3 (Indirect emissions) - Extra Supply chain	Emissions (tCO2e/year)	Emissions (%)
1 Other manufactured products	192,539	33%
2 Construction	131,685	22%
3 Business services	109,858	19%
4 Medical Instruments / equipment	52,513	9%
5 Paper products	45,744	8%
6 Water and sanitation	24,058	4%
7 Food and catering	20,251	3%
8 Other procurement	6,211	1%
9 Information and communication technologies	4,205	1%
10 Manufactured fuels, chemicals and gases	39	0%



Top 5 emitter categories represent 91% of the Scope 3 (Indirect emission) - Supply chain emissions

Fig. 4.12: Indirect emissions – extra supply chain of HCFs in Nepal

4.4 Comparison of GHG emissions

Table 4.12: Comparison of GHGs emissions

S.N.	Study area	GHGs (tCO_2e)	Percent	Sources
1	This study (Nepal's GHGs emission from health sector)	1,164,719	0.0023% of global GHGs emissions; 4.1% of Nepal's GHGs emissions; and 0.05% of global GHGs emissions from health sector	This study, 2023
2	Nepal's GHGs emissions	28,166,060	0.06 % of global GHGs emissions	MoFE, 2021
3	Global GHGs emissions	50,000,000,000	-	Ritchie & Roser, 2013
4	Global GHGs emissions from health sector	2,200,000,000 - 2,300,000,000	4.4 – 4.6% of global GHGs emissions	HCWH, 2019; The Commonwealth Fund, 2022
5	India GHGs emissions from health sector	750,000,000	1.5% of global GHGs emissions	HCWH, 2019
6	USA GHGs emissions from health sector	5,460,000,000	8% of all national GHG emission	Chung and Meltzer, 2009
7	Canada GHGs emissions from health sector	330,000,000	4.6% of the nation's overall emissions	Eckelman, 2016
8	Australia GHGs emissions from health sector	35,772,000	7% of the nation's overall emissions	Malik et al., 2018
9	China GHGs emissions from health sector	315,000,000	2.7% of the nation's overall emissions	Wu, 2019
10	Japan GHGs emissions from health sector	62,500,000	4.6% of the nation's overall emissions	Nansai et al., 2020

Table 4.13: Summary table of Nepal's GHG emissions and removal 2011 (MoFE, 2021)

S.N.	Sector	GHG Emissions		
		CO_2e (Gg)	CO_2e (tons)	%
1	Energy	14751.66	14751660	52.37%
2	Industrial Processes and Product Use	368.4	368400	1.31%
3	AFOLU	12121.33	12121330	43.04%
4	Waste	924.67	924670	3.28%
	Total	**28166.06**	**28166060**	**100%**

Note:

1. Energy includes sub-sectors such as energy industries, manufacturing industries and construction, transport, others (Commercial/Institutional, Residential, Agriculture)
2. AFOLU includes Livestock, land (forest and cropland), land (Grassland, settlement, and other land), aggregate sources and non-CO_2 emissions sources on land
3. Waste includes solid waste disposal, biological treatment of solid waste, open burning of waste, wastewater treatment and discharge, domestic wastewater and industrial wastewater

Table 4.14: Summary table of Nepal's GHG emissions (%) from HCFs of Nepal

Sources	GHG (%)
Stationary Combustion	9
Fugitive	28
Waste	<1
Electricity	1
Extra Supply Chain	49
Transportation	12
Inhalers	<1

4.5 Discussion

The GHGs emissions is one of the global issues contributing about 50 billion tons of CO_2e each year globally (Ritchie & Roser, 2013). The developing country like Nepal, also contributes to it, accounting for about 0.06% of the total global GHGs emissions (MoFE, 2021). Nepal's GHG emissions may appear low compared to other nations, but they are on the rise from 2004 to 2014. According to the Initial National Communication (INC) and Second National Communication (SNC), Nepal's contributions to global GHG emissions were 0.025% and 0.027%, respectively (MoPE, 2004; MoSTE, 2014). In Nepal's Third National Communication, the comprehensive emission inventory encompasses sectors such as energy (52.37%), industrial processes and product use (1.31%), agriculture, forestry and other land use (43.04%), and waste (3.28%). Additionally, it incorporates a thorough vulnerability and impact assessment on human health resulting from the effects of climate change (MoFE, 2021) (Table 4.12). Health sector is also the one contributing in global GHG emissions. About 4.2 – 4.6% of the of total global GHGs emission are contributed from health sector (HCWH, 2019; The Commonwealth Fund, 2022) worldwide. This study presents the data regarding contribution of health sector from Nepal with respect to total global GHG emissions, Nepal's GHGs emissions and global GHGs emissions from health sector. Health care facilities in Nepal contributed about 0.0023% of global GHG emissions; 4.1% of Nepal's GHGs emissions and 0.05% of global GHG emissions from health sector.

As discussed earlier, the total GHG emissions from health sector in this study are estimated based on scope 1 (direct emissions), scope 2 (emissions from purchased electricity), and scope 3 (indirect emissions). The total contribution of GHG emissions was maximum from indirect emissions (58.2%) followed by direct emissions (40.8%) and emissions from purchased electricity (1%). Prior studies in GHG emissions in USA published in 2020 presented the highest contribution of GHG emissions from scope 3 (82%) followed by scope 2 (11%) and scope 1 (7%) (Eckelman et al., 2020). The contribution to GHG emissions from scope 2 is second highest in USA, whereas it is the lowest contributing scope in Nepal. There might be multiple reasons among which one could be the source of energy used in these countries. In USA, about 60% of the electricity was generated from fossil fuels in 2022 (EIA, 2023). Moreover, GHGs emissions from health sector from neighboring countries like India contributed about 1.5% of global GHGs emissions (HCWH, 2019). The details on the comparison of GHGs emission can be found in table 4.12 and 4.13. However, in Nepal, hydropower contributed the majority of the electricity being generated (Basnet, 2022; Bhatt, 2017). Previous research conducted in 2019 in case of global context reflected the contribution of scope 3 in total GHG emissions similar to USA and

Nepalese context representing 71%. The lowest GHG emissions was contributed by scope 2 (12%) which was similar to Nepalese context in this study (HCWH, 2019).

Extra supply chain and fugitive emissions were the responsible sources that contributed highest total GHG emissions among different sources contributing 50.4% and 28.13% respectively. The fugitive emissions especially cooling and fire suppression from HCFs are mainly due to the use of refrigerator, vaccines, freezer, centralized equipment and fire extinguisher. Previous studies emphasized the contribution of fugitive emissions emitted during the utilization, maintenance and disposal of equipment (International Carbon Registry, 2023).

About 91% of the GHG emissions of scope 3 – supply chain sub-category was contributed by top 5 emitter categories which included other manufactured products as 33%, construction as 22%, business services 19%, medical instruments/equipment 9%, and paper products 8%. In the global context, the contribution of distribution of electricity, gas, heat or cooling was the highest (40%) and second highest was from other manufacturing products that contributed 11% of the total GHGs emission under scope 3 (HCWH, 2019). In that research, distribution of electricity, gas, heat or cooling was not considered under scope 3. However, other manufactured products contributed the highest GHG emissions.

There were basically two types of inhalers used in Nepal viz. MDI and DPI. MDI inhalers contain propellants that are powerful GHGs (NHS, 2023). However, DPI does not contain these propellants and have lower contribution towards emission of GHGs (NHS, 2023). The highest no. of inhalers used was of DPI (75%) and the remaining was MDI (25%). However, the total GHG emissions was contributed by MDI (93%) due to the higher global warming potential propellant used in it.

Under patients commuting category, the most preferred type of vehicle by patient was SUV or light goods vehicle (diesel) which was 76% followed by motorbike (13%). The number of motorbikes was the highest counted vehicles during road count survey compared to SUV or light goods vehicle (diesel) (This study, 2023). However, the emission factor of SUV or light goods vehicle (diesel) was almost three times more than that of motorbike, contributing it as the highest emitter among vehicle type.

CHAPTER 5

5. Conclusion and recommendations

This study estimates Nepal's GHGs emission from health sector 1,164,719 tCO_2e which is 4.1% of Nepal's GHGs emissions. The total contribution of GHG emissions was maximum from indirect sources i.e. 678,317 tCO_2e (58.2%) (i.e. business trips, employee computing, patient commuting, inhalers, extra supply chain, electricity transmission and distribution losses, and off-site waste) followed by direct emission i.e. 474,847 tCO_2e (40.8%) (i.e. stationary combustion, mobile combustion, fugitive emission, and on-site waste) and purchased electricity i.e. 11,555 tCO_2e (1%).

Under indirect emissions, the extra supply chain contributed the most to GHG emissions (50.4%), followed by patient commuting (4.8%), and other sources (business travel, employee commuting, inhalers, and garbage) contributed the final 3%. The largest portion of the total GHG emissions under direct emission was from fugitive emissions (28.1%) to which cooling, and fire suppression made the largest contributions (27.7%). Others (stationary combustion, mobile combustion, and waste) accounted for 12.6% of the total GHG emissions.

Based on the findings of this assessment, following measures are recommended to minimize contribution of health sector to GHG emissions in Nepal, which could be useful for development of national action plan on sustainable low carbon health system in the country.

1. To reduce direct emissions, following emission reduction actions are suggested:

- Replace/substitute with more efficient energy consuming stationary combustion appliances (i.e., solar, boiler, water heaters, biofuel generators, and autoclaves). Also, more waste recycling facilities/centers should be built, and healthcare waste management should be done using non-burn technologies, together with organized waste disposal techniques to reducing air pollution and its impacts.
- Replace/substitute more efficient energy consuming mobile combustion vehicles (i.e., transport vehicles: ambulance, cars, and motorcycles etc.) to electric vehicles (EVs).

- LPG is used to cook in the facilities, thus recommended to gradually replace them with electrical cooking/induction and biogas plants, which reduces the demand of the purchased LPG. There is also the provision for subsidy of NRs 57,000 for Terai and NRs 68,000 for Hilly region for construction of GGC 2047 biogas model for public hospital.
- Organize campaigns for energy efficient technologies, promote public transport, implement sustainable and environment friendly procurement policies and encourage use of bicycles alongside other appropriate technological measures.

2. To reduce the emission from the indirect emissions, following emission reduction strategies are suggested:
   - Replace/substitute existing business trip, employee commuting and patient commuting transport vehicles to electric vehicles.
   - It is recommended to use mass transportation (e.g. electric buses) instead of motor bikes/Scooters.
   - Reduce the paper use by digitization of the system (i.e. interdepartmental networking, digital reports, and billing system etc.).
   - Use green construction materials instead of conventional materials.
   - Recycle the wastewater and reuse it to garden, rest room and cleaning purpose as appropriate.
   - Carry out energy audit of the HCFs together with electric audit of electricity transmission and distribution system and reduce the losses.
   - Replace MDI with DPI as MDI are more carbon intensive than DPI.

3. To reduce emissions from purchased electricity, following emission reduction actions are suggested:

   Currently, only few fossil-fuel power plants are operating in the country to generate electricity. Additionally, multifuel sources have been reported to produce electricity in Nepal. This could be a contributing factor to generate emissions in the electricity sector. Therefore, it is recommended to advocate for substitution of the existing fossil-fuel power plants and multi-fuel plants with use of other renewable energy sources such as solar photovoltaic system. This changes not only improve energy security but also increase the quality and reliability of the power supply in the facility.

