Energy poverty in Nepal: A Case Study on the Use of Biomass in the Rural Villages of Biratnagar

By

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Abstract

This thesis focuses on the situation of energy poverty and traditional biomass energy (TBE) use in the rural villages of Biratnagar Metropolitan city of Nepal. Although it is believed that the TBE use and energy poverty can be eradicated through the supply of modern energy services, this case study reflects the minimal role of grid electricity supply in eradicating the use of TBEs in the study area. The result of the study shows how the poor socio-economic condition and low awareness level on the negative impacts of TBE use have been the main factors guiding the energy choices of the households. Lastly, based on the overall study about the energy situation of Nepal and the findings of the area study, the study provides recommendation to the state and the non-state actors to promote cleaner energy sources to reduce the energy poverty levels in Nepal.

Keywords: *Biomass, energy poverty, socio- economic development, traditional biomass energy, modern biomass technologies, Improved Biomass Technologies*

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Declaration of originality

I hereby declare that this master's thesis submitted to the Graduate School of Public Policy of The University of Tokyo is a product of my own research and hard work. Neither the whole nor any part of this paper has been submitted to any other institution or university.

Furthermore, I certify that I have not violated the copyright or any other proprietary right of any author, academic institution or publisher. Following the standard APA reference requirement, I have acknowledged the sources through citation in case of the inclusion of the opinions, ideas and words in this paper.

POUDYAL Ritu

May, 2019

List of abbreviations

ADB	:	Asian Development Bank
AEPC	:	Alternative Energy Promotion Centre
BC	:	Black Carbon
BMC	:	Biratnagar Metropolitan City
DFID	:	Department for International Development
GDP	:	Gross Domestic Product
GIZ	:	Deutsche Gesellschaft für Internationale Zusammenarbeit
GoN	:	Government of Nepal
IBT	:	Improved Biomass Technologies
ICS	:	Improved cooking stoves
IEA	:	International Energy Agency
IPP	:	Independent Power Producers
JICA	:	Japan International Cooperation Agency
LPG	:	Liquid Petroleum Gas
MBT	:	Modern Biomass Technologies
MDG	:	Millennium Development Goals
MH	:	Micro Hydro
NEA	:	Nepal Electricity Authority
NRREP	:	National Rural and Renewable Energy Programme
SE for All	:	Sustainable Energy for All
TBE	:	Traditional Biomass Energy
UN	:	United Nations
UNDP	:	United Nations Development Programme
WB	:	The World Bank
WHO	:	World Health Organization

Measurements

FY	–	Fiscal Year
GWh	–	gigawatt-hour
km	–	kilometer
kV	–	kilovolt
kW	–	kilowatt
MW	–	megawatt

Currency Equivalents (as of April 2019)

Currency Unit	-	Nepali Rupee/s (NRs)
NRs 1.00	=	$ 0.0089
$1.00	=	NRs 111.80

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CHAPTER I. INTRODUCTION

I.1 Research Background

Energy is a prerequisite for the development of humans and the society they live in. States invest in sustainable energy production because energy is interlinked to all other infrastructures that act as a backbone of the country. It is essential for the development of education, health, sanitation, clean water, communication, finance and many other sectors. Furthermore, in this age of globalization where the reliance on technology and Internet is snowballing, the unavailability of constant energy supply would further hinder the advancement of individuals, societies and the country. Thus, the growth of a country and its citizens is largely correlated to the status and source of sustainable energy supply.

Despite being a basic necessity, it is an astonishing fact that the scarcity of energy even for routine activities like cooking, electrification and heating is affecting billions of people in this world and the situation is expected to persist until more than 2 decades to come (IEA, UDP, UNIDO, 2010, p. 8). Particularly in the developing countries, the lack of energy access has been impeding their growth and has been causing inconvenience to their citizens (particularly the ones residing in the rural areas of the country). The demand of energy is increasing every year with the advancement in technology, rapid urbanization and population growth but not all areas have access to clean and modern energy sources therefore, this problem of energy poverty is leading to a high reliance on traditional sources of energy like biomass.

In the case of Nepal, it is one of the poorest countries in the world with about 81 percent of its total population living in the rural areas as of 2017 (The World Bank, 2018). Being a Himalayan country, it has abundant water resources to produce hydroelectricity of more than 80,000 MW but until 2018 it has only succeeded in the generation of less than 1,000 MW (Kaini & Annandale, 2019). Due to the underutilization of its power capabilities predominantly due to lack of technical and financial abilities, the households and industries throughout the country

had been facing power cuts for a decade until 2018 that hindered the growth of the country. Furthermore, the lack of connectivity and distribution networks of grid-power in the rural areas has been a constant cause of suffering for the people. With only about 72 percent of the rural areas connected to power, the people are compelled to rely on traditional biomass sources like firewood, charcoal, agricultural wastes and animal wastes for their daily cooking, lighting and heating. Particularly, traditional biomass energy (TBE) is common throughout the country because it is easily available and is a cheaper choice for people due to the abundant forest resources and a majority of the people working for the agricultural sector.

Biomass is considered to be a carbon neutral form of energy as the plants absorb carbon from the atmosphere throughout their lifetime but it still does release black carbon (BC) (core element of soot) during combustion. BC is not only one of the highest contributors to the increase in the global warming, its smoke also has hazardous effects on the health of people. According to the World Health Organization (WHO) forecasts, deaths due to the inhalation of fumes from the inefficient indoor biomass combustion in the world is expected to be higher than 1.5 million annually by 2030, which is greater than the deaths by diseases like AIDS, tuberculosis or malaria (IEA, UDP, UNIDO, 2010, p. 13). The excessive use of TBEs on a daily basis in the houses with poor ventilation has led to the level of air pollution inside rural households to be higher than the overall outdoor levels. Deaths and complications in the respiratory system mostly affect the women as they are the ones engaged in the domestic works and it also affects the young children as they are mostly indoors and are helping with the household works. However, due to high poverty rates, these people have no choice but to use the cheapest energy source available and due to the low literacy rates in these areas, most of these people are not even aware about the negative effects of TBE use.

The Government of Nepal (GoN) has been failing in expanding its power connectivity to the rural areas and providing a sustainable alternative to TBEs. Even in the areas where the

electricity grids laid out by the Nepal Electricity Authority (NEA), the power is mostly used only for electrification while imported kerosene and firewood is widely used for cooking and heating purposes. The government has established institutions like Alternative Energy Promotion Centre (AEPC) since 1996 that is responsible in the expansion and promotion of the use of renewable energy sources for the betterment of the environment and increasing the quality of life of the Nepalese people (Alternative Energy Promotion Centre). Partnering with various international organizations like the ADB, GIZ, UNDP, DFID, WB, the AEPC has been actively working towards the overall replacement of biomass with other cleaner sources of energy along with the substitution of the traditional inefficient biomass systems with technologically efficient biomass systems. It has also implemented the National Rural and Renewable Energy Programme (NRREP) to carry out extensive research on the existing systems of biomass and the emerging technologies to increase the efficiency of the overall system and reduce the negative impacts of traditional biomass on the environment and human health. Despite the continuous efforts by the government and the collaboration with different development agencies, there is still no significant change in the status of high dependency on TBEs in the country.

The NEA and GoN are focusing highly on the development of the hydropower potential of Nepal to fill in the existing power gap in the country. However, the development of hydropower plants requires high financial investments and technical expertise so the government has been mostly relying on international organizations and other countries for assistance. Furthermore, the lack of collaboration within different government agencies is further slowing down the development of the existing power projects and energy distribution system in the country. However, hydropower is not the only option in solving the energy poverty in the country. Advancement of the renewable energy sector through micro-hydro and solar could address the power needs of the rural areas of Nepal (Banarjee, Singh, & Hussain, 2011,

p. xiii). Likewise, even if the existing TBE system is modernized and replaced with Improved Biomass Technologies (IBTs) or Modern Biomass Technologies (MBTs), it would be better for the health of the people and the environment they live in. A high proportion of the carbon in the biomass can be captured as CO_2 with a very little added cost during the conversion process of the TBEs into MBTs and carbon captured (even partial) from sustainably grown biomass results in an overall negative CO_2emissions per unit of energy produced throughout its lifecycle (Faaij, 2006, p. 361). Nevertheless, in order to make MBTs competent and affordable, the government should produce it in a larger scale. Likewise, to guarantee a sustainable source for its production, it needs to increase its forest coverage and raise environmental awareness to conserve the forest.

The constant delays in guaranteeing the sustainable energy supply is leading to the continuation of the use of TBEs that has been increasing the risks related to people's health and environment. The lack of proper data records and studies about the impact of TBEs and the benefit of the implementation of cleaner renewable energy sources are also responsible for the low awareness and lack of initiatives taken on the issue. It is essential to conduct research on the subject and increase awareness of the government and the Nepali citizens (particularly the residents in the rural areas) about the risks of high reliance on TBEs on a daily basis and the need to make changes in their energy consumption pattern to create sustainable development while guaranteeing a cleaner environment.

This research aims to focus on 50 households in 6 of the rural villages of Biratnagar Metropolitan city (BMC) that are highly reliant on Traditional Biomass Energy (TBEs) particularly for their daily cooking and heating during winter. The findings of the study highlight that despite majority of the households have connectivity to the electricity grids supplied by the NEA, almost all of the households continue to use TBE (mostly firewood and bamboo) as their main energy source. The high use of TBEs is primarily due to the low level of income of most of the households that compels them to opt for cheaper energy sources. In

addition, low level of awareness is also contributing to the continuous consumption of TBE sources. Based on these findings, the research recommends the state and the non- state actors to encourage its stakeholders to work collaboratively in creating energy policies that focus highly on achieving overall development through sustainable and clean energy sources. Furthermore, it encourages high investment in MBTs to provide the low-income households with an affordable energy source and possible employment opportunities while guaranteeing a cleaner environment for the generations to come. Lastly, it emphasizes on the need of awareness about the negative impacts of TBE use and the need for strong legislations and collective action in safeguarding the forests and the environment.

I.2 Research Problem of the Study

Many researchers have conducted the study on the issue of energy poverty. The increase in the awareness on the need of clean and renewable energy sources has also led to a significant amount of research on the use of traditional and modern biomass sources and its effects on the society and its development. However, in the case of Nepal, although traditional biomass accounts for about 80 percent of the total energy consumption of the country, there has been a minimal amount of research on the subject. The issue of regular use of TBE is an area that needs dire attention because the inefficient combustion of biomass sources in the households of rural Nepal is a leading cause of indoor air pollution, deforestation and is increasing health risks that might lead to respiratory diseases and even death. Moreover, clean and safe environment is essential for the proper growth of young children but, the regular use of TBE is hindering their development and is further creating an adverse effect on Nepal's future. Thus, a proper research on the subject matter is essential to highlight the negative effects of the regular use of TBEs as to emphasize on the need for it to be replaced with IBT, MBT or other renewable energy sources.

In past studies on the energy sector of Nepal, mostly focus on the existing and potential hydropower plants, and water politics. Due to the abundance of fresh water sources from the

Himalayan glaciers, Nepal is the country with one of the highest potentials of hydropower generation. However, due to the failure of the country to harness its capabilities and utilize its strategic geopolitical importance, hydropower is a topic of interest for most researchers. There are a few studies conducted on the effect of biomass use but they mostly focus on its connection to various respiratory diseases or on the increasing levels of deforestation and environmental degradation without covering the socio-economic and development aspects.

This study focuses more on the status of the use of TBEs and its relation to the socio-economic condition of the studied rural households to fill the research gap in the area. Firstly, conducting the household interviews and observation, this study aims to understand the economic conditions of the respondents by enquiring about their income, housing conditions, health condition and education levels. The study also focuses on the energy sources used in the household by inquiring about its purpose, duration and cost. Focusing on the aspects listed above, the study aims to find the reasons behind the continuous use of TBEs in the rural households and come up with recommendations for the government and non-government agencies to decrease the reliance on traditional sources of energy and work towards the promotion of sustainable energy sources.

I.3 Research Questions

This research aims to answer the following research questions:

- In what ways and to what extent are the rural households in Biratnagar using TBE?
- How does the socio-economic status of a household impact on its choice of energy sources?
- What are the possible measures that can be taken to reduce the high level of energy poverty in Nepal?

I.4 Research Objectives

This paper aims to answer the research questions and investigate the effects of the extensive use of biomass in the households in Biratnagar, through the following objectives:

1. To identify the extent of the use of TBE in the selected 6 rural villages of Biratnagar city.
2. To analyze the correlation between poverty and the use of TBE in the area.
3. To identify the effects of TBE use on the quality of life of the respondents.
4. To investigate the level of awareness among the locals on the effect of the regular use of TBE and other alternative sources of energy.
5. To identify the role of government, non-governmental organizations and other institutions involved in the energy sector in finding and promoting the best alternative energy source to replace TBE in the area.

I.5 Significance of the Study

The use of TBE as an energy source in Nepal has been quite high due to the lack of alternate sources of energy and low awareness levels among the population. Although there are some literatures existing in the subject, people still lack knowledge about the possibility of upgradation of traditional biomass into modern biomass sources that could yield larger benefits. Thus, this study aims to highlight the positive as well as the negative impacts of the use of TBE. Furthermore, it focuses on the need of awareness in the community and the government on the negative aspects of TBE use.

Lastly, this research aims to add on to the pool of minimal research done on the subject of biomass energy in Nepal and its effects. Diverting the focus of the government and the research agencies on other sources of energy besides hydropower, this study could help in attracting more research on the subject matter. Increased research and study on the current sources of energy and their impacts on the socio-economic condition, way of living and overall

development of the society could also help in gathering the attention of government which could ultimately create an impact on its policy making process. Thus, this research could be a stepping-stone for future research on the topic and its recommendations and findings could also guide the government in making positive changes in the existing energy policies of Nepal.

I.6 Limitations of the Study

Firstly, the primary limitation of this study is the time and budget that led to the smaller sample size for the interviews. Furthermore, as the respondents of the survey live in a few rural villages within the city of Biratnagar, the findings of this research do not represent the opinion of the entire population (rural and urban) of Biratnagar or of all the rural areas of Nepal. The effect of the use of biomass or the causes of use of biomass might be different in different regions within the country. In particular, as Nepal is a country with extreme geographical variations, the same study is likely to lead to different findings if conducted in some other geographical region.

Secondly, the research area for this study is an area with low income households with low literacy rates. The population of the area belong to different ethnicities and speak different local languages. Therefore, the actual interviews were conducted in their local languages (Maithili, Bhojpuri, Tharu, Hindi and Nepali) but they have been translated to English by the interviewers to make it easier to analyze and evaluate the responses. Thus, due to the need of translation, the responses might not cover the exact words of the respondents but it does cover their actual sentiments and opinions on the questions.

Lastly, this study does not provide enough evidence or statistical data from various sources as minimal studies have been done on this issue targeting the exact same research group (rural households of Biratnagar) or energy source (traditional biomass). Therefore, additional and continuous study on the subject matter needs to be done in a larger scale to better analyze the holistic impact of excessive use of TBE in the whole of Nepal.

CHAPTER II. LITERATURE REVIEW

II.1 Energy poverty

The lack of access to modern and clean energy services in the households for electricity, heating and cooking is defined as the state of energy poverty (International Energy Agency, n.d.). Energy poverty is a difficult term to define as people use different sources of energy, in different proportions, for different purposes. For example, households in some rural areas of Nepal have connection to grid electricity but they continue to use traditional sources of energy like biomass for cooking or heating. Thus, although there is connection to modern energy sources, the reliance on fuel wood and inefficient stoves continues. In addition, there are even cases when some people have access to modern energy sources but cannot afford it, or even situations when people can afford energy but have no access to it so they suffer from energy poverty. However, generally, many people in the world (especially in the underdeveloped and rural communities) suffer from energy poverty, as they cannot have access or afford the bare minimum amount of modern energy sources like solar power, wind power, nuclear power, hydropower and others. Therefore, they are dependent on traditional sources of energy like biomass that exposes them to health risks, reduces their productivity, reduces the air quality and deteriorates the environment.

In the world, 1 billion of the total population does not have access to electricity and 3 billion people suffer from energy poverty due to the lack of access to clean and modern means of cooking (Benoit & Ladislaw, 2017, p. 15). Realizing the extent of this problem, the United Nations (UN) set a goal under the Sustainability Energy for All (SEforAll) initiatives and included the issue under the Sustainable Development Goal for energy (SDG 7) to eliminate energy poverty by 2030. Under this objective, the UN in collaboration with other international organizations and governments aims to ensure access to modern energy services, multiply the use of renewables by a twofold and increase the energy efficiency throughout the world

(International Bank for Reconstruction and Development, 2017, p. 2).

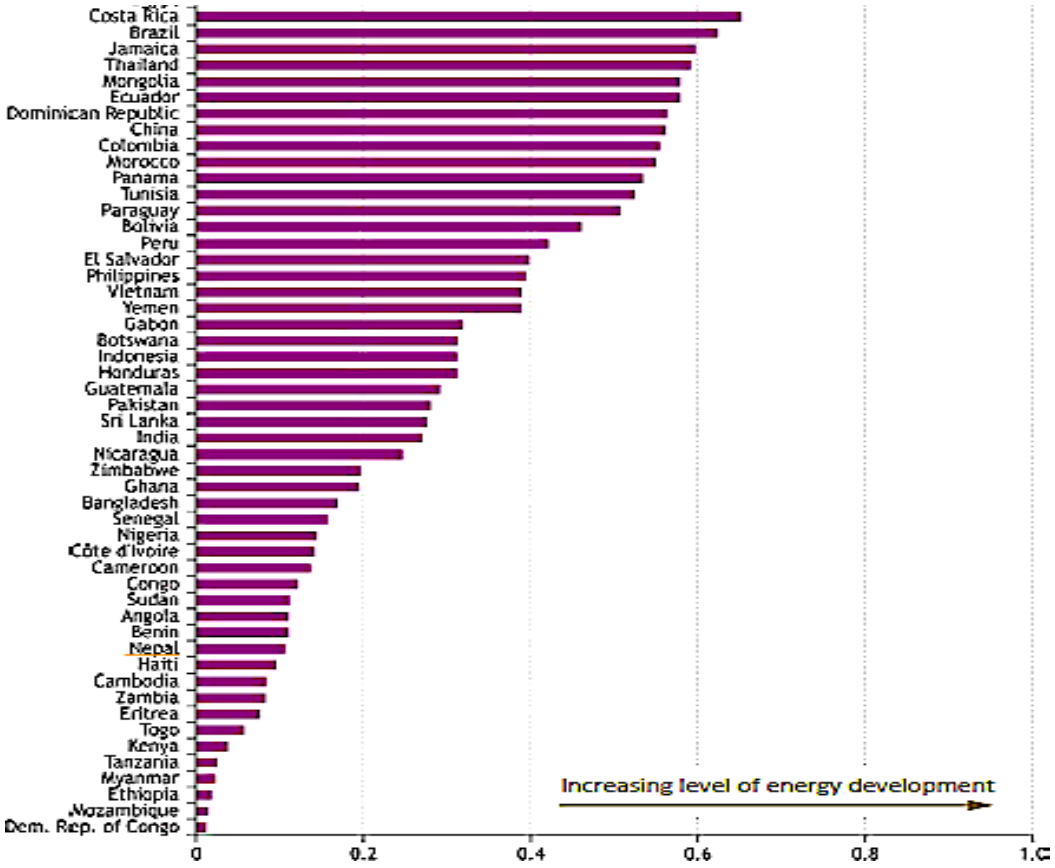

Figure 1: Energy development index of countries (IEA, UDP, UNIDO, 2010, p. 31)

The involvement and initiation of gigantic organizations like the UN in solving the global energy problem is increasing the network of collaboration with other organizations and agencies and is helping in changing the energy situation throughout the world. However, providing clean and modern energy services worldwide is a difficult objective to achieve. Figure 1 shows the data of the countries with the lowest Energy Development Indexes (EDI) in 2010. Through the figure it can be known that the development of energy has been a challenge even for countries like Costa Rica, Turkey, Thailand, China, Mexico, Brazil and Botswana that are now the upper-middle income countries. Likewise, the low-income countries like Nepal, Kenya, Congo, Haiti and others, continue to struggle to develop their energy capabilities. According to the IEA's estimates, in 2030, the rate of electricity access is still expected to be

91% and clean cooking access rate would only be 72% so, to achieve the 2030 target, the investment in the energy efficiency sector needs to increase 6 times from the current amount of $250 billion per year (International Bank for Reconstruction and Development, 2017, pp. iii-2).