4. Emissions are also generated from management, treatment, and disposal of waste products in the hospitals, whether these activities occur inside or outside the facility. Therefore, it is recommended to follow 3R principles of waste management practices (i.e. reduce, reuse, and recycle); utilize biogas trapping from bio-degradable waste; and advanced waste treatment facilities (e.g. bio-drying, gasification, in-vessel composting, mechanical biological treatment, and plasma arc waste disposal) to reduce GHGs emissions. It should be also in line with II NDC target on use of non-burn technology for healthcare waste management.

5. Given that the scale-up activity data used in this analysis and the majority of the EFs are derived from global sources and accordingly there may be some uncertainties in national context. At certain interval, it is recommended to conduct a comprehensive study of activity data by increasing the sample size or combining it with top-down analysis to reduce the level of uncertainties. Additionally, studies on country based EFs for HCFs are essential.

6. In light of Nepal's commitment to achieving net-zero GHGs emissions by 2045, the Government of Nepal is implementing different plans, strategies, and actions which also includes development of low carbon health system as key initiative. Other effective measures include conducting research studies to establish GHG emission standards for HCFs; continuous measurement of GHG emissions from the major sources of HCFs; enhancing the capacity of health professionals on climate change and health; conduct trainings, seminars and workshops related to operation and maintenance of climate friendly technologies/ equipment; promotion campaign of eco-friendly and energy efficient technologies in HCFs; appropriate budget allocations for low carbon HCFs; building networking and collaborations among related stakeholders of all tiers of the government; and keeping up a regular schedule of monitoring and evaluation.

CHAPTER 6

References

- Acharya, B. K., Cao, C., Xu, M., Khanal, L., Naeem, S., & Pandit, S. (2018). Present and future of dengue fever in Nepal: mapping climatic suitability by ecological niche model. International journal of environmental research and public health, 15(2), 187.
- Adhikari, S., Mahapatra, P. S., Sapkota, V., & Puppala, S. P. (2019). Characterizing emissions from agricultural diesel pumps in the Terai region of Nepal. Atmosphere, 10(2): 56. https://doi.org/10.3390/atmos10020056
- Anwar, A., Anwar, S., Muhammad, A. Y. U. B., Nawaz, F., Hyder, S., Noman, K. H. A. N., & Malik, I. (2019). Climate change and infectious diseases: evidence from highly vulnerable countries. Iranian journal of public health, 48(12), 2187.
- Basnet, S. (July 29, 2022). The Role of and Challenges and Prospects for Hydropower Development in Nepal's Energy Sector. Nepal Economic Forum. Accessed on 26 July 2023 from https://nepaleconomicforum.org/the-role-of-and-challenges-and-prospects-for-hydropower-development-in-nepals-energy-sector/#:~:text=Hydropower%20plays%20a%20predominant%20role,remaining%2032%25%20imported%20from%20India.
- Bhandari, D., Bi, P., Sherchand, J. B., Dhimal, M., & Hanson-Easey, S. (2020). Climate change and infectious disease research in Nepal: Are the available prerequisites supportive enough to researchers?. Acta tropica, 204, 105337.
- Bhatt, R. P. (2017). Hydropower development in Nepal-climate change, impacts and implications. Renewable hydropower technologies, 1, 75-98. DOI: 10.5772/66253
- Biddle, L., Wahedi, K., Bozorgmehr, K. (2020). Health system resilience: a literature review of empirical research. Health Pol Plann; 35(8):1084-1109
- Campion, N., Thiel, C. L., Woods, N. C., Swanzy, L., Landis, A. E., Bilec, M. M. (2015). Sustainable healthcare and environmental life-cycle impacts of disposable supplies: a focus on disposable custom packs. J Clean Prod. 2015;94(1):46–55.
- Chung, J., Meltzer, D. (2009). Estimate of the Carbon Footprint of the US Health Care Sector.
- Das, B., Bhave , P. V., Puppala, S. P., and Byanju, R. M. 2018.A GLOBAL PERSPECTIVE OF VEHICULAR EMISSION CONTROL POLICY AND PRACTICES: AN INTERFACE WITH KATHMANDU VALLEY CASE, NEPAL. Journal of Institute of Science and Technology. [available at: https://www.nepjol.info/index.php/JIST/article/view/22199]
- Das, B., Bhave , P. V., Puppala, S. P., Shakya, K., Adhikar, S., Sainju, S., Mool, E., and Byanju, R. M. 2022. Emission factors and emission inventory of diesel vehicles in Nepal. Science of the Total Environment (IF: 10.753). [available at: https://www.sciencedirect.com/science/article/abs/pii/S0048969721076178]
- Das, B., Bhave , P. V., Puppala, S. P., Shakya, K., Maharjan, B., and Byanju, R. M. 2020. A model-ready emission inventory for crop residue open burning in the context of Nepal. Environmental Pollution (IF: 9.988). [available at: https://www.sciencedirect.com/science/article/pii/S0269749119377723?via%3Dihub]
- Das, B., Bhave , P. V., Sapkota, A. and Byanju, R. M. 2018. Estimating emissions from open burning of municipal solid waste in municipalities of Nepal. Waste Management (IF: 8.816). 79: 481-490 [Available at: https://www.sciencedirect.com/science/article/pii/S0956053X18304963]

- Department of Health Services (DoHS), 2077/78 (2020/21). Annual Report. Government of Nepal, Ministry of Health and Population, Department of Health Services, Kathmandu.
- Dhimal, M., Kramer, I. M., Phuyal, P., Budhathoki, S. S., Hartke, J., Ahrens, B., Kuch, U., Groneberg, D. A., Nepal, S., Liu, Q., Huang, C., Cisse, G., Ebi, K. L., Klingelhofer, D., & Muller, R. (2021). Climate change and its association with the expansion of vectors and vector-borne diseases in the Hindu Kush Himalayan region: a systematic synthesis of the literature. Advances in Climate Change Research, 12(3), 421-429.
- DoHS (2022). Annual Report 2078/79 (2021/2022). Kathmandu: Department of Health Services, Ministry of Health and Population, Government of Nepal.
- DoHS. (2014). Annual Report 2069/70 (2012/2013). Kathmandu: Department of Health Services, Ministry of Health and Population, Government of Nepal.
- Ebi, K. L., Boyer, C, Bowen, K. J., Frumkin, H., Hess, J. (2018). Monitoring and evaluation indicators for climate change-related health impacts, risks, adaptation, and resilience. Int J Environ Res Public Health;15(9):1943.
- Eckelman, M. J. (2016). Sherman J. Environmental Impacts of the U.S. Health Care System and Effects on Public Health. PLoS ONE
- Eckelman, M. J., Huang, K., Lagasse, R., Senay, E., Dubrow, R., & Sherman, J. D. (2020). Health Care Pollution And Public Health Damage In The United States: An Update: Study examines health care pollution and public health damage in the United States. Health Affairs, 39(12), 2071-2079.
- Eckelman, M. J., Sherman, J. D., & MacNeill, A. J. (2018). Life cycle environmental emissions and health damages from the Canadian healthcare system: an economic-environmental-epidemiological analysis. PLoS medicine, 15(7), e1002623.
- Economic Survey of Nepal (2021/22). Ministry of Finance, Government of Nepal.
- Health Care Without Harm & Arup (2021). Global Roadmap for Health Care Decarbonization. Retrieved from Global Roadmap for Health Care Decarbonization: healthcareclimateaction.org/ roadmap on 26 July 2023 / https://noharm-europe.org/sites/default/files/documents-files/7186/2022-08-HCWH-Europe-Designing-a-Net-Zero-Road-Map-for-Healthcare.pdf
- Health Care Without Harm (2019). Health Care's Climate Footprint. Accessed on 27 July, 2023 from https://noharm-global.org/sites/default/files/documents-files/5961/HealthCaresClimateFootprint_092319.pdf
- https://doi.org/10.4209/aaqr.2019.03.0159
- Intergovernmental Panel on Climate Change (2018). Special Report on Global Warming of 1.5°C (SR15). Accessed on 1 October 2023 from https://www.ipcc.ch/sr15/
- Intergovernmental Panel on Climate Change, IPCC (2006). Guidelines for national greenhouse gas inventories. Chapter 5, 5.1-5.66.
- International Carbon Registry. (2023). Fugitive emissions from production and consumption of halocarbons and SF6. Accessed on 27 July, 2023 from https://www.carbonregistry.com/explore/sectors/fugitive-emissions-from-production-and-consumption-of-halocarbons-and-sf-6
- International Conference of Mountain Countries on Climate Change, 5-6 April 2012, Ministry of Environment, Kathmandu, Nepal.
- IPCC, Climate Change 2013. The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change-Abstract for decision-makers, T.F. Stocker, et al., Editors. 2013: Cambridge, United Kingdom and New York, NY, USA.
- Kanabkaew, T., & Oanh, N. T. K. (2011). Development of spatial and temporal emission inventory for crop residue field burning. Environmental Modeling & Assessment, 16: 453-464. https://doi.org/10.1007/s10666-010-9244-0
- Keim M. E. (2008). Building human resilience: the role of public health preparedness and response as an adaptation to climate change. Am J Prev Med.;35(5):508-516.
- MacNeill, A. J., Lillywhite, R., Brown, C. J. (2017). The impact of surgery on global climate: a carbon footprinting study of operating theatres in three health systems. Lancet Planet Health;1(9):e381–e388.

- Malik, A., Lenzen, M., McAlister, S., McGain, F. (2018). The carbon footprint of Australian health care. Lancet Planet Health; 2(2):27-35.
- Maplecroft. (2010). Maplecroft: South Asia most at risk from climate change, Scandinavia safest. Retrieved on 2 July 2023 from https://www.preventionweb.net/news/maplecroft-south-asia-most-risk-climate-change-scandinavia-safest
- Marcott, S. A., Shakun, J. D., Clark, P. U., & Mix, A. C. (2013). A reconstruction of regional and global temperature for the past 11,300 years. science, 339(6124), 1198-1201.
- McGain, F. (2010). Sustainable hospitals? An Australian perspective. Perspect Public Health;130(1):19–20.
- MoE. (2010). National Adaptation Program of Action to Climate Change (NAPA). Kathmandu: Government of Nepal, Ministry of Environment.
- MoFE (2018): Nepal National REDD+ Strategy (2018). Kathmandu: Ministry of Forest and Environment
- MoFE (2019). Climate Change Policy 2019. Kathmandu: Ministry of Forests and Environment.
- MoFE (2019). Environment Protection Act 2019. Kathmandu: Ministry of Forests and Environment.
- MoFE. (2021). Nepal's Third National Communication to the United Nations Framework Convention on Climate Change. Ministry of Population and Environment, Government of Nepal, Singh Durbar. p. 3
- Mojahed, N., Mohammadkhani, M. A., & Mohamadkhani, A. (2022). Climate Crises and Developing Vector-Borne Diseases: A Narrative Review. Iranian Journal of Public Health, 51(12), 2664-2673.
- Mool, E., Bhave, P. V., Khanal, N., Byanju, R. M., Adhikari, S., Das, B., & Puppala, S. P. (2020). Traffic condition and emission factor from diesel vehicles within the Kathmandu Valley. Aerosol and Air Quality Research, 20(3): 395-409.
- MoPE (2004). Initial National Communication to the Conference of the Parties of the
- MOPE (2016). Renewable Energy Subsidy Policy 2078 BS. Kathmandu: Ministry of Population and Environment.
- MoPE. (2010). National Adaptation Programme of Action to Climate Change Ministry of Environment, Kathmandu, Nepal.
- MoPE. (2012). Mountain Environment and Climate Change in Nepal: National Report prepared for the
- MoPE. (2016). Stocktaking Report on Urban Settlement and Infrastructure. National Adaptation Plan Formulation Process in Nepal. Ministry of Population and Environment, Government of Nepal.
- Mora, C., McKenzie, T., Gaw, I. M., Dean, J. M., Hammerstein, H. V., Knudson, T. A., Setter, R. O., Smith, C. Z., Webster, K. M., Patz, J, A., & Franklin, E. C. (2022). Over half of known human pathogenic diseases can be aggravated by climate change. Nature Climate Change, 12(9), 869-875.
- MoSTE (2014). Second National Communication to the United Nations Framework Convention on Climate Change. Ministry of Science, Technology, and Environment (MoSTE), Government of Nepal, Singhadurbar, Kathmandu, Nepal, p. 177.
- Nansai, K., Fry, J., Malik, A., Takayanagi, W., Kondo, N. (2020). Carbon footprint of Japanese health care services from 2011 to 2015. Resour Conserv Recycl:152.
- NEA (2022). Nepal Electricity Authority: A Year in Review– Fiscal Year 2021/22. Kathmandu: Nepal Electricity Authority.
- NHS. (2023). The environmental impacts of inhalers – Carbon footprint. Accessed on 27 July 2023 from https://northeast.devonformularyguidance.nhs.uk/formulary/chapters/3.-respiratory/the-environmental-impact-of-inhalers
- NPC (2019). 15th plan 2019/20-2023/24, National Planning Commission, Kathmandu, Nepal
- Pichler, P., Jaccard. I., Weisz, U., Weisz, H. (2019). International comparison of health care carbon footprints. Environ Res Lett..
- Quitmann, C., Sauerborn, R., & Herrmann, A. (2021). Gaps in reporting greenhouse gas emissions by German Hospitals—A systematic grey literature review. Sustainability, 13(3), 1430.