In addition to the problem of investment, it is hard to ensure the attainment of the target as most people in the underdeveloped countries (particularly rural areas) use readily available and cheaper resources for biomass like firewood, charcoal, animal waste, leaves and agricultural waste. These people continue to use these sources due to its high affordability and lack of awareness about its negative impacts and so, the proportion of the use and the dependence on these sources continue to increase. The smoke produced during combustion of these sources is associated to high risks of respiratory problems and high levels of indoor pollution due to the release of Black Carbon (BC). In the long term, these problems escalate to bigger problems like increase in the mortality rate, decrease in the productivity levels, increase in the health spending and higher levels of poverty. Furthermore, these energy sources are also harmful for the environment as the use of firewood contributes to the depletion of the forest that could lead to greater natural disasters like flood and landslides, and the release of BC along with deforestation and high air pollution leads to the acceleration of global warming. Thus, with the increasing consciousness towards climate change and the increasing energy prices, the developing nations would have to opt for a solution that is sustainable to tackle energy poverty rather than following the technologies and methods followed by the developed countries since the 1950s and 1960s (IEA, UDP, UNIDO, 2010, p. 14).

II.1.1 Energy poverty and developing nations

Energy plays a significant role in the development process of a country. A country needs a stable and continuous source of energy to ensure the development of its infrastructural, educational, medical, industrial, water supply and financial capability. The sustainable provision of energy for lighting, heating, cooking, transport, telecommunication and

mechanical power leads to the supply of cleaner water, better health care, proper sanitation and better manpower that expedites a country's development (IEA, UDP, UNIDO, 2010, p. 11). Furthermore, in the past 50 years, it has been observed that there is a strong link between per-capita energy consumption and the increase in life expectancy (Lloyd, 2017). Thus, energy is a prerequisite for the development of a country and its manpower so the underdeveloped countries need to ensure a sustainable energy supply to achieve holistic development.

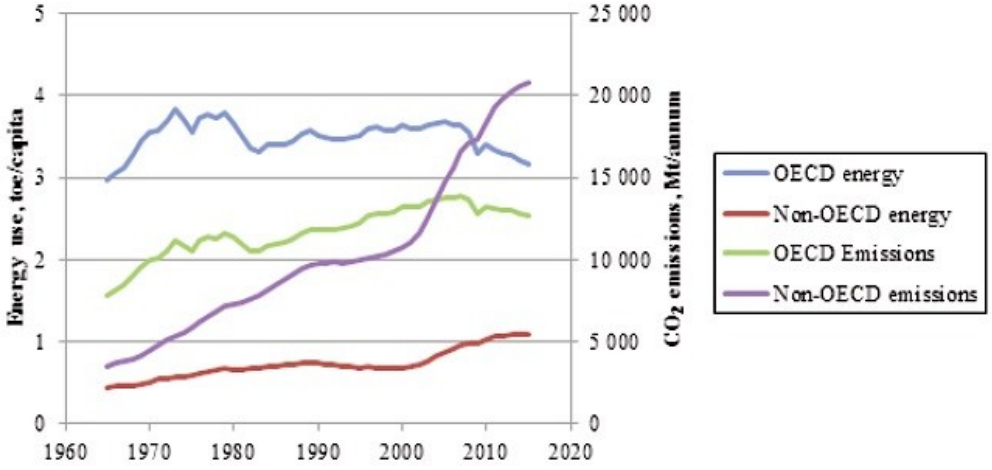

Figure 2: The total energy consumption and CO_2 emissions of OECD and Non- OECD countries (Lloyd, 2017, p. 61)

Development and modern energy sources have a strong correlation so the countries with the majority of their Per Capita Income (PCI) being below $2 per day have lower electrification rates and higher rates of biomass use (IEA, UDP, UNIDO, 2010, p. 11). Whereas in the developed economies, modern and more environment friendly energy sources like solar, wind, hydro, geothermal, nuclear and hydrogen fuel are being developed although they are comparatively expensive to produce. Referring to Figure 2 that shows the data trend from 1965, the energy consumption of the Non- OECD countries is gradually increasing but their CO_2 emission levels is comparatively very high as majority of those countries suffer from energy poverty and depend on inefficient sources of energy like TBE that result in high emissions. However, in the case of OECD countries, the emission level is low and they are experiencing a decrease in the use of energy as they are utilizing the cleaner and more

efficient energy sources. Furthermore, through the bar graph in Figure 3 it can be known that, in the low-income countries, the consumption of fuel for different sectors is low but the most common fuel used is biomass. However, in the high-income countries, there is diversity in the fuel mix as with the income increase of the population, the overall fuel consumption is increasing too.

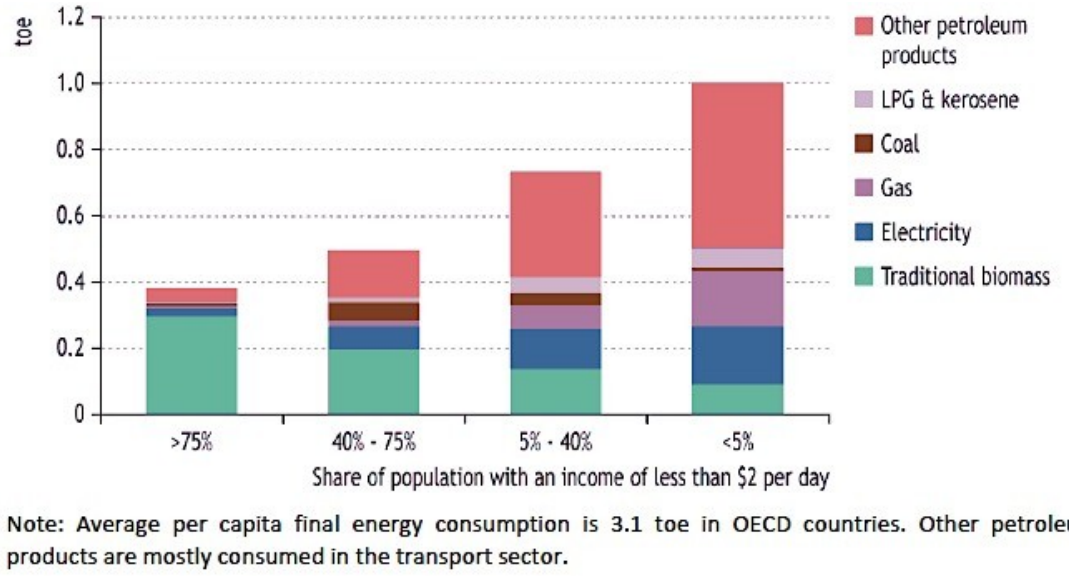

Figure 3: Energy consumption and its relation to income (IEA, UDP, UNIDO, 2010, p. 33)

Most of the developing countries are trapped in a "cycle of energy poverty" as a significant part of their population are deprived from the modern energy sources and the state itself does not have the financial, technical or managerial capability to utilize its resources in developing its energy potential. Furthermore, due to the lack of energy, they have a sluggish growth so they fall into the "poverty cycle" where the lack of the fundamentals for development hinder the overall development process. For example, many remote villages of Nepal lack the connection to electricity so, the children in those areas are unable to study well in the dark as they rely on firewood or kerosene lamps that increases the risk of developing poor vision and having respiratory problems. These children are unable to utilize their full potential during their learning process that would lead to lower productivity and reduced qualifications. As a result,

their chances of finding better paying jobs decreases and so they would have to continue to fight poverty. Likewise, due to the inability of these children to make a larger contribution to the economy, the overall development process of Nepal would be slower. Realizing the urgency and the long-term effects of this problem, the developing countries highly depend on the assistance of international organizations, development agencies and other high-income countries to develop their energy and other sectors that are the foundation for their progress.

The developing countries have been experiencing an exponential increase in their energy demands while undergoing their development process. The IEA expects the global energy demands to increase by 25 percent from 2014 to 2040 but for the developed countries average demand is projected to shrink to 0.1 percent per year whereas for the developing countries it will continue growing up to 1.6 percent per year (Benoit & Ladislaw, 2017, p. 3). This explains the present global energy mix where countries like India and China that have been focusing on the mass production of energy and are one of the largest energy importers in the world. Furthermore, China along with other developed countries has also been massively investing in the energy sector. The global investment in the energy sector in 2016 was 1.7 trillion dollars which is 2.2 percent of the global GDP and it is expected to surpass 44 trillion dollars within 2016- 2040 (Benoit & Ladislaw, 2017, p. 12). Consequently, the increasing energy investments from the highly developed and the middle-income countries could help in eradicating the global energy poverty levels. However, as economic development is accompanied by high-energy consumption, it is also leads to high emissions that contribute in the acceleration of global warming (Lloyd, 2017). Thus, there is a continuous struggle in maintaining a balance between development, energy consumption and pollution levels.

The primary challenge in the development and use of the modern energy services has been due to the alarming increase in the CO_2 levels leading to climate change concerns and high cost of switching from traditional or existing sources of energy to cleaner forms of energy.

However, the declining cost of renewable energy sources and the rising awareness in the subject matter has helped in gathering attention on the need to reduce the energy poverty in the developing countries. According to the WHO reports, IEA estimates that a 7 percent increase in the spending on every energy related technology from 2016- 2040 is required to alleviate local air pollution as it leads to 6.5 million deaths each year (Benoit & Ladislaw, 2017, p. 20). Thus, although it might increase the cost of production, when developing their energy related infrastructures, sources and policies, the developing countries should invest in cleaner and sustainable sources of energy to avoid development at the expense of the environment. Sustainable development is possible through the development of renewable energy as it can guarantee the unlimited supply energy for generations without compromising the quality of the environment and diminishing the fossil fuel reserves (Goldemberg & Coelho, 2004, p. 711). When comparing the figures of the share of renewables, it is mostly higher in the case of developing countries rather than developing countries but it is mostly because of the inclusion of TBE in renewables. However, only modern biomass, that is produced in a sustainable manner to generate electricity, heat and transportation fuels from household wastes, agricultural wastes and forest residues can be included as renewable energy source as traditional biomass is produced in an unsustainable manner by the cutting down of forests. Traditional biomass can also be included as a renewable source if the forest resources are being realistically replaced but in the case of developing countries, the excessive use of traditional biomass has been leading to large-scale deforestation and is leading to other environmental problems so it cannot be included as a sustainable source (Goldemberg & Coelho, 2004, p. 711).

II.2 Energy Situation of Nepal

Nepal faces a severe shortage of energy production and supply that has been contributing towards its slow growth and high rate of energy poverty. This section introduces the energy situation of Nepal by underlining the governance structure, production potential,

consumption, demand, and policies related to energy.

II.2.1 Energy production and potential

The power production potential of Nepal is high enough for it to become the powerhouse of South Asia but, as of now, its production is not even enough to meet its domestic energy demands. The country has high biomass and hydropower potential along with the capability produce some thermal and solar energy. Nevertheless, as illustrated by the figure 4, biofuels and waste dominate the energy production in Nepal and sources like hydropower and solar, wind, geothermal, wind, tide, heat and others account to less than 1 percent of the total production.

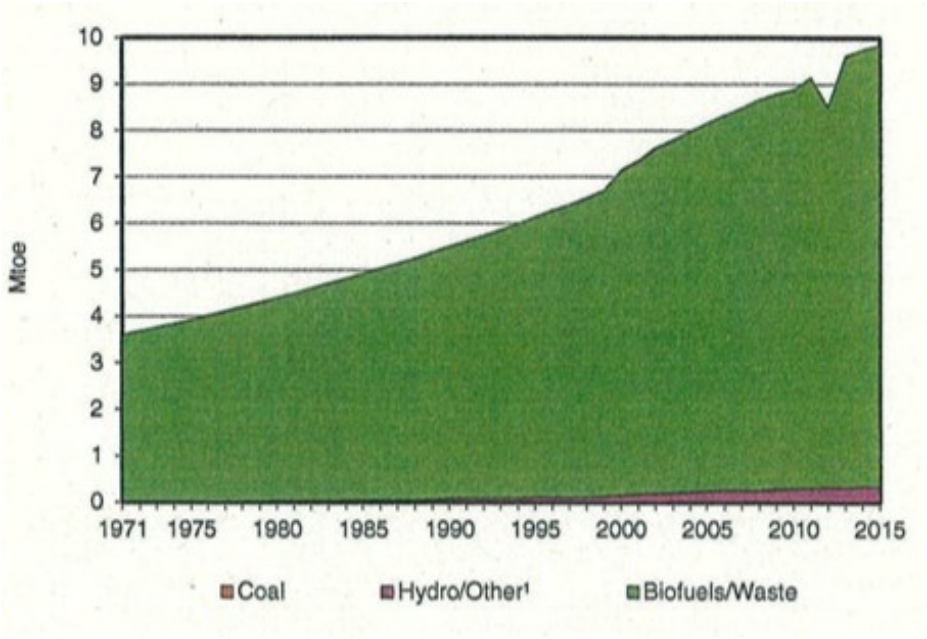

Figure 4: Energy production in Nepal (International Energy Agency, 2017, p. 304)

The total hydropower development capability of Nepal is 83,000 MW out of which about 42,000 MW can be generated commercially but even until 2016, it has only succeeded in generating less than 2% of its commercial generation capability (The Asian Development Bank, 2017, p. 5). Furthermore, despite having discussed and contracted different hydropower projects for different fast flowing rivers of Nepal, most of them are disrupted due to some political or financial problem and even the ones that are completed fail to generate the initially

expected capacity. Until the FY 2017/2018, the hydropower plants and the Micro Hydropower plants generated a total of 2,308.37 GWh compared to 2,305.17 of the last fiscal year (Ghising, A Year in Review 2017/2018, 2018, p. 10). Since 2002, the country has only increased 400MW of its potential in the hydropower generation (The World Bank, 2019, p. 37). Hence, it is an irony that despite having abundant resources and the potential to export hydropower, slow improvements in the domestic power generation has contributed to constant energy crises in the country.

According to the NEA Annual report of FY 2015/2016, besides hydropower (grid connected, small/micro hydro and IPP) that accounts to 93.8 percent of the total installed capacity of energy in the country, thermal power accounts to the remaining 6.2 percent (Refer to figure 5). However, the lack development infrastructure, technical expertise and financial capabilities to exploit its power potential has led to the energy scarcity in the country that has contributed to the high reliance on traditional sources like biomass and energy import from India. Biomass accounts for 80 percent of the total energy consumption while petroleum imports accounts for 12 percent (The World Bank, 2019, p. 37).

Generation Source		Capacity (MW)	% of Total
Hydro	NEA grid connected	473.4	55.4
	NEA small hydro	4.5	0.5
	IPP	324.4	37.9
	Subtotal	802.4	93.8
Thermal	NEA	53.4	6.2
Solar	NEA	0.1	0.0
Total Installed Capacity		**855.9**	**100.0**

Figure 5: Nepal Electricity Generation Mix (Nepal Electricity Authority, 2016)

Nepal lacks fossil fuel reserves due to which it imports petroleum from other countries. About two thirds of the imported petroleum is used by transport sector and the remaining is

used by the household, agriculture, commercial and public services sector while the entire import of coal is used by the industrial sector (Oxford Policy Management, UK Aid & University of California Berkely, 2016). As demonstrated in figure 6, Nepal has been importing oil since the 1970s and the import of oil has been increasing since then. This is largely due to the increase in the purchase of different means of transport by the public and private sector and also due to development of the commercial sector. The figure also shows the import of coal beginning from around 1998 that has not increased much due to the slow growth of the industries in the country. Additionally, the data shows the share of hydropower that has had almost no change since the levels in about 2005. However, the figure does not include the data on the electricity trade between Nepal and India that has been carried out to meet the electricity demands of the country.

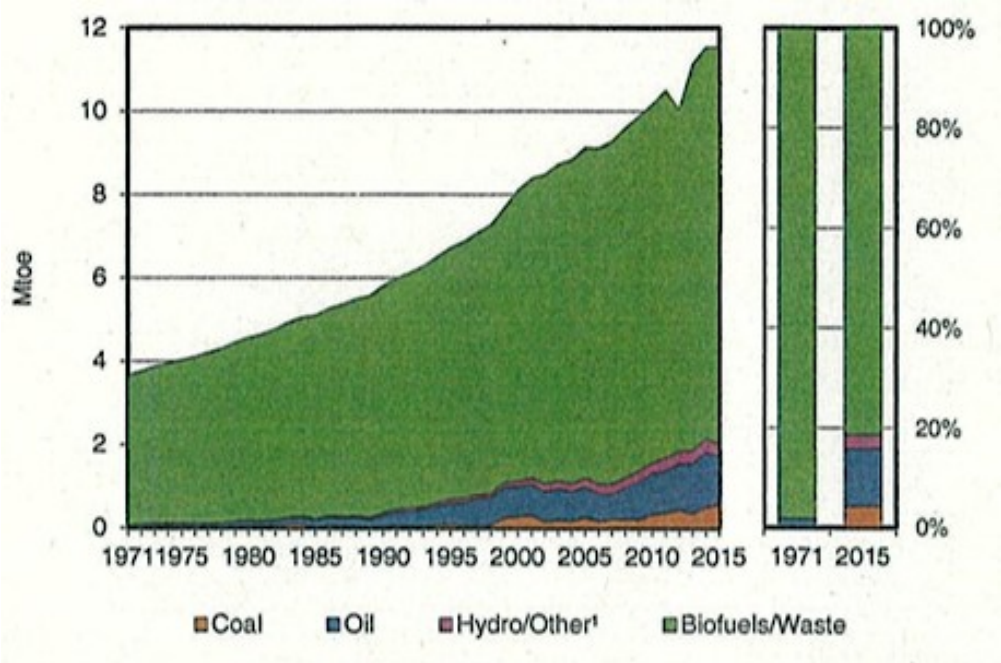

Figure 6: Total primary energy supply of Nepal (International Energy Agency, 2017, p. 304)

II.2.2 Energy consumption and demand

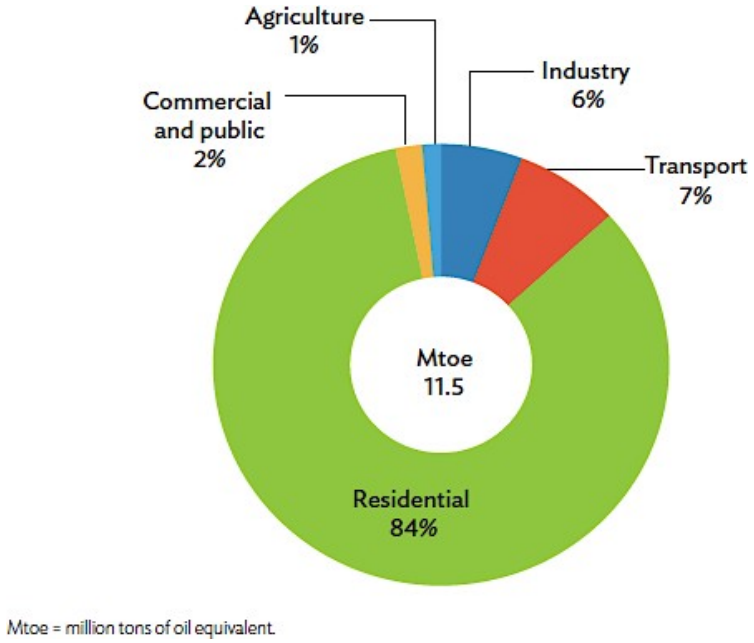

Figure 7: Final Energy Consumption Mix of Nepal, 2014 (Asian Development Bank, 2017, p. 4)

In Nepal, the largest share of energy consumption is by the residential sector. In 2014 (Refer to Figure 7), the residential sector was responsible for 84 percent of the total energy consumption mix of Nepal, which was followed by transport (7 percent), Industry (6 percent), Commercial and Public sector (2 percent) and Agriculture (1 percent). The share of the industry and transport is comparatively small but gradually, with the growth of the country, the energy demands of the commercial sectors are likely to increase rapidly in the coming years. According to the NEA and the Water and energy Commission Secretariat of Nepal (figure 8), under the current business scenario with economic growth rate of 4.5 percent from 1998-2018, the growth rate of energy consumption demand has been doubling in every eight years but the GoN is targeting an average economic growth to be 7.2 percent from 2018- 2040, under which the government expects the energy growth rate to double in every six years (The World Bank, 2019, p. 10).

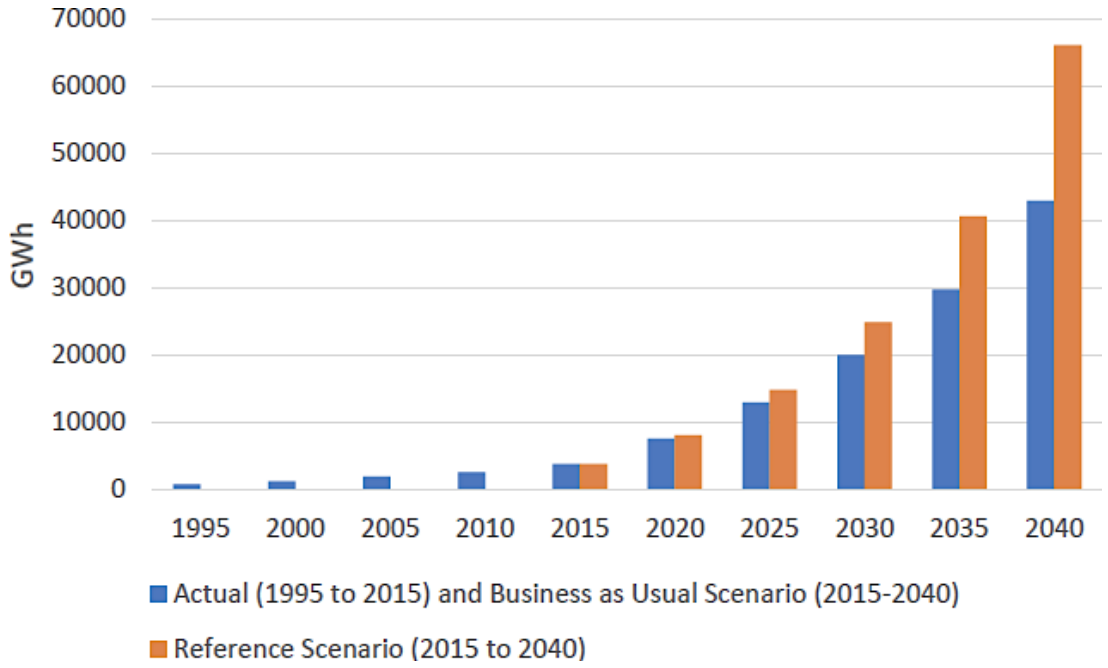

Figure 8: Actual and projected electricity demand of Nepal (The World Bank, 2019, p. 10)

Even in the case of NEA, in the FY2017/ 2018, its consumers increased from 3.26 million (in the last FY) to 3.55 million out of which 3.33 million consumers were the domestic households that accounted for 93.83 percent of the total consumers (Ghising, A Year in Review 2017/2018, 2018, p. 9). In addition, comparing to 1990, when the country used to import 312 ktoe (5.4% of the total energy consumption of the year) of electricity, petroleum products and coal, the demand in 2014 has vastly increased to 2,069 ktoe (17.7%) (The Asian Development Bank, 2017, p. 2). According to the forecasts by ADB (Refer to Figure 9), the consumption of oil and coal is expected to experience a two-fold increase by 2035 whilst the net import ratio would remain as high as 95 percent for coal and 100 percent for oil (Oxford Policy Management, UK Aid & University of California Berkely, 2016). Thus, as to ensure a smooth development process without any hindrance due to energy shortages, the GoN needs to accelerate its power production or make other arrangements to fulfill the growing power demands.

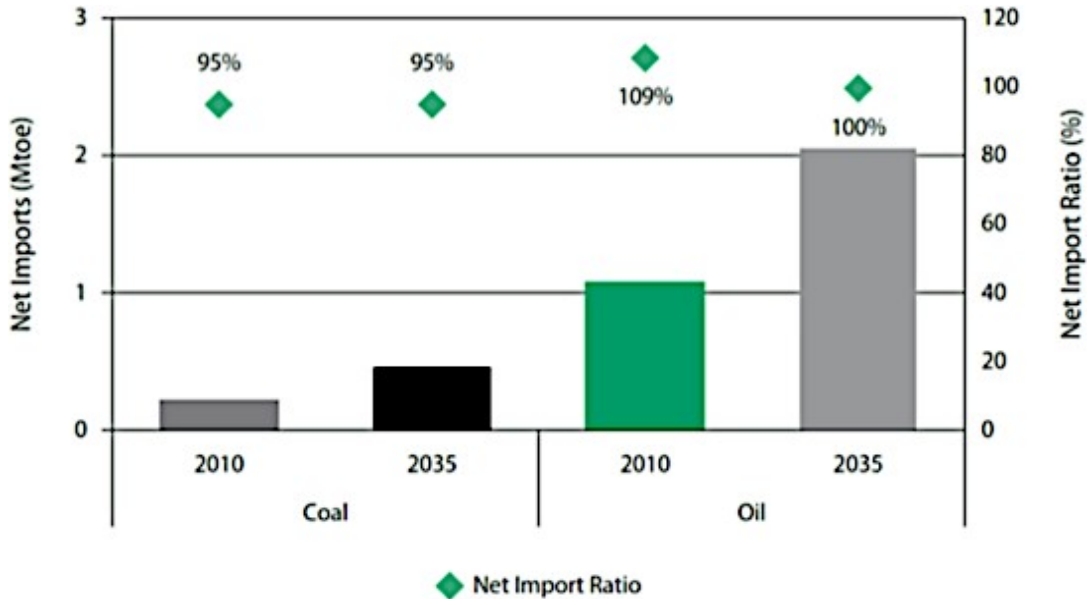

Figure 9: Net Imports of Coal and Oil and Net Import Ratio (ADB, 2015); (Oxford Policy Management, UK Aid & University of California Berkely, 2016)

The demand and the consumption of energy of Nepal has been increasing rapidly and is projected continue increasing but its overall quantity of consumption is still low in comparison to other countries in the region. The per capita energy consumption of Nepal is only 177 kWh per year, which is a fifth of the total per capita consumption in South Asian Region (Refer to Figure 10) (The World Bank, 2019, p. 37). However, when comparing the intensity of the consumption with the same countries, Nepal's energy intensity (amount of energy consumed per unit of GDP) is 1.8 ties higher than that of its neighboring countries India and China and is 4.5 times higher than the global average (NEEP, 2015) (Oxford Policy Management, UK Aid & University of California Berkely, 2016). Thus, there is a need for Nepal to manage the utilization the available energy sources and to increase the efficiency of its existing and future energy production.

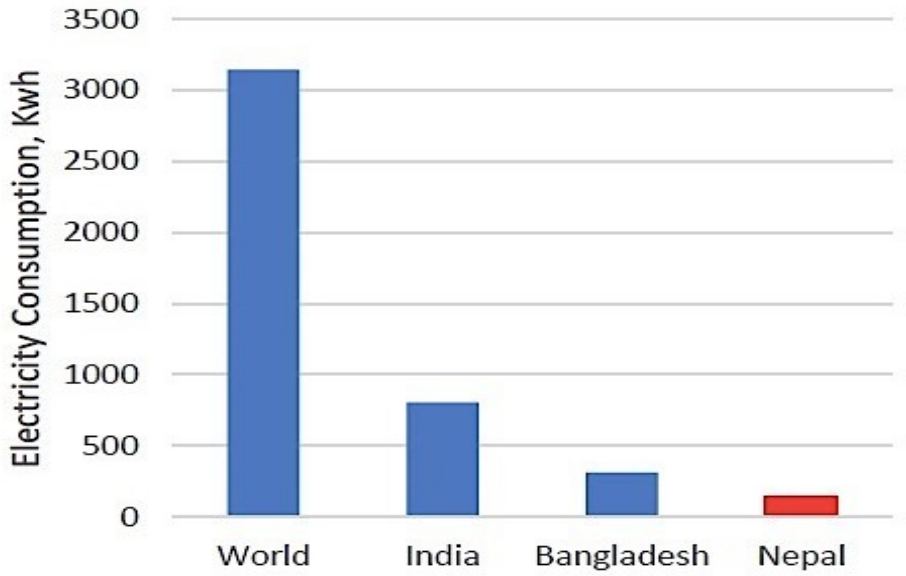

Figure 10: Per Capita Energy Consumption of Nepal, India, Bangladesh and the World

(The World Bank, 2019, p. 38)

II.2.3 Governance of the energy sector

The Prime Minister is the highest authority with power and control of the Nepalese government and the energy sector of Nepal. Under him, the ministry of energy handles the NEA and the water and energy secretariat and the ministry of environment handles the AEPC and promotion of the renewable energy and ministry of commerce and supplies handles the oil corporation and regulates the petroleum imports in the country (Refer to figure 11). These government bodies are responsible in formulating and regulating the energy policies of Nepal.

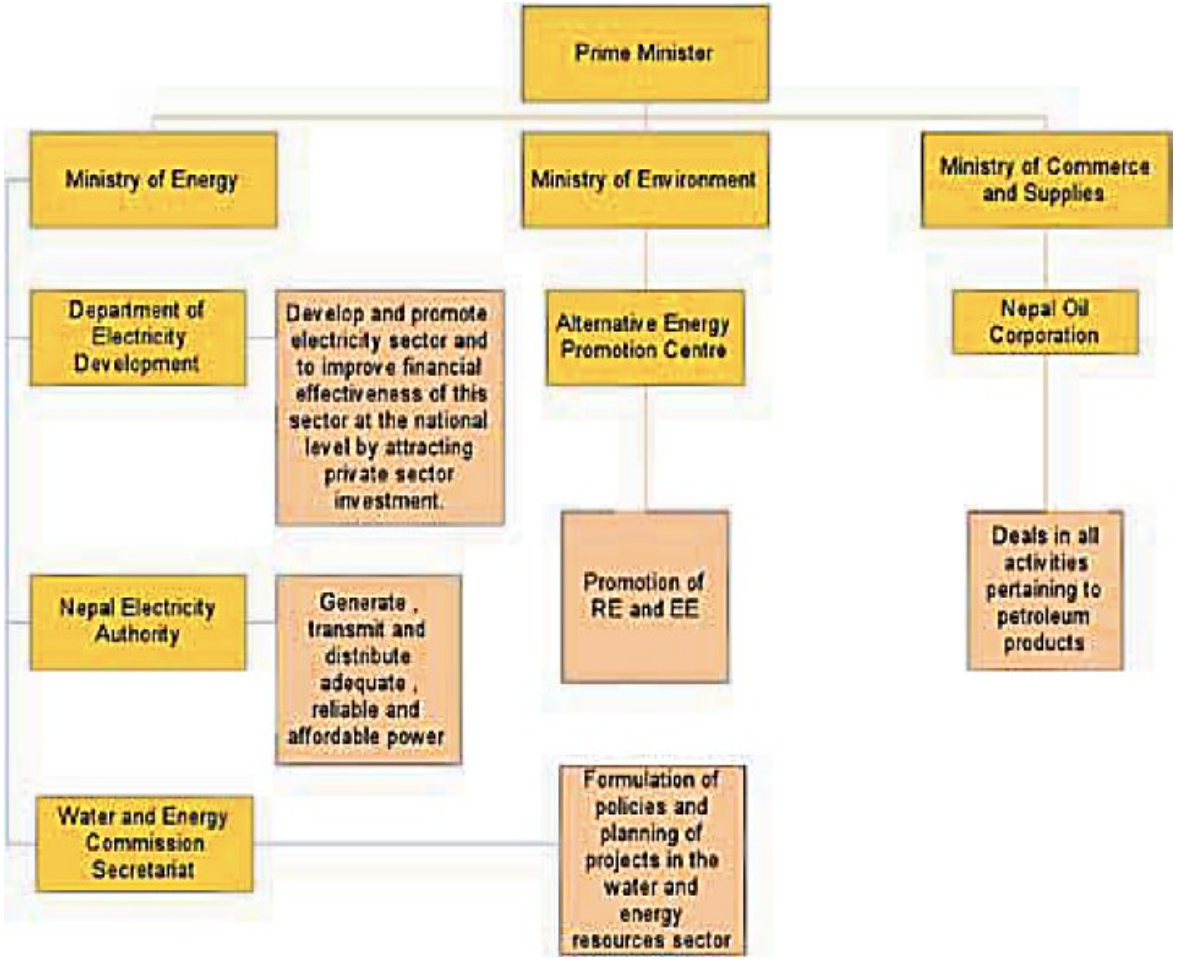

Figure 11: Institutional Structure of Energy in Nepal (Banarjee, Singh, & Hussain, 2011, p. 4)

According to the Government of Nepal (GoN) sources of energy are classified into three groups:

(i) Traditional sources that include wood, agricultural waste, animal waste and human waste;

(ii) Commercial sources in Nepal that include grid electricity, petroleum products (including LPG) and coal; and

(iii) Alternative sources that include modern biomass, hydropower, wind power, biogas and solar power (Asian Development Bank, 2018, p. 2).

Moreover, Nepal is rich in alternative sources (predominantly hydropower and biomass sources) but it has been importing commercial sources (particularly petroleum and grid

electricity) that cannot reach all or cannot be afforded by all so, majority of the population uses TBEs. The government has been taking initiatives to develop the alternative sources through which it can reduce the use of the TBEs and decrease its reliance on commercial sources like petroleum and coal. Figure 12 lists out the major policies introduced by the government in collaboration with the associated ministries to promote renewable energy in Nepal. Despite taking various policy initiatives, the GoN has been unable to motivate the people in using alternative energy sources and conserving the forest resources in the country. The following section on the problems related to energy will highlight the weaknesses of the government in addressing these issues.

Policy	**Details**
National Agricultural Policy 2006	- Control deforestation through agroforestry and conservation - Promotion of forest, biodiversity and environment protection, and proper use of natural resources
Rural Energy Policy 2006	- Poverty reduction - Environment conservation in rural areas - Promotion of the use of IBTs and MBTs
Forest Policy 2015	- Afforestation of public and private lands - Subsidy, credit and insurance to promote forest enterprises and nurseries - Financial and technical support to the alternative energy users
Renewable Energy Subsidy Policy 2016	- Subsidy for promoting biomass energy technologies (IBTs and MBTs) with additional support to the marginalized groups.

Figure 12: Policies related to promotion of alternative energy sources in Nepal (Figure reproduced from (Ministry of Population and Environment, 2017, p. 2))

In addition to the government and its ministries, the Nepal Electricity Authority (NEA) plays a major role in the energy sector of Nepal, as it is responsible in supplying, distributing, regulating, monitoring and managing the entire electricity sector (Refer to figure 11). It handles the transmission lines and has control over the power generated from various power plants (public and privately owned) all over the country. The main load center of the power transmission lies in Kathmandu Valley- comprising of the city of Kathmandu, Kirtipur, Lalitpur, Bhaktapur and Madhyapar Thimi- the commercial center of the country. The existing power plants in Nepal are producing a total of 1,073 MW, out of which, 562 MW is owned by Nepal Electricity Authority (NEA) and the remaining 511 MW is owned by the private sector but the general demand of electricity in the country is 1,300 MW and during peak seasons, it even rose to 1,450 MW in 2017 compelling the country to import 450 MW of electricity from India (The World Bank, 2019, p. 37). Due to the scarcity of power, Nepal has been importing power from India of about 2,581.80 GWh and Independent power producers (IPPs) of about 2,167.76 GWh in FY 2017/ 2018 which increased by 18.70 percent and 21.97 percent respectively when compared to the imports in FY 2016/ 2017 (Ghising, A Year in Review 2017/2018, 2018, p. 10). The electricity demand of the country has been increasing by the years but there is a slow growth in the power production capabilities of the country due to which its reliance on India and IPPs for fulfilling the power gap is increasing. Thus, if the country is unable to utilize its existing resources to produce power, with the rapidly increasing energy demands, Nepal will face severe energy shortages in the future.

II.2.4 Problems related to energy

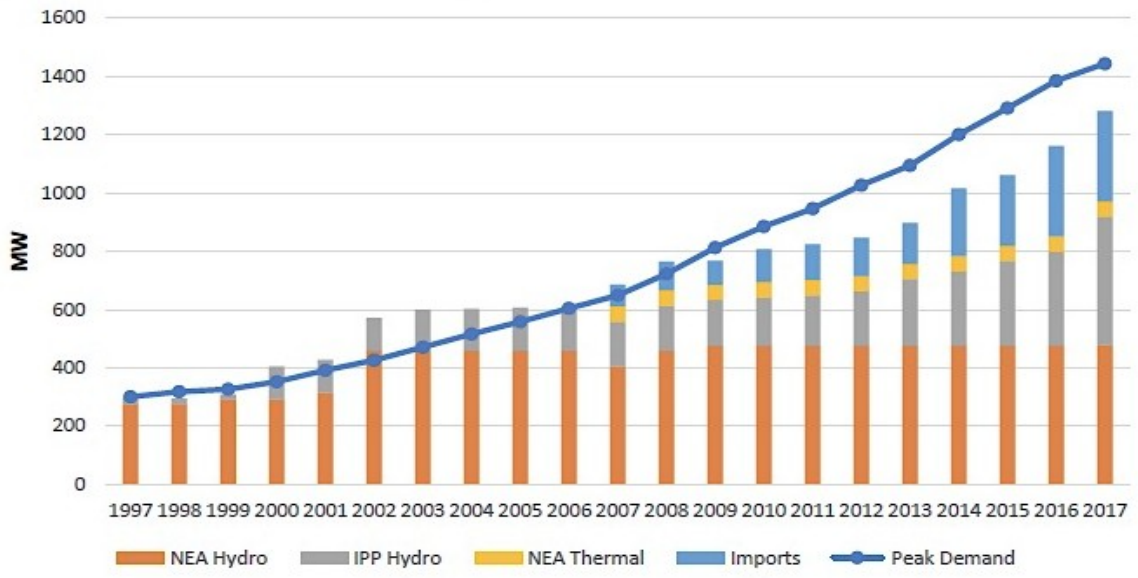

Figure 12: Peak Demand of Energy Versus Electricity Supply of Nepal (1997-2017) (The World Bank, 2019, p. 38)

Nepal has been dealing with acute energy shortages due to higher demand than its domestic production so, it has been managing through energy import and power cut implementation (Refer to Figure 12). The Nepalese people have been facing power cuts for such a long time that they have been habituated to it. Since 2006 till about 2016, the whole of Nepal, particularly the central region of Nepal (including Kathmandu and its neighboring cities) had to face power cuts of up to 16 hours a day during the dry season. Due to these extreme conditions of load shedding and continuous power generation fluctuations due to the high dependence on the seasonal rivers, Nepal ranks 137th out of 147 countries in the quality of electricity supply (The Asian Development Bank, 2017, p. 5). Since 2016, through transparency and proper regulation of the energy supply by the NEC, the situation improved and led to the almost elimination of the load shedding (at least for the residential sectors). The industries were still facing 3-4 hours of power a day but since May 2018, the NEA Managing Director Kulman Ghising announced the end of power cuts throughout the country which was made possible

through the gradual increase of the domestic power production and imports from India (The Kathmandu Post, 2018).

The NEA and the GoN blamed the undersupply of power for the reason behind the decade long blackouts throughout the country. However, through a proper management system and proper regulation in the power system of the country, the problem was easily managed in no time. However, the power cuts led to the slow growth of all sectors of the country for a long time. In the year 2008- 2016, the economic loss through the continuous power cuts were estimated to be around US$1.6 billion per year (The World Bank, 2019, p. 39). For an underdeveloped country like Nepal, that sum of money could have made a huge difference in its development. Besides the economic loss, the citizens had to face various hardships and inconveniences that hindered the overall development of the individuals, businesses and the society. Thus, negligence and ignorance could be observed in the way the leaders of Nepal have been handling the severe energy problems of the country.

Different factors have led to the worsening of the energy situation of Nepal. Figure 13 gives a summary and a detailed analysis of the different factors that have contributed to the weakening of the energy sector of Nepal.