- Ritchie, H. & Roser, M. (2023). Greenhouse gas emissions. Our World in Data. Accessed on 27 July 2023 from https://ourworldindata.org/greenhouse-gas-emissions#:~:text=Greenhouse%20gases%20are%20measured%20in,were%20around%2035%20billion%20tonnes.
- Romanello, M., Napoli, C. D., Drummond, P., Green, C., Kennard, H., Lampard, P., Scamman, D., Arnell, N., Ayeb- Karlsson, S., Ford, L. B., Belesova, K., Bowen, K., Cai, W., Callaghan, M., Campbell-Lendrum, D., Chambers, J., Daalen, K. R. V., Dalin, C., Dasandi, N., Dasgupta, S., Davies, M., Dominguez-Salas, P., Dubrow, R., Ebi, K. L., Eckelman, M., Ekins, P., Escobar, L. E., Georgeson, L., Graham, H., Gunther, S. H., Hamilton, I., Hang, Y., Hänninen, R., Hartinger, S., He, K., Hess, J. J., Hsu, S., Jankin, S., Jamart, L., Jay, O., Kelman, I., Kiesewetter, G., Kinney, P., Kjellstrom, T., Kniveton, D., Lee, J. K. W., Lemke, B., Liu, Y., Liu, Z., Lott, M., Batista, Ma. L., Lowe, R., MacGuire, F., Sewe, M. O., Martinez-Urtaza, J., Maslin, M., McAllister, L., McGushin, A., McMichael, C., Mi, Z., Milner, J., Minor, K., Minx, J. C., Mohajeri, N., Moradi-Lakeh, M., Morrissey, K., Munzert, S., Murray, K. A., Neville, T., Nilsson, M., Obradovich, N., O'Hare, M. B., Oreszczyn, T., Otto, M., Owfi, F., Pearman, O., Rabbaniha, M., Robinson, E. J. Z., Rocklöv, J., Salas, R. N., Semenza, J. C., Sherman, J. D., Shi, L., Shumake-Guillemot, J., Silbert, G., Sofiev, M., Springmann, M., Stowell, J., Tabatabaei, M., Taylor, J., Triñanes, J., Wagner, F., Wilkinson, P., Winning, M., Yglesias-González, M., Zhang, S., Gong, P., Montgomery, H., & Costello, A. (2022). The 2022 report of the Lancet Countdown on health and climate change: health at the mercy of fossil fuels. The Lancet, 400(10363), 1619-1654.
- Romm, J. (2018). Climate Politics and Policies. Climate Change: What Everyone Needs to Know. Oxford University Press; 2018.
- Sadavarte, P., Rupakheti, M., Bhave, P., Shakya, K., & Lawrence, M. (2019). Nepal emission inventory – Part I: Technologies and combustion sources (NEEMI-Tech) for 2001–2016. Atmospheric Chemistry and Physics, 19(20): 12953-12973. https://doi.org/10.5194/acp-19-12953-2019
- Sapkota, R., & Rijal, K. (2016). Climate change and its impacts in Nepal. Tribhuva n University.
- Schmidt, L., & Bohnet-Joschko, S. (2022). Planetary Health and Hospitals' Contribution—A Scoping Review. International Journal of Environmental Research and Public Health, 19(20), 13536.
- Shrestha, R. M. (2018). Emissions of air pollutants and greenhouse gases in Nepal, an integrated inventory. A study carried out for Regional Resource Centre for Asia and the Pacific (RRC.AP) as a part of activities of Project Atmospheric Brown Cloud, Regional Energy Resources Information Center (RERIC), Asian Institute of Technology, Thailand.
- Shrestha, R. M., Oanh, N. T. K., Shrestha, R. P., Rupakheti, M., Rajbhandari, S., Permadi, D. A., Kanabkaew, T., & Iyngararasan, M. (2013). Atmospheric brown clouds emission inventory manual. UNEP/AIT, 1-194.
- Stockert EW, Langerman A. (2014). Assessing the magnitude and costs of intraoperative inefficiencies attributable to surgical instrument trays. J Am Coll Surg; 219(4):646–655.
- Stockwell, C. E., Christian, T. J., Goetz, J. D., Jayarathne, T., Bhave, P. V., Praveen, P. S., Adhikari, S., Maharjan, R., DeCarlo, P. F., Stone, E. A., Saikawa, E., Blake, D. R., Simpson, I. J., Yokelson, R. J., & Panday, A. K. (2016). Nepal Ambient Monitoring and Source Testing Experiment (NAMaSTE): emissions of trace gases and light-absorbing carbon from wood and dung cooking fires, garbage and crop residue burning, brick kilns, and other sources. Atmospheric Chemistry and Physics, 16(17): 11043-11081. https://doi.org/10.5194/acp-16-11043-2016
- The Commonwealth Fund (2022). How the U.S. Health Care System Contributes to Climate Change. Accessed on 26 July 2023 from https://www.commonwealthfund.org/publications/explainer/2022/apr/how-us-health-care-system-contributes-climate-change
- Tuladhar, R., Singh, A., Banjara, M. R., Gautam, I., Dhimal, M., Varma, A., & Choudhary, D. K. (2019a). Effect of meteorological factors on the seasonal prevalence of dengue vectors in upland hilly and lowland Terai regions of Nepal. Parasites & vectors, 12(1), 1-15.
- Tuladhar, R., Singh, A., Varma, A., & Choudhary, D. K. (2019). Climatic factors influencing dengue incidence in an epidemic area of Nepal. BMC research notes, 12(1), 1-7.

- U.S. Energy Information Administration (EIA). (Feb, 2023). What is U.S. electricity generation by energy source? Accessed on 26 July 2023 from https://www.eia.gov/tools/faqs/faq.php?id=427&t=3
- United Nations Framework Convention on Climate Change. Ministry of Population and Environment (MOPE), Singhadurbar, Kathmandu, Nepal. pp. 181.
- United Nations. (2018). The 2030 Agenda and the Sustainable Development Goals: An opportunity for Latin America and the Caribbean (LC/G.2681-P/Rev.3), Santiago.
- United Nations. (2022). The Sustainable Development Goals: Report 2022. UN. Department of Economic and Social Affairs.
- Venkatesh, R., van Landingham, S. W., Khodifad, A. M., et al (2016). Carbon footprint and cost-effectiveness of cataract surgery. Curr Opin Ophthalmol.;27(1):82–88.
- World Bank (2023). Health and Climate Change. Accessed on 02 October 2023 from https://www.worldbank.org/en/topic/health/brief/health-and-climate-change
- World Health Organization (2021). Climate change and health. Accessed on 1 October 2023 from https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health
- Wu, R. (2019). The carbon footprint of the Chinese health-care system: an environmentally extended input-output and structural path analysis study. Lancet Planet Health; 3(10):e413-e419.
- Zygourakis CC, Yoon S, Valencia V, et al (2017). Operating room waste: disposable supply utilization in neurosurgical procedures. J Neurosurg;126(2):620–625.
- https://www.carbonregistry.com/explore/sectors/fugitive-emissions-from-production-and-consumption-of-halocarbons-and-sf-6
- https://www.orfonline.org/research/decarbonising-the-healthcare-sector/
- https://noharm-global.org/sites/default/files/documents-files/5961/HealthCaresClimateFootprint_092319.pdf
- https://noharm-europe.org/sites/default/files/documents-files/7186/2022-08-HCWH-Europe-Designing-a-Net-Zero-Road-Map-for-Healthcare.pdf

CHAPTER 7

Annex: Supplementary Information

1. Total emissions from selected 12 HCFs

Table S1: Total emissions from selected 12 HCFs

	GHG total emissions (tCO2e)	**18,701.94**	**100%**
	Scope 1 (Direct emissions)	5,477.22	29.3%
1.1	Stationary Combustion	558.52	3.0%
1.2	Mobile combustion	694.71	3.7%
1.3	Fugitive Emissions	4,201.17	22.5%
1.3.1	Cooling & fire suppression	4,005.59	21.4%
1.3.2	Medicinal / Anesthetic gases	195.58	1.0%
1.4	Waste	22.83	0.1%
1.4.1	Solid waste disposal	Estimated in indirect emissions	0.0%
1.4.2	Composting	Estimated in indirect emissions	0.0%
1.4.3	Incineration	22.8	0.1%
	Non-hazardous/general health care waste	14.6	0.1%
	Clinical mix (biohazardous & hazardous)	7.3	0.0%
	Hazardous	0.9	0.0%
	Scope 2 (Emissions from purchased electricity)	231.44	1.2%
2.1	Purchased electricity	231.44	1.2%
2.2	Purchased steam, heat and cooling	Not Ocurring	0.0%
	Scope 3 (Indirect emissions)	12,993.28	69.5%
3.S	Extra Supply Chain	10,205.40	54.6%
3.1	Business trips	193.78	1.0%
3.2	Employee commuting	430.86	2.3%
3.3	Patient commuting	1,581.72	8.5%
3.4	Inhalers	209.76	1.1%
3.4.1	MDI	196.97	1.1%
3.4.2	DPI	12.80	0.1%
3.5	Electricity transmission and distribution losses	7.45	0.0%
3.6	Waste	364.31	1.9%
3.6.1	Solid waste disposal	361.39	1.9%
3.6.2	Composting	2.9	0.0%
3.6.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	Estimated in direct emissions	0.0%
	Clinical mix (biohazardous & hazardous)	Estimated in direct emissions	0.0%
	Hazardous	Estimated in direct emissions	0.0%