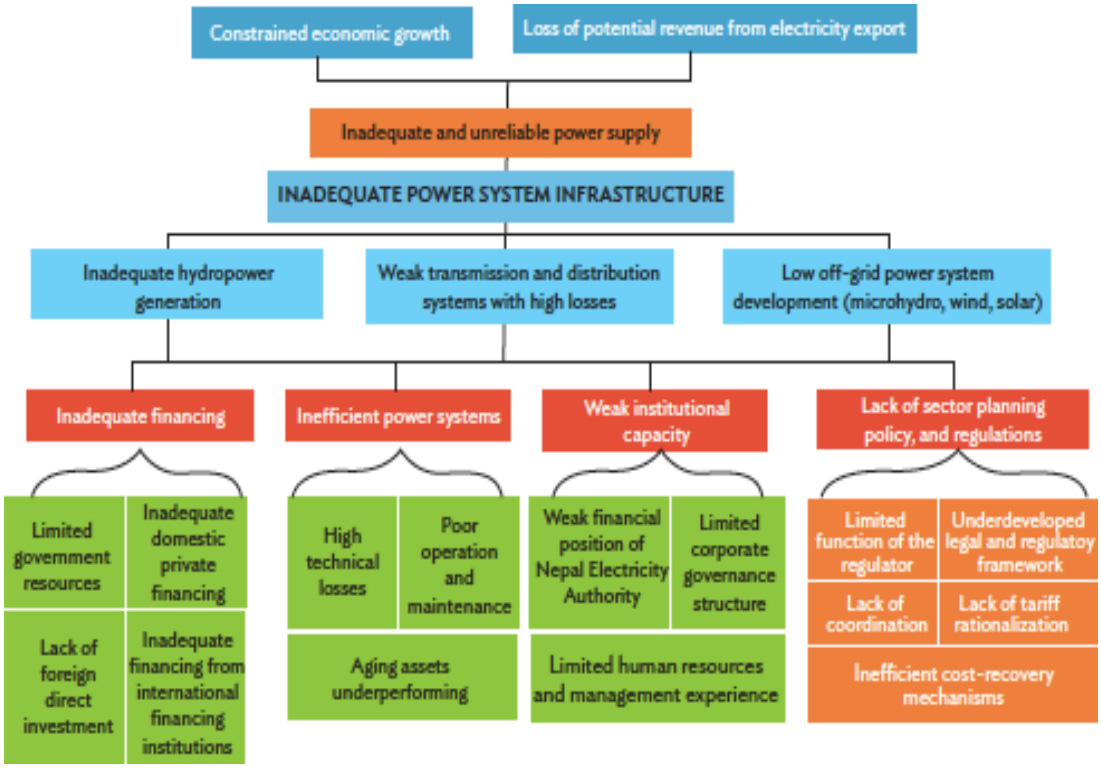

Figure 13: Problem Tree Analysis of the Energy Sector (ADB, 2013); (Asian Development Bank, 2017, p. 25)

(i) Problems in Production:

Nepal has been facing various challenges in harnessing the maximum capacity from its power generation projects and it is also failing in creating a better environment for increased investment in the power generation sector. Clearly there is a demand for energy in Nepal and with it being sandwiched between two of the most rapidly developing countries in the world - China and India, the demand for energy is very high in the region. Furthermore, the investment in the power generation sector in Nepal (particularly hydropower) is guaranteed to bring profits due to the high demands. However, why has it failed in exploiting this capability? Why have the country and its resources failed to attract foreign or private investments? The following are the major obstacles that have led to this situation.

***Seasonal challenges**:* The downward sloping fast-flowing rivers of Nepal are generated from the melting of the glaciers in the mountain region. In addition, during the rainy season, the precipitation contributes in increasing the water level in the rivers that further intensifies the flow of the water and increases the hydropower generational capacities. However, in the case of the energy demand, it is the opposite because during the winter season, the power is also used for heating purposes and the reduction on the daylight hours further increases the hours of electricity use per day. Furthermore, during the peak of summer, the seasonal rivers dry up and are incapable of generating power. In the Fiscal year 2016, the demand during the winter season was 1,385 MW with 534 MW of load shedding that led to a power cut of 11 hours every day from January to April (dry season in Nepal) (The Asian Development Bank, 2017, p. 6). Thus, it is difficult to manage and store the electricity as the change in the season, creates disruptions in the production and constant supply of power throughout the country.

***Management challenges**:* The GoN has been failing in managing the ongoing projects and exploiting the investment potential of various financial sources. According to the ADB reports (The Asian Development Bank, 2017, p. 5), the primary causes of the sluggish development of the existing hydropower projects in Nepal is due to,

(i) Lack of proper planning and investment in the infrastructures related to generation, distribution and transmission of electricity: The ministries responsible have been failing to carry out studies before and after the execution of the projects that leads to the lack of required facilities that enable proper energy production and its utilization.

(ii) Lack of credibility and responsibility taking of the NEA in the energy contracts and payment system: Due to the involvement of different ministries and the NEA, there is no proper channel to coordinate the payment system. In addition, the lack of communication and transparency has made the hydropower projects a source of corruption for the authorities involved.

(iii) Inconveniences caused due to rigid or insufficient legal policies and regulations regarding

energy and investments: The insufficient finance of the GoN and NEA has led to the country depending on external sources for finance but most of the control of the decision making and finance of the projects are solely carried out by the two parties without involving the contractors, other investors and stakeholders. Furthermore, due to the lack of set targets and regulations regarding the project execution and completion, the projects have a lower quality than expected and is often delayed or incomplete.

In addition to the lack of proper invigilation of the ongoing power projects and electricity systems, the country has been failing in dealing with various environmental and political challenges that have been delaying its energy generation. During the great earthquake of April 2015, the government halted the ongoing projects and took a long time in resuming with the projects that led to postponements of the deadline of the infrastructural projects and power generation projects throughout the country. Furthermore, due to the absence of a proper management system for recovery, the GoN was unable to resume with the invigilation, reconstruction and rehabilitation process throughout the country. Thus, the weak management system of the country has led to the elongation of the ongoing projects and has led to the creation of unappealing environment for the foreign and other private investors to finance in the power generation projects of the country.

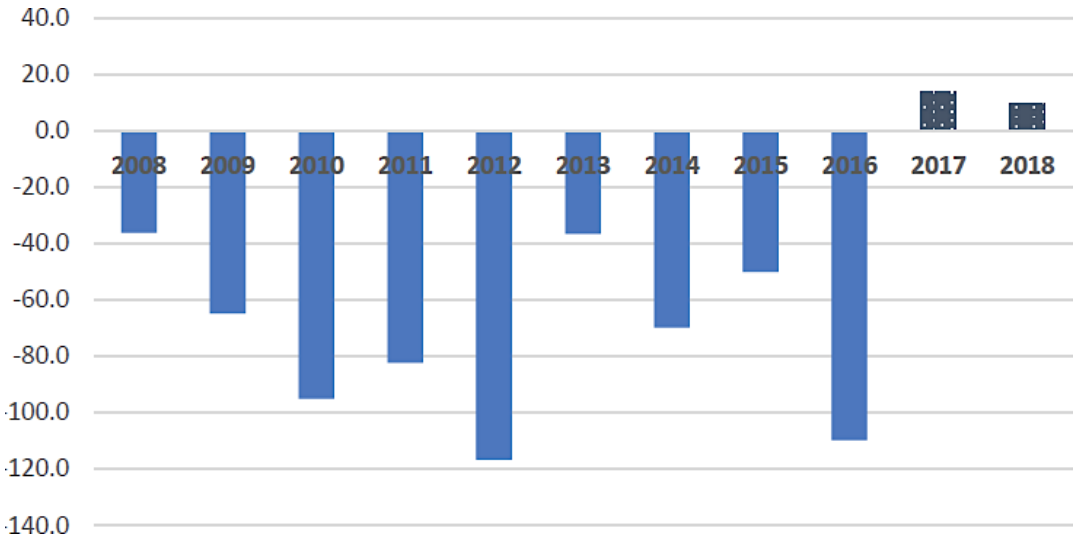

Figure 14: NEA Net Income (USD million) (Nepal Electricity Authority, 2018)

The NEA is responsible for the electricity supply and distribution throughout Nepal but due to its poor management system, it had been operating with a loss until 2016. Only from the year 2017, after reviewing its cost and pricing strategies, it decided to increase its tariffs on electricity that led to its profit since 2017 (Refer to Figure 14). Furthermore, the high level of power loss during electricity transmission had also been leading to its losses. Only after launching a nationwide drive, it has succeeded in decreasing the losses from 25.78 percent in FY 2015/ 2016 to 20.45 percent in 2017/2018 but, the existing losses is still not within the acceptable limits so, the institution needs to continue to strengthen its management system to reduce the power losses that would be helpful in meeting the rising energy demands (Ghising, A Year in Review 2017/2018, 2018, p. 10).

Political challenges*:* Despite having abundant resources to produce power, being landlocked is a great disadvantage to Nepal. The fast-flowing rivers that originate from the Himalayas flow downward while passing through Nepal to India and finally they flow into the Indian Ocean. Consequently, these rivers are the source of power and water not only for Nepal but also for India. However, the production of hydropower requires the construction of dams that disrupts the fast flow of the water current. Through experienced and skillful politicians, Nepal could make a deal with the Indian Government to provide them with water and energy security in return of better trade deals through the borders. However, the incapability of the Nepalese politicians in this front has led to the continuous water politics leading to trade blockades in the area and has been deteriorating the relation between the two countries. Furthermore, this problem has also led to continuous disturbance or abandonment of the hydropower projects. Thus, the incapability of Nepalese government to implement projects, deal with natural disasters and occasional trade blockades with India has led to the delay in the successful construction of the ongoing hydropower projects (The World Bank, 2019, p. 39).

The rigid policies of Nepal rarely contribute in increasing the domestic and foreign investments in the power sector. However, due to the need of large-scale investments for hydropower generation, the government is bound to rely on other external sources for finance. The GoN has set a target to progress into middle-income country by 2030 but with minimal exports from other sectors and continuous import of petroleum and electricity, it is impossible for the country to achieve its target. If it succeeds in harnessing its hydropower capabilities, it can address the energy needs within the country and it can also export the excess power to other countries. Thereafter, the income generated could be invested onto the development of other infrastructures that could assist in achieving its ambitious growth plan. However, with the current rate of increase in the energy demands and the moderate rate of energy production due to low investments, the shortage of power would presumably continue to persist for decades to come.

(ii) Problems in Distribution:

The efficient use of power is only possible through a proper power storage and distribution system but it is lacking in the case of Nepal. There is an inadequacy of a proper power transmission system to deliver electricity from the power plants to the load centers and the country also faces a scarcity of infrastructure to enable cross-border transmission with primarily only 150 MW of transmission connectivity with India except in some border areas (The Asian Development Bank, 2017, p. 8). Thus, the lack of a proper plan to change the power transmission system in the country makes it difficult to export power to other countries and it also impedes IPP investment in advancing new power projects (Asian Development Bank, 2018).

The complex topography of Nepal due to the mountains and hills covering about 50 percent of the country makes it hard for energy transmission and transportation. In these regions

and other rural areas, there is no connection or constant connection to electricity that is leading to high rates of energy poverty. In addition, the management of the existing facilities has also been a weakness of the NEA. There is no underground transmission system or fiber optic cable transmission so, there are bundles of wires connected from one area to another that are only supported by weak poles around the city that do not have the capability to hold the tangled mass of wires. Thus, there is a constant problem of the fuse of electric transmitter or electrocution especially in during the rainy season. Moreover, the improper management and regulation of the existing systems makes it prone to wastage, theft and it has been causing many hazards leading to further economic losses for the NEA.

According to Figure 15, the access to grid and off- grid electricity (a quarter of which is mini-grid and off-grid electricity) in Nepal has been increasing at a higher rate than the rates of India, Bangladesh and the entire world. In the FY 2016/2017, 70 percent of the Nepalese population had access to grid electricity (Ghising, NEA a Year in Review 2017/2018, 2018, p. 10). However, similar to other countries in South Asia, in Nepal, the division of the society based on caste, gender, geography and many other social structures, worsens the situation of access to opportunities and energy for the marginalized groups (Asian Development Bank, 2018, p. 1). Therefore, although the electrification rate in urban areas about 97 percent of the urban population, the rate in the rural areas is only 72 percent (The Asian Development Bank, 2017, p. 9). Thus, as a result, the poor people in the rural areas face severity of the energy crisis and have to rely on TBEs.

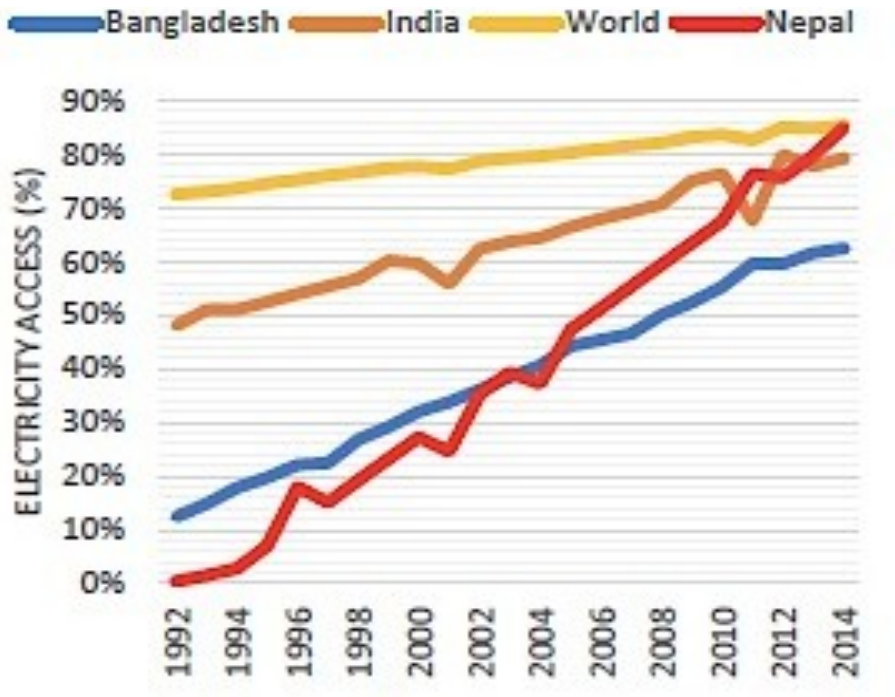

Figure 15: Electricity Access in Nepal, India, Bangladesh and the World

(The World Bank, 2019, p. 38)

II.3. Biomass

Biomass is one of the most widely used sources of energy in the world. It accounts for 70 percent of the total household fuel use in Asia (USAID, 2010, p. 12). It is the source of energy generated from the waste of plants and animals. During their lifetime, the plants store energy from the sun while undergoing the process of photosynthesis and during its combustion that stored chemical energy changes into heat energy. Biomass energy can be divided into three categories:

1. Traditional Biomass Energy Technologies (TBEs) that include direct combustion of wood, agricultural wastes, leaves, charcoal and animal, human, household or urban wastes;
2. Improved Biomass Energy Technologies (IBTs) that include improved cooking stoves (ICSs) and improved biofuel kilns;

3. Modern Biomass Energy Technologies (MBTs) that involves the conversion of biomass energy to liquid fuels, gas and electricity through thermochemical conversion, biochemical conversion or extraction (Refer to Figure 16) (Karekezi, Lata, & Coelho, 2012, pp. 233-240).

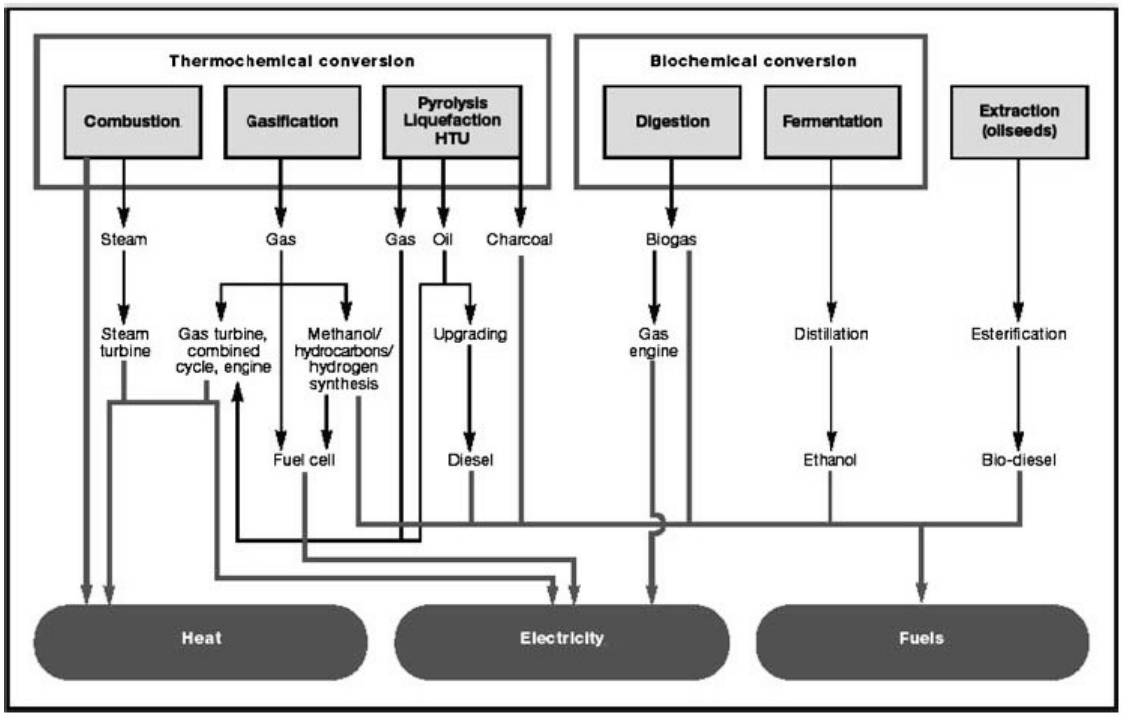

Figure 16: Biomass Conversion Methods (Turkenburg, 2000); (Faaij, 2006, p. 345)

Traditionally, when there was a limited development of technology and there were minimal energy sources, TBE was widely used throughout the world. However, with the development of other modern energy sources like petroleum, thermal power, nuclear, hydrogen power cells and modern renewable energy sources like solar power, hydropower, wind power, the use of TBE is declining particularly in the developed countries. However, even in 2015, the share of bio energy in the world's energy mix was 9 percent out of which, 50 percent was due to the high use of TBE by the developing countries primarily for cooking and heating (International Energy Agency, n.d.). Furthermore, according to the statistics over the years, the share

of biomass in the global energy consumption has remained almost constant over the past 30 years (Karekezi, Lata, & Coelho, 2012, p. 230). This is mostly due to the increase in the use of TBE in the developing countries despite a decrease of its use in the developed countries.

TBE is still widely used in the underdeveloped countries that have low electrification rates and have rural areas suffering from the lack of access to modern energy services. At present, the commonly used devices for cooking with biomass are three-stone fires, traditional mud stoves or metal, cement and pottery or brick stoves, with no operating chimneys or hoods (IEA, UDP, UNIDO, 2010, p. 13). However, according to the public health scientists, these devices that are commonly used for biomass lead to serious health risks especially on women and children as they spend most of their time cooking and doing the household works while continuously exposing the infants to the open fire and primitive biomass devices (Luoma, 2010). Furthermore, the houses that use these devices lack proper ventilation that causes the smoke to be trapped indoors and increase the chances of respiratory problems. Additionally, the contribution of the BC to the acceleration of the global warming and the increased rate of deforestation due to the continuous use of firewood is also a matter of concern for the states and the development agencies that work in the field of energy, environment or health. Thus, they have been continuously attempting to reduce the use of biomass through the supply of better and cleaner energy sources.

II.3.1 Biomass in Nepal

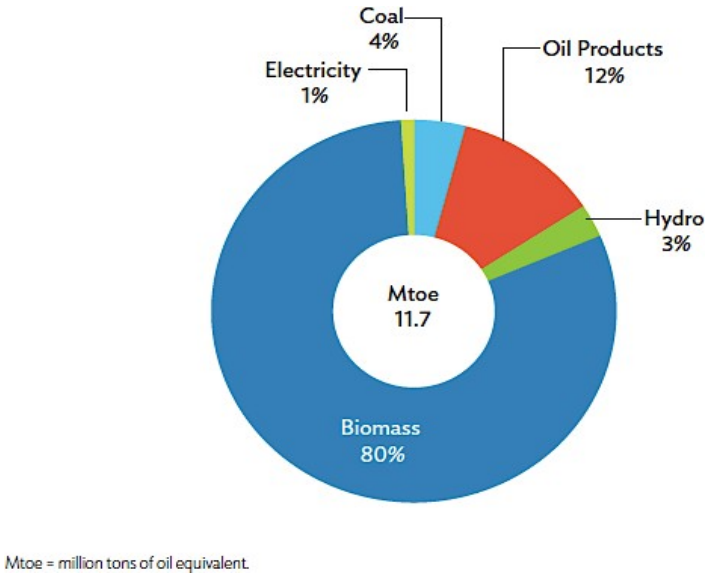

Figure 17: Primary Energy Supply Mix of Nepal, 2014 (Asian Development Bank, 2017, p. 4)

TBE is the most widely used source of energy throughout Nepal but it is mainly due to its high use by the residential sector in the rural areas of the country. It accounts to about 77 percent of the country's energy consumption and according to the National Census (2011), out of the 5.4 million households in Nepal about 4 million households were still using biomass energy (including firewood) for cooking (Ministry of Population and Environment, 2017, p. 2). According to the figure 17, in 2014, biomass accounted for 80 percent of the share in the total energy supply mix of the country, which was followed by petroleum products (12 percent), coal (4 percent), hydropower (3 percent) and other electricity (1 percent). The numbers for Nepal are very high compared to other high income and middle-income economies because more than 80 percent of Nepalese live in rural areas and due to the underdevelopment of the hydropower potential within the country, all regions are not electrified. Furthermore, being a landlocked country, it has to import and distribute other cheaper sources of power like kerosene, petroleum and LPG so, not all areas have access to other power sources. Thus, being an agriculture dependent country with abundant forest resources, TBE is a common choice for cooking,

heating and lighting for the households.