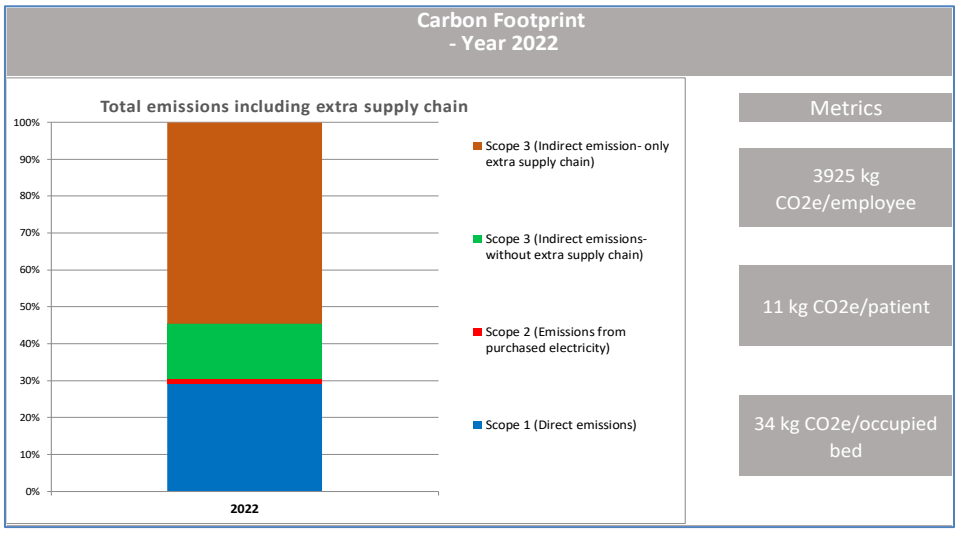


Figure S1: Total emissions from selected 12 HCFs

2. TU Teaching Hospital

Table S2: TU Teaching Hospital

	GHG total emissions (tCO2e)	**8,056.45**	**100%**
	Scope 1 (Direct emissions)	2,575.06	32.0%
1.1	Stationary Combustion	15.80	0.2%
1.2	Mobile combustion	173.05	2.1%
1.3	Fugitive Emissions	2,379.94	29.5%
1.3.1	Cooling & fire suppression	2,168.01	26.9%
1.3.2	Medicinal / Anesthetic gases	211.93	2.6%
1.4	Waste	6.26	0.1%
1.4.1	Solid waste disposal	Estimated in indirect emissions	0.0%
1.4.2	Composting	Estimated in indirect emissions	0.0%
1.4.3	Incineration	6.3	0.1%
	Non-hazardous/general health care waste	-	0.0%
	Clinical mix (biohazardous & hazardous)	6.3	0.1%
	Hazardous	-	0.0%
	Scope 2 (Emissions from purchased electricity)	63.47	0.8%
2.1	Purchased electricity	63.47	0.8%
2.2	Purchased steam, heat and cooling	Not Ocurring	0.0%
	Scope 3 (Indirect emissions)	5,417.92	67.2%
3.S	Extra Supply Chain	3,474.15	43.1%
3.1	Business trips	119.23	1.5%
3.2	Employee commuting	233.14	2.9%
3.3	Patient commuting	1,214.80	15.1%
3.4	Inhalers	23.01	0.3%
3.4.1	MDI	19.00	0.2%
3.4.2	DPI	4.01	0.0%
3.5	Electricity transmission and distribution losses	2.04	0.0%
3.6	Waste	351.54	4.4%
3.6.1	Solid waste disposal	351.54	4.4%
3.6.2	Composting	-	0.0%
3.6.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	Estimated in direct emissions	0.0%
	Clinical mix (biohazardous & hazardous)	Estimated in direct emissions	0.0%
	Hazardous	Estimated in direct emissions	0.0%

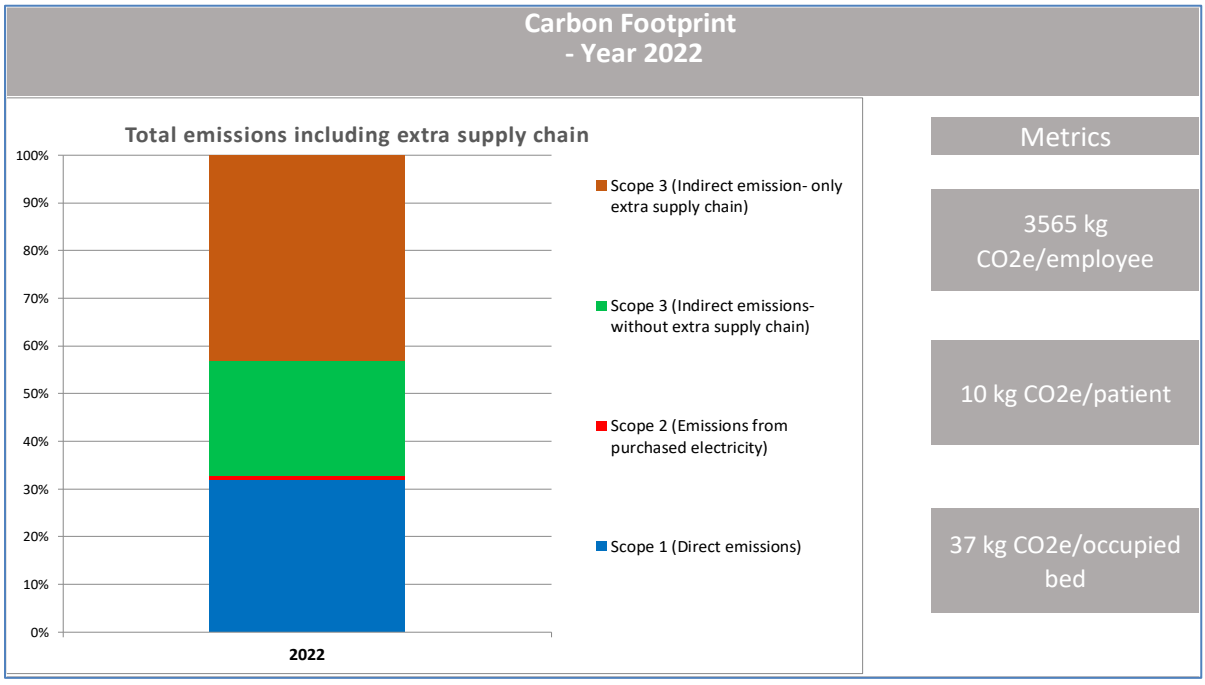


Figure S2: TU Teaching Hospital

3. Rasuwa District Hospital

Table S3: Rasuwa District Hospital

	GHG total emissions (tCO2e)	**523.42**	**100%**
	Scope 1 (Direct emissions)	471.22	90.0%
1.1	Stationary Combustion	20.81	4.0%
1.2	Mobile combustion	10.19	1.9%
1.3	Fugitive Emissions	439.73	84.0%
1.3.1	Cooling & fire suppression	439.73	84.0%
1.3.2	Medicinal / Anesthetic gases	-	0.0%
1.4	Waste	0.48	0.1%
1.4.1	Solid waste disposal	Estimated in indirect emissions	0.0%
1.4.2	Composting	Estimated in indirect emissions	0.0%
1.4.3	Incineration	0.5	0.1%
	Non-hazardous/general health care waste	0.3	0.1%
	Clinical mix (biohazardous & hazardous)	0.1	0.0%
	Hazardous	0.0	0.0%
	Scope 2 (Emissions from purchased electricity)	3.34	0.6%
2.1	Purchased electricity	3.34	0.6%
2.2	Purchased steam, heat and cooling	Not Ocurring	0.0%
	Scope 3 (Indirect emissions)	48.85	9.3%
3.S	Extra Supply Chain	12.79	2.4%
3.1	Business trips	2.77	0.5%
3.2	Employee commuting	2.58	0.5%
3.3	Patient commuting	25.06	4.8%
3.4	Inhalers	5.26	1.0%
3.4.1	MDI	5.24	1.0%
3.4.2	DPI	0.02	0.0%
3.5	Electricity transmission and distribution losses	0.11	0.0%
3.6	Waste	0.28	0.1%
3.6.1	Solid waste disposal	0.26	0.0%
3.6.2	Composting	0.0	0.0%
3.6.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	Estimated in direct emissions	0.0%
	Clinical mix (biohazardous & hazardous)	Estimated in direct emissions	0.0%
	Hazardous	Estimated in direct emissions	0.0%

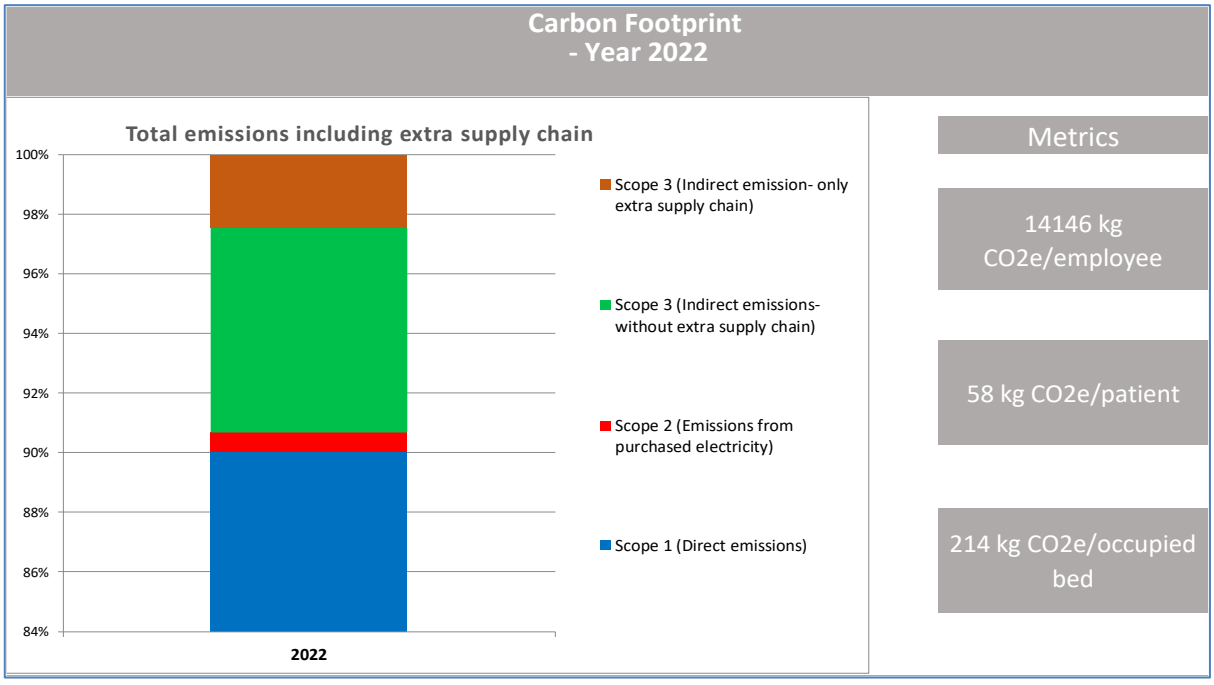


Figure S3: Rasuwa District Hospital

4. Gajendra Narayan Singh Sagarmatha Zonal Hospital

Table S4: Gajendra Narayan Singh Sagarmatha Zonal Hospital

	GHG total emissions (tCO2e)	**360.82**	**100%**
	Scope 1 (Direct emissions)	21.08	5.8%
1.1	Stationary Combustion	2.55	0.7%
1.2	Mobile combustion	16.24	4.5%
1.3	Fugitive Emissions	2.29	0.6%
1.3.1	Cooling & fire suppression	-	0.0%
1.3.2	Medicinal / Anesthetic gases	2.29	0.6%
1.4	Waste	-	0.0%
1.4.1	Solid waste disposal	Estimated in indirect emissions	0.0%
1.4.2	Composting	Estimated in indirect emissions	0.0%
1.4.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	-	0.0%
	Clinical mix (biohazardous & hazardous)	-	0.0%
	Hazardous	-	0.0%
	Scope 2 (Emissions from purchased electricity)	18.83	5.2%
2.1	Purchased electricity	18.83	5.2%
2.2	Purchased steam, heat and cooling	Not Ocurring	0.0%
	Scope 3 (Indirect emissions)	320.91	88.9%
3.S	Extra Supply Chain	274.11	76.0%
3.1	Business trips	11.79	3.3%
3.2	Employee commuting	4.50	1.2%
3.3	Patient commuting	27.91	7.7%
3.4	Inhalers	1.40	0.4%
3.4.1	MDI	1.20	0.3%
3.4.2	DPI	0.20	0.1%
3.5	Electricity transmission and distribution losses	0.61	0.2%
3.6	Waste	0.59	0.2%
3.6.1	Solid waste disposal	0.23	0.1%
3.6.2	Composting	0.4	0.1%
3.6.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	Estimated in direct emissions	0.0%
	Clinical mix (biohazardous & hazardous)	Estimated in direct emissions	0.0%
	Hazardous	Estimated in direct emissions	0.0%

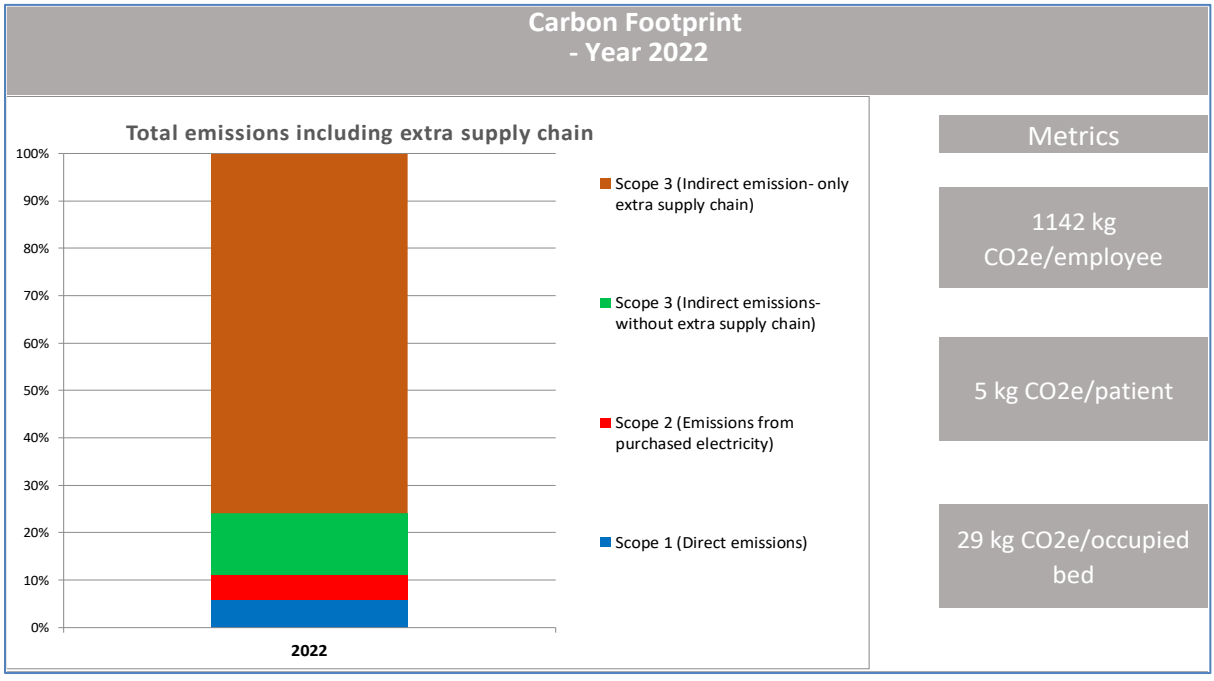


Figure S4: Gajendra Narayan Singh Hospital

5. Salyan District Hospital

Table S5: Salyan District Hospital

	GHG total emissions (tCO2e)	**76.23**	**100%**
	Scope 1 (Direct emissions)	23.94	31.4%
1.1	Stationary Combustion	9.41	12.3%
1.2	Mobile combustion	13.95	18.3%
1.3	Fugitive Emissions	-	0.0%
1.3.1	Cooling & fire suppression	-	0.0%
1.3.2	Medicinal / Anesthetic gases	-	0.0%
1.4	Waste	0.58	0.8%
1.4.1	Solid waste disposal	Estimated in indirect emissions	0.0%
1.4.2	Composting	Estimated in indirect emissions	0.0%
1.4.3	Incineration	0.6	0.8%
	Non-hazardous/general health care waste	0.6	0.8%
	Clinical mix (biohazardous & hazardous)	-	0.0%
	Hazardous	-	0.0%
	Scope 2 (Emissions from purchased electricity)	2.73	3.6%
2.1	Purchased electricity	2.73	3.6%
2.2	Purchased steam, heat and cooling	Not Ocurring	0.0%
	Scope 3 (Indirect emissions)	49.56	65.0%
3.S	Extra Supply Chain	3.24	4.3%
3.1	Business trips	10.76	14.1%
3.2	Employee commuting	0.59	0.8%
3.3	Patient commuting	20.17	26.5%
3.4	Inhalers	8.23	10.8%
3.4.1	MDI	8.20	10.8%
3.4.2	DPI	0.03	0.0%
3.5	Electricity transmission and distribution losses	0.09	0.1%
3.6	Waste	6.49	8.5%
3.6.1	Solid waste disposal	6.49	8.5%
3.6.2	Composting	-	0.0%
3.6.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	Estimated in direct emissions	0.0%
	Clinical mix (biohazardous & hazardous)	Estimated in direct emissions	0.0%
	Hazardous	Estimated in direct emissions	0.0%

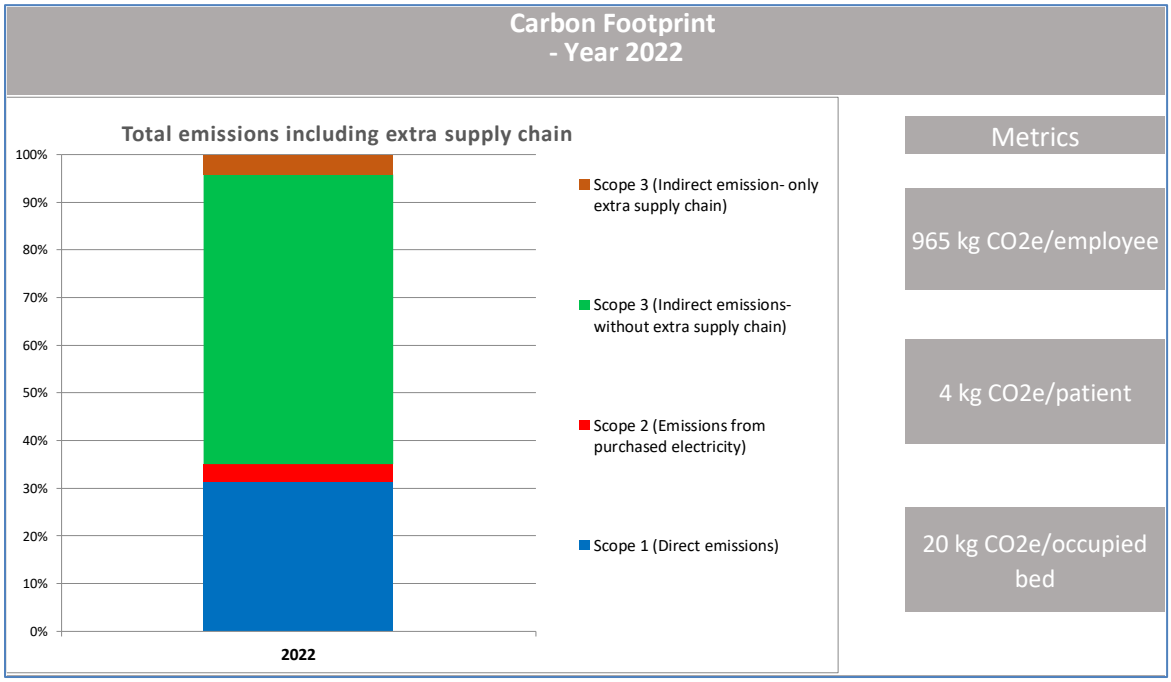


Figure S5: Salyan District Hospital

6. Koshi Hospital

Table S6: Koshi Hospital

	GHG total emissions (tCO2e)	**115.03**	**100%**
	Scope 1 (Direct emissions)	46.64	40.5%
1.1	Stationary Combustion	14.39	12.5%
1.2	Mobile combustion	1.40	1.2%
1.3	Fugitive Emissions	2.13	1.9%
1.3.1	Cooling & fire suppression	-	0.0%
1.3.2	Medicinal / Anesthetic gases	2.13	1.9%
1.4	Waste	28.72	25.0%
1.4.1	Solid waste disposal	Estimated in indirect emissions	0.0%
1.4.2	Composting	Estimated in indirect emissions	0.0%
1.4.3	Incineration	28.7	25.0%
	Non-hazardous/general health care waste	28.1	24.4%
	Clinical mix (biohazardous & hazardous)	-	0.0%
	Hazardous	0.6	0.5%
	Scope 2 (Emissions from purchased electricity)	10.02	8.7%
2.1	Purchased electricity	10.02	8.7%
2.2	Purchased steam, heat and cooling	Not Ocurring	0.0%
	Scope 3 (Indirect emissions)	58.37	50.7%
3.S	Extra Supply Chain	32.35	28.1%
3.1	Business trips	6.11	5.3%
3.2	Employee commuting	0.13	0.1%
3.3	Patient commuting	19.46	16.9%
3.4	Inhalers	-	0.0%
3.4.1	MDI	-	0.0%
3.4.2	DPI	-	0.0%
3.5	Electricity transmission and distribution losses	0.32	0.3%
3.6	Waste	-	0.0%
3.6.1	Solid waste disposal	-	0.0%
3.6.2	Composting	-	0.0%
3.6.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	Estimated in direct emissions	0.0%
	Clinical mix (biohazardous & hazardous)	Estimated in direct emissions	0.0%
	Hazardous	Estimated in direct emissions	0.0%