According to the existing socio-economic condition of the Nepalese people, biomass energy is expected to remain dominant for a long time (Ministry of Population and Environment, 2017, p. 1). The commonly used sources of biomass fuel in Nepal are firewood, animal dung and agricultural residue. The people usually use these fuels in traditional cooking stoves or the inbuilt mud stoves in their houses for cooking and heating. However, these traditional devices consume a high amount of firewood, cook really slow and emit excessive smoke while negatively affecting the health of its users. Therefore, over the years, these sources have been upgraded to modern bio energy technologies like improved cooking stoves (ICS), biogas, briquettes, gasifiers, cogeneration and liquid bio fuels (Alternative Energy Promotion Centre, n.d.). AEPC, an organization established by the GoN in 1996 to promote the use of renewable energy sources within the country through the provision of technical and financial assistance in partnership with various development agencies, local authorities, private sector and the public sector has been undertaking these initiatives to promote and distribute modern bio technologies (Ministry of Population and Environment, 2017, p. 1). Nevertheless, the installment of these technologies and the implementation of the projects highly depend on the area covered by the initiatives and does not cover all areas of Nepal.

II.3.2 Effects of Biomass Use

(i) Positive effects

- **Abundance:** Biomass is also an easily available source of energy. Nepal being a country that is rich in natural resources and highly dependent on agriculture, it is easier for people to use biomass. Furthermore, as majority of the area of Nepal is rural and not all areas are connected to the urban areas. Thus, although most of the areas have connection to the electricity lines, they still have to depend on TBE for heating and cooking purposes due to the lack of access to

other alternative sources of energy.

- **Cheapness:** Biomass is a cheaper form of energy as it can be produced through household, animal and agricultural waste or communal forest resources. Nepal being an agricultural country, there is a lot of waste produced so it is easier for people to use biomass. Furthermore, being a landlocked country with abundant forest reserves but no energy self-sufficiency, other forms of energy like petroleum, solar power or electricity grids are expensive for majority of the population. Thus, using biomass could be a cheaper alternative for most of the people especially in the rural areas.

- **Source of income**: Firewood and charcoal provide employment opportunities and are a major source of income for many households in the rural areas of developing economies (Trossero, 2000), (Karekezi, Lata, & Coelho, 2012, p. 241). There are many people that earn their living by chopping down the wood from the forests and making them into size appropriate for the households to use as firewood or turn them into charcoal and sell it to the households.

- **Usefulness in waste reduction:** Better use of animal waste and other biodegradable wastes can be guaranteed if it used to form energy. Particularly, due to lack of awareness on the importance of preserving the environment, these wastes are usually dumped into the rivers and other areas where they pollute the environment. Furthermore, the contamination of the river and the environment act as the catalyst in spreading diseases and attracting insects. In addition, there are people that burn plastic and other toxic materials for heat in winter that leads to higher air pollution when compared to burning firewood and other biodegradable wastes.

- **CO_2 free energy source:** Compared to other source of energy like coal or petroleum, biomass is a CO_2 free energy source as the use of TBE involves the burning of wood and other wastes, they do release carbon during combustion but since they also consume the carbon during their lifetime, biomass is considered to be a carbon neutral source of energy. Furthermore, if the IBT or MBT is used, the carbon released would be lower than the TBE or it can be absorbed

completely while processing into cleaner biomass sources.

(ii) Negative effects

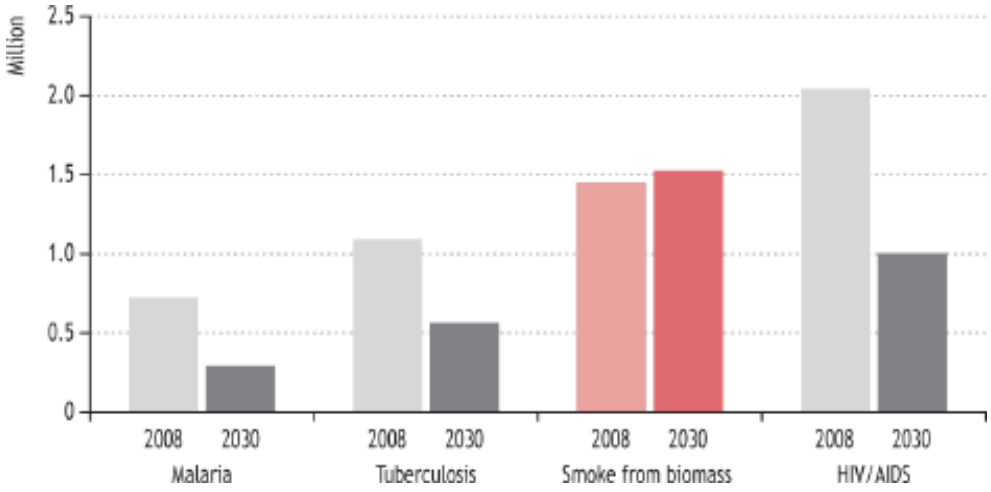

Figure 18: Premature Annual Deaths from Household Air Pollution and Other Diseases (Mathers & Loncar, 2006); (WHO, 2008); (IEA, UDP, UNIDO, 2010, p. 14)

- Health complications: The regular use of biomass in households with improper ventilation causes the smoke to be trapped and could lead to various respiratory diseases and even death. According to the WHO estimates, every year indoor air pollution and inefficient biomass combustion leads to premature death of 1.45 million people of the world (majority being women and young children), which is more than the deaths caused from tuberculosis and malaria (IEA, UDP, UNIDO, 2010, p. 13). According to the projected demands in Figure 18, the number of deaths from the smoke from biomass is expected to surpass the number of deaths from HIV/ AIDS by 2030. In the case of Nepal, the rural houses are mostly made out of clay and mud with a traditional in-built kitchen stove that requires firewood for cooking. During winter, burning firewood and enjoying the heat together is also a regular communal activity. In addition, there are stereotypes and norms even in the urban areas where the new born baby and the mother is supposed to be kept in front of the fire (made from charcoal or firewood) for a few hours daily and massaged with the oil heated in the fire until about 6 months after birth to keep them healthy. However, according to studies, acute lower respiratory infections (in children), chronic

obstructive pulmonary disease, reduced lung function, asthma in school-age children, tuberculosis, and interstitial lung disease, heart disease, stillbirth, cataracts and other visual impairments, pre-term delivery, low birth weight, and even lung cancer are some of the health problems attributed to the exposure to the indoor air pollution from biomass (Smith et al., 2004; Smith, 2000) (USAID, 2010, p. 21). Nevertheless, majority of the population is still not aware about the harmful effects of the regular use of TBE. Thus, TBE is helping people in the cooking and heating process but its smoke is also leading to several health complications in the society.

- **Environmental degradation:** The use of firewood as a fuel for biomass is increasing the rate of deforestation and is leading to other natural disasters. In the case of Nepal, biomass is commonly used because it is a cheaper form of energy as people use the communal forests for collecting firewood. Understanding this need of firewood, many people cut down large number of trees and sell it to other people for money but there are very few efforts in planting new trees. Deforestation is also leading to the loosening of the topsoil and causing landslides and floods. Furthermore, it is also contributing in decreasing in precipitation rates and increasing the rate of global warming throughout the world. The GoN introduced the National Energy Strategy of Nepal to emphasize on the provision of electricity to all areas and the continuation of the import of fossil fuel as to reduce the alarming rates of deforestation for biomass use that is leading to other environmental and economic losses (Ministry of Population and Environment, 2017). Although biomass is considered to be a renewable source of energy as the trees can grow again, if people do not take the responsibility of planting new trees, it will continue to snowball into greater environmental disasters.

- **Air pollution and global warming:** The burning of wood and other wastes cause air pollution and also release carbon into the atmosphere that expedites global warming. However, biomass is considered to be a carbon neutral form of energy because the wood and agricultural waste that we burn consume carbon from the environment throughout their lifetime so, the carbon

released by biomass during combustion is considered to be neutralized. Although the plants do consume carbon, it is important to reduce the overall carbon emission to reduce the global warming. Particularly as the Himalayan ranges and its surrounding areas are warming five times faster than other areas there is a need for awareness in countries like Nepal that are blessed with majority of the highest peaks and glaciers of the world (Luoma, 2010). However, according to researchers, the tiny particles of black carbon (BC) released by TBE during its combustion through household cookstoves is the second highest contributor in expediating global warming after carbon dioxide (Luoma, 2010) (IEA, UDP, UNIDO, 2010). Furthermore, BC aerosols also impact the weather, climate and the fresh water masses as it has been decreasing the Monsoon rainfall in India, shifting the rainfall patterns in East China, accelerated the melting of the Hindu Kush-Himalayan- Tibetan glaciers and the land ice in the Artic region (USAID, 2010, p. 19). Thus, as Nepal has abundant potential of other clean and renewable sources like hydropower and come amount of thermal power, it should make use of it. It can even use the opportunity to convert TBE to IBT or MBT by utilizing its biomass resources. However, it should also focus on the regeneration of the forest to make the source sustainable.

- **Time consuming and dangerous:** The practice of chopping down wood, collecting twigs, leaves and fodder for biomass fuel is not only time consuming and tiring, but it is also very dangerous. During the collection and transportation process, the women and children use a lot of their strength that could lead to long term physical problems and there is a possibility of falling, being wounded or even getting bitten by snakes or insects (IEA, UDP, UNIDO, 2010, p. 14). In the rural villages of Nepal, there are several cases of such incidents leading to injuries and even death. Additionally, due to the lack of well-developed roads, means of transport and health posts, the people have to face greater challenges in getting immediate medical assistance. Hence, the collection of the fuels for biomass involves various hardships and can lead to tragic accidents.

CHAPTER III. RESEARCH METHODOLOGY

This research is a case study based on the rural households within the Metropolitan city of Biratnagar, the capital of the Province 1 that lies in the East Zone of Nepal. Primarily, the research is based on the field study conducted in several rural villages to understand the situation of energy poverty and the use of biomass in the area. Nevertheless, theoretical aspect of the research has been developed through the study of the available articles, data, journals, reports and books on the topic. Moreover, this research utilizes the primary and secondary sources of information to carry out a quantitative data analysis as to fulfill the research objectives.

III.1 Selection of the Study Area

The Terai region of Nepal that covers the flat lands in the south is one of the most important regions in terms of agriculture and industry. The Metropolitan city of Biratnagar is one of the most crucial cities in terms of trade and industry in the terai region especially because it lies 6km North to *Jogbani* which is the Indian border of Bihar. Despite being in close proximity to India and being a pioneer of the Jute Mill Industry of Nepal, the region has failed to achieve holistic development throughout the years. The city is a home to many Nepalese and Indian businessmen, is highly active in politics and has a high literacy rate but it also has a mix of people from different ethnicities primarily working as laborers and farmers while battling poverty to meet every day needs of their family. Despite being a commercial hub, several regions in the area are still economically backward, lack connectivity to even the basic infrastructures like energy so, they highly depend on biomass for their everyday household activities. Therefore, Biratnagar is an ideal location to conduct a field study to understand more about energy poverty, use of biomass and its effects on the society. Furthermore, as the researcher of the study has her family in the region and is quite familiar with the lifestyle and

culture of the region since her childhood, it was easier for her to conduct the research efficiently in a lower cost.

III.2 Sampling Method

The stratified purpose sampling method was used in collecting the data for the field study. Target areas were selected throughout the city that comprised of very poor, relatively poor and comparatively better off households to ensure a representative sample for the study as to better understand the energy situation of the region. After the stratification of the population, opportunity sampling method was carried out by talking to random residents in the area and by asking them if they were willing to participate in the study. The sample was random as the interviews were conducted without listing any specified group of people as to reduce biasness of the study. Due to time and budget restrictions, this type of sampling method ensured the convenience of both the respondents and the interviewee. However, as most of the people in the area spoke their ethnic language, the interviews were conducted with the help of local volunteers that helped in translating the answers of the respondents and filling out the questionnaires in English.

III. 3 Sources of Data Collection

The budget, time and resource constraints for the study limited the research to be a quantitative data analysis study. Primary and secondary sources of information were utilized to gain an overall perspective about the issue of energy poverty and biomass by understanding its history, present situation and comparing the status of Nepal with other underdeveloped countries.

III.3.1 Research design

The research was designed following the Hammersley's evaluative criteria that prioritize the validity and relevance of a research case study. The replication of the exact same

study might not bring out the same results as produced by the results not due to the problem in the existing datasets or findings of the research but due to the different aspects of different researchers and the possibility for the situation to change overtime. Nevertheless, the relevance of the study on the society and the policy recommendations and impact was kept into consideration when designing the study as to enable the readers to decide the relevance (Hammersley, 1990). Furthermore, following the guidelines of research and existing knowledge gained on the subject matter, the conclusion has been made based on the collected evidences to ensure full credibility and make proper validity assessment.

The study design also focuses on Yardley's evaluative criteria that emphasizes on the consideration of social context, relationships, data and making sure that the interpretation of the results was sensitive to the context. In particular, as this study involved the collection of data from the households and included personal and sensitive issues, Yardley's criteria helps in the designing the research accordingly to meet the required objectives of the research. Reflexivity was also used as the researcher could reflect on her own perspectives, experiences, ideas and interests that helped in shaping the research process (including the research question, analysis and interpretation) as to add a practical and theoretical utility to the research (Yardley, 2000). Lastly, transparency and openness were maintained throughout the field study as the respondents could choose if they wanted to participate in the interview and they could also choose to omit the questions they did not want to answer. Nonetheless, most respondents were open for participation as to help in fulfilling the purpose of the study and the overall response rate for the questions (including details about personal issues) was very high.

III.3.2 Questionnaire design

The questionnaire (Refer to Appendix I) was designed based on the prior study and experiences of the researcher on the state of energy and way of life of the people living in these areas. As to ensure stratified purposeful sampling, the questions targeted the people living in

the rural areas of Biratnagar that are more likely to use biomass and it aimed to understand their quality of life by covering economic, personal and social issues. The questionnaire followed a certain pattern to cover categories like energy used for cooking, lighting and heating but it was followed by questions related to health, education and quality of life to aid in conducting a semi structured interview with the respondents. Furthermore, both open ended and close ended questions were included to get an in-depth knowledge about specific issues based on the objectives of the research.

Majority of the questions required the respondents to answer in a numerical scale like monthly income, approximate percentage of use of energy, approximate cost, approximate distance, approximate hours to get exact quantifiable results with natural ranking rather than ordinal scale that involves answers based on quality preferences. The use of numerical answering method for most of the questions also decreased the amount of time spent on each question and made it efficient for the respondent and interviewee. The latter part of the questionnaire comprised of more open-ended questions that demanded descriptive answers and it also included a section on additional information where extra notes were taken about the respondent's personal view on the issues that contributed in developing a framework for the research.

III.3.3 Primary Data Collection

Primary data collection was carried out through the following methods:

Semi structured interviews: The questionnaire was prepared with a mix of close ended and open-ended questions to ensure interaction between the respondent and the interviewee. Through the interview process, it was easier to gather first hand data related to energy use, living conditions, monthly income, monthly spending and quality of life to evaluate if it is an ideal environment for a child's growth. Furthermore, gaining the insights about the lives of people, hearing their story and the perception on the energy related issues helped in the

identification of the existing problems within the society and formulation of recommendations for the study. Moreover, face-to-face interviews helped in avoiding misinterpretations of the questions and guaranteed high response rates.

Direct observation: Visiting the villages and households assisted in gaining a stronger perspective about the living conditions of the people and helped in assessing the validity and reliability of their responses. It not only helped in designing and reviewing the questionnaire for the study, it also helped in developing friendly relations with the community members that aided in gaining direct information to develop the background, existing situation and future recommendations of the research.

Indirect observation: Interaction with the locals from the urban areas of Biratnagar, local government officials and the people working for the electricity supply office contributed in the supplemented the data findings and helped in gaining additional insights about the overall energy situation and development of the region. Furthermore, gaining various perspectives on the same issue also helped in understanding the lack of communication between different parties and overall lack of awareness regarding the negative impacts of regular use of biomass throughout the country.

III.3.4 Secondary Data Collection

Secondary data collection sources were limited due to the lack of previous studies conducted on the same topic focusing on the same area. However, government datasets and statistics from various development agencies were utilized to understand the background and history of Biratnagar, similar regions within Nepal and other underdeveloped countries that are or have had experiences in dealing with related issues.

III.3.5 Data Analysis

The quantitative data analysis was done following the grounded theory framework developed by sociologists Glaser and Strauss in 1967. The theory involves the categorization

and coding of data to make constant comparisons and carry out theoretical sampling to enable the development of a theory from the data (Kolb, 2012). Rather than following a proposed hypothesis before the study, the data collection focused on identifying the effect of biomass in the development of the children and the society. After the collection of data through the semi-structured interviews, the codes were input into excel spreadsheets and were classified into different categories by analyzing the results on the basis of frequency, percentage and mean. Thereafter, the data was graphically represented through bar graphs and pie charts that enabled an interaction and clear understanding through design.

Educators and researchers do not lack ideas but they fail to emphasize on listening, questioning and comparing ideas before drawing meanings and conclusions of their research (Kolb, 2012). Thus, as to avoid rushing through the ideas and results, the recurring data patterns in different categories were observed and consultations were done with the locals to discuss and question the findings of the data. Subsequently, secondary sources of information were used for gaining theoretical explanations and the data was revisited to identify any missed patterns or evidences. Lastly, the focus was made on the critical areas identified by the research objectives to draw better conclusions from the study.

CHAPTER IV: STUDY AREA

IV.1 Biratnagar Metropolitan City (BMC)

Figure 20: Map of the major cities of Nepal (City Population, 2017)

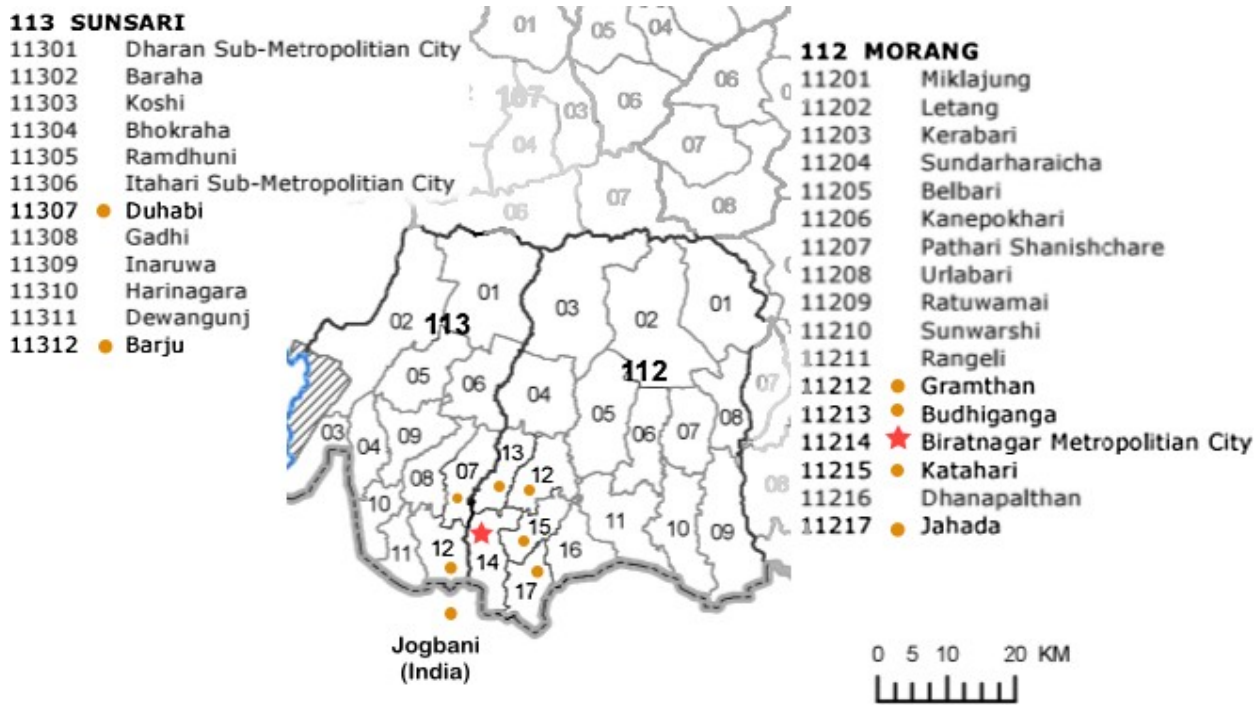

Figure 21: Map of Sunsari and Morang district with its cities (Source: Author)

Biratnagar Metropolitan City (BMC) is the headquarter of Morang District (previously under the Koshi Zone) that lies in the Province 1 that is the eastern most province out of the 7 provinces of Nepal. The city covers a total area of 77.5 sq.km and lies between the altitude 26°28'60"N and longitude 87°16'60"E. Previously it was a sub-metropolitan city (*Upamahanagarpalika*) but since the reform of the administrative divisions of the country from 5 zones to 7 provinces in 2017, the city has been declared to be one of the six metropolitan cities (*Mahanagarpalika*) out of the 293 municipalities (*Nagarpalika*) in the country. On three sides, other rural municipalities (*Gaunpalika*) surround the city. On its west is the city of Barju that falls under Sunsari District, on its north lies Budhiganga City and Gramtham city of Morang district, on its east lies Katahari City and Jahada City of Morang district and it borders with the Indian state of Bihar on the south (Refer to Figure 20 and 21). The cities with international borders are of high importance to Nepal not only for business purposes but also for the geopolitics as it is a landlocked nation. In particular, the international border in Biratnagar (*Jogbani*) is one of the central trading checkpoints between India and Nepal. Furthermore, although Nepal does not have a well-established railway system, the town of *Jogbani* has direct railway lines to the major cities of India like New Delhi and Kolkata that increases the significance of the area for the locals and the government.