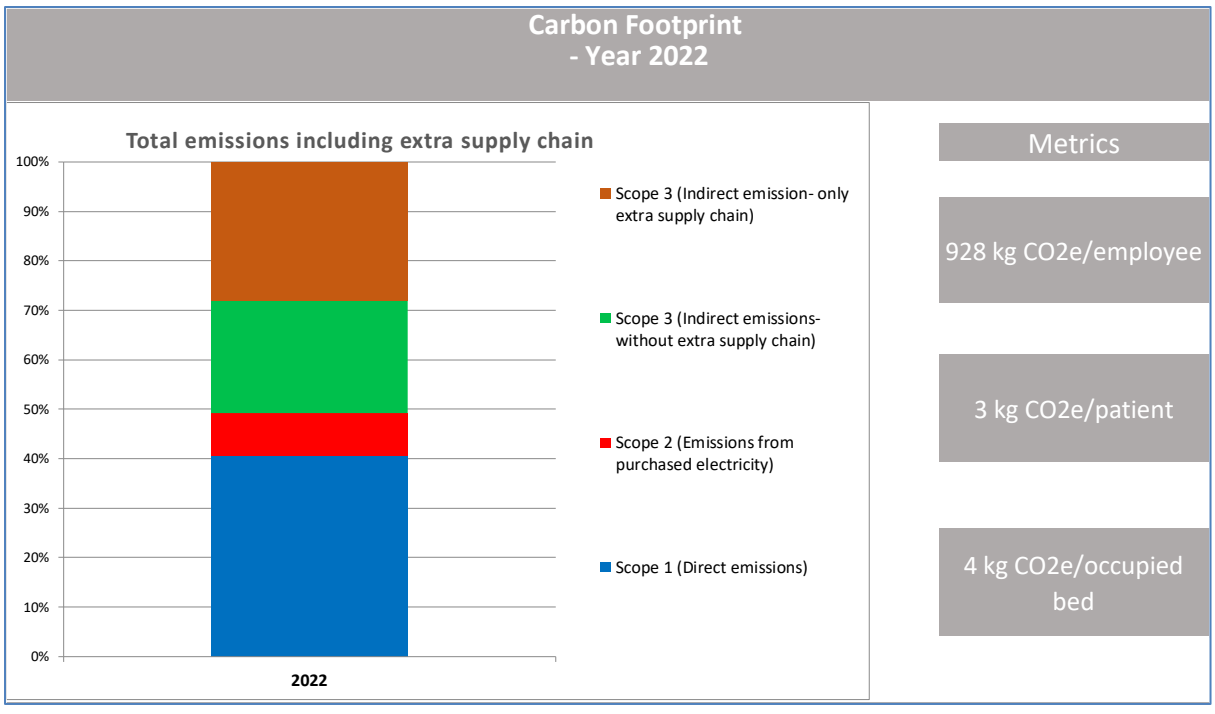


Figure S6: Koshi Hospital

7. Okhaldhunga Community Hospital

Table S7: Okhaldhunga Community Hospital

	GHG total emissions (tCO2e)	**495.52**	**100%**
	Scope 1 (Direct emissions)	124.06	25.0%
1.1	Stationary Combustion	117.20	23.7%
1.2	Mobile combustion	0.84	0.2%
1.3	Fugitive Emissions	6.02	1.2%
1.3.1	Cooling & fire suppression	-	0.0%
1.3.2	Medicinal / Anesthetic gases	6.02	1.2%
1.4	Waste	-	0.0%
1.4.1	Solid waste disposal	Estimated in indirect emissions	0.0%
1.4.2	Composting	Estimated in indirect emissions	0.0%
1.4.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	-	0.0%
	Clinical mix (biohazardous & hazardous)	-	0.0%
	Hazardous	-	0.0%
	Scope 2 (Emissions from purchased electricity)	3.87	0.8%
2.1	Purchased electricity	3.87	0.8%
2.2	Purchased steam, heat and cooling	Not Ocurring	0.0%
	Scope 3 (Indirect emissions)	367.59	74.2%
3.S	Extra Supply Chain	245.11	49.5%
3.1	Business trips	16.25	3.3%
3.2	Employee commuting	1.18	0.2%
3.3	Patient commuting	29.21	5.9%
3.4	Inhalers	70.00	14.1%
3.4.1	MDI	70.00	14.1%
3.4.2	DPI	-	0.0%
3.5	Electricity transmission and distribution losses	0.12	0.0%
3.6	Waste	5.72	1.2%
3.6.1	Solid waste disposal	3.82	0.8%
3.6.2	Composting	1.9	0.4%
3.6.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	Estimated in direct emissions	0.0%
	Clinical mix (biohazardous & hazardous)	Estimated in direct emissions	0.0%
	Hazardous	Estimated in direct emissions	0.0%

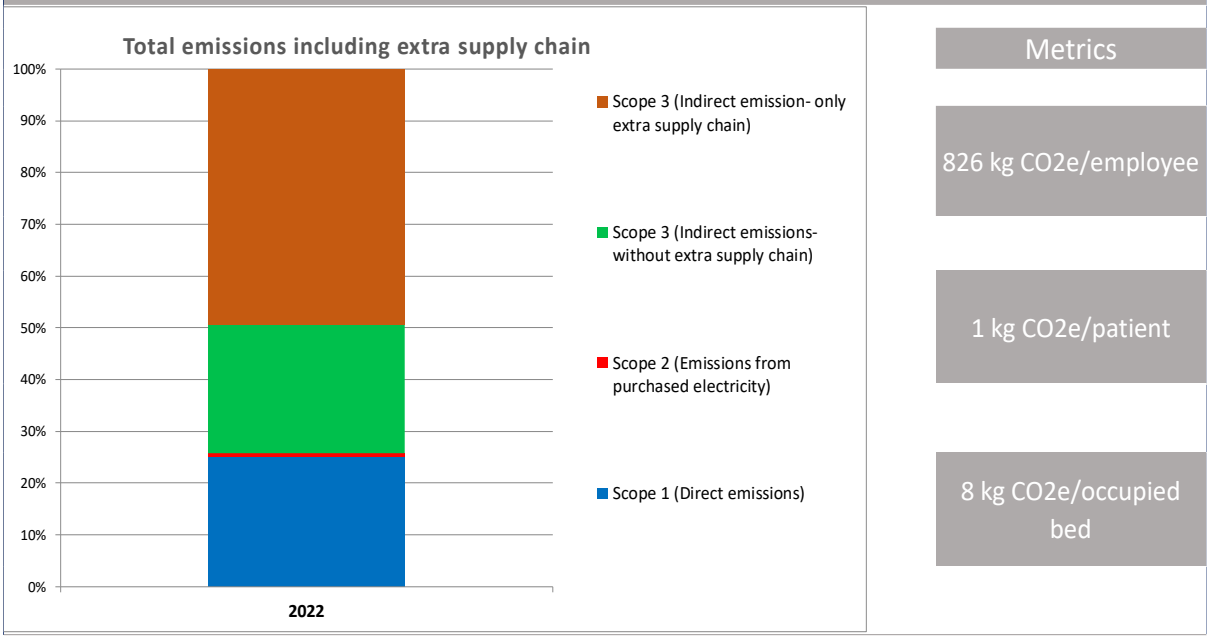


Figure S7: Okhaldhunga Community Hospital

8. Nisarga Hospital and Research Centre

Table S8: Nisarga Hospital and Research Centre

	GHG total emissions (tCO2e)	**3,238.27**	**100%**
	Scope 1 (Direct emissions)	1,341.51	41.4%
1.1	Stationary Combustion	28.00	0.9%
1.2	Mobile combustion	60.65	1.9%
1.3	Fugitive Emissions	1,249.25	38.6%
1.3.1	Cooling & fire suppression	1,241.17	38.3%
1.3.2	Medicinal / Anesthetic gases	8.08	0.2%
1.4	Waste	3.62	0.1%
1.4.1	Solid waste disposal	Estimated in indirect emissions	0.0%
1.4.2	Composting	Estimated in indirect emissions	0.0%
1.4.3	Incineration	3.6	0.1%
	Non-hazardous/general health care waste	2.5	0.1%
	Clinical mix (biohazardous & hazardous)	0.9	0.0%
	Hazardous	0.2	0.0%
	Scope 2 (Emissions from purchased electricity)	18.06	0.6%
2.1	Purchased electricity	18.06	0.6%
2.2	Purchased steam, heat and cooling	Not Ocurring	0.0%
	Scope 3 (Indirect emissions)	1,878.70	58.0%
3.S	Extra Supply Chain	1,674.85	51.7%
3.1	Business trips	8.15	0.3%
3.2	Employee commuting	20.70	0.6%
3.3	Patient commuting	162.30	5.0%
3.4	Inhalers	9.45	0.3%
3.4.1	MDI	7.19	0.2%
3.4.2	DPI	2.26	0.1%
3.5	Electricity transmission and distribution losses	0.58	0.0%
3.6	Waste	2.67	0.1%
3.6.1	Solid waste disposal	2.31	0.1%
3.6.2	Composting	0.4	0.0%
3.6.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	Estimated in direct emissions	0.0%
	Clinical mix (biohazardous & hazardous)	Estimated in direct emissions	0.0%
	Hazardous	Estimated in direct emissions	0.0%

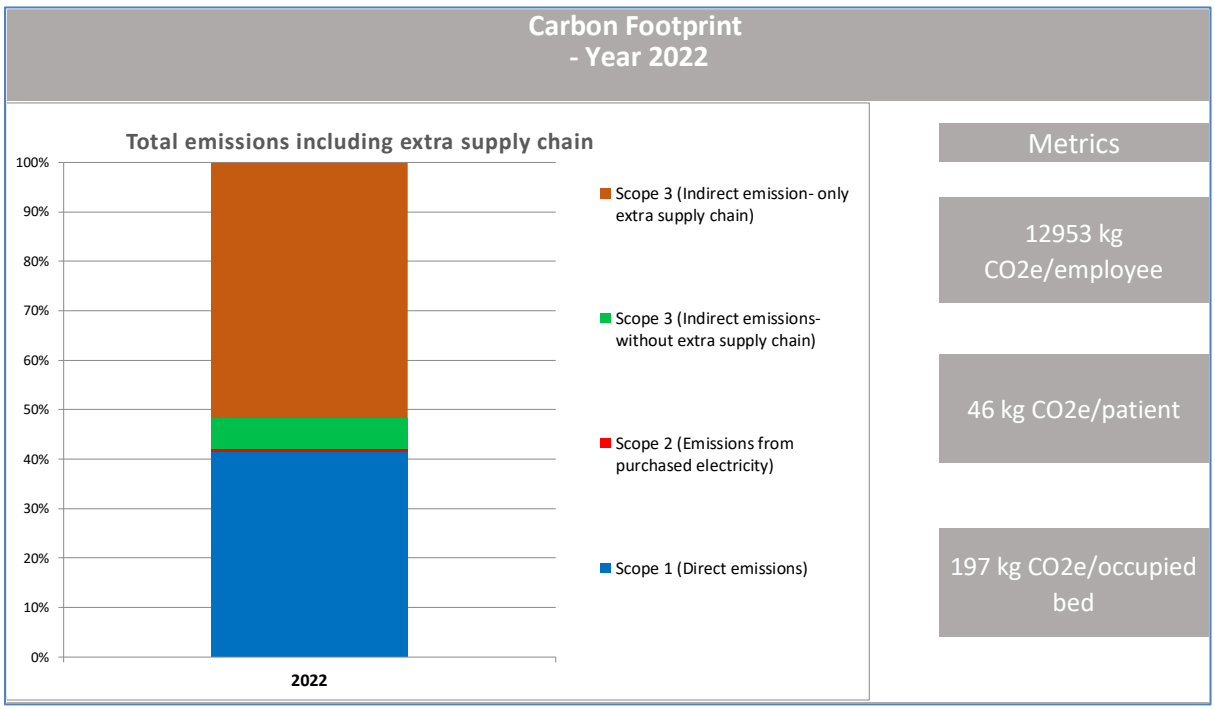


Figure S8: Nisarga Hospital and Research Centre

9. B.P. Koirala Memorial Cancer Hospital

Table S9: B.P. Koirala Memorial Cancer Hospital

	GHG total emissions (tCO2e)	**3,638.76**	**100%**
	Scope 1 (Direct emissions)	362.89	10.0%
1.1	Stationary Combustion	122.03	3.4%
1.2	Mobile combustion	34.77	1.0%
1.3	Fugitive Emissions	206.09	5.7%
1.3.1	Cooling & fire suppression	156.50	4.3%
1.3.2	Medicinal / Anesthetic gases	49.59	1.4%
1.4	Waste	-	0.0%
1.4.1	Solid waste disposal	Estimated in indirect emissions	0.0%
1.4.2	Composting	Estimated in indirect emissions	0.0%
1.4.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	-	0.0%
	Clinical mix (biohazardous & hazardous)	-	0.0%
	Hazardous	-	0.0%
	Scope 2 (Emissions from purchased electricity)	95.36	2.6%
2.1	Purchased electricity	95.36	2.6%
2.2	Purchased steam, heat and cooling	Not Ocurring	0.0%
	Scope 3 (Indirect emissions)	3,180.50	87.4%
3.S	Extra Supply Chain	2,972.54	81.7%
3.1	Business trips	4.74	0.1%
3.2	Employee commuting	94.18	2.6%
3.3	Patient commuting	26.49	0.7%
3.4	Inhalers	-	0.0%
3.4.1	MDI	-	0.0%
3.4.2	DPI	-	0.0%
3.5	Electricity transmission and distribution losses	3.07	0.1%
3.6	Waste	79.48	2.2%
3.6.1	Solid waste disposal	79.48	2.2%
3.6.2	Composting	-	0.0%
3.6.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	Estimated in direct emissions	0.0%
	Clinical mix (biohazardous & hazardous)	Estimated in direct emissions	0.0%
	Hazardous	Estimated in direct emissions	0.0%