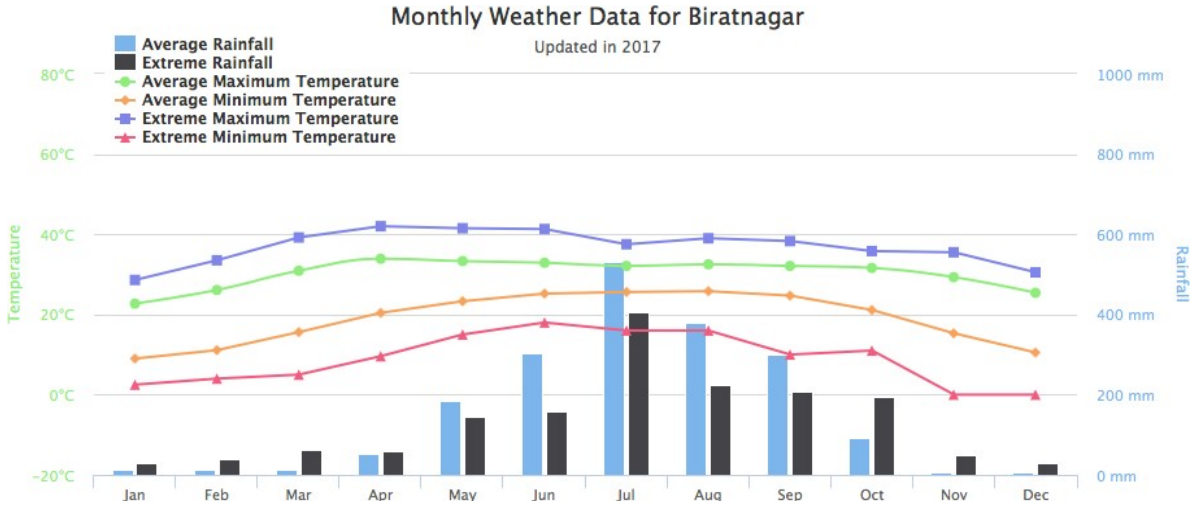

Figure 22: Monthly weather data of Biratnagar (Meteorological Forecasting Division, 2017)

The geographical location of Biratnagar lies in the South Eastern region of the country that is mostly covered of flat lands of terai (Refer to Figure 20). Unlike the constant cold climate observed by the mountainous regions in the north and the temperate climate in the central hilly region of Nepal, the southern region mostly experiences warm climate. The warmest time of the year is from the month of March to the month of September with high rainfalls around the month of July (Refer to Figure 22). As majority of the people in BMC depend on agriculture for their livelihood, the rainfall period is very important for the city and the entire terai region for maintaining their harvests and income.

According to the National Population Report 2017 that carried out the census of all the municipalities of Nepal, the total population of BMC is 214,663 out of which, 108,827 are male and 105,836 are female (Biratnagar Municipality Office, 2017). In 2011, BMC had a total of 45,228 households and a total population of 204,949 out of which 104,935 were male and 100,014 were female with the average population growth rate of 2.07 per cent (Central Bureau of Statistics, 2012). Thus, the population of the area has been gradually increasing by the years. Particularly after the upgrade of the city from a Sub-metropolitan city to a Metropolitan city in

2017, the population of BMC is expected to grow further in the years to come. The city and the entire Morang district are a popular destination for migration for people from nearby areas due to the availability of quality education and medical services. 80 percent of the total population in the area is able to read and write with 87 percent of males and 74 percent of females being literate (Refer to Figure 23). Compared to the capital, the Kathmandu Metropolitan City (KMC), where there are the maximum numbers of educational institutions that provide high level of education, the literacy rate of BMC is less by only 9 percent which is very good compared to other cities (Refer to Figures 23 and 24). In the case of KMC, the difference between the literacy rate between the male and female population is only 10 percent while for BMC it is 13 percent. However, in both the cities, the male population is more literate than the female which is common throughout Nepal as it is a patriarchal society where even at present, the female population is mostly engaged in household works and are married off at a younger age. When comparing with the data of Nepal, the overall and the gender-based literacy rate of BMC is higher by more than 15 percent because the overall literacy rate of Nepal is only 66 percent with only 75 percent of males and 57 percent of females being literate (Refer to Figures 23 and 25).

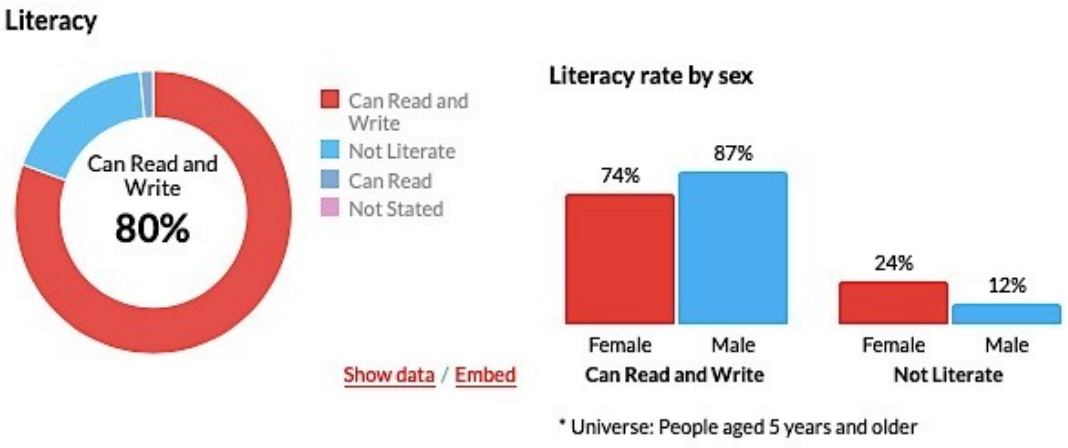

Figure 23: Literacy rate of Biratnagar City (NepalMap, 2011)

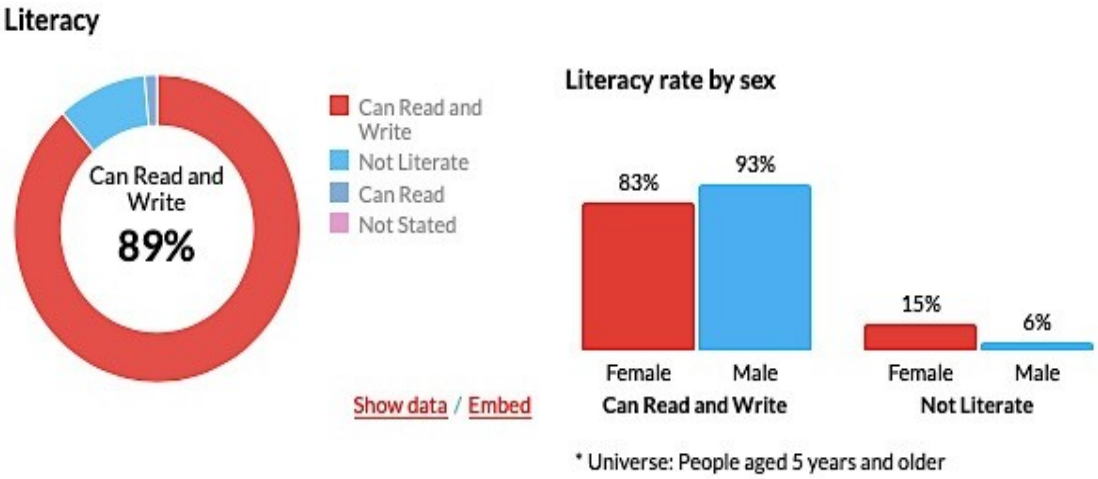

Figure 24: Literacy rate of Kathmandu City (NepalMap, 2011)

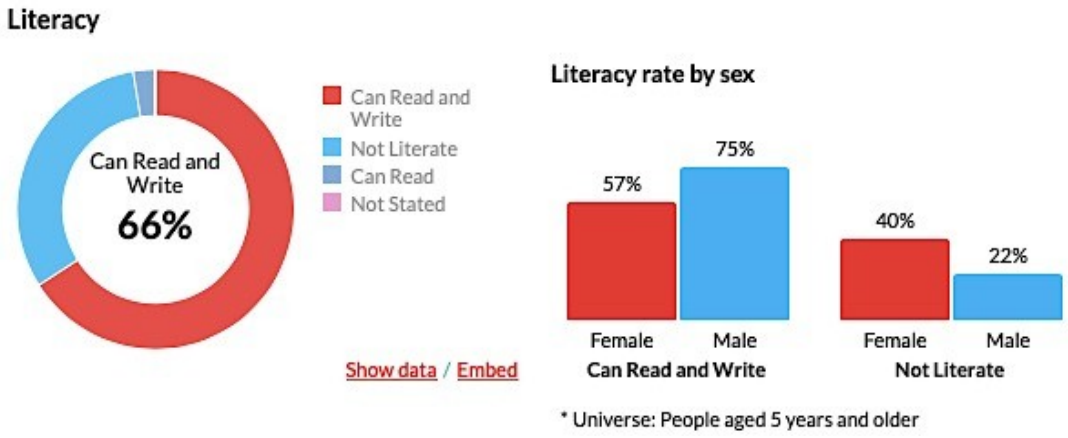

Figure 25: Literacy rate of Nepal (NepalMap, 2011)

The BMC is one of the most ethnically diverse regions with ethnic groups like Brahmin, Tharu, Chettri, Marwari, Maithili, Rajbansi and Rai living together in the same area despite having different cultures, languages and norms. It is also a popular living destination for the rich Nepalese and Indian businessmen but a large number of poor people also reside in the areas and they mostly engage in labor, agriculture or other low skill jobs. Despite being considered as a major industrial city of Nepal, there is high inequality in the income in the region that can be reflected on the quality of life and the living standards of the people in different communities.

The people residing in the urban areas of Biratnagar have access to most of the infrastructures related to transport, drinking water, sanitation, communication, electricity, education and health but the people living in poor villages lack proper access or affordability to even the basic services.

IV. 2 Areas Focused on during the Field Study:

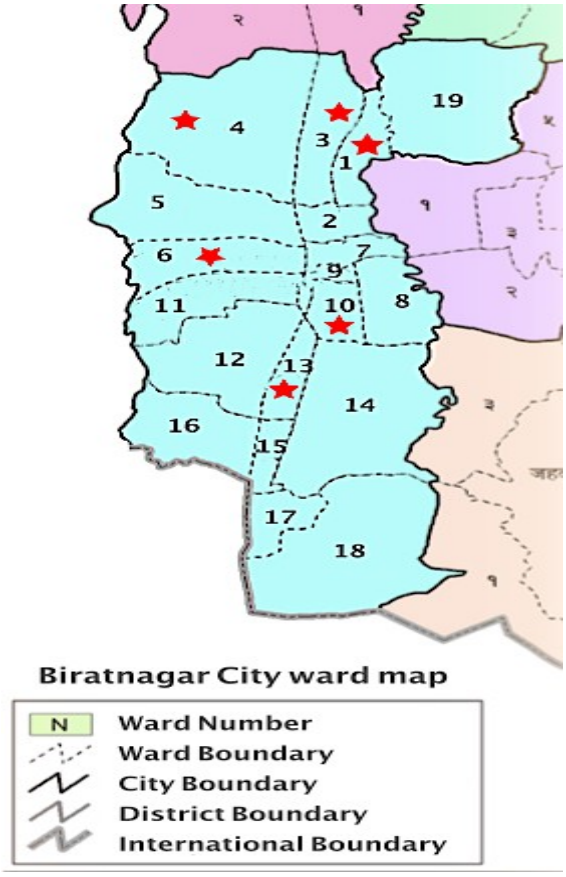

Figure 26: BMC map that indicates the area studied (Source: Author)

This study is based on the households in poor villages in different parts of Biratnagar city where people mostly rely on traditional biomass as their primary source of energy. The villages covered are Singhya (Ward No. 1), Dhat (Ward No. 3), Rajbansi (Ward No. 4), Keshalia (Ward No. 6), Amartol (Ward No. 10) and Janpath (Ward No. 13). To make it easier to locate the wards and understand the area, the wards covered during the study have been marked with

a red star in Figure 26 that includes the detailed map of the entire city with all its boundaries.

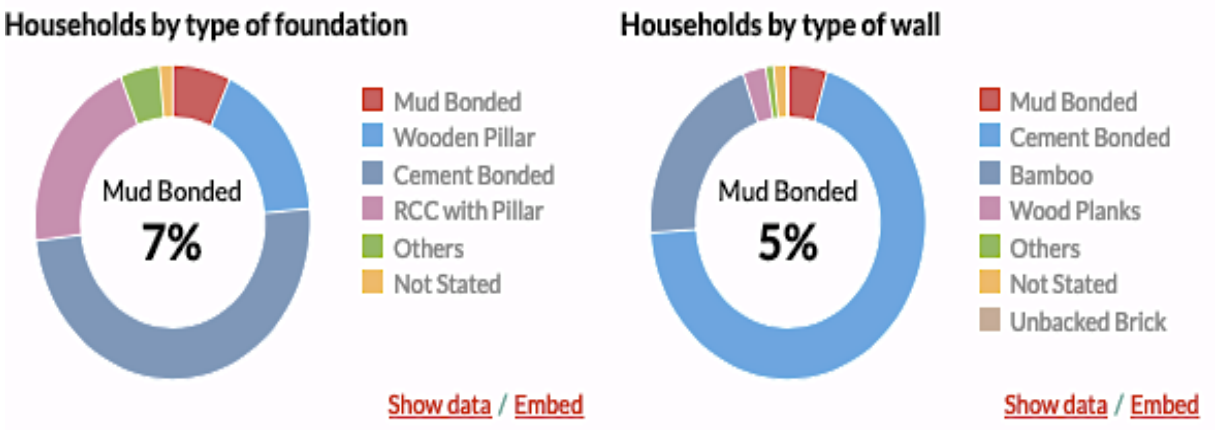

Figure 27: House construction materials in Biratnagar (NepalMap, 2011)

Figure 28: Children playing in front of a weak type house (Made out of bamboo and mud) (Source: Author)

Figure 29: Children play in front of average type houses (Made out of mix of mud, bricks and bamboo)

(Source: Author)

Figure 30: Women of the community talking in front of a strong type house (made out of cement, brick and bamboo) (Source author)

Majority of the houses in these villages have a weak structure that is made out of mud and bamboo (Refer to figure 28). Figure 27 illustrates the construction materials used in the houses in Biratnagar. The households covered during the study mostly fall into the mud-bonded categories highlighted in both of the figures in figure 27 (Refer to Figure 28, 29 and 30). Furthermore, due to the lack of a proper and safe structure for their housing, many of these houses lack windows and proper ventilations in their kitchen that traps the smoke inside the houses and increases the health risks involved with the daily use of biomass.

The men residing in these households are mostly engaged in farming or low skilled jobs that require high labor but pay very less. The women in the family are responsible for the domestic works while helping with the farming and other activities that help in bringing some income to the family. In addition, the children also help their mothers in the household works, running errands, collecting biomass sources whilst attending school during the day. In some instances, there were cases where the parents could not afford to send their children to school so they helped with the domestic chores and also helped in farming or other income generating activities that their parents were involved in. Majority of these families have very low income that compels them to even prioritize between their basic needs and to minimize their household spending. The following chapter will highlight the findings and provide detailed information about the status of energy and the way of life of the people in the study area.

CHAPTER V. FINDINGS

V.1 Energy situation

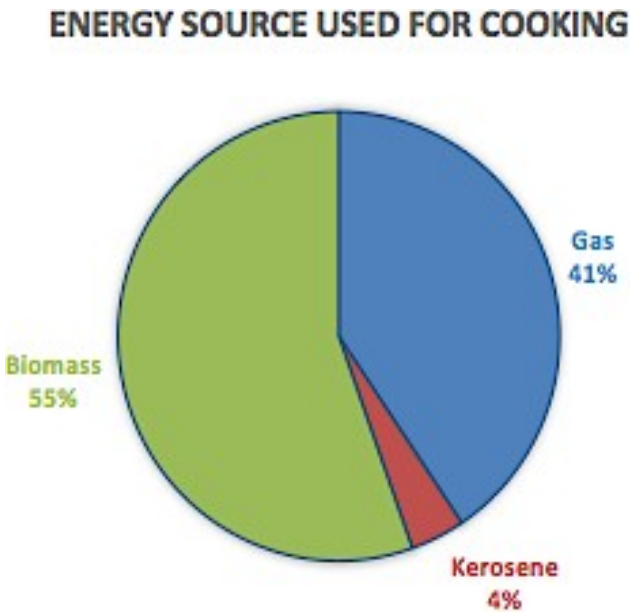

Figure 31: Energy mix for cooking in the 50 households studied

(Source: Author)

Figure 32: Traditional cooking stoves used in most of the rural parts of Nepal (K.C & Bastola, 2018)

According to findings of the study, the people living in the 6 villages are highly dependent on TBE for their daily energy use. Biomass accounted for 55 percent of the source of energy used for cooking (Refer to figure 31). Under the biomass used for cooking, the people mostly used firewood and some also used bamboo. The source for the firewood was said to be from the communal forests within the area and the district of Morang. Most of the people bought the wood from different wood sellers while some of them even went to collect the wood by themselves. Following biomass, 41 percent of the energy used for cooking was gas (Refer to figure 31). The gas used is the liquefied petroleum gas (LPG) that is sold inside cylinders that weigh around 7-8 kilograms. On average, a cylinder can be used from 2.5 to 3 months. Therefore, the monthly cost of the LPG would be about 1300 NRs- 1500 NRs (approximately 11.57 USD to 13.35 USD) depending on its supply in the market. Very few people use electricity for cooking in the area and the whole of Nepal because the decades of energy scarcity and discontinuous energy supply led to people relying on other alternatives for cooking. Furthermore, the electronic devices used for cooking are not that common throughout Nepal.

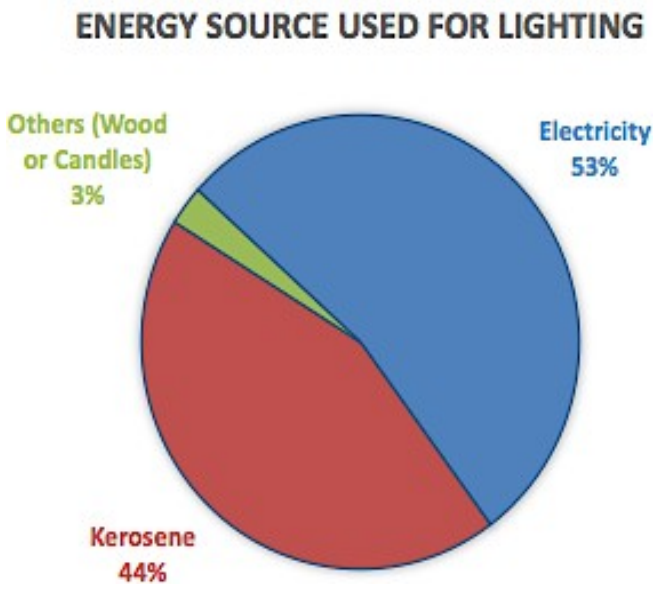

Figure 33: Energy mix for lighting in the 50 households studied

(Source: Author)

The NEC grid electricity supply accounts for 53 percent of the total energy source for electrification in these households (Refer to figure 33). The houses pay within the range of NRs 500 to NRs 1800 (Approximately 4.45 USD to 16.02 USD) monthly for their electricity with the cost differing based on the location of their village and the duration of use. The second most used power source for electrification was kerosene that accounted for 44 percent of the energy mix (Refer to figure 33). The households used traditional lighting lamps that burn on kerosene. Compared to other petroleum products, kerosene is cheaper and it can be used for a longer duration so, these households use kerosene for lighting purposes. Some of these houses used both electricity and kerosene whereas most fully depended on it. Lastly, biomass and candles accounted for 3 percent share in the energy mix.