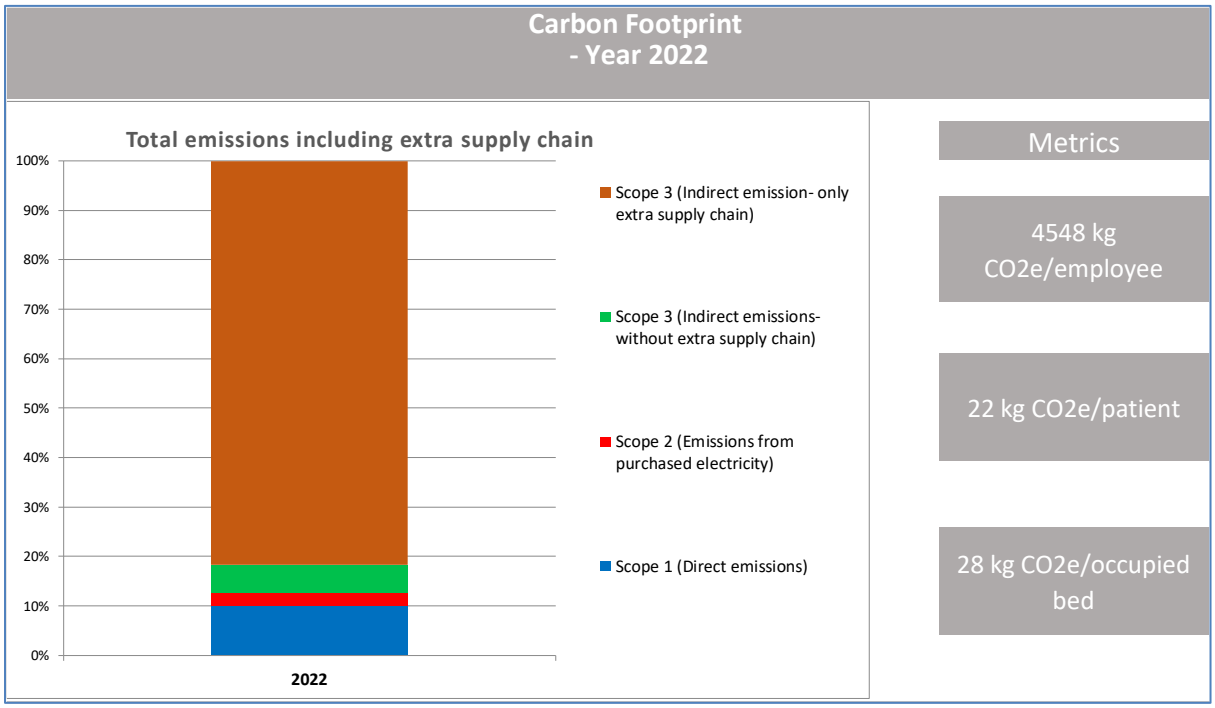


Figure S9: B.P. Koirala Memorial Cancer Hospital

10. Sagarmatha Choudhary Eye Hospital

Table S10: Sagarmatha Choudhary Eye Hospital

	GHG total emissions (tCO2e)	**1,712.14**	**100%**
	Scope 1 (Direct emissions)	91.45	5.3%
1.1	Stationary Combustion	77.35	4.5%
1.2	Mobile combustion	3.03	0.2%
1.3	Fugitive Emissions	10.77	0.6%
1.3.1	Cooling & fire suppression	0.18	0.0%
1.3.2	Medicinal / Anesthetic gases	10.59	0.6%
1.4	Waste	0.29	0.0%
1.4.1	Solid waste disposal	Estimated in indirect emissions	0.0%
1.4.2	Composting	Estimated in indirect emissions	0.0%
1.4.3	Incineration	0.3	0.0%
	Non-hazardous/general health care waste	0.2	0.0%
	Clinical mix (biohazardous & hazardous)	-	0.0%
	Hazardous	0.1	0.0%
	Scope 2 (Emissions from purchased electricity)	14.89	0.9%
2.1	Purchased electricity	14.89	0.9%
2.2	Purchased steam, heat and cooling	Not Ocurring	0.0%
	Scope 3 (Indirect emissions)	1,605.80	93.8%
3.S	Extra Supply Chain	1,447.81	84.6%
3.1	Business trips	9.93	0.6%
3.2	Employee commuting	77.05	4.5%
3.3	Patient commuting	55.95	3.3%
3.4	Inhalers	-	0.0%
3.4.1	MDI	-	0.0%
3.4.2	DPI	-	0.0%
3.5	Electricity transmission and distribution losses	0.48	0.0%
3.6	Waste	14.58	0.9%
3.6.1	Solid waste disposal	14.30	0.8%
3.6.2	Composting	0.3	0.0%
3.6.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	Estimated in direct emissions	0.0%
	Clinical mix (biohazardous & hazardous)	Estimated in direct emissions	0.0%
	Hazardous	Estimated in direct emissions	0.0%

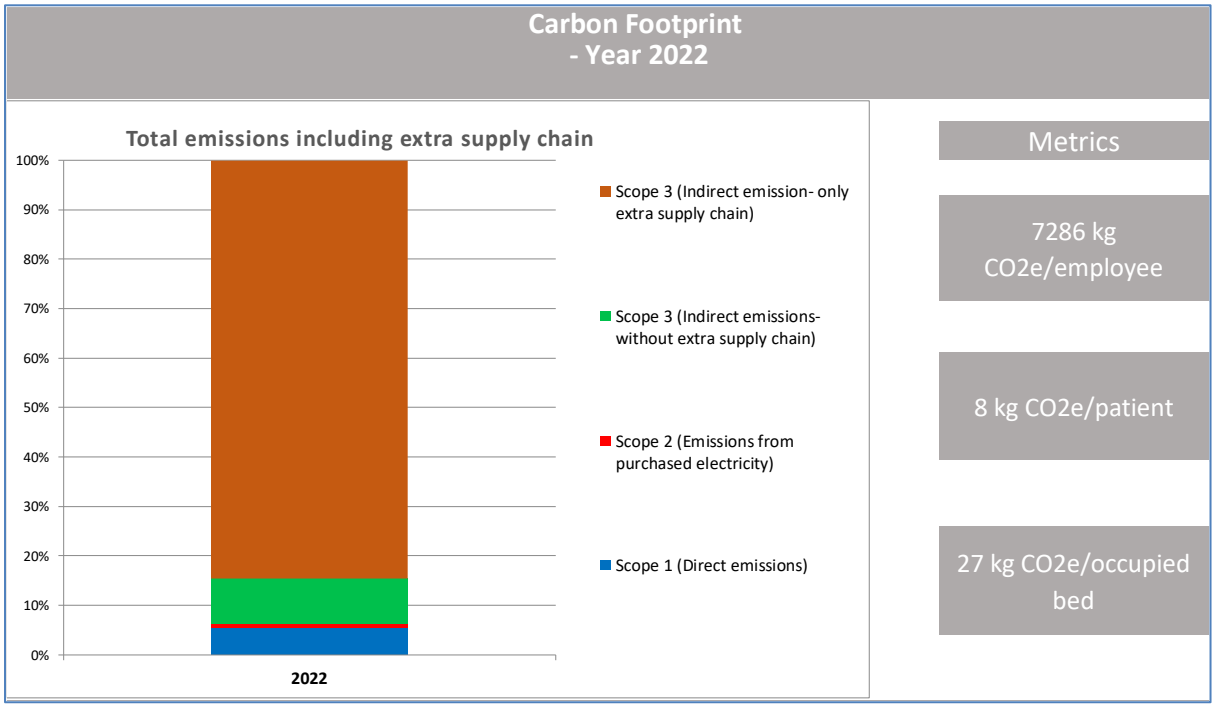


Figure S10: Sagarmatha Choudhary Eye Hospital

11. Urban Health Center, Pokhara

Table S11: Urban Health Center, Pokhara

	GHG total emissions (tCO2e)	**2.38**	**100%**
	Scope 1 (Direct emissions)	0.97	40.7%
1.1	Stationary Combustion	0.13	5.4%
1.2	Mobile combustion	0.84	35.3%
1.3	Fugitive Emissions	-	0.0%
1.3.1	Cooling & fire suppression	-	0.0%
1.3.2	Medicinal / Anesthetic gases	-	0.0%
1.4	Waste	-	0.0%
1.4.1	Solid waste disposal	Estimated in indirect emissions	0.0%
1.4.2	Composting	Estimated in indirect emissions	0.0%
1.4.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	-	0.0%
	Clinical mix (biohazardous & hazardous)	-	0.0%
	Hazardous	-	0.0%
	Scope 2 (Emissions from purchased electricity)	0.02	0.8%
2.1	Purchased electricity	0.02	0.8%
2.2	Purchased steam, heat and cooling	Not Ocurring	0.0%
	Scope 3 (Indirect emissions)	1.39	58.5%
3.S	Extra Supply Chain	0.19	7.9%
3.1	Business trips	0.53	22.3%
3.2	Employee commuting	0.16	6.6%
3.3	Patient commuting	0.38	15.9%
3.4	Inhalers	-	0.0%
3.4.1	MDI	-	0.0%
3.4.2	DPI	-	0.0%
3.5	Electricity transmission and distribution losses	0.00	0.0%
3.6	Waste	0.14	5.9%
3.6.1	Solid waste disposal	0.14	5.8%
3.6.2	Composting	0.0	0.1%
3.6.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	Estimated in direct emissions	0.0%
	Clinical mix (biohazardous & hazardous)	Estimated in direct emissions	0.0%
	Hazardous	Estimated in direct emissions	0.0%