24 percent of the total households studied (They were all from Singhya Village of Ward Number 1 and Keshalia Village of Ward Number 6) lacked connectivity to the grid electricity supplied by the NEC. All of these households ranked electricity as their last or second last priority when asked to rank their priorities out of food, money, education, health and electricity. In those households, they have to prioritize other needs over electricity, as the total monthly average income of these households was 3,583 NRs (31.88 USD) while having an average of 3 or more family members. Thus, they have no other option besides depending on biomass and kerosene for their daily cooking and lighting. Within these households, there was also a case of pneumonia, a case of minor brain stroke and a case of minor heart attack within the past 6 months. In addition, several households reported of suffering constantly from cold and headaches. However, getting medical assistance and visiting the hospital was rare due to high costs involved and for some villages, they had to travel a long distance.

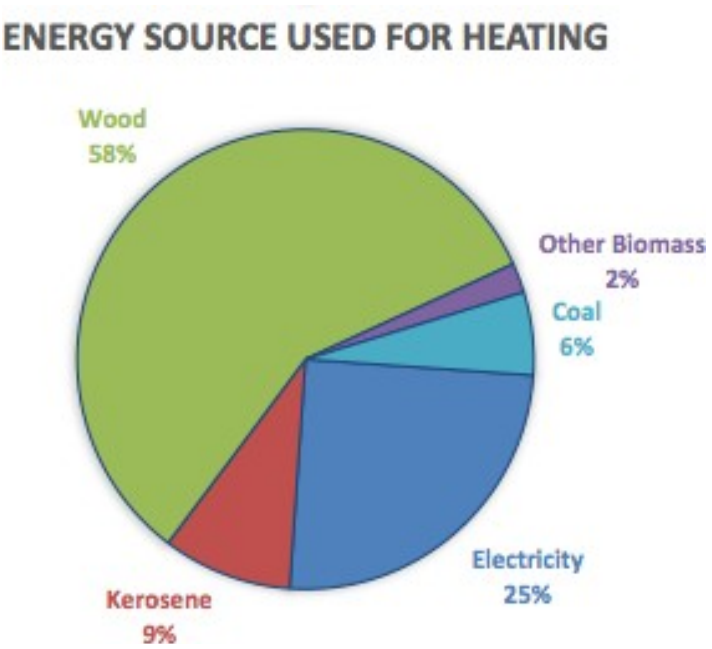

Figure 34: Energy mix for heating in the 50 households studied

(Source: Author)

Figure 35: A woman with her baby in their house lighting twigs to keep themselves warm (SNV Netherlands Development Organisation, 2019)

Figure 36: It is a common practice all over Nepal to keep the pregnant woman and the new born warm in enclosed spaces using firewood (K.C & Bastola, 2018)

Biomass accounted for 60 percent of the total share of energy used for heating purposes in these households (Refer to figure 34). 58 percent of the people used wood and the remaining 2 percent used other agriculture waste and other wastes to warm themselves. Electricity, kerosene and coal accounted for 25 percent, 9 percent and 6 percent respectively in the energy mix for heating. However, the BMC mostly has a warm climate and has low temperatures only from November to March. Within these months, the people usually use energy for heating only from November to January when the temperatures are the lowest (Refer to figure 22). Thus, even though the people mostly burn wood inside their houses that do not have enough ventilation, they use it for a shorter period of time so, the duration of exposure to the smoke is minimized.

V.2 Housing situation

58 percent of the households (29 out of 50 houses) had their kitchen outside and the remaining households had their kitchen inside the house. 10 of the families that had their kitchens outside were cooking in open spaces by using bricks and other rocks to balance the firewood while cooking. Out of them, some had used mud and clay to build a traditional cooking stove that was also the most commonly used device in the indoor kitchens. The remaining 19 of the households that had their kitchens outside had built a room or structure separate from their house but within a distance of a few steps.

Out of the 40 houses that had enclosed kitchens inside or outside their houses, only 12 of them had proper ventilation in their kitchen. Although the majority did not have proper ventilation, they did have a window to let the air out. However, 9 of the houses neither had windows nor any other kind of ventilation to guarantee the release of the smoke while cooking. When inquiring the houses that had windows or had made a kitchen outside, they exclaimed that they did not do it fearing health risks like respiratory issues but they did it to avoid chances of suffocation from the smoke or to avoid the smell of smoke from sticking on to other items in the house (Refer to appendix 3.2). Nevertheless, 60 percent of the people that use wood, bamboo or other wastes to burn for heat, they continue to light it inside their houses as 21 of the families lived in average strength house type (house made out of brick and mud) while 22 of the families lived in low strength house type (made out of bamboo and mud) so their houses were not strong enough to protect them from the cold.

V.3 Role of the Community

Village	Income range	House type (Low: Mud + bamboo, Average: Brick + mud, Strong: Cement + brick)	First priority	Second priority
Singhya	2000-6000 NRs (17.8 USD- 53.4 USD)	Almost all low	Mostly money	Mostly health
Dhat	4500-9000 NRs (40.5 USD- 80.1 USD	Mostly low, few average	Mostly money	Mostly food
Rajbansi	3000-7000 NRs (26.7 USD- 62.3 USD)	Low and average	Food or health	Money
Keshalia	2000-8000 NRs (17.8 USD- 71.2 USD)	Mostly low, some average	Mostly money	Health or food
Amartol	4000-9000 NRs (35.6 USD- 80.1 USD)	Low and average	Mostly money	Mostly health
Janpath	15000-35000 NRs (133.5 USD- 311.5 USD)	Mostly strong and average; a few low	Mostly food	Education or health

Figure 37: Socio-economic details of the villages (Source: Author)

The communities in Nepal play a big role in influencing the way of life and shaping the way of thinking of its members. Some of these communities are bound by the same culture, language and ethnicity while some are bound by similar socio-economic status and occupation. In the studied villages, the people followed the latter and were mostly belonging to the same socio-economic status and occupation while also sharing some similarities in the language and culture. As the range of monthly income was similar in the households of the community, the

structures of their houses and their spending on different energy sources and other needs were also similar within each villages.

Out of the 6 villages, the Singhya village had the lowest income level with the weakest housing structures (Refer to figure 37). Keshalia village had the second lowest income group and the majority of the houses in the village had weak structures made out of mud and bamboo. All the villages except Janpath village had their monthly income ranging from 2000-9000 NRs (17.8-80.1 USD) and listed money, health or food as their top two priorities. Only in the case of houses in Janpath village that had their monthly income ranging from 15,000-35,000 NRs (133.5-311.5 USD), prioritized food, education and health within their top two priorities. In this community, almost all the kids were attending private schools. Even for the houses that had weaker structure and had lower income than the majority, they were sending their children to private school even though it was costing them a large proportion of their income.

V.4 Role of the Government

The GoN has been taking initiatives in providing these households with electricity and other infrastructures that could help the people live a better quality of life and utilize their potential while living in a cleaner environment. However, through the study, it was known that these households that have connectivity to the electricity grids use it at an average of only 3 hours per day as they use it only for electrification while continuing to rely on TBE for the everyday cooking and heating. In these households, they mentioned that due to the high cost of electricity, it is cheaper for them to use biomass for cooking because it requires high amount of energy to cook and since all the households cook at home about 2-3 times a day, it is cheaper for them to use biomass (Refer to appendix 3.1).

There were even a few cases where the households were involved in energy theft as they joined the electricity cable from their house to the electric transmitter. However, despite stealing, these people claimed to be using the electricity for about 2-3 hours a day mostly for

electrification at night. When asked for the reason, they mentioned that they cannot afford to pay for the electricity while paying for other basic needs so, as the regulation and service of the GoN and the NEC has many loopholes, they chose the illegal way to get connected to the power lines.

In terms of education, the public schools have been quite helpful for most of these households as it is cheaper than the private schools. There were 28 Percent of households that sent their children to public schools while paying an average of about 440 NRs (3.9 USD) per month per child. However, there were 42 Percent of households sent their children to private schools despite having to pay about an average of 2,285 NRs (20.3 USD) per month per child, as they believed that private schools provided a higher quality of education than the public schools and would lead to a brighter future for their children. Nevertheless, 10 households out of the 50 households had cases where they did not send any children (with an exception of a few that sent only the boy) to schools due to their poor financial conditions and needing the children to contribute to the family income by helping out with the work.

Vast majorities of the people in the studied households have not been visiting the hospital or getting medical care in a timely manner. The GoN does not provide the people with public health insurance but the public hospitals provide cheaper services to the people. However, due to the low price and service fees, these hospitals are usually very crowded. As for the vaccination of children, the ward office arranges several vaccinations for free and some are sold for a low price. However, when asked if their children were vaccinated, only 3 households answered yes while 29 households answered no and the remaining 18 households said they did not know. When asked about any illnesses or any health-related problems, 12 percent of the households that were highly dependent on firewood for their daily energy use exclaimed to be suffering from frequent headaches or cough and cold. There were 2 cases where people had severe respiratory problems like pneumonia or breathing problem and there were 2 cases of

problems related to the heart (Refer to appendix 3.1). Besides that, there were other cases of physical injury like leg fracture, knee problem, body pain and falling off the wall that occurred while playing, riding bike or doing domestic works. Moreover, the people seemed to be ignorant about getting medical care due to their financial problems and also due to the lack of awareness. Although most of the people were living in weak structured houses with almost no ventilation while using biomass daily for about 5 hours on average, they were not aware about the high risks associated with high biomass use or were ignoring the fact due to their poor financial conditions (Refer to appendix 3.1 and 3.2).

CHAPTER VI. CONCLUSION AND RECOMMENDATIONS

VI.1 Conclusion

Traditional biomass is a useful source of energy for the developing nations where there is a scarcity of modern energy sources and a lack of finance or expertise to utilize their domestic power potential. However, it is essential to consider the negative impacts caused by the continuous use of TBEs and ensure its conversion into more effective means of biomass like MBTs or IBTs or guarantee its complete replacement through the introduction of other clean and renewable energy sources. Nepal is one of the countries with one of the highest rates of dependency on biomass (about 80 percent of the total energy mix). The lack of alternative sources of energy, high rate of poverty in the rural areas and lack of awareness regarding the negative effects of TBE use have been the main causes behind this excessive dependency on the energy source. Most commonly, biomass is being used for cooking and heating as most people use either electricity grid supplied by the NEC or kerosene for electrification.

Majority of the households use firewood as their biomass source which then leads to high rate of deforestation in the country. Furthermore, the use of traditional stoves for cooking in houses without proper ventilation increases the risk of respiratory problems and even death especially for women and children as they spend most of their time indoors or in the kitchen. For a developing country like Nepal, its women and children are its assets for its development so there is a need for the government to take the necessary actions to provide modern energy sources or efficient biomass technologies. The same biomass can be used efficiently though the uses of modern technologies like ICS, biogas, briquettes, gasifiers, cogeneration and liquid biofuels. However, the lack of proper research on the subject and the unavailability of data for evaluation studies or analyzing the effect of TBE use has contributed to the lower rate of awareness among the GoN and the Nepalese citizens about these problems and the lack of implementation of effective solutions towards it. Thus, this study on the 50 households in the 6

rural villages of BMC were carried out to gather some interest on the issue of the continuous use of TBE in the rural areas and its negative impacts on the overall development of Nepal. Likewise, this study aims to create awareness on the urgency of the replacement of TBE with other cleaner energy sources while emphasizing that the role of GoN lies beyond guaranteeing electricity connectivity to these villages through the NEA. It needs to examine whether the people are making use of the services and should inquire more about the reasons why the use of TBE is continuing despite providing other alternative energy sources. Thus, conducting research on energy poverty, is very essential to gather the attention of the state and non-state actors and encourage them to act towards ensuring availability of modern energy services to create an environment that encourages the development of the people, community and the country with less health risks, higher literacy rates and productivity along with a cleaner environment.

According to this study, the dependency of the studied households on biomass is very high. The households mostly used biomass for cooking and heating while they used grid electricity and kerosene for lighting purposes. According to the findings, the low income of the household was the main reason behind the high use of biomass as after paying for food and other primary necessities, people had very less to pay for expensive power sources like grid electricity or LPG. Most of the studied households had weak structures made out of mud, bamboo and bricks with almost no ventilation in the kitchen and very few windows that raised the risk of smoke being trapped inside the house and causing various health problems.

The limitation in the sample size of this study and time constraint did not allow the study to be conducted at numerous time durations, so the findings were not able to prove direct link of the excessive use of biomass to the cases of respiratory problems. Some residents in the households did have respiratory problems but most of them had cases of frequent cold and cough or headache that could be a symptom for a bigger health problem due to the poor living

conditions and excessive use of TBEs. Nevertheless, as of now, there can be no certain answer as this hypothesis can only be proven if, the same study is conducted after a few years with the same households. The poor income of the households was also commonly seen to be a constraint for majority of the families when receiving medical help. Most of the families answered not to have received any medical care in the past 6 months and the few families that answered to have had visited the heath center were mostly due to unbearable or unavoidable conditions. Thus, it cannot be known if the households were facing any health concerns resulting from the daily use of TBEs as they did not have a medical record.

According to the informal consultations with the residents and additional questioning about their answers given during the interview, it was found that the people had very low awareness about the negative effects of TBE use on human health and the environment (Refer to appendix 3.2). About 40 percent of the households knew that the direct inhalation of smoke of the firewood is harmful to their body but they did not know the extent to which it could have negative impacts on the health of people. Likewise, the people knew that the smoke was causing air pollution but they did not know about the existing problem of global warming and how the use of TBE contributes in its intensification. However, as of now, as there is no better energy alternative that they can afford and due to the practice of using the energy source for a long time, the majority continues to use TBEs (Refer to appendix 3.1 and 3.2). The lack of affordability also led to a few households not being able to send their children to schools, as they needed them to contribute to the household income. Thus, lack of education could also be a factor influencing the low level of awareness in these households.

The findings from this research state that in the poor households, the high spending on other sectors leads to the low spending on the energy sources as the people in the poor communities are struggling to meet most of their day to day basic needs. In addition, due to the lack of awareness in the community and in the government about the high health risks

associated with the continuous use of TBEs, there is a high rate of indoor pollution that could lead to respiratory problems. This further increases their spending on health and leads to the continuation of the cycle of in biomass use while leading to the lower spending on education and other cleaner energy sources. Furthermore, the high rate of firewood use without new tree plantations would lead to deforestation, worsening of the quality of environment, increase the global warming and would also lead to various natural disasters. This could further increase the problems for the rural households as they depend highly on agriculture for their income, while living in weaker household structures and having less or no financial security.

The GoN has been taking actions and initiatives to eradicate the use of biomass but the allocation of the financial resources for the sector that accounts for more than two thirds of the country demand of Nepal has been minimal (Ministry of Population and Environment, 2017, p. 3). Through the initiatives taken by the government like the NREP, AEPC and renewable energy projects undertaken in collaboration with other non-state actors, about 600 households have been using solar cooker and 365,000 households have been using biogas in Nepal (Ministry of Population and Environment, 2017, p. 3). Furthermore, as to achieve the UN SE for all targets under the SDG 7, "clean cooking solutions for all" campaign has been introduced in Nepal to provide clean cooking technologies and the government has also been investing in the clean energy sector and has been strengthening its agroforestry policies (Ministry of Population and Environment, 2017, p. 3). However, over the years, the impacts of these projects are limited to the project destination and these initiatives have failed to create a significant impact throughout Nepal. As a result, families even in the rural villages of metropolitan cities like Biratnagar continue to fight energy poverty.

VI.2 Recommendations

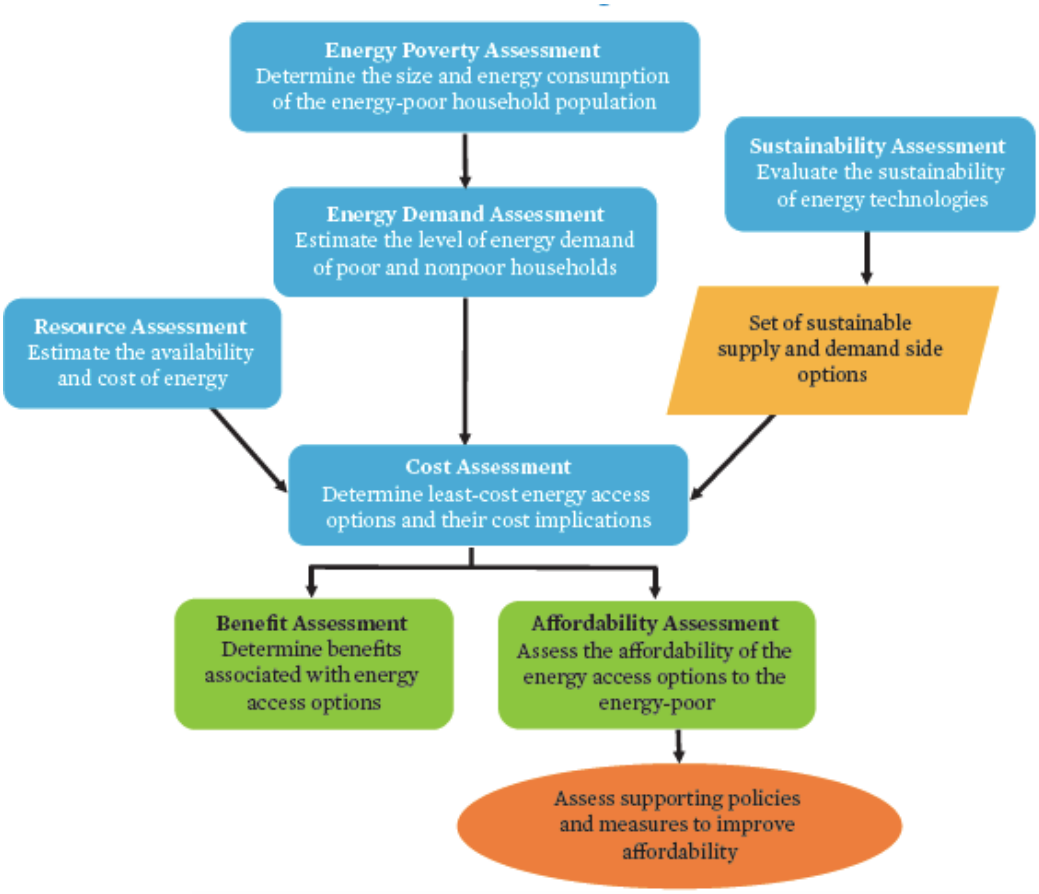

Figure 38: Sustainable Energy Access Planning Overall Flow Diagram (Shrestha & Acharya, 2015); (Asian Development Bank, 2018, p. 6)

The state and non-state actors make a huge contribution in improving the energy situation of Nepal and helping in its development. Nepal successfully achieved the overall MDG targets but there is a need to speed up the development while balancing the inequality in the society by higher government investments on infrastructure (particularly energy) that would enable the social development, economic development and improvement in the quality of life of its citizens (Asian Development Bank, 2017, p. 2). The government needs to start addressing this problem by solving the problem of coordination and communication within itself and its ministries. As TBE use directly affects the energy, health and environment ministry, the ministries need to work together in solving the issues of excessive traditional biomass use and

safeguard the energy supply to enable development creation. Furthermore, the government should set proper short term and medium-term goals while maintaining transparency between the stakeholders and the ministries involved to ensure proper collaboration in replacing the TBEs with IBTs or MBTs and develop it hydropower capabilities to achieve the target of providing electricity and clean cooking facilities to the entire country by 2030. The conversion of TBEs to MBTs would require large-scale investments and proper planning. However, it is essential to take immediate action in this sector and even a small improvement can create a great impact on the environment, health and productivity of the people so, the governments should start with the introduction of IBTs to replace the TBEs.

As Figure 38 illustrates, to achieve its clean energy target, the GON needs to conduct proper assessment on the energy poverty status of the country that should be followed by energy demand assessment, sustainability assessment and resource assessment to further carry out cost assessment of the proposed project or solution. Thereafter, the departments involved should carry out benefit assessment and affordability assessment to carry out efficient sustainable energy access planning. Progress assessment should be carried out while the project is ongoing and upon its completion, impact assessment should be carried out even after the project completion to guide similar projects in the future.

A country's policies should support the goals of its ministries as to achieve their long- term targets and create development in the country. The eradication of energy poverty depends on the prioritization of the international community and national governments on solving the issue through policy changes, long term commitments and development strategic development plans by creating strong institutional, regulatory and legal frameworks and financing from all available sources, including the private sector (IEA, UDP, UNIDO, 2010, p. 37). To ensure the continuity and improvement of the energy sector, the projects and policies introduced to develop the biomass energy sector should be made binding even in the case of a change in the government. In the past,

the now developed countries mostly developed at the cost of the environment but now they are changing their approach and are investing on cleaner energy alternatives to develop further. The developing countries should start with a sustainable development approach so that they will not have to change their energy sources in the future and can continue growing with the same energy development plan. Thus, the developing countries need to introduce policies that increase energy efficiency, encourage renewable energy production, ensure capacity building for energy related data collection and promote research on the sustainable energy sector whilst increasing the clean energy access and affordability to use energy in aiding the efficiency of other key economic sectors (International Bank for Reconstruction and Development, 2017, p. 12).

Designing and establishing a legal and regulatory framework for biomass energy is a major challenge for the government and the analysts in the developing countries that has led to its underdevelopment (Karekezi, Lata, & Coelho, 2012, p. 251). A sole institution should be established to govern the biomass energy use and implement the related policy changes in a holistic manner. The organization should be responsible in dealing with the legal and regulatory issues, funding, project implementations and should be involved in the promotion of MBTs and IBTs. Furthermore, it should spread awareness about the consequences of using TBEs and work towards eliminating the use of TBEs in the rural parts of the country. In the case of Nepal, AEPC was established for that purpose but the organization works as a branch under the ministry that gives it very less authority to take decisions and implement projects. Furthermore, most of the developing countries also lack reliable databases with records on the use and consumption of traditional sources of energy like biomass over a period of time so, it is important to emphasize and improvise on this weakness (IEA, 2002), (Karekezi, Lata, & Coelho, 2012, p. 255). The data base and research would help in setting effective goals and would also increase the awareness about the urgency in working towards the eradication of energy poverty from Nepal.

As the study highlights, the rural areas of BMC are highly reliant on TBE due to the easy

availability and low price of the source. In addition, due to the low awareness levels and the tradition of using TBE since generations, the people continue to use TBEs. Therefore, the government needs to either subsidize the grid electricity based on the income of the people or it needs to provide them with a cheaper alternative. As NEA is a profit oriented private company and it is already facing difficulties in managing and regulating the production, storage and distribution of electricity throughout Nepal, it would be difficult for the government to subsidize the price of electricity based on the income levels of people. Furthermore, in the context of Nepal, with majority of people just above the poverty line, it will be hard to implement an electricity subsidy based on the income of people. Differentiating the price of electricity based on the income of people would lead to the increase in electricity theft and would raise the possibility of protests from the higher earning groups of people.

Instead, the government should utilize the existing dependence on TBE as it is a competitive alternative to other energy sources but in order to expand its use and make it more competitive, the development and full optimization of the bio-energy systems, conversion technologies and modern biomass production is essential (Faaij, 2006, p. 364). The government needs to invest in the large-scale production of MBTs in rural areas throughout the country as to reduce its price and make it affordable for the low-income group to purchase it. MBTs can provide improved and cleaner energy services to the rural households and support the development of the society, promote environmental protection, and improve the living conditions of the people by utilizing the existing biomass resources and agricultural residues (Karekezi, Lata, & Coelho, 2012, p. 246). As the total switch of energy sources is difficult, the efficiency of the existing biomass resources can be increased through the initiation of ventilation and use of low combustion stoves. The biomass gasifiers can achieve the level of emissions close to the LPG, by the use of exhaust fan, proper ventilation of homes through bigger doors and windows but although these changes would have a substantial contribution in eradicating the indoor air

pollution levels, the outdoor air pollution would continue to be the same (IEA, UDP, UNIDO, 2010, p. 13). Furthermore, the installation of the ICS can decrease the rate of indoor air pollution by 62 percent, the use of firewood by 43 percent but only 3 million households in all of Nepal have access to this means of cooking (Ministry of Population and Environment, 2017, p. 3). Thus, increasing the focus on environment conservation, the IBTs needs to be introduced in these communities and slowly it should progress towards full replacement by cleaner energy sources like MBTs or hydropower.

The government can also take initiatives in improving the poor economic condition and reducing the income inequalities in the rural areas so that people can afford cleaner energy sources or energy grid connections. As the men and women in the studied households were mostly involved in low skilled, menial jobs, the government could take initiatives in providing them with increased employment opportunities, increase in the menial wage, and provision of skill development trainings. Furthermore, the development of MBTs could also help in creating employment opportunities for many people in the developing economies as it has the highest job generation potential out of all other primary energy sources (Refer to Figure 39).

Sector	*Jobs-person-years (terawatt-hour)*
Petroleum	260
Offshore oil	265
Natural gas	250
Coal	370
Nuclear	75
Wood energy	**1000**
Ethanol (from sugarcane)	**4000**

Figure 39: Comparison of Job Creation through Biomass and Other Conventional Energy Forms

(Goldemberg, 2002); (Karekezi, Lata, & Coelho, 2012, p. 247)

As firewood was the dominant biomass source used in the studied households, it would be contributing in receding the forest coverage in the area. Therefore, the government needs to act towards protecting the diverse range of flora and fauna species in the country and in reducing the rate of global warming that is melting the ice caps of the mountains and the glacial lakes in the Northern region of the country. The government should keep proper track of the forest coverage of the country and legislate the deforestation. In addition, it should initiate afforestation programs to ensure that new trees replace the trees cut down for biomass energy.

Lack of awareness about the health risks related to the excessive use of TBEs is prevalent not only in the rural areas but also the urban areas and in the government sector. Being a resident of Kathmandu, the capital city of Nepal, I spent about 1-2 hours every day of my first 6 months after being born in a room where me and my mother got traditional oil massage in front of burning firewood in an enclosed room. The same tradition continues for my sisters, cousins and all the children that are born in Nepal as people are unaware about the hazardous effect of biomass use. Thus, local level awareness campaigns that emphasize on the amount of BC released with each traditional and modern biomass source and how its inhalation could affect the human lungs (especially infants) should be carried out. Furthermore, the promotion of IBT and MBT should carried out so that people are eager to invest in those sources for a healthier lifestyle. The impact of the deforestation for firewood should also be highlighted in the campaigns to create awareness among the people about the endangered species and the rising global warming levels that are shifting the weather patterns, increasing natural disasters and is also affecting the precipitation levels that is essential for their farming. Furthermore, the need of preservation of the forest resources and the eradication of the use of traditional sources of energy need to be included in the education curriculum of the schools. In addition, the government and other educational institutions need to promote the study of energy development, environment protection and energy policies in the university level to encourage the participation and the innovation in the sectors from the youth of

the country.

	Average Annual Investments (US$ million, 2018 Prices)					Total investment financing needs (US$ million)
	Historical Investments	Forecast Periods -Reference Scenario				
	2010-2017	2018-2025	2026-2030	2031-2035	2036-2040	2018-2040
Hydro-storage	-	393	404	631	1,017	13,012
Hydro (ROR+PR0R)[2]	372	301	485	757	1,221	14,424
Solar	-	43	34	54	87	1,177
Wind	-	26	23	36	58	768
T&D	156	414	539	842	1,356	16,587
Total	**527**	**1,177**	**1,487**	**2,320**	**3,739**	**45,968**
Total (% of GDP)	**2.1**	**2.7**	**2.4**	**2.6**	**3.0**	**2.0-3.0**

Sources: Historical investments based on PPI database and NEA Annual Report 2018. Projected investments are World Bank estimates based on the Water and Energy Commission Secretariat's 2017 reference case electricity demand projections.
Note: GDP = gross domestic product; NEA = Nepal Electricity Authority; PPI = private participation in infrastructure; PROR = peaking run-of-the-river; ROR = run-of-the-river; T&D = transmission and distribution.
a. Run-of-the-river hydroelectricity is the type of hydroelectric generation plant whereby little or no water storage is provided. Peaking run-of-the-river hydropower plants are defined by the NEA as hydropower plants that can provide at least four hours of electricity during peak hours.

Figure 40: Historical investments (2010-2017) and projected investment needs (2018-2040) in the Energy Sector of Nepal (The World Bank, 2019, p. 11)

Despite high hydropower development potential, Nepal has been failing in energy production due to the need of high investments in the hydropower sector. As we can know from the figure 40, the investment forecasts for hydropower is expected to keep increasing and the share out of the total GDP to be invested in the energy sector would be about 3 percent which cannot be met solely through the investment from the public sector. Until now, the state has relied on various sources for financing its energy sector and it has led to the share of the existing power development projects being divided between the NEA and the Independent Power Producers (IPP) however, the country still needs to increase its energy sector investments by

fourfold to utilize the domestic power capabilities and meet its energy targets (The World Bank, 2019, p. 9). The government should not only seek the expertise and financial support from the international organizations and agencies but it should also encourage the participation of the businesses and individuals within the country by targeting the domestic institutions and international private institutions. However, in order to attract these sources of finance, political stability needs to be maintained, investment policies need to be made lenient, proper regulation of the existing power plants need to be carried out in order to portray a promising environment for investments and high returns.

In the past years, there have also been cases where the government was unable to properly manage the investments in the energy sector and the proportion of the spending. The power sector of Nepal received annual investments of US$527 million from the year 2010 to 2017 but, more than 70 percent of the investment went into the hydropower generation projects (The World Bank, 2019, p. 10). Unlike other countries that have been exploring the production of energy from varied resources, despite having abundant natural resources, Nepal has been failing in exploring different possibilities and is highly fixed on developing the hydropower that is consuming a large amount of time and financial resources while giving minimal output over the years. In addition, there has been a case in Nepal where 50 percent of the total cost of a micro-hydropower and efficient cooking stove supply project was spent on capacity building (IEA, UDP, UNIDO, 2010, p. 36). Thus, although target development and training are essential, the government should ensure a proper distribution of its resources and spending while properly monitoring the ongoing projects.

VI.3 Recommendations for future research

At present, in the world, the rate of TBE use has decreased with the increase in the clean energy innovations. Therefore, the majority of the research focus on the sector has also been diverted to emerging technologies or green technologies. Furthermore, due to the modernization

of energy sources in most of the developed countries, the knowledge about the continuous use of traditional sources of energy is decreasing. Nevertheless, as the rate of energy poverty is still high in the world with people depending highly on TBEs (especially in the rural communities), it is essential to conduct more research on the subject matter.

The dependency on biomass is very high in Nepal but most of the studies related to energy in the country, explore hydropower and its possibilities or problems related to it. Although the research on hydropower is essential, it is important to increase the research on biomass (particularly TBEs) and its effects on health, environment and the overall development of the society, as to increase the awareness and focus on the subject matter. Furthermore, evaluating the existing living conditions based on the energy source used and the change in the living conditions after the adaptation of cleaner energy sources could bring interesting results. It would also contribute in filling the data gap on the subject matter and could lead to the exploration of the dynamics of energy poverty in Nepal.

In the case of the data collected for traditional and modern biomass use, it is included under the renewable sources of energy although traditional biomass can only be included under that umbrella if the trees that are cut down from the forest are being planted again which makes the data collection very tricky and difficult as it requires detailed information with desegregated figures to conduct effective and accurate evaluations (Goldemberg & Coelho, 2004, p. 712). Thus, planned and proper research should be conducted with detailed data collection over different time periods to examine the situation of biomass use throughout the country. In addition, in the case of Nepal, although there are many ministries and governmental institutions involved in the energy sector, due to the lack of updated and reliable data figures, it is difficult to understand the gravity of the situation in the rural areas. For example, while doing this study, the most reliable studies carried out on the socio-economic and demographic situations of Nepal was carried out in 2010-2011. Since the data is from almost 10 years back, I had to rely on

external sources like the data sets from ADB, WB and IEA to conduct my study about the overall energy situation and socio- economic condition of Nepal. Thus, I believe, detailed data collection and study is important as it would also assist in making better policy recommendations and would help in the planning of the renewable energy projects in different areas of Nepal that would ultimately help in eliminating energy poverty.

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APPENDICES

Appendix 1: Questionnaire used during the field study

Household Survey on Access to Energy and its Effect on Education and Health

1. Name:	2. Gender: M / F
3. Occupation:	4. Income: _____ Rs. /Month
5. House type: a. Strong (Brick/Cement) b. Average(Brick/Mud) c. Low(Bamboo/Mud)	
6. No. of rooms in the house:	7. No. of people living in a room: ___/___/___/___
8. No. of windows in the house:	9. Location of the kitchen: Outside / Inside
10. No. of windows in the kitchen:	11. Is the kitchen ventilated? Yes / No
12. Do you light mosquito coil in the house? Yes / No	13. Do you light incense in the house? Yes / No
14. Source of energy used for cooking: a. Gas_____% b. Kerosene_____% c. Biomass_____%	
15. You cook at home _____ times/ day	16. Cost of energy for cooking: _____ Rs. /Month
17. Source of light in the house: a. Electricity____% b. Kerosene lamp___% c. Others: _____%	
18. Electricity use: _____ hr./day	19. Cost of electricity: _____ Rs. /Month
20. Source of heating in the house: a. Electricity___% b. Kerosene lamp__% c. Coal___% d. Wood _____% e. Biomass_____%	
21. Number of children in the house: a. How many are boys? _____ b. How many of the boys go to school? _____ c. How many are girls? _____ d. How many of the girls go to school? _____ e. If they do not go to school, explain why? _____	
22. Education cost/child: _____ Rs./Month	23. Type of school they attend: Public / Private
24. Have your children had any health concerns in the past few months? If yes, explain.	
25. Have you had any health concerns in the past few months? If yes, explain.	
26. What vaccinations have your child/ children taken? (Write don't know if you don't know)	
27. How far is the health post/clinic/hospital that you visit? _____Km	
28. Did you visit any health center in the past 6 months? If yes, explain the reason and the cost.	
29. Does anyone smoke in the house? Yes / No a. If yes, since how often? _____times/day	
30. List your priorities from highest to lowest: Food/Electricity/Health/ Education/ Money 1. 4. 2. 5. 3.	*Any additional information:

Appendix 2: Nepal power generation related statistics

S.N.	Power Stations	Total Installed Capacity (MW)	Total No. of Units Installed	Actual Generation(MWhr)			Maximum Generation in a year till date/year (MWh)
				FY 2072/73 2015/2016 AD	FY 2073/74 2016/2017 AD	* FY 2074/75 2017/2018 AD	
1	Kaligandaki 'A'	144.00	3	750,842.00	842,149.00	865,075.00	929,983.00 (2071/72)
2	Middle Marsyangdi	70.00	2	435,558.76	454,651.62	437,286.87	457,318.09 (2071/72)
3	Marsyandi	69.00	3	441,736.60	465,305.50	447,490.30	483,928.20 (2052/53)
4	Kulekhani-I	60.00	2	71,356.00	73,402.00	62,131.00	249,680.00 (2056/57)
5	Kulekhani-II	32.00	2	36,055.35	37,795.13	31,754.10	122,757.00 (2056/57)
6	Trishuli	24.00	7	125,025.70	125,969.40	121,316.50	154,423.75 (2053/54)
7	Gandak	15.00	3	16,249.00	21,872.70	17,495.80	52,272.70 (2043/44)
8	Modi Khola	14.80	2	62,787.20	69,556.40	66,422.70	69,556.40 (2073/74)
9	Devighat	15.00	3	94,306.49	97,609.96	86,238.79	106,277.70 (2056/57)
10	Sunkoshi	10.05	3	35,994.20	46,190.70	55,050.50	66,383.10 (2068/69)
11	Ilam (Puwa Khola)	6.20	2	33,831.51	36,414.24	35,790.53	36,414.24 (2073/74)
12	Chatara	3.20	2	-	-	22.25	5,219.75 (2063/64)
13	Panauti	2.40	3	2,052.59	2,603.33	1,112.34	4,654.80 (2058/59)
14	Seti	1.50	3	10,996.74	8,044.86	10,186.74	11,616.19 (2067/68)
15	Fewa	1.00	4	1,664.77	1,467.69	1,911.68	3,919.47 (2034/35)
16	Sundarijal	0.64	2	4,293.95	4,490.73	4,332.29	4,530.26 (2071/72)
17	Pharping	0.50	2	1.93	0.88	-	48.65(2064/65)
	Total (Hydro)	**469.29**	**48**	**2,122,752.79**	**2,287,524.14**	**2,243,617.39**	-
18	Multifuel	39.00	6	-	26.66	15.78	86,215.07 (2055/56)
19	Hetauda Diesel	14.41	4+3	122.07	325.98	127.19	24,203.64 (2055/56)
	Total (Thermal)	**53.41**	**13**	**122.07**	**352.64**	**142.97**	-
	Grand Total	**522.70**	**61**	**2,122,874.85**	**2,287,876.78**	**2,243,760.35**	-

Note: ***Provisional figures subjected to final audit***
 # Metering problem

Source: NEA Annual Report FY 2017/2018 (p.43)

Appendix 3: Interview responses from the residents of the studied households

3.1. Why did you choose not to connect your house to the grid electricity supplied by the NEA?

"What is the point of getting electricity connection and paying all the basic charges that are so high? The power supplied through those lines is not constant. The government keeps cutting power. Before it was more because of load shedding so even the houses that had electricity lines, they kept paying money but they were using firewood just like us. Now, it still gets disconnected from time to time due to construction going on somewhere in the city or when there is lightning and rainfall or due to some other maintenance problem. We are happy that we use firewood and kerosene as there is a constant supply."

–Shiv Kumar Gupta from Keshalia Village works as a painter and has a monthly income of NRs.6000 (53.4 USD).

"My monthly cost of cooking, lighting and heating is NRs. 1500 (13.35 USD) which is half of my monthly income. Due to the high cost of food and vegetables and fuel, I cannot even send my boy and three girls to school. Using firewood and not getting connected to electricity is not a choice for us, it is the only way we can make ends meet."

- Baban Dev from Singhya Village works as a rickshaw puller and has a monthly income of NRs. 3000 (26.7USD).

"Wood has been used as a source of energy by my family and the entire village since generations. It has not been that long since the households in this village started using electricity. My family can live without electricity as we have been living this way since we were

born. At least with that money I can send my boy to school and pay NRs 700 for his monthly fees. I want him to live a better life so I would rather spend on his education. For me, health is the main priority and then comes education. My son recently suffered from pneumonia. That is when I realized, without a good health, all my investment in his education will go in vain. Even for me, without a good health, how can I earn?"

- Raju Kamat from Rajbansi village works as a sweeper and has a monthly income of Nrs. 3000 (26.7 USD).

3.2. Did you know that the daily use of traditional biomass increases the risk of respiratory problems and even death? Did you know that it is harmful for the environment too?

"My house is connected to the electricity but we still use firewood for cooking because it is cheaper for us. This has been a practice that has been carried out since generations. I did not know that burning wood has such effects. We use it everyday in our house and I don't seem to have any problem. I have 3 boys and 2 girls that do not go to school and spend most of their time at home or helping me with my work but I don't know if they have such kinds of health problems."

- Baiju Bhagat from Amartol Village works as a laborer and farmer and has a monthly income of about Nrs.5000 (44.5 USD).

"We completely rely on firewood for our daily cooking and heating. We use kerosene to light our house. I am sending my son to public school and paying NRs.800 (7.12 USD) monthly for his fees. Electricity is my main priority as I think it will help my son study well and will help me while cooking too. Biomass use might have such negative effects that I don't know of but that is the only source we can afford for now. I hope nothing happens to my son."

- Bimala Bhagat from Keshaliya village works as a street sweeper and she has a monthly income of NRs. 4000 (35.6 USD).

"We have connection to the LPG gas in our home but mostly use firewood for cooking because it has been our practice since a long time. No, I had no idea about the health impacts of biomass use. I knew that the firewood is coming from the jungle around here so it is causing deforestation but I do not know any thing about global warming or air pollution."

- Munna Sahani from Japnpath village works as a foreign worker and has a monthly income of NRs. 30, 000 (267 USD).

"I have my kitchen outside but it is not because I knew about the effect of burning wood on our health. We decided to have it outside so that the smell of the smoke does not stay inside the house as I keep getting headaches. We also wanted more room inside the house. We fully rely on wood for our cooking so I knew a lot of trees are probably cut down because of people like us but we do not have any other choice."

- Moti Ram Karna from Dhat village works as a laborer in the jute factory of Biratnagar and has a monthly income of Nrs. 8000 (71.2 USD).

"I have two girls and a boy that help around at home and are unable to go to school because of our poor financial condition. We use firewood and bamboo daily for our cooking and we use kerosene for our lighting. Firewood is all we can afford so we use it. The kitchen is inside the house so the smoke is a bit suffocating at times but we are used to it. I did not know about any effect of smoke on our health. I am okay although I grew up in a similar environment."

- Nagesh Dev from Keshaliya ward works as a laborer and has a monthly income of Nrs. 4000 (35.6 USD).