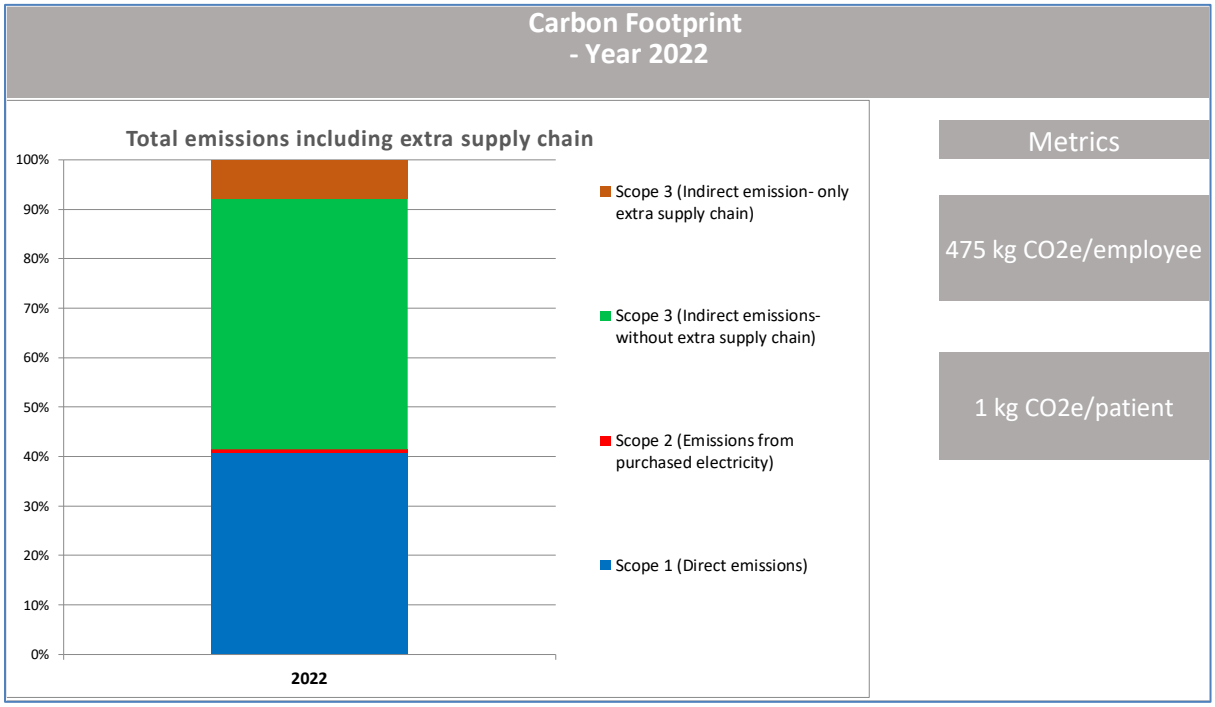


Figure S11: Urban Health Center, Pokhara

12. Health Directorate Pokhara

Table S12: Health Directorate Pokhara

	GHG total emissions (tCO2e)	**181.96**	**100%**
	Scope 1 (Direct emissions)	175.49	96.4%
1.1	Stationary Combustion	150.33	82.6%
1.2	Mobile combustion	25.17	13.8%
1.3	Fugitive Emissions	-	0.0%
1.3.1	Cooling & fire suppression	-	0.0%
1.3.2	Medicinal / Anesthetic gases	-	0.0%
1.4	Waste	-	0.0%
1.4.1	Solid waste disposal	Estimated in indirect emissions	0.0%
1.4.2	Composting	Estimated in indirect emissions	0.0%
1.4.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	-	0.0%
	Clinical mix (biohazardous & hazardous)	-	0.0%
	Hazardous	-	0.0%
	Scope 2 (Emissions from purchased electricity)	0.77	0.4%
2.1	Purchased electricity	0.77	0.4%
2.2	Purchased steam, heat and cooling	Not Ocurring	0.0%
	Scope 3 (Indirect emissions)	5.69	3.1%
3.S	Extra Supply Chain	4.06	2.2%
3.1	Business trips	-	0.0%
3.2	Employee commuting	0.75	0.4%
3.3	Patient commuting	-	0.0%
3.4	Inhalers	-	0.0%
3.4.1	MDI	-	0.0%
3.4.2	DPI	-	0.0%
3.5	Electricity transmission and distribution losses	0.02	0.0%
3.6	Waste	0.85	0.5%
3.6.1	Solid waste disposal	0.85	0.5%
3.6.2	Composting	-	0.0%
3.6.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	Estimated in direct emissions	0.0%
	Clinical mix (biohazardous & hazardous)	Estimated in direct emissions	0.0%
	Hazardous	Estimated in direct emissions	0.0%

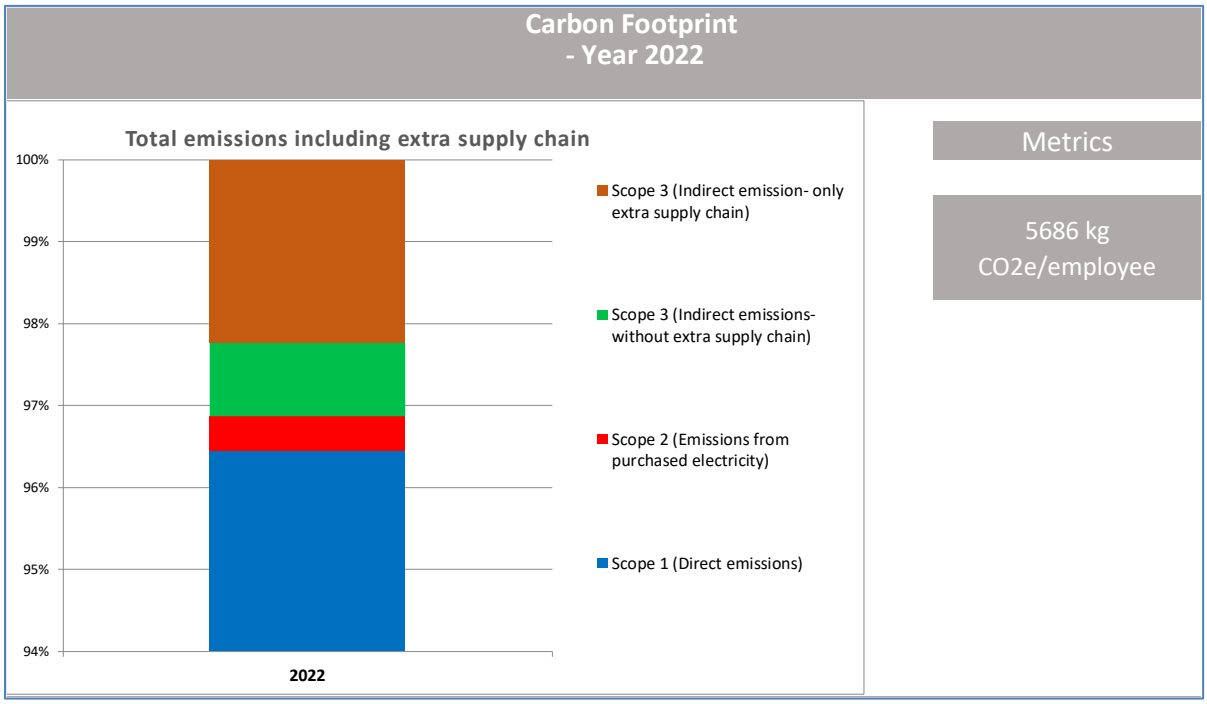


Figure S12: Health Directorate Pokhara

13. Health Directorate Lumbini

Table S13: Health Directorate Lumbini

	GHG total emissions (tCO2e)	**72.61**	**100%**
	Scope 1 (Direct emissions)	3.39	4.7%
1.1	Stationary Combustion	0.51	0.7%
1.2	Mobile combustion	2.88	4.0%
1.3	Fugitive Emissions	-	0.0%
1.3.1	Cooling & fire suppression	-	0.0%
1.3.2	Medicinal / Anesthetic gases	-	0.0%
1.4	Waste	-	0.0%
1.4.1	Solid waste disposal	Estimated in indirect emissions	0.0%
1.4.2	Composting	Estimated in indirect emissions	0.0%
1.4.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	-	0.0%
	Clinical mix (biohazardous & hazardous)	-	0.0%
	Hazardous	-	0.0%
	Scope 2 (Emissions from purchased electricity)	0.06	0.1%
2.1	Purchased electricity	0.06	0.1%
2.2	Purchased steam, heat and cooling	Not Ocurring	0.0%
	Scope 3 (Indirect emissions)	69.16	95.2%
3.S	Extra Supply Chain	64.20	88.4%
3.1	Business trips	3.52	4.8%
3.2	Employee commuting	0.39	0.5%
3.3	Patient commuting	-	0.0%
3.4	Inhalers	-	0.0%
3.4.1	MDI	-	0.0%
3.4.2	DPI	-	0.0%
3.5	Electricity transmission and distribution losses	0.00	0.0%
3.6	Waste	1.04	1.4%
3.6.1	Solid waste disposal	1.04	1.4%
3.6.2	Composting	-	0.0%
3.6.3	Incineration	-	0.0%
	Non-hazardous/general health care waste	Estimated in direct emissions	0.0%
	Clinical mix (biohazardous & hazardous)	Estimated in direct emissions	0.0%
	Hazardous	Estimated in direct emissions	0.0%

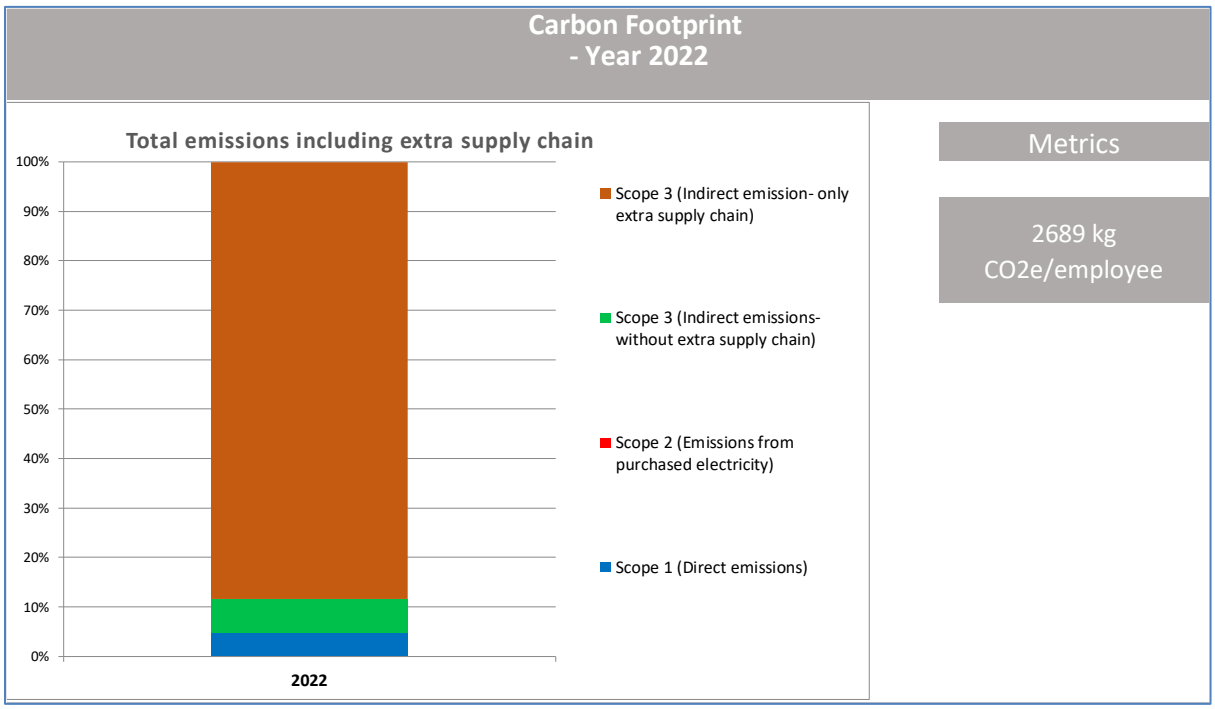


Figure S13: Health Directorate Lumbini

Supported by: