Exploring Mechanisms to Promote Renewable Fuel Strategies for Rural Area

Case of Ratibad Village Cluster, Bhopal, Madhya Pradesh

Masters of Planning
(Environmental Planning)

By:
Preetam Karmakar
2015MEP006

Under Guidance of
Dr. Kakoli Saha

Co-Guide
Ar. Prashanti Rao

School of Planning and Architecture, Bhopal

May 2017

Department of Planning

School of Planning and Architecture, Bhopal

Declaration

I **Preetam Karmakar**, Scholar No. **2015MEP006** hereby declare that the thesis titled "**Exploring Mechanisms for renewable fuel strategies in Rural Areas**" submitted by me in partial fulfilment for the award of Master of Planning (Environmental Planning) in School of Planning and Architecture, Bhopal, India is a record of bonafide work carried out by me. The matter embodied in this thesis has not been submitted to any other university or institute for award of any degree or diploma.

Preetam Karmakar

Certificate

This is to certify that the declaration of **Preetam Karmakar** is true to the best of my knowledge and that the student has worked for one semester in preparing this thesis.

Ar. Prashanti Rao
Thesis Co-Guide

Dr. Kakoli Saha
Thesis Guide

Recommended

Prof. Nikhil Mandal
Head, Planning Department

Prof. Ajay Khare
Dean, Academic Affairs

Approved

External Examiners
May 2017, Bhopal

Acknowledgement

Prima facea, I am grateful to the God for the good health and wellbeing that were necessary to complete this research.

I am grateful to **Dr. Kakoli Saha**, Assistant Professor, Department of Planning. I am extremely thankful and indebted to him for sharing expertise, sincere and valuable guidance and encouragement extended to me.

I am grateful to **Ar. Prashanti Rao**. I am extremely thankful and indebted to him for sharing expertise and sincere guidance. I would like to thank him for providing me with all the necessary facilities for the research.

I am grateful to **Dr. Rama Umesh Pandey**, Assistant Professor and thesis coordinator, Department of Planning. I am thankful to him for providing guidance and necessary inputs in the thesis which has helped me in improving the study at all stages.

I am also grateful to **Dr. Kshama Puntambekar**, Assistant Professor, Department of Planning. I am thankful to them for providing me much required guidance during the middle stage of the thesis.

I take this opportunity to express gratitude Head of Department, Department of Planning, **Dr. Nikhil Rnajan Mandal**; and all of the faculty members of Department of Planning and Architecture for their help and support.

At last I would like thank my parents **Lt. Sadhan Chandra Karmakar** and **Mrs. Jayanti Rani Karnarkar**, for the unceasing encouragement, support and attention.

I also place on record, my sense of gratitude to one and all, who directly or indirectly, have lent their hand in this venture especially **Heena, Madhuri, Mrunmayi, Abhilash, Atray, Bijay, Parikshit.**

Preetam Karmakar

Abstract

In today's context Newton's third law which says "every action has an equal and opposite reaction" seems to be realistic. Climate change is also one of such reaction of which has been observed due to increasing greenhouse gases in atmosphere. The largest share of greenhouse gases emissions is through industrial sector (25%) followed by Transportation sector (16%). Carbon-di-oxide is one of the abandoned greenhouse gas and 65% of its emissions is occur due to burning of fossil fuel. Huge amount of fossil fuel is used for production of energy. Coal (Non-Renewable) is the main raw fuel used for production of power generation. Energy in present context has become an essential component for economic activity and day to day life. Although, apart from coal there are many other resources which are being used for power generation. Considering energy as a commodity, distribution charges is proportional to distribution area and it is proportional to distribution losses. However, India do have sufficient infrastructure to supply energy to every precinct but due to dependency on limited non-renewable energy sources it is unable to cater the whole demand. Hence it is essential to identify renewable and clean energy sources to fill those gaps. This is also reflected and observed through continuous load shading in different areas at different time. In purview of this, Government of India has also promised to have huge renewable energy source for production of energy by 2022. India comprises of 97% area and 68.3% population under rural characteristic. Electrification charges are also comparatively more than that of urban area. Hence local generation will be more beneficial. Therefore there is a need to develop a mechanism for generation of energy based on renewable and clean fuel locally available in rural areas. In this purview Ratibad Village Cluster has been identified for detailed study. The area is rich in cattle population and agricultural farm-land as well. The study area also has a potential of generating 5.6kW/day/m^2 from solar energy. This thesis is an attempt to develop a mechanism or framework to use locally available clean fuel mechanism to strengthen the local power generation and meet the demand through a sustainable process.

Key words: Fuel Shifting, Renewable energy sources, Rural area

सार

आज के संदर्भ में न्यूटन के तीसरे कानून में कहा गया "हर कार्रवाई में एक समान और विपरीत प्रतिक्रिया होती है" यथार्थवादी लगता है. वातावरण में बढ़ती ग्रीनहाउस गैसों के कारण जलवायु परिवर्तन भी ऐसी प्रतिक्रिया में से एक है। ग्रीनहाउस गैसों के उत्सर्जन का सबसे बड़ा हिस्सा औद्योगिक क्षेत्र के माध्यम से होता है (25%) इसके बाद परिवहन क्षेत्र (16%)। जीवाश्म ईंधन के जलने के कारण कार्बन-डाई-ऑक्साइड निर्भित होती है जो ग्रीनहाउस गैस में से एक है। ऊर्जा के उत्पादन के लिए जीवाश्म ईंधन का भारी मात्रा में उपयोग किया जाता है। कोयला (गैर-नवीकरणीय) मुख्य कच्चा ईंधन है जो बिजली के उत्पादन के लिए इस्तेमाल किया जाता है। वर्तमान संदर्भ में ऊर्जा आर्थिक गतिविधि और दिन-प्रतिदिन जीवन के लिए एक आवश्यक घटक बन गई है। हालांकि, कोयले के अलावा कई अन्य संसाधन हैं जिनका उपयोग विद्युत उत्पादन के लिए किया जा रहा है। एक वस्तु के रूप में ऊर्जा को ध्यान में रखते हुए, वितरण शुल्क एवं वितरण क्षेत्र के लिए आनुपातिक होता है और यह वितरण हानियों के लिए आनुपातिक होता है। भारत में हर क्षेत्र में ऊर्जा की आपूर्ति करने के लिए पर्याप्त बुनियादी ढांचा है लेकिन सीमित गैर-अक्षय ऊर्जा स्रोतों पर निर्भरता के कारण यह समस्त मांग को पूरा करने में असमर्थ है। इसलिए उन अंतराल को भरने के लिए अक्षय और स्वच्छ ऊर्जा स्रोतों की पहचान करना आवश्यक है। यह अलग-अलग समय पर विभिन्न क्षेत्रों में निरंतर भार छायांकन के माध्यम से भी परिलक्षित होता है और देखा जाता है। इसके दायरे में, भारत सरकार ने 2022 तक ऊर्जा के उत्पादन के लिए विशाल नवीकरणीय ऊर्जा स्रोत होने का भी वादा किया है। भारत में 97% क्षेत्र और 68.3% जनसंख्या ग्रामीण विशेषता के अंतर्गत शामिल है। विद्युतीकरण शुल्क शहरी क्षेत्र की अपेक्षा तुलनात्मक रूप से अधिक हैं। इसलिए स्थानीय पीढ़ी अधिक फायदेमंद होगी। अतः ग्रामीण क्षेत्रों में स्थानीय स्तर पर उपलब्ध अक्षय और स्वच्छ ईंधन पर आधारित ऊर्जा पैदा करने के लिए एक क्रियाविधि विकसित करने की आवश्यकता है। इस कार्यविधि में विस्तृत अध्ययन के लिए रतीबाड ग्राम समूह की पहचान की गई है। यह क्षेत्र मवेशी आबादी और कृषि खेत-भूमि के रूप में अच्छी तरह से समृद्ध है। अध्ययन क्षेत्र में सौर ऊर्जा से 5.6kW / day / m2 पैदा करने की क्षमता है। यह शोध प्रबंध स्थानीय बिजली उत्पादन को मजबूत करने और एक स्थायी प्रक्रिया के माध्यम से मांग को पूरा करने के लिए है। स्थानीय रूप से उपलब्ध स्वच्छ ईंधन क्रियाविधि का उपयोग करने के लिए क्रियाविधि या ढांचा विकसित करने का एक प्रयास किया गया है ।

Contents

List of Tables

List of Figures

List of Equations

List of Annexure

Abbreviations

A	-	Current
ACU	-	Adult Cattle Unit
Ah	-	Amp-Hour
BkWh	-	Billion-Kilowatt Hour
BTU	-	British Thermal Units
CHP	-	Combined Heat and Power
CSP	-	Concentrated Solar Power
DNI	-	Direct Normal Irradiance
GHG	-	Greenhouse Gas
GHI	-	Global Horizontal Irradiance
GoI	-	Government of India
GW	-	Giga Watt
HH	-	Household
IO	-	Input-Output
IPCC	-	Intergovernmental Panel on Climate Change
IREDA	-	Indian Renewable Energy Development Agency
kW	-	Kilo-watt
kWh	-	Kilo-watt Hour
LED	-	Light Emitting Diode
MNRE	-	Ministry of New and Renewable Energy
MPSEDC	-	Madhya Pradesh State Electricity Distribution Centre
MW	-	Mega-watt

MWh	-	Megawatt Hour
MV	-	Mega-volts
PV	-	Photovoltaic
RPM	-	Rotations per minute
SHC	-	Solar Heating and Cooling
SI	-	System International of units
V	-	Electrical Voltage
W	-	Watts

Chapter 1. Introduction

This chapter will explain the background study and idea behind processing this research topic as thesis for Masters of Planning, Environmental Planning. This will also explain the aim of this study and objectives behind achieving the aim with methodology. Discussion will go till the expected outcomes of this study. Following chapters will continue the analysis of this study.

1.1 Background

The recent concept emerged in India today is the Smart City and Smart Villages. Typically this means a self-sustaining settlement which responds to the activities done on it. (Smart Cities, 2016). The idea of this study came through the study of Carbon Emission. If we see the share of emission with respect to sectors, electricity generation is the one which has the biggest share of 40% followed by other sectors as Transportation with 34%, Industrial with 16% rest are by residential, commercial and other sectors (Center for Climate and Energy Solutions, 2013). Greenhouse-Gas *[here after GHG]* effect is a major component for climate change. The share of CO_2 is 77% within which 65% from fossil fuel and industrial process and rest 11% from forestry and other land use (IPCC, 2014). In terms of Global Emissions by Economic sector, Electricity and Heat Production is about 25% and Agriculture, forestry and other land use has a share of 24% followed by Industry, Transportation, Other Energy and Buildings (IPCC, 2014).

Hence, it says that Energy sector is the one which has the largest share in GHGs emission, but what is the actual demand of energy for present condition and also for future. A study done by TARU in India states that the present consumption of energy is about 778 BkWh in annual basis which is expected to increase to 2280 BkWh by the year 2022 (TARU, 2016). However, India being the seventh biggest country, has the second biggest capacity of generating solar energy of around 6-7 kW per Acre (IBGeography-Lancaster, 2015). Having that much capacity of generation, India only generates about 43GW of energy (Government of India, 2015). This revels that the power consumption will increase twice in coming years. Hence, there is a need of finding different methods of generating power to cater the upcoming demand of energy.

However, new technology which is coming these days, are much more energy efficient. This energy efficiency can be determined according to the star rating given with the manual of the electrical device. Following Figure 1 and Figure 2 shows some examples to identify the energy savings.

Figure 1: Energy Savings Certified Logo

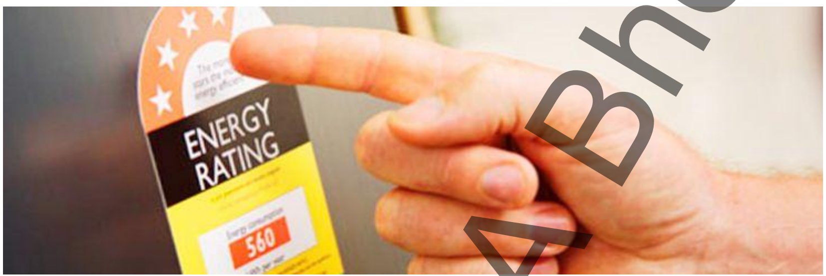

Figure 2: Star Ratting (Example)

Hence, there is a possibility that the number of devices can increase but the consumption do not increase in the same rate. For an example, previously household lighting provided using filament bulbs, which consumed around 40W on an average, but at present an LED bulb (on an average of 7-10W), which can give the same amount of light while consuming less power. It is also true that the advance technology will cost more.

Swapping of electrical devices to save more energy needs economy. However, economic condition of urban areas is much better in comparison of rural area. However, India's almost 97% of area is rural. This share of rural area holds 68.9% of rural population with nearly 80,888,766 households according to year 2011 (Census of India, 2011). This was about the consumption of electricity, but if we see the cooking fuel, than among the rural households 62% still uses firewood as major fuel for cooking and about 43% of them still uses Kerosene for lighting.

Presently India uses a system of point source generation and distribution to other area, which means the source of the commodity is a point, or certain geographical area, and supplied to other places. According, to the laws of physics, loss of commodity is proportional to the area it is being supplied and it is proportional to the charges invested on the system. Also in our traditional system, Electricity transmission is done in different steps. This intends the electricity to be stepped down and up depending on the consumer. One of the important attributes to be considered is that the transformer's output power is not the same as the input, rather it is little less that the input. Hence it is justified that the electricity and fuel supply to the rural areas if India is much more expensive compared to what is for urban area. Rural Electrification charges is about Rs46 Billion only and for urban it is about Rs26 Billion (Energy Atlas, 2005).

Fuels that we use these days are either fossil fuels or the basic renewable energy sources like solar and wind. Hydro energy is also a renewable energy source of energy. However, construction of hydro power plant changes the native ecosystem as the reservoir cover a huge area of land and changes the ecosystem which was there when it was not under water

Therefore, there might be a need of local power generation for rural areas, to reduce energy losses and price. There are many studies done on this subject as well as several examples are there where this kind of initiatives has been taken,but most of them are failure. This also means that the traditional energy resources may change depending upon the analysis. This step can also be called as *fuel shifting*, because this study is trying to find out alternate energy sources to replace the traditional energy sources. Therefore this study has following aim.

1.2 Aim

This study is aimed to find the applicability of renewable and clean energy sources for rural areas using local resources by exploring different mechanisms.

1.3 Objectives

To achieve the above aim, following objectives are framed:

1. To understand the context of energy sources and harnessing technologies for fuel shifting.
2. To explore the consumption pattern of energy sources in the study area.
3. To identify the renewable and clean energy sources in study area and analyse the relation between demand and supply

4. To propose suitable mechanism for replacing non renewable energy sources with new and renewable and clean energy sources in the study area.

1.4 Scope

The scope of this study is to find out the possibility of having self-sustained rural area in terms of energy. This will include the energy consumption of energy sources and finding other sources to reduce the load at national electricity grid supply for electricity and reduce the load on fossil fuel usage.

1.5 Limitation

As there are several types of energy production as well as consumption, however, this study will consider only two types of consumption which are fuel for cooking and source of lighting at residential level only.

1.6 Methodology

To achieve the aim, different objectives have different set of works to perform and have different output. The sequence is as follows:

1. **Objective 1** – Background study is done to prove that the study is needed. This also explains the present status of energy usage by different sectors, extent of energy consumption, fuels and their efficiency and pollution. This will also find out the best techniques of harnessing renewable energy sources. (Chapter 1 and 2)
2. **Objective 2** – Here a study area is identified and assessed the pattern of energy consumption in terms of cooking and lighting. Public perception survey is also done to identify the need of people. (Chapter 3)
3. **Objective 3** – Population projection is also done for estimation of future demand. Potential is also assessed to identify the extent of generation of energy resource and how much the demand can be coped. (Chapter 3)
4. **Objective 4** – A suitable framework to utilize the local resources to address the energy demand of the local population. Details of feasibility of one aspect of energy supply. (Chapter 4)

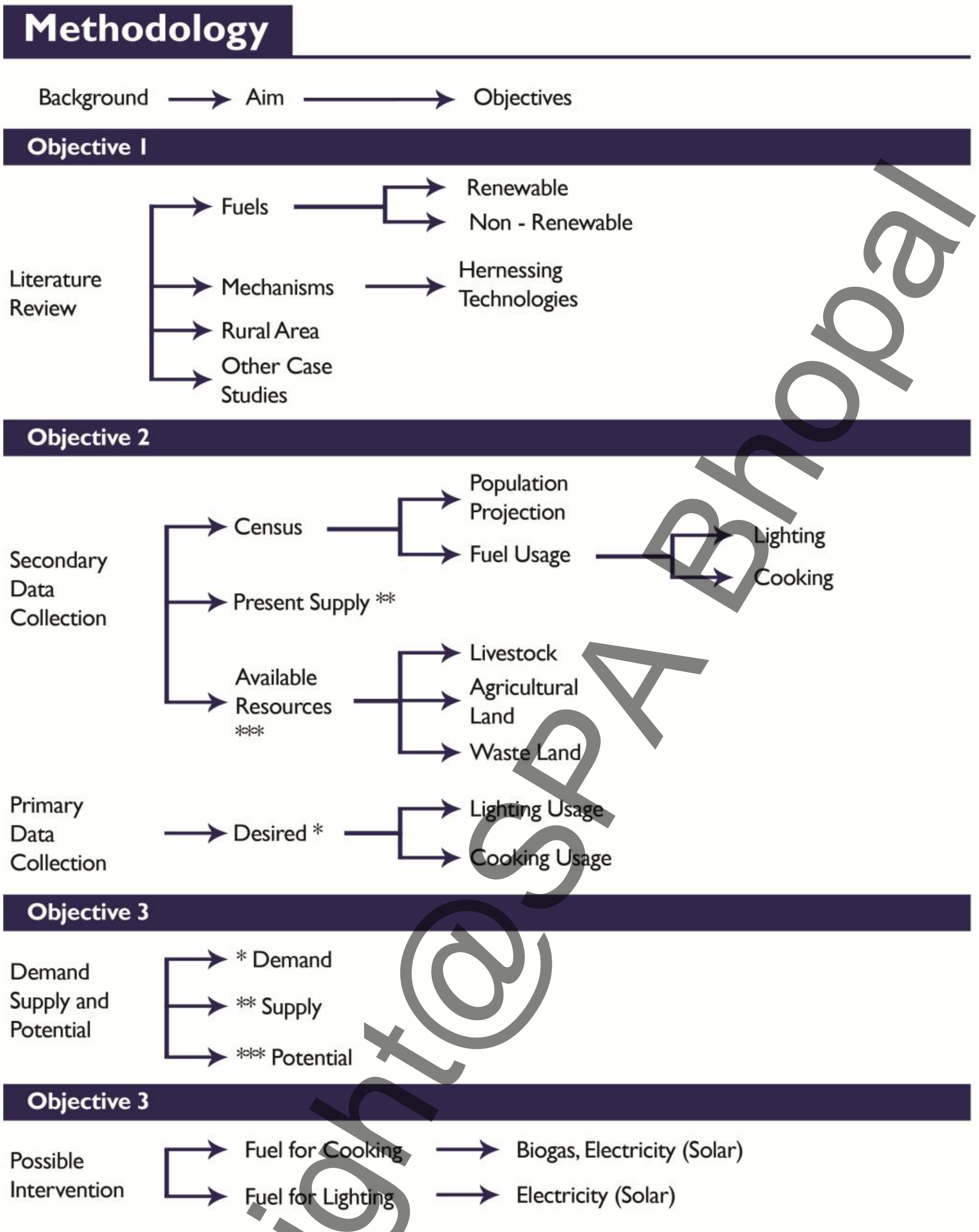

Figure 3: Methodology

1.7 Expected outcomes

As discussed earlier, this study intends to find out the possibility of application of renewable and clean energy sources especially for rural areas in India to cater the energy demand while reducing load in national resource supply system. It is presumed that the supply of energy will not be fully self-sustainable at the first place, rather it may be a phase wise project. The expected outcome will be a framework which will explain the amount of different resources being used for different purposes.

Chapter 2. Literature Review

This chapter intends to explain the theories and concepts behind the study to understand in detail about energy and it's relation with nature, human and technology. This chapter also tries to explain about the goals and strategies made by central and state government. It also explains traditional power production and supply system, energy harnessing techniques status of biogas and solar energy production and analysing local sources.

2.1 Energy sources

Energy is explained as the capability of performing any activity at certain condition. This can be of many types and forms, such as Kinetic Energy, Mechanical Energy, Electrical Energy, Chemical Energy etc. Energy can neither be created nor be destroyed, it can only be transformed from one form to other. However, it is a known notion that Sun is the ultimate source for all kind of energy on earth but, due to technology and natural activity have made us to use other sources of energy. Few of these sources have took millions of years to produce. This types of energy sources are globally classified in two different types which are as follows:

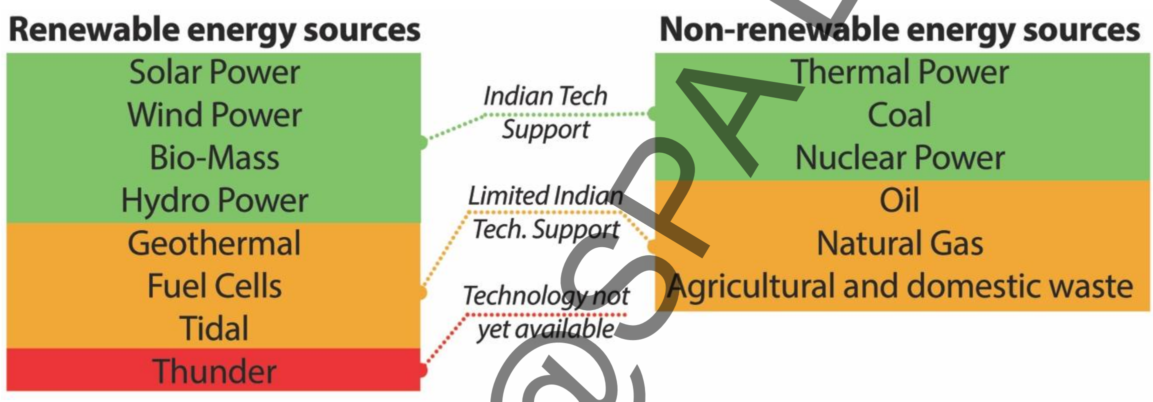

Figure 4: Types of energy sources

1. **Non-Renewable Energy Sources** – These are the energy sources which can be used only once so they are known as "Non-Re-new-able" energy resources. Fossil fuels are one example of non-renewable energy sources. These fuels are majorly hydro carbons, which releases Carbon-Di-Oxide after burning. Nuclear energy is also considered to be cleaner than fossil fuel, but the radiation emitted from those elements are much more harmful for human health. Hence, of nuclear waste is disposed with proper care
2. **Renewable Energy Sources** – these are sources which can be used again and again. These can also be defined as those fuels which can be regenerated within human life time. These are also one of the cleanest energy sources. Although few of the energy sources do have some emissions but considered as cleanest because, those emission cannot be stopped irrespective to use, hence its beneficial for use rather than keeping it unused.

2.2 Energy's relation with quality of life

Energy is one secondary need of human being for living. Almost everywhere we use some kind of energy to perform certain kind of work. The definition of energy is itself says that the capacity of performing any kind of activity which involves motion. In some places this motions are visible and some places it is not. For example, glowing of light needs energy, but we do not see any kind movement. However, lighting involves movement of atoms and electrons to create certain frequency which is visible by human eye. Another example is for this is working of fan, where you can see the movement of blades which circulates the air. Similar thing happens with cooking also and any other activity too. Importance of energy can be classified in five different ways as follows (TARU, 2016):

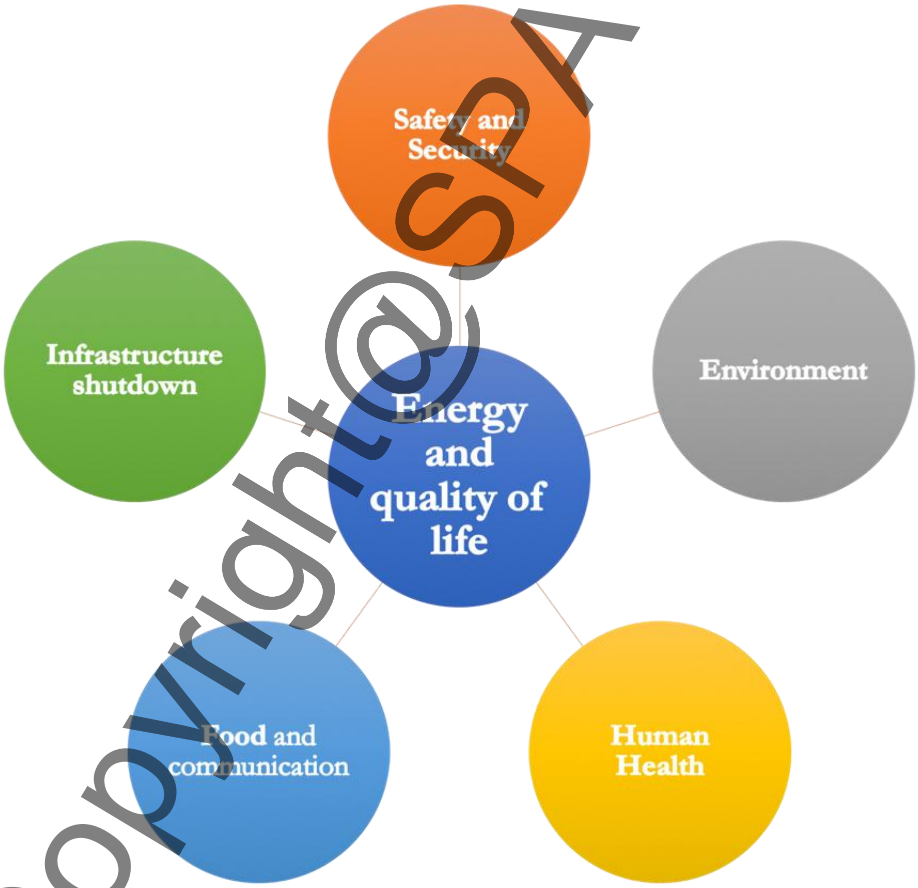

Figure 5: Energy's Relation with quality of life

1. **Food and Communication** – energy is required for cooking food. This involves heat or wave energy of particles to cook food. However, Indian foods are generally cooked using fire. Energy is also necessary for maintaining the quality of food, like cold storage and house refrigerators

and many others. It is also known that all kind of electrical devices needs electrical power to run. Communication devices are also one important support system for our living. These devices also run using electricity. Another kind of communication devices are the transport system which runs in petrol and high speed diesel. Vehicle uses fuel combustion process to generation motion. Hence communication also needs energy to run.

2. **Environment** – although, humans are not capable to control the environment of globe, but they are equipped to control the environment within individual buildings for living comfort and productivity. However, human activities can affect earth's environmental condition. Climate change is one example of environment getting hampered.
3. **Safety and Security** – either we consider macro or micro, security is necessary to protect assets and safety is necessary to protect humans from any king of harm. There are various systems which cross checks the presence of every element thousands of times per second. Safety should be considered in buildings, road, streets, vehicles, and virtually any things which is a threat to humans. Lighting is one major safety parameter for both inside and outside building.
4. **Human Health** – parameters like temperature, comfort, education, food, air quality, are few which is necessary to keep humans healthy. All the systems which control these parameters need energy to run. In case of any kind of accident, emergency service is very handy to handle human health for certain period of time, which again needs energy to run. Present Hospitals are one big example which drinks energy to keep humans heal and keep them healthy afterwards.
5. **Infrastructure** – above every aspect is supported with infrastructure which keeps them connected and helps run them adequately. However, energy is also needed to keep the infrastructure running. Things like road signals, street lighting, and communication network needs continuous energy to keep running. This is not only for urban area; it is also same for rural area.

Considering the energy usage for productivity, and productivity is necessary to have economic growth (Tiwari, 2015). According to present technology, energy is produced using fossil fuels, which contributes to Carbon emission. Hence economic growth is proportional to energy consumption, and to cater that demand, energy production will be more, which is again proportional to carbon emission. Hence, economic growth is directly proportional to carbon emission, and contributes to GHG emissions.

2.3 Anthropogenic GHG emissions

Transportation is a major contributor for air pollution and followed by industries with mainly by the power generation industries. Discussing about the energy consumption by human, it is nearly 3.7 Gigajoules per annum (Trend in consumption of and production of energy, 1999). Indian economy is growing day by day. More economic growth needs more productivity and activities to be performed in the same amount of time. This increase amount of productivity needs more energy consumption as well. Hence, economic growth and energy consumption are directly proportional to each other. According to past technology, more energy generation means more fuel used and hence leads to more carbon emission (Tiwari, 2015), and more over it is also assumed that the carbon emission is directly proportional to the resource use (Shah, Humans and energy consumption, 2015). As the losses are more in distribution, losses are also there in usage as well as conversion/transformation of energy from one form to other, which also increases the demand and this can be mitigated by at least efficient use of energy (TARU, 2016). More of carbon emission and less too might create issue for living environment. However, sufficient energy is also required to perform activities. This energy consumption is both in terms of electricity and in terms of cooking because human body also function in the same manner which is, for more work more food is needed, or soon a person may run out of strength and health issues.

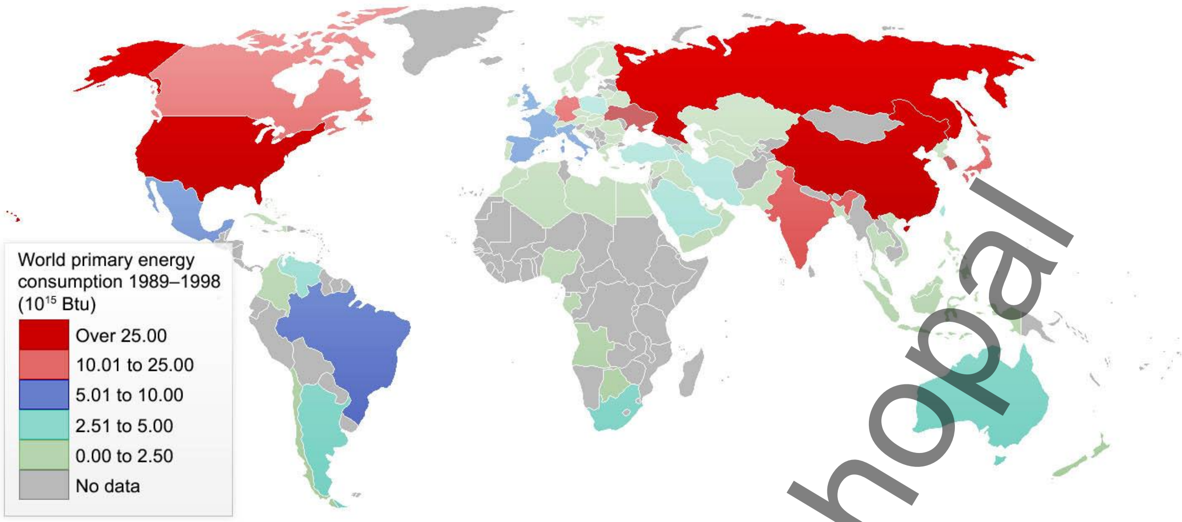

Figure 6: Worldwide primary energy consumption

Now the improving technology have gave us different Many other cases came on using cleaner fuel for cooking in local areas. Government has proposed many bio gas plants for provision of cooking fuel in rural areas. Burning of coal is much more carbon based product and is used in huge amount for power generation in India as well as for cooking. Energy has a direct relation with human quality of life in different aspects. Energy is important for safety and security, because it is needed for adequate lighting at night time in buildings and street as well, also to run surveillance equipment. Energy is also dependent on environment because major part of energy at present comes from fossil fuels, hence more of fuel use will surely affect the environment.

This explains mainly the production of electricity, but, if we consider the fuel for cooking in different places of India in two different areas, one being urban area and other being rural area.

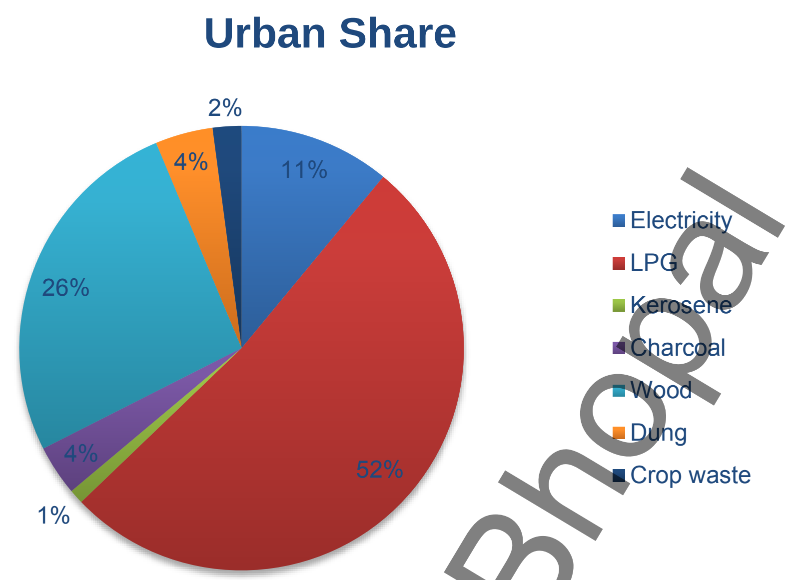

Figure 7: Share of fuels being used in urban areas

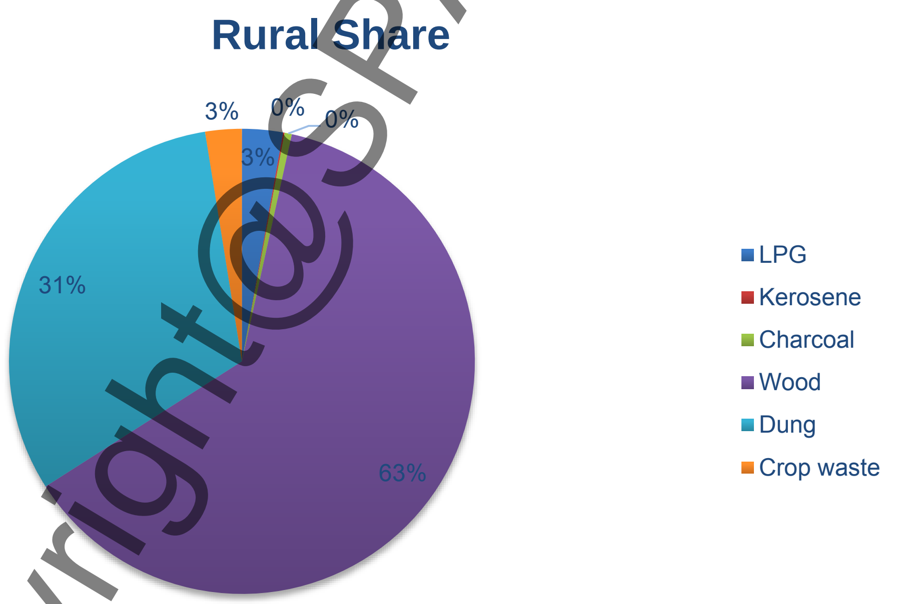

Figure 8: Share of fuel being consumed in rural areas

In Global anthropogenic Green-House-Gases (GHG) emission Energy has the biggest share. Following Figure 9 shows the share of GHG emission through various sectors, and also the share of gasses within that.

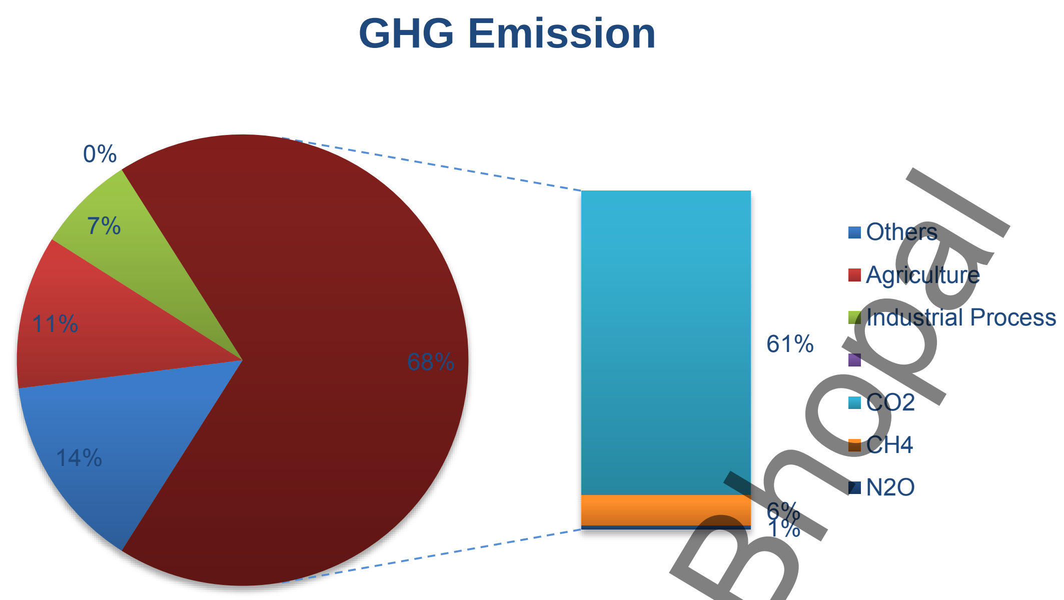

Figure 9: GHG Emissions

In the above figure, others include large scale biomass burning, post-burning, decay, peat, indirect N_2O emission from non-agricultural emission of NO_X and NH_3, Waste and solvent use (IEA estimates for CO2 for fuel combustion and EDGAR 4.3.0/4.2 FT 2010)

2.4 Fuels

Before going to the characteristics of fuels for fuel shifting, it is very much necessary to know that how much fuel is being used to generate a unit energy. In following Figure 10 one can understand the quantity of fuel which is required to generate the same amount of energy. Here the we can perfectly see that chemically active material (generally heavy metals found in lower layers of periodic table) do have large amount of energy stored in them compared to other fossil fuels. This is because the number of protons and neutrons an atom has, and because of huge in number it is hard for the nucleus to control the outer layer of electrons and so these are reactive material. This nature of atoms is used to generate energy. Just for an example; previous US battle ship used to have liquid fuel (High Speed Diesel/ HSD), which can give a maximum run time of about 7-8 months. However, the new ship uses uranium as its primary fuel which gives a minimum run time of about 25 years, and it also allows the ship to have more equipment on-board due to huge reduction in space (Megastructures – Discovery, 2012)

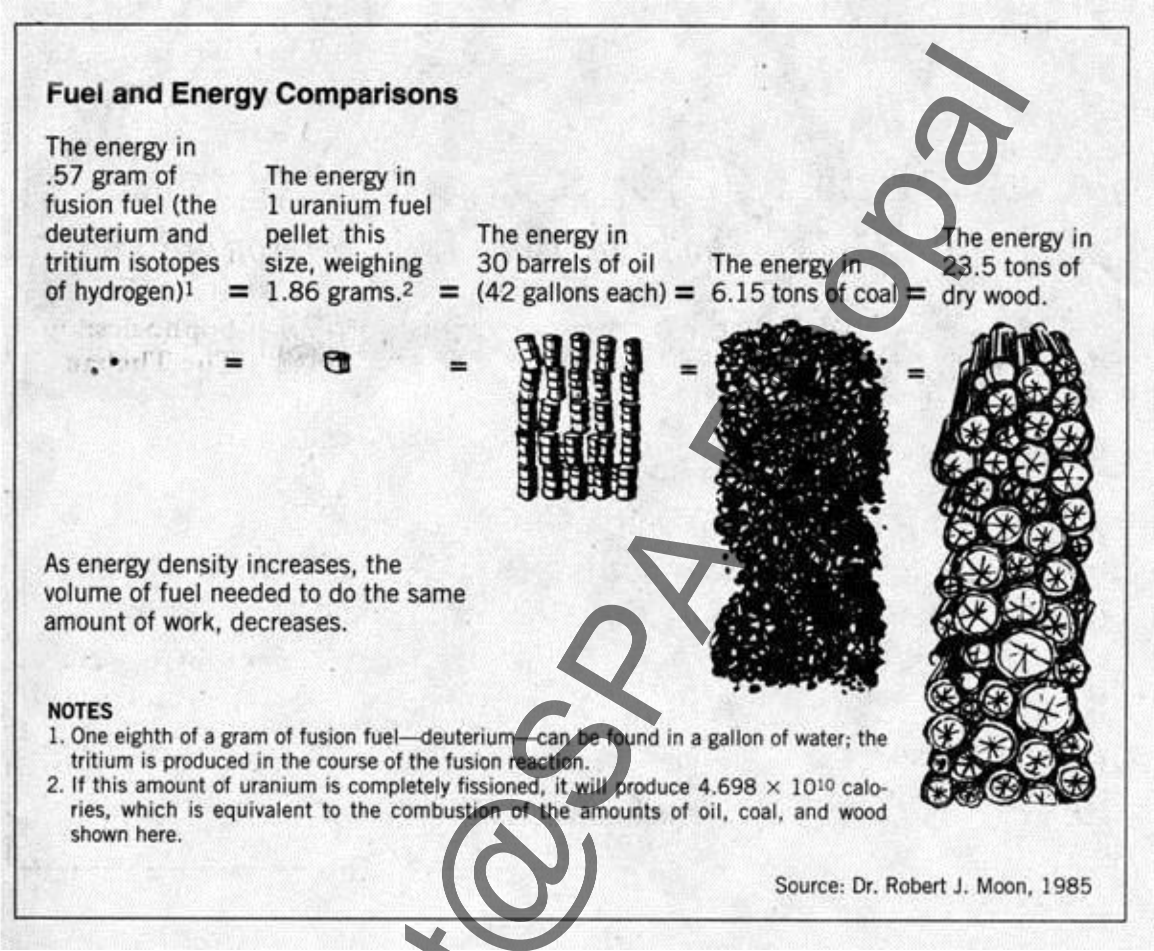

Figure 10: Typical comparison of fuel to generate equal amount of energy

We know that all types of fuels which we know about, cannot be used in every use. Whereas, following Table 1 shows a detailed comparison of different types of fuels being used in different types of activities. This usage of fuels are extracted from different literature, and have been filtered for better understanding at a glance.

Table 1: Fuel usage

Fuels	Uses					
	Cooking	Lighting	Electricity	Transport	Classified	Other
Anthracite Coal	✓		✓			
Bituminous Coal (Coking Coal)	✓		✓			
Blast Furnace Gas			✓			
Bunker C			✓	✓	✓	
Crude Oil		✓	✓	✓		✓
Diesel			✓	✓		
Ethanol					✓	
Gasoline				✓		
Hydrogen				✓	✓	
Jet A1				✓	✓	
Kerosene	✓	✓	✓	✓		
Lignite (Soft Coal)	✓		✓			
Lithium Ion Battery			✓	✓		
LNG/CNG				✓		
LPG	✓			✓		✓
Methane	✓		✓	✓	✓	
Methanol						✓
Municipal Waste			✓			
Natural Gas	✓	✓		✓	✓	
Peat	✓		✓	✓		
Propane					✓	
Water			✓			
Wood	✓	✓				

Note that among this fuels, only lithium ion cells can provide energy on the go, whereas others needs certain particular equipment to extract energy from them. Although other fuels depending upon the usage, they can be used directly, like for cooking, wood and coal can directly be used, if one only use the mechanism of radiation[1] technique for energy transfer.

Hence, it is clear that different fuels are used in different activities, because every activity does not need the same amount of energy outlet and that also in the same flow. Hence, this is also clear that the fuels do not have the same king of energy output as well as emission. However in case of replacing fuel, it is also necessary to take in attribute the mass density of fuel because every fuel of same volume do not have the same mass. Similarly the CO_2 emission per unit energy generation is also not same. Hence, it might present give a fair comparison if we compare all these fuels, in four different parameters being, Mass Density,

[1]Note: Heat transfer are of three types, conduction, convection and radiation

Specific Density[2], Energy Density[3], Carbon-di-oxide generation per unit energy output. Note: many of the fuel's output is globally present in form of mega-joules, which are converted to same unit in Kilo-Watt-Hour using standard comparison ratio. Following *Figure 11*, *Figure 12*, *Figure 13* and *Figure 14* shows the values of fuels which are taken in this study. Among this fuels, Oil shale is a kind of fine grain sedimentary rock from which oil can be extracted.

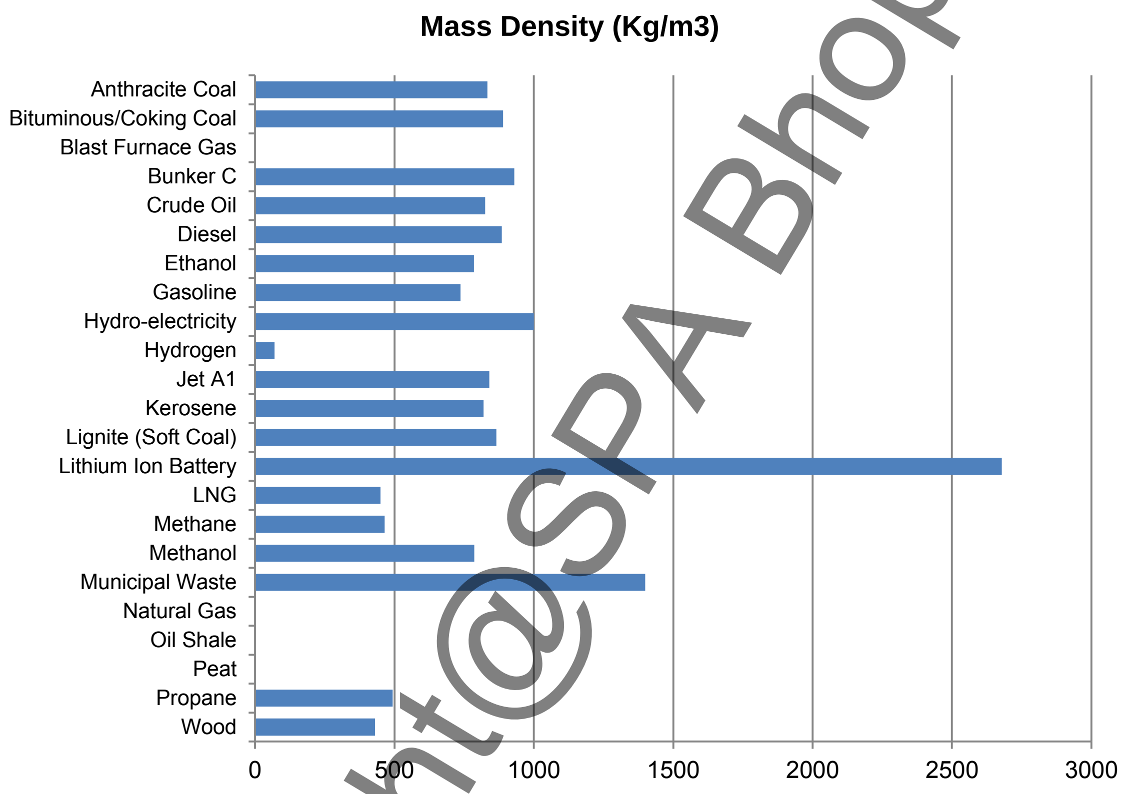

Figure 11: Mass density of fuels

[2]Energy output calculated per unit mass of the fuel. This is a mathematical value and losses are not included.
[3]Energy output calculated per unit volume of the fuel. This is much more accurate and includes fait share of energy loss too.

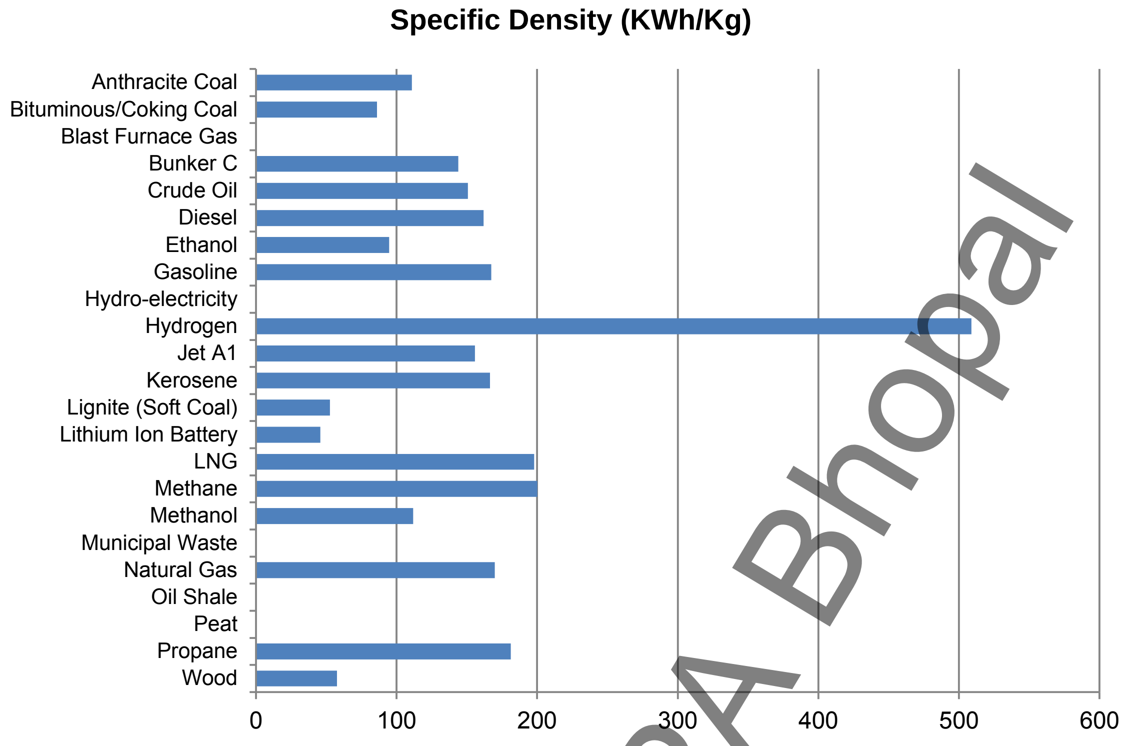

Figure 12: Specific Density of fuels

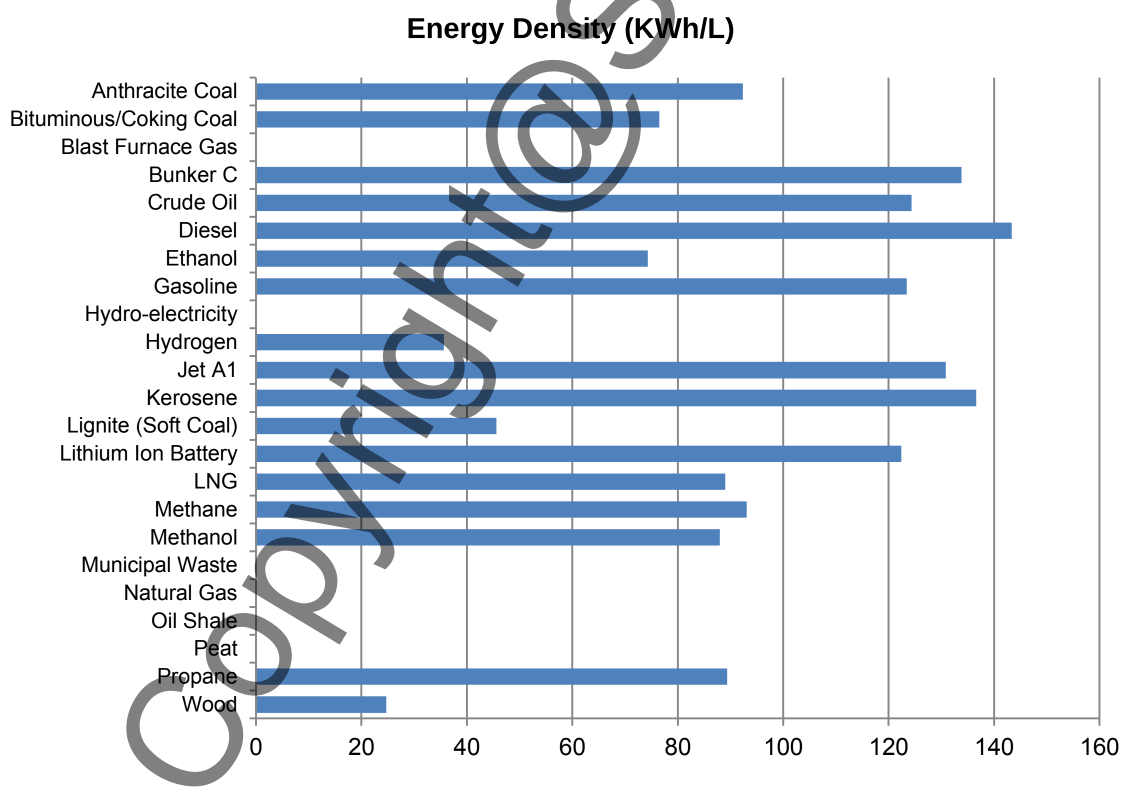

Figure 13: Energy density for all fuels

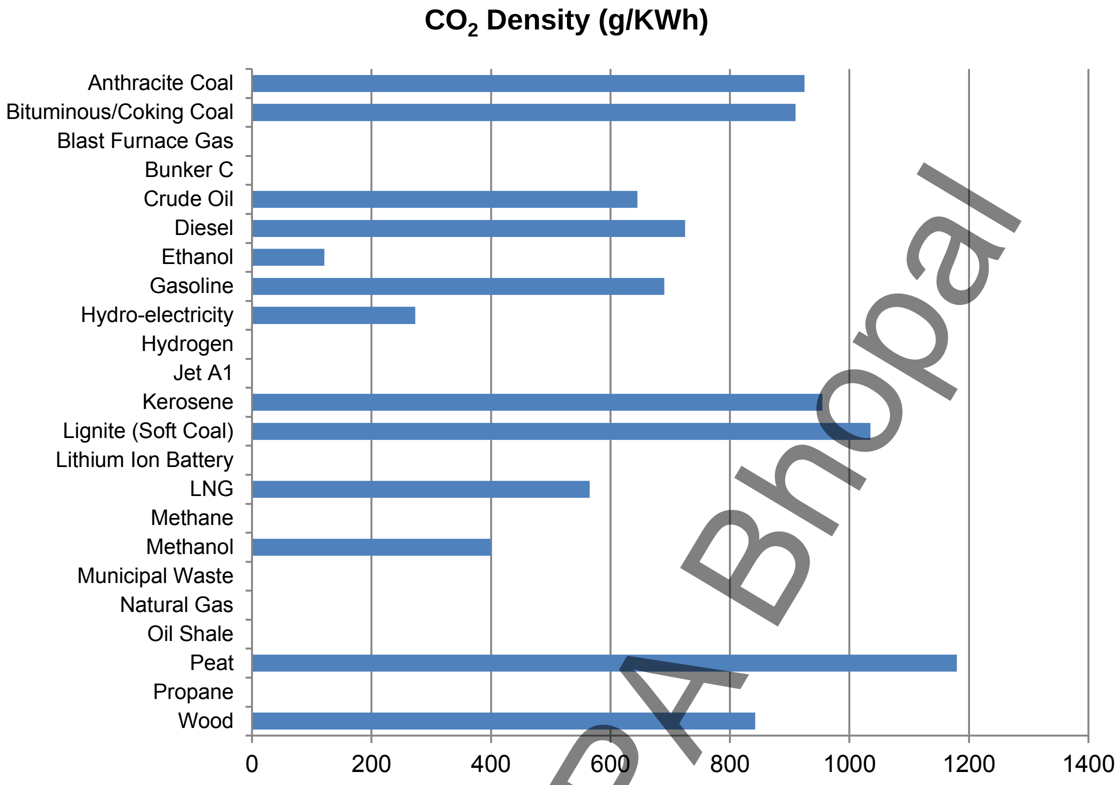

Figure 14: CO2 Density per unit energy output of fuels

Information of mass density for oil shale and peat, information of specific density for hydroelectricity, municipal waste, oil shale and peat, information of energy density for hydroelectricity, municipal waste, oil shale and peat, and information of CO_2 emission for Blast furnace gas, bunker c oil, Jet 1 oil, methanol, municipal waste, natural gas, oil shale, peat and propane cannot be found or cannot be converted into same unit for comparison.

2.5 Solar Irradiance

About the generation of energy, solar energy is one of a kind, and unending energy source for Human. This type of energy is counted two different ways

1. **Global Horizontal Irradiance (GHI)** – which represent the irradiation received on top of a unit surface area aligned parallel to horizontal ground over a certain period of time, and
2. **Direct Normal Solar Radiation (DNI)** – this represent the solar irradiation received by a unit surface aligned facing towards the sum all the time, over

a certain period of time. This means that the surface would follow the path of sun over the day time like a sunflower

Within this two types of solar irradiation, DNI is a greater value than GHI for most of the cases, but traditional sources in India uses GHI over DNI because it is much more cheaper for installation. DNI also requires a solar tracking system to locate the sun and aligned the panel according to it so as to get the maximum amount of output which increases the cost value of this kind of system.

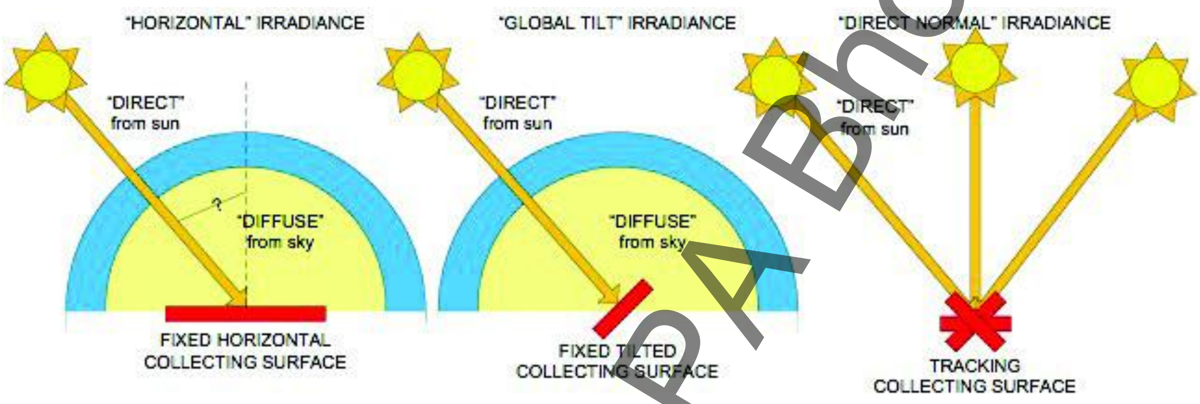

Figure 15: Types of Irradiance

Source: www.earthexhibit.com

2.6 Electricity Supply and consumption

Concentrating the electricity distribution, in India, typically there are stages of transformers and distribution network. Generally the power outlet from the power station is at least 33,000V. However, some time it reaches up to 2,66,000V, which is then stepped down to 11,000V and distributed for city scale and industries and about 25,000 to 30,000 volts for railways. This 11KV line is then stepped down to 440V and then again to 220V or 110V in three or four phase depending upon the use. This 220V power supply fluctuates from about 170V-250V in general cases. It is considered that one power supply plant can cater the population it needs to serve in just 80% of its full capacity (EPA, 2012). This is because demand of electricity is not the same in overall day. 50% is the medium capacity to run and 98% of total capacity is the maximum load.

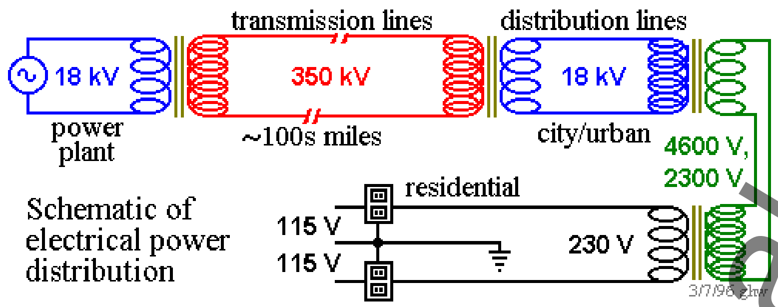

Figure 16: Traditional Transmission process with multiple step-downs

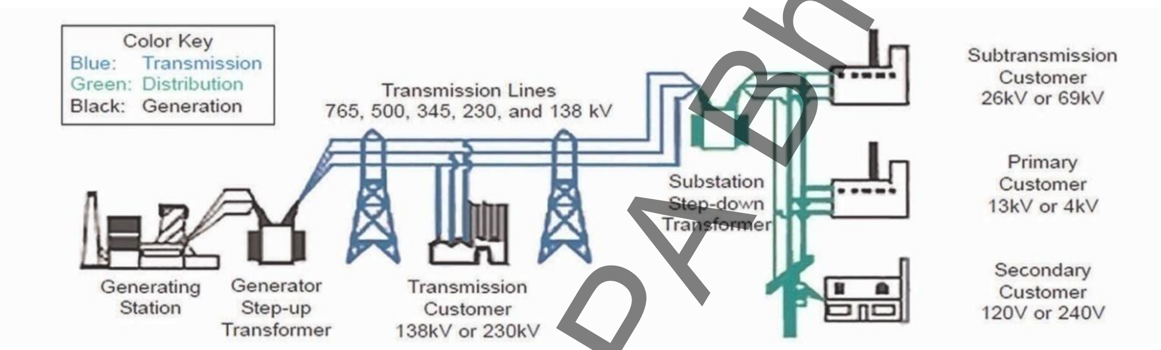

Figure 17: Schematic representation of Transmission system

Presently the generation of electricity is done in three steps. Following Figure 18 shows the process of electricity generation of a traditional thermal power plant where coal and water is used as raw material. This also explains the conversion of energy from one form to other. According to laws of physics, transformation between forms of energy induces few per cent of loss. Hence, three times conversion means more energy loss, and less efficiency. However, hydroelectricity plants also works in the same manner, but there is only two conversions are involved in that process. This means the losses are comparatively less and it is clean too. In case of hydroelectricity production, instead of pressurized water vapour, natural water flow is used.

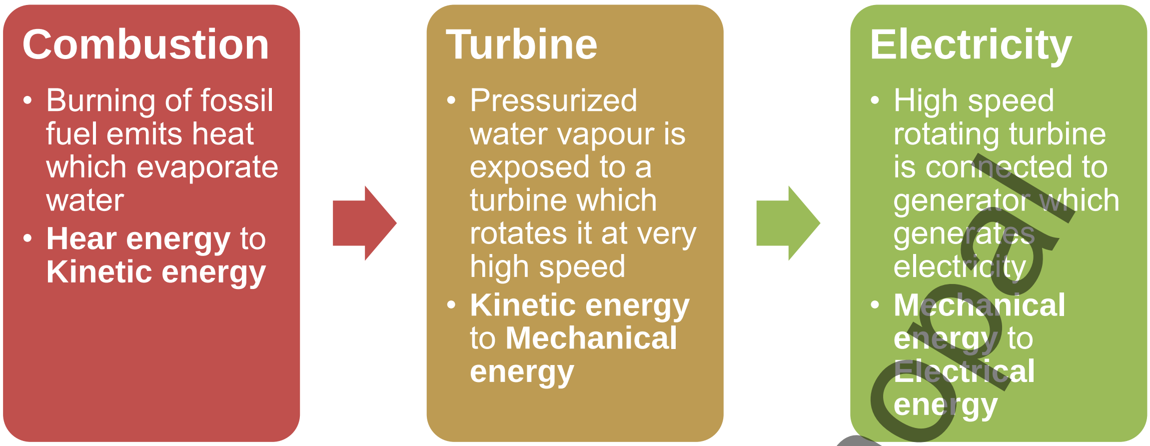

Figure 18: Traditional process of thermal power plant

Source: Arouri, Youssef, M'henni, & Rault, 2012

This many step down is needed because to supply certain MW of electricity to a far apart location is because the flow if electricity contains two components, Voltage and Current. Both of them are related to each other to represent the amount of energy get supplied at certain period of time. Following equation represents the relation between energy, voltage, and current.

$$\boldsymbol{V \times A = W}$$

Equation 1: Relation of components of Power supply

Source: NCERT, 2009

Here ***V*** represents the Voltage or the speed in which electrons are flowing, ***A*** stands for Current or the amount of electrons which is passing the cross-section at certain amount of time and ***W*** represents watts. Hence, to supply large amount of energy, it is necessary to either increase the voltage or the current. However, increased current flow would need bigger cross-section through which electricity is flowing. Rather increased voltage flow do not have certain restriction, but it do increase the radiation/induction radius around the media through which power is flowing. Large voltage would create bigger magnetic field. Hence, the second option is more feasible and so the wires are placed in much higher altitudes from living area, and it also avoids going over the residential areas. Also there are losses at user level. This also includes the efficiency of electrical equipment. In typical condition, power supply shares are as residential, commercial, industrial, transportation and others[4]. Following Figure 19 shows the share of electricity being used in different sectors.

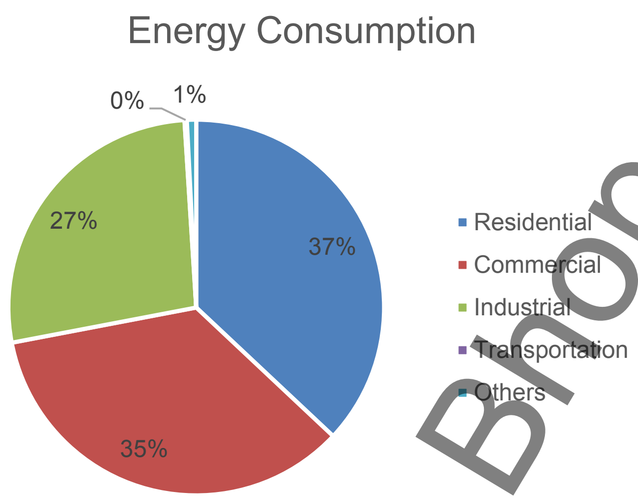

Figure 19: Energy consumption by different sectors

In rural areas, the above mentioned fuels can be availed as well as there are some vernacular fuels which are available with us, which are crop residue and animal dung. These are the two major local sources which are available in almost every rural areas. Now that we have seen fuels, issues, power supply, price, emissions, local area, equipment, losses, transformations, uses of fuel etc., it can now be fair if we go for area selection and see what actually going on ground and what all opportunities that we have. At present per capita Electricity consumption is about 805 kWh of India, however, if we see only of rural it is about 637 kWh per capita in the year 2014/15 (The World Bank, 2015)

Area selection is based on rural area, rural population, cattle population, solar radiation opportunity and others which will be discussed in detailed later. There are three steps of classification. First one being that in which state this study is going to experiment on. This classification is done in very simple manner by considering total surface area, total rural area, and rural population. There is not much importance because it is not really mandatory because the characteristics of rural over the country is about the same. However, the basic income sector may vary. Following Figure 30 shows the area difference of different states. This

[4]This includes PSP, recreational areas, and other land use.

figure only shows the top seven states. This classification is further considered for selection of study area (but not as a major parameter of selection). Accessibility is taken in consideration while selection. *(Explained in Heading 3.1 P42)*

2.7 Renewable Energy Harnessing Technologies

As we have seen earlier that there are various sources of renewable energies. To harness those energy sources, there are various techniques too. Following paragraphs will explain about the technologies to harness different renewable energy sources and for different uses. There are also active and passive use of these renewable energies.

2.7.1 Solar energy harnessing technologies

Solar energy is one of the renewable energy sources. Virtually its energy is being used. Changes in atmospheric condition, gas composition, temperature, seasons, and every other environmental condition are maintained due to the energy received by the earth from sun. It is considered to be the ultimate source of energy. Technologies are available which uses this energy for different purposes, like generation of electricity, passive lighting, and temperature control, heating and cooling, cooking etc. last few decades we came across solar panels which converts solar energy (actually light energy) into electrical energy. At present day, we have more technologies for harnessing solar energy both for electricity and heating and cooling. Following are some of the technologies:

2.7.1.1 Photovoltaic (PV) cells

These are traditional solar panels which energize when exposed to extreme light. These are generally made of flat glass plates filled with silicon and other photo-electric materials. These filled materials have two poles, which acts as anode and cathode while it is exposed to sun. These panels are aligned as facing south at 25-43 degree angle for maximum efficiency. These panels are generally fixed panels and work only about 8 hours per sunny day. These panels are about 15% efficient in generating electricity when compared to the area they consume.

Hence, power generation is proportional to the area used for setting up panels. The calculation of their potential can be done using DHI.

Figure 20:Photovoltaic (PV) cells

To increase the efficiency, these panels are generally fixed at roof or south facing walls at household level. These panels cost around Rs.3800/- for $4ft^2$. These same panels also power the artificial satellites at space. They do have limited lifetime, but it is enough for one human to use it over his/her lifetime. This technology is also used in micro level. We can see calculators having solar panels at the top to increase battery life. This generally uses 3-4 PV cells. Few of the pioneer watch companies also use it inside watches, which power it even in low light. Now that the technology is changing, and much more efficient panels are one the way to market, they are more efficient and pricy too. The new panels are coming with fibre coating instead of glass. This reduces the weight and also makes the panels flexible and durable.

2.7.1.2 Smart flower

This is relatively new technology compared to PV cells. However, this system also contains PV cells as the source of generation, but they are much more efficient. This is a hybrid system and it has its own stand, sun tracking system, battery backup, all direction rotating arm and an advance IO system to control these elements. This system is portable and flexible and advance. Like the name says that “smart” it is smart enough to judge the direction of sun and according moves the panels towards it. The rotating property of this complex system makes it more efficient using the same PV cells.

Figure 21: Smart Flower

This system is about 60% efficient compared to the area it consumes. The battery backup is about 3kAh at 90V. This can be a stand-alone system for one household. This system can generate power up to 9 hours per sunny day, and power storage makes it active for more than 9 hours. However, the extra backup time depends upon the extent of usage.

2.7.1.3 Concentrated Solar Power (CSP) type 1

As the term explains that the usage of solar energy in concentrated form. This is generally referred to a thermal power plant, where water is heated using solar rays. First type consists of a system where a fluid (generally water) runs through a small pipeline which is surrounded by concave reflector surface. This concaved surface helps in concentrating the sun rays which heats up the fluid, and this fluid runs through a turbine which is further connected to generator. This involves a series of concave reflective surfaces placed in parallel. The pipeline generally runs in either north to south or opposite direction.

Figure 22: Concentrated Solar Power (Type 1)

This system also has sun tracking system to increase the overall day usage of solar energy. As it is a Solar *Thermal Power Plant* it runs only for day time.

2.7.1.4 Concentrate Solar Power: type 2

This system is also the same as above. It is also a thermal power plant, with fluid running through the system. Unlike the above system, where there are multiple rows of reflective surfaced in parallel with multiple pipelines for heating the water, this system only contain one pipeline at the centre of the system. The system contains an elevated tower through which fluid flows. The top of the tower is covered with clear black surface, which helps in quick heating. This helps in heating the water. To make the black surface much more heated, the tower is surrounded with several reflective surfaces, which reflects sunlight towards it.

Figure 23: CSP (type 2)

In this system there is one sun tracker and a motion control system which controls every single reflective surface. These reflective surfaces rotate according to the sun. This system is more efficient compared to the above type because of less number of pipelines running through. These needs less maintenance compared to type 1. However, these are not the only devices which uses concentrated solar energy, there are few more and are explained in next paragraphs

2.7.1.5 Solar Sunflower

This technology is kind of mixture of smart flower and CSP. The machine uses both solar PV cells as well as reflective surface, but in a different manner. This system works by concentrating the solar rays to a small point where very efficient PV cells are kept. Here, we do not have any king of power transformation like CSP. The solar energy is directly getting converted into electricity. If we consider the smart flower, than replacing the solar panels by concave reflective surfaces and placing an efficient PV cell at the focal point of the surface, this will make a solar sunflower. However, this technique is much more costlier than any of them above but also it is the most efficient system available in market today. Althoughthis system is still under research and development. This is also a stand-alone device and can power an average sized household included backup.

Figure 24: Solar Sunflower

This can generate an average of 12kW per unit per day. This system also has sun tracker to make it more efficient.

2.7.1.6 Solar heating and cooling

This system is now a days used in many buildings in many places. The name itself tells that solar energy is used for heating and cooking of certain materials. The common device is solar water heater, and solar cooking kit. This contains small reserve water tank from which water is discharged to multiple pipes arranged parallel. The pipes are half coated with black reflective materials which helps to make the flowing water hot. Further that hot water is directly used for different services.

Figure 25: Solar water heater

2.7.1.7 Passive solar energy

This refers to a concept where solar energy is not used directly or immediately as the above mechanisms do. This is generally used for lighting certain places which needs to be lighted over the day. However, running electrical lights for 24 x 7 is not recommended because it reduces the lifetime of the light source as well as consumes lot amount of electricity. Also not only lighting, in some cold places, sun is used to heat-up the walls of building so as to get comfortable temperature during night time.

2.7.2 Hydro energy Harnessing technologies

The technologies which allows and supports us in harnessing the energy from water bodies are known as hydro energy harnessing technologies. It is a concept of that era when humans didn't know about electricity. During that time the flow of canals or rivers is used for farming. That system itself throws water to the cultivable area. Although at modern times, the energy is used for electricity generation. Following are some of the techniques of energy harnessing from hydro.

2.7.2.1 Run-of-river hydropower

The generation of electricity or any kind of power using natural flowing water without having it stopped. This is generally done at small rivers and canals. These are generally small scale power generation for locality. However, this needs continuous flow of water in canal or river. This system contains a funnel like structure, the small end is connected with generator via turbine and the wider end is subjected towards the way from which water is flowing. There can be multiple fittings like this one after other. This system also provides continuous generation of power with little amount of flexibility for daily usage fluctuations. This system do not need any kind of power storage facility due to its continuous running capability.

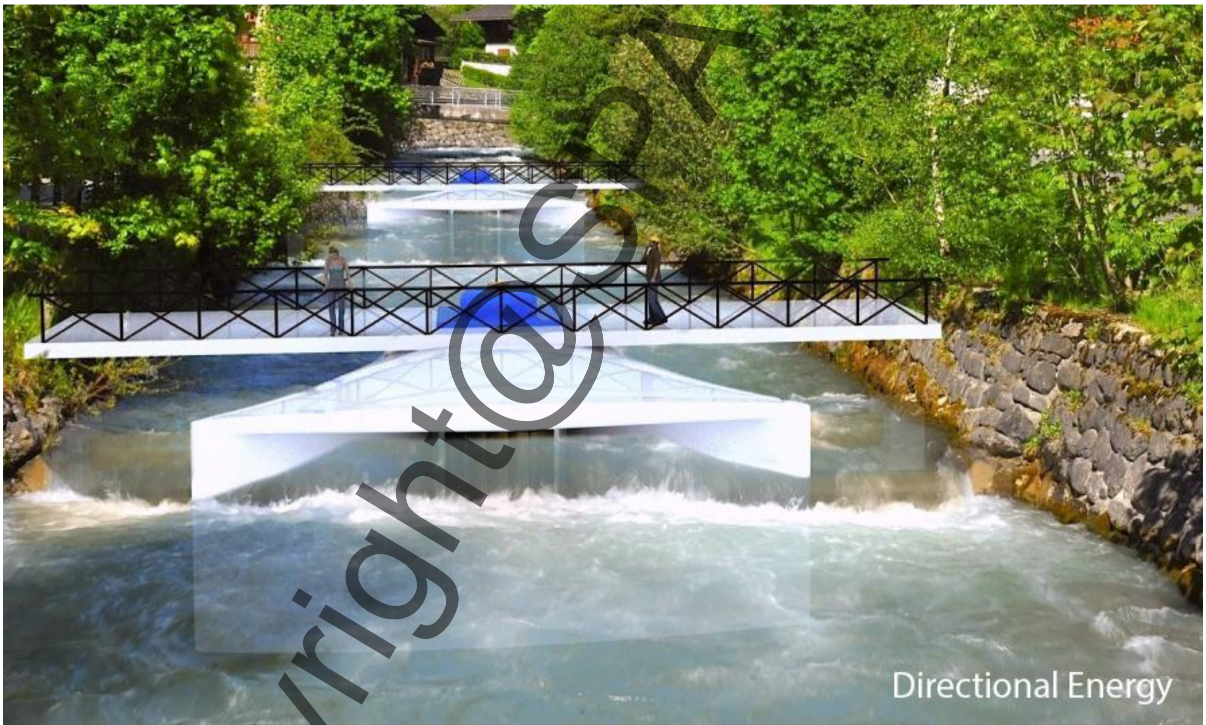

Figure 26: Run-of-river hydropower

2.7.2.2 Storage hydropower

This is a basic concept of general hydro electricity generation plant. This has a huge reservoir to hold water at higher altitude. This elevated tank is connected to a turbine chamber via a small duct. Through this small duct, water is released, and due to its altitude and capacity, the flow of water is very high. This pressurized water is then exposed to the turbine within a closed chamber, which rotates the turbine at very high speed. A generator is connected to the turbine which generates electricity. In India Damodar valley corporation (DVC) is one body which has good history in generation of hydroelectricity. These projects are very large projects, and the generation capacity is huge. The reservoir is designed in such a manner that it can last about a week.

Figure 27: Storage Hydropower

DVC was also one of the first body made which involves "regional planning" after the west ghats

2.7.2.3 Pumped storage hydropower

All the hydropower energy generation system have one basic concept, that is, water drives the turbine. In this case also the same thing happens. However, in this the elevated storage tank is artificial and filled using the same power which is generated and sometime outer sources is also needed. This system needs backup storage as well as breakup time to refill the tank. This system also works as a backup system for other power generation sources during peak demand.

2.7.2.4 Offshore hydropower

This is also known as tidal power generation. Due to increase and decrease in sea level near coast, it is confirm that there is movement in sea water. This movement is used to drive turbines dipped inside water. However, installation of this kind of techniques needs at least 5m difference in tidal level. There are three types of offshore hydropower generation which are; Barrages, Fences and turbines.

2.7.3 Wind energy

This is a system which utilizes the flow of wind to generate energy. This is also a direct mechanism of power generation where wind drives a turbine which is connected to a generator. This system needs an internal controller for number of rotations made by the turbine. Although other system control the RPM (Rotation per Minute) of turbine by controlling the flow of substance which drives the turbine. Installation of these kind of system a hilly terrine to have continuous air flow at sufficient speed. This system are installed at high level to reduce the chance of impact on materials at ground level. This system has very less ground footprint. The above system that we have seen, uses the raw material/source in different manner to generate energy, but in this case wind is only used directly to rotate the turbine. However the difference lies in the orientation of axis of the turbine. Following are the two types:

- Horizontal axis wind turbine
    - Up/down-wind turbine
    - Shrouded wind turbine
- Vertical axis wind turbine
    - Savonius wind turbine
    - Flapping panel wind turbine
    - Darrius wind turbine
    - Giro-mill wind turbine

2.7.4 Biogas and Biomass

Unlike the above system, this is totally different system. Mainly cattle dung, and crop residue and organic waste are used for power generation. Although biomass and biogas are two different things. Biogas plant essentially uses dung waste to generate different types of gases like CO_2, N_2 (Nitrogen), CH_4 (Methane), H_2 (Hydrogen) and O_2 (Oxygen).Biomass energy production is typically an thermal power plant, but at small level. The raw materials for biomass may be the these gases or other organic waste. This is considered as renewable fuel because, these can be generated multiple times within the lifespan of humans. Also to make more understanding, these are not 100% clean fuels, because these has certain amount of emissions. However, these are considered to be the cleanest because the organic raw materials are anyways going to decompose and contribute to emission. However, if we can use the emission for some use than it is of some importance. This is the reason that it is considered as one of the cleanest fuel.

Biomass and biogas production system needs real concentration towards the maintenance, and regular input of resources. The energy generation is also affected by the climate. This system is very much popular in rural areas.a. Biomass power generation units also produce a significant economic benefit to the area surrounding the plant. A 10 MW biomass power generation can create approximately employment for 100 workers during the 18 months' construction phase, 25 full-time workers employed in the operation of the facility, and 35 persons in the collection, processing and transportation of biomass material.a.

The principal source of biomass is rice husk, woody biomass (such as Julie flora, casuarina), other agro residues (such as stalks/cobs/shells), sugarcane trash, cotton stalks, groundnuts shells etc.a. The economic viability for the capacity below 6 MW is not sustainable. However, biomass power plant in the initial setup phase in India had an installed capacity of 6 to 7.5 MW. The right kind of capacity from economic viability point of view should be between 7.5 to 10 MW. Beyond this capacity, the logistics of managing raw material would be difficult. The project size depends on the fuel (biomass) availability near the project location. For a capacity of 10 MW and for a biomass fuel with average gross calorific value of 3150 Kcal/Kg, the total fuel requirement is around 1.0 lakh/annum. The collection and storage of biomass is the critical activity for any biomass project to succeed.a. The Fly ash discharged could be used in the manufacture of bricks for construction of buildings and civil works or as bio compost fertilizers in dry agriculture lands.a.Capital subsidy, exemption from payment of excise duty on machineries and equipments purchased for initial setting up of a power plant are available. Apart from this CDM benefits on reduction of CERs and preferential tariff for power exported to grid are also available.

2.8 Electricity Consumption

It is observed that electricity is used in every work. But for transportation, only trains are now fully electrified. Other all transportation system are still running in fossil fuel. Very little share of transportation sector uses electricity. Here, fuels are used for many different purposes which are as follows:

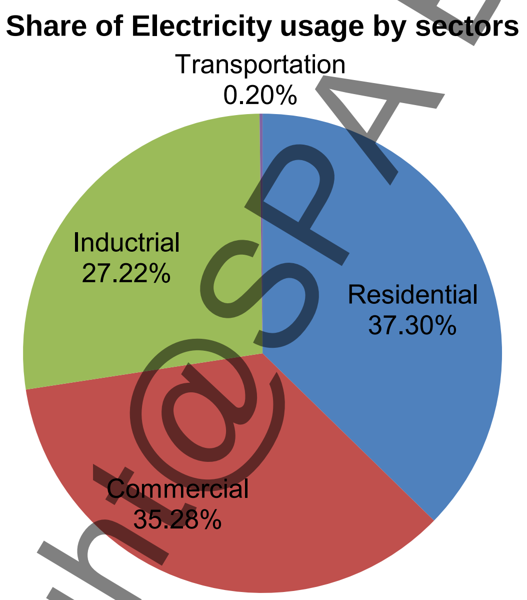

Figure 28: Share of Electricity usage by sectors (EPA, 2012)

2.9 Cattles

In purview of energy production, cattle play a major role. This is because of their capability of helping human to live life. Previously when machinery was not there, then cattle are used for agriculture, transportation, and many other uses. However, they also needed special care because they are also living organisms and they also have needs like humans. Cattle can be of various types such as cow, buffalo, pig, goat etc. hence, for calculation, one single unit is needed. The single unit is named as Adult Cattle Unit (ACU) below Table 3 shows the needs of one ACU in daily basis. However, like we count our traffic volume using Passenger Car Unit (PCU), ACU also has factors for different species. Below Table 2 shows the multiplication factor for calculation of one Adult Cattle Unit.

Table 2: ACU Multiplication Factor (MEP2015, 2016)

Cattle species	ACU Factor
Buffalo	1
Cow	1
Pigs	0.3
Goat	0.1

Table 3: Requirements adn Outputs of one ACU per day (Government of India, 2012)

Weight of Adult Cattle Unit	500 kg
Total Fodder consumption	50 kg
Wet fodder requirement	40 kg
Dry fodder requirement	10 kg
Water required	40 l
Milk Production	3.8 kg
Dung production	27 kg

2.10 Biomass and Biogas Production in India

India is a rural based country, and it have lots of agricultural and livestock resources. Other than the energies mentioned above in page 24, other resource is also there, which is biogas energy. This is a mechanism of generating energy from organic waste and livestock dung. However, this system needs periodic maintenance and regular input of raw materials. Conventional biomass system are 35% efficient in terms of energy production while combined heat and power system (CHP) uses heat and electricity and it is 90% efficient in performance.

Production of energy depends on the type of raw material being supplied for the plant. This includes moisture, quantity per day, quantity of water, quality of waste and other filling materials. For an example one ton of rice paddy will produce about 290 kg of straw and 220 kg of husk. This 290 kg of straw is able to produce about 100 kWh of power and one ton of husk is equivalent to 410 – 570 kWh of power with a moisture content of 5% to 12%. Following Figure 29 shows the production of biogas in the year 2014-15 in lakh cubic meter.

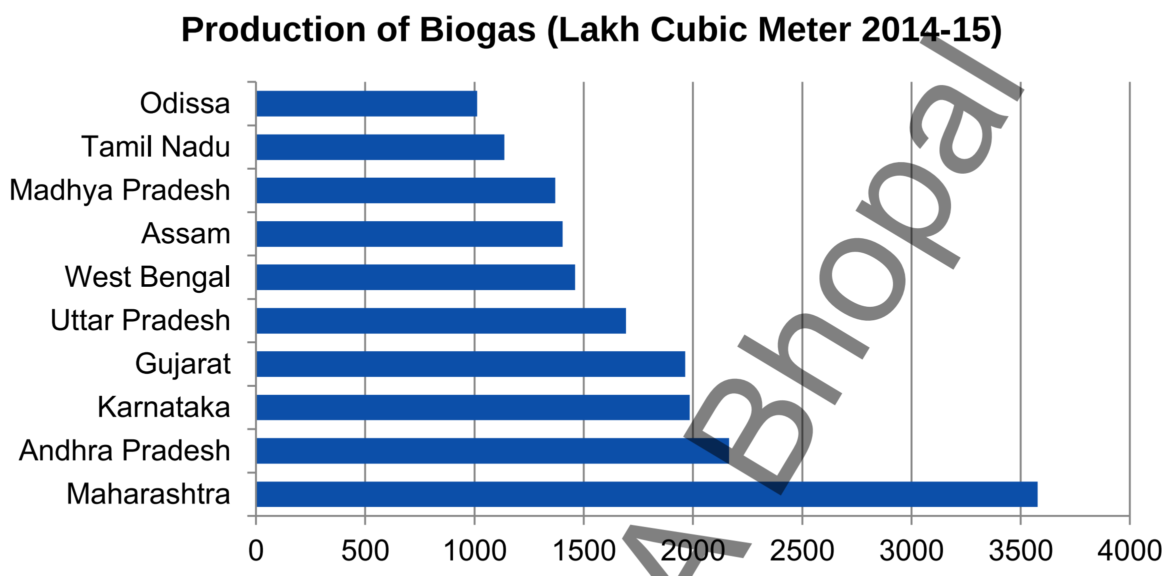

Figure 29: State wise production fo Biogas (WELTEC Bio Power, n.d.)

India's revolution regarding renewable energy is very old. After so many years of independence, India still has areas which are un-electrified. However, India also has huge potential of renewable energy generation. Hence, technologies, production of fuel, fuel characteristics, activities, government targets, energy sources are identified. Now the important is whether fuel shifting is possible in rural areas. For this study, next chapter will explain.

2.11 Government's Targets

Other than solar energy there is also wind energy, which is one of the most cleanest energy sources. Some of the countries are generating 1MWh of electricity from one wind tower. In India, Government of India has recently launched many missions for cleaner energy and provision of energy specially for rural areas. One of which is Jawaharlal Nehru National Solar Mission (JNNSM), has three phases in which aims to certain works to be done. Phase one was from 2013 to 2017, Phase two is from 2017 to 2021 and third phase is from 2021 to 2025. There are mainly three segments which are firstly Utility grid power including rooftop solar energy generation, secondly off-grid solar application to reduce distribution charges and losses and lastly solar collectors. Following Table 4 shows the targets of each phase in each segment.

Table 4: JNNSM targets

Sr. No.	Segments	Targets for phase 1	Cumulative target for phase 2	Target for phase 3
1	Utility grid power including rooftop	1000-200 MW	4000-10000 MW	20000 MW
2	Off-grid solar applications	200 MW	1000 MW	2000 MW
3	Solar collectors	7 million m^2	15 million m^2	20 million m^2

Madhya Pradesh state also has different targets for cleaner energy supply. The state has developed its own mission, which is known as "Madhya Pradesh Urja Vikas Nigam Mission (MP-UVNM)" which have following objectives (MNRE, 2016)

1. To promote and create awareness about the uses of solar, wind, biomass, biogas and energy efficient products based various technologies among the public
2. To promote the policies the programs necessary for popularising the applications of various new and renewable energy technologies in the state
3. To promote the installation of power plants based on renewable energy sources for energy security
4. To promote the energy conservation measures for efficient use of energy resources, and
5. To promote green building design for efficient use of energy in housing, commercial and industrial sector

Day by day, the price of fuel is increasing as well as the price of equipment too. Many factor increase the price of this elements one of them is the demand and supply, but other factors do have significant effect, which are like the quality of fuel, service delivery, efficiency, and etc. This efficiency means the capability of generating more energy in less fuel giving certain amount of fuel saving. The price of fuels have nearly increased from 8% to 53% for different fuels in last two decades and about an average 30% increase in price of equipment (Ryan and John, 2013). Major components of output of daily life fuels are CO_2 and H_2O.

Chapter 3. Introduction to case study area

This chapter will give an detailed introduction about the study area, Ratibad Village cluster. Location details, population, area, land-use, and furthermore.

3.1 Site selection

The village cluster from Madhya Pradesh state has been selected for study. Madhya Pradesh (M.P) is second biggest state, and also second largest state having rural area. MP is also second in terms of potential of solar energy generation.

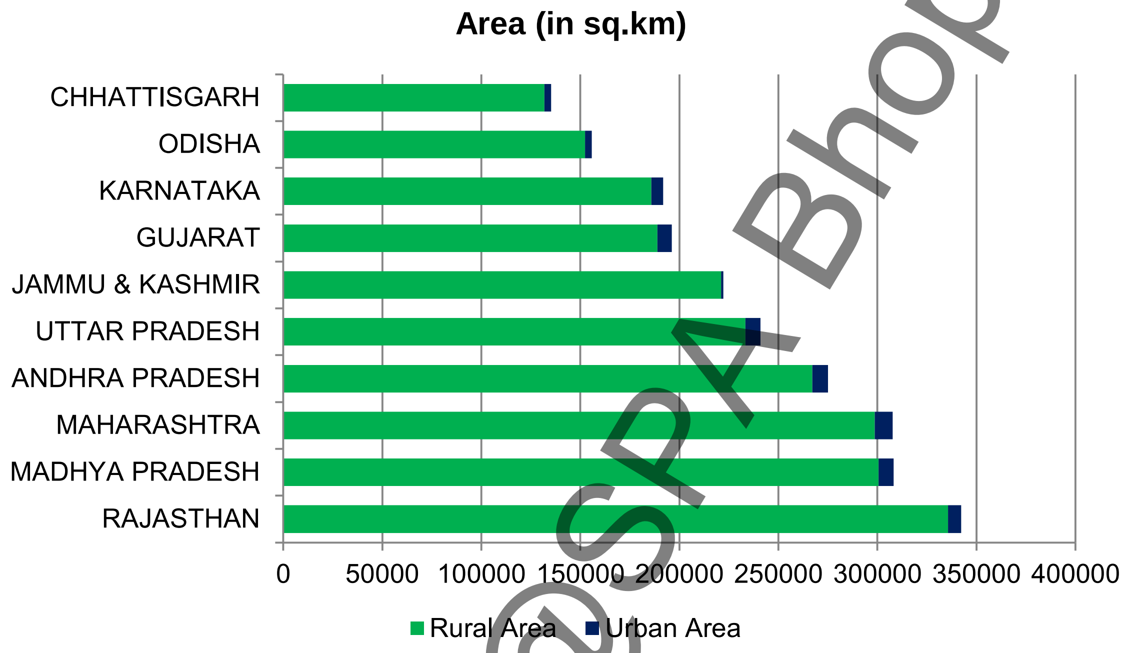

Figure 30: State selection according to area

The selection criteria for the study area has kept as that it should lie in legal jurisdictions of government so as to increase the flexibility of implementation of any kind of intervention. Hence the ongoing project of Integrated Cluster Action Plan (ICAP) for rural development has selected seven clusters of villages. Out of those seven clusters, one is within the boundary of Bhopal District. The Ratibad village Cluster has been already categorized as non- tribal cluster among seven allocated clusters in Madhya Pradesh under Shyama Prasad Rurban mission. The Ratibad is a Village in Phanda Block in Bhopal District of Madhya Pradesh State shown in Figure 32. It belongs to Bhopal Division. It is located 14 KM towards South-west from District headquarters at Bhopal, 15 KM from Phandakalan and 15 KM from Bhopal city. The Cluster comprises of thirty five (35) villages that comes under Huzur Tehsil, within 5-7 km radius of centrally located Ratibad village. The major concern for selection is to identify the renewable and clean fuel resources to exploit it for energy so that mechanism should be developed for fuel shifting for major uses like electricity generation and cooking fuel.

3.2 Land-use

Here, predominant land use is agriculture which is then followed by waste land. Following Figure 31 shows the share of land-use. This is about 26,279 Acre and the next major land is waste land, which is spread across the south of the cluster shown in Figure 32

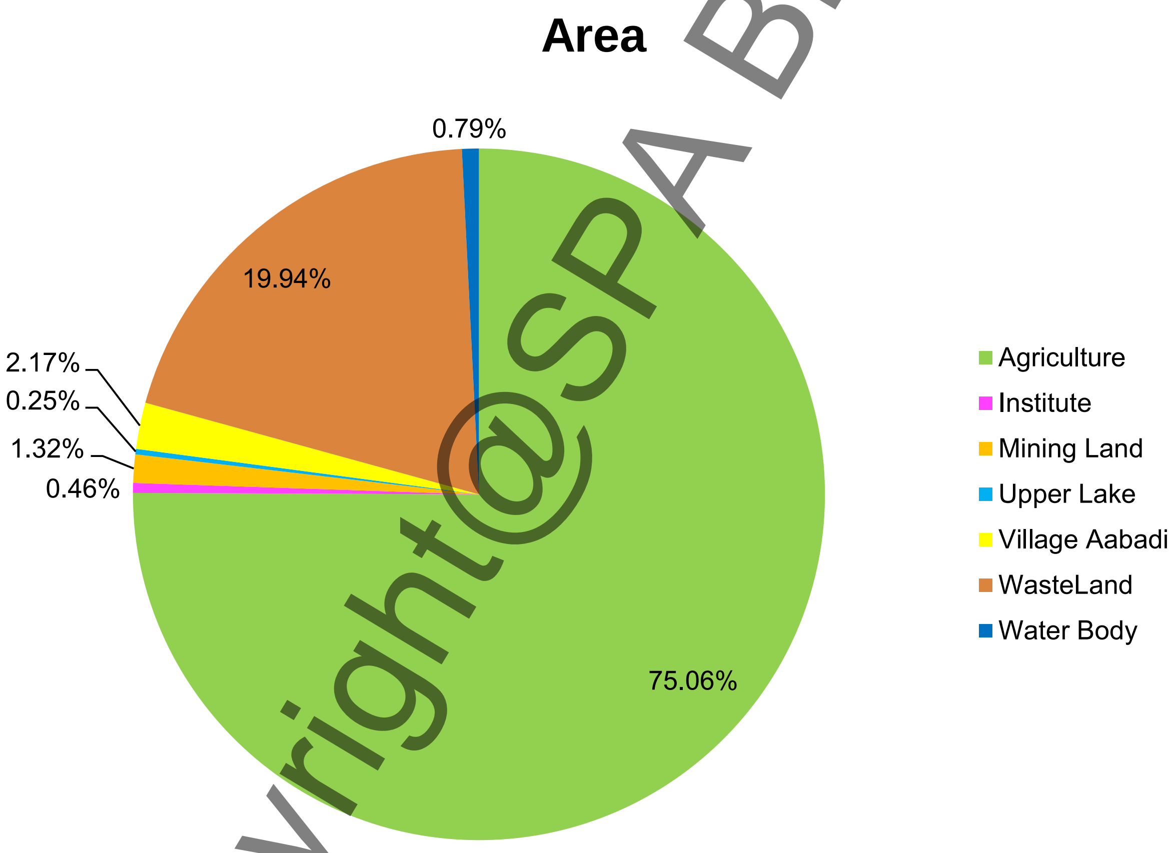

Figure 31: Land use share of Ratibad village cluster

Land Use Land Cover is one of the important feature which helps to make any feasible plan for any place. Land cover of Ratibad Cluster is shown in Figure 32 which is prepared by studying various patches from imagery and other relevant document. Land cover map is prepared under 6 heads namely village abadi area, agricultural land, water body, Institution, forest land and Mining land

Selection of ICAP village cluster makes the plan more sucessful in terms of any kind of intervention. As this also represents government identified land only. Hence, jurisdiction boundary is fixed, there might not be any expectection of failing to implement any kind of intervention.

Other than the land-use, terrien is also one major concern which needed to be considered. This will help in understanding the flat and steap land areas. These areas can also be used for different purposes. Such as for this study, solar panal can be fixed as flat as well as steap areas, but for native agriculture, flat plane land is a primary requirement. Following is one map showing the elevation of the study area. If we concentrate on the south east of the area, it has more uneven surface compared to other areas. North east and north west corners are comparitively low lieng and has water bodies.

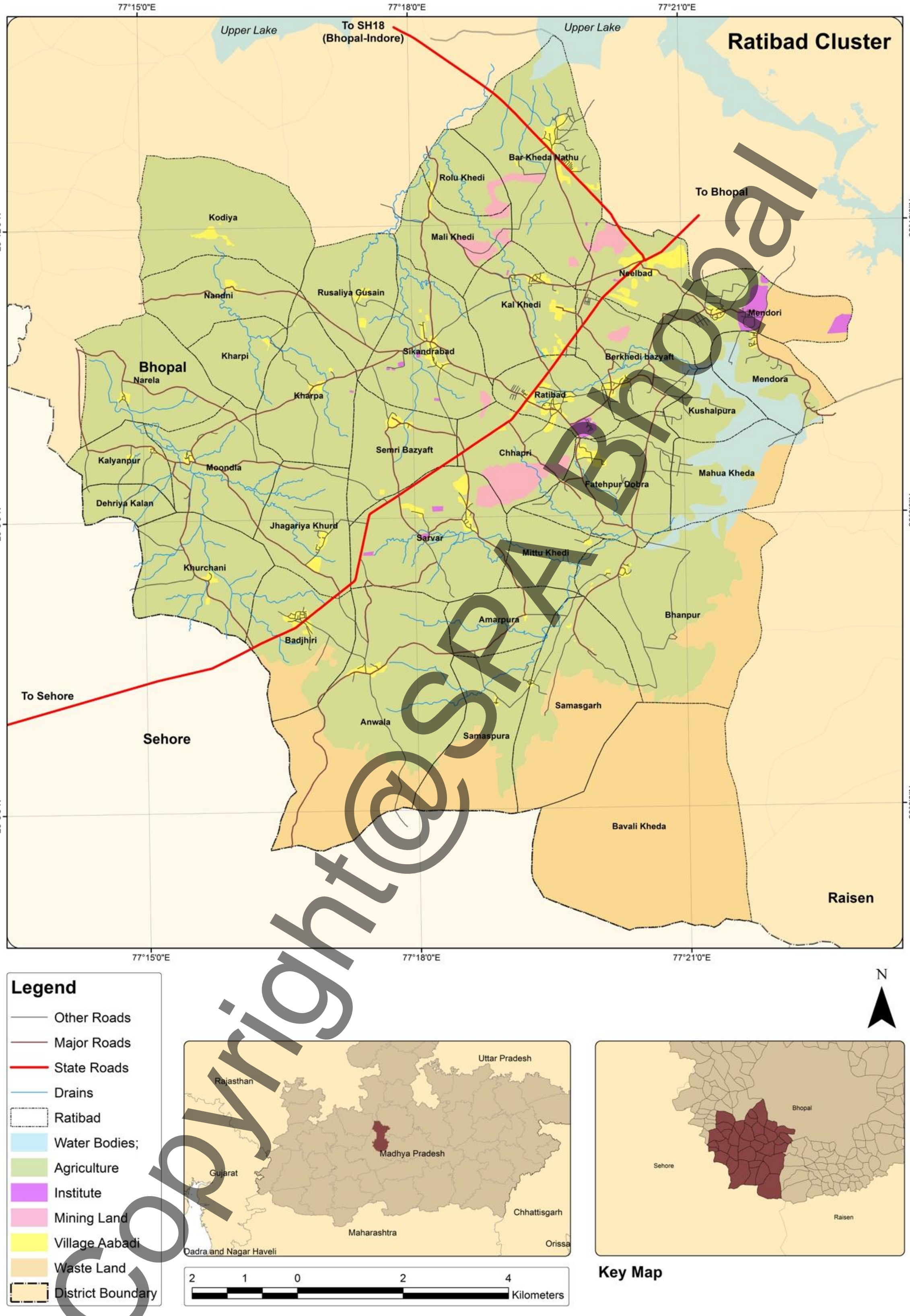

Figure 32: Land use map of Ratibad Cluster

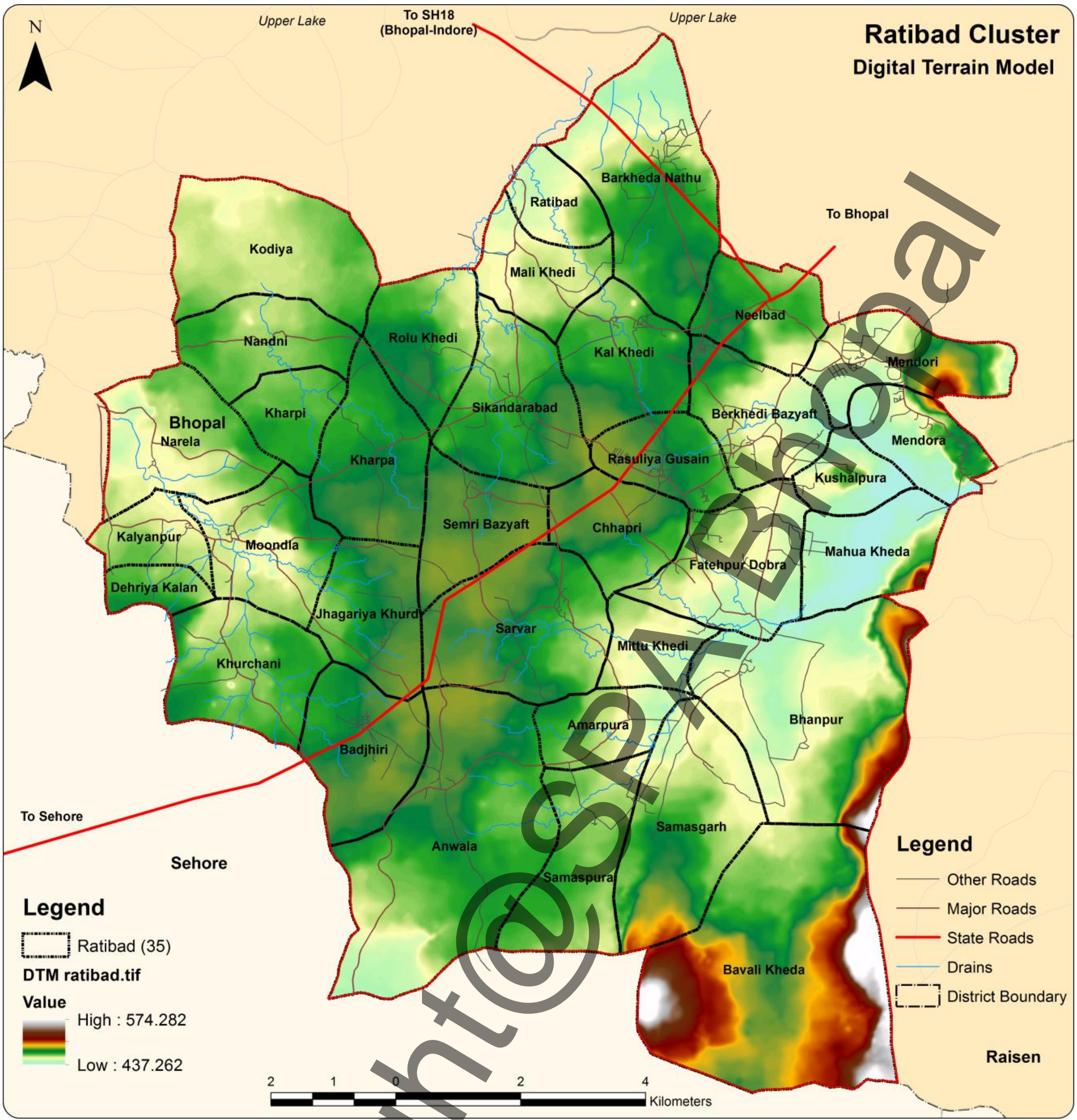

Figure 33: Terrien Map

Source: SPA, 2015

Chapter 4. Data Collection and analysis

This chapter explains the raw data needed and collected to complete this study. This includes primary survey, secondary data collection, Estimation, population projections, estimation of demand, calculations, strategies and other parts of analysis. Before going to the analytical part, study area would be explained.

4.1 Study area profile

In previous chapter we have seen the study area, which is Ratibad. Here, Ratibad cluster lies just adjacent of Bhopal Municipal Corporation. Few villages do have a mixture of rural and urban characteristics with less agricultural area in them. The villages towards the border of Bhopal district (south) are few of the least populated areas.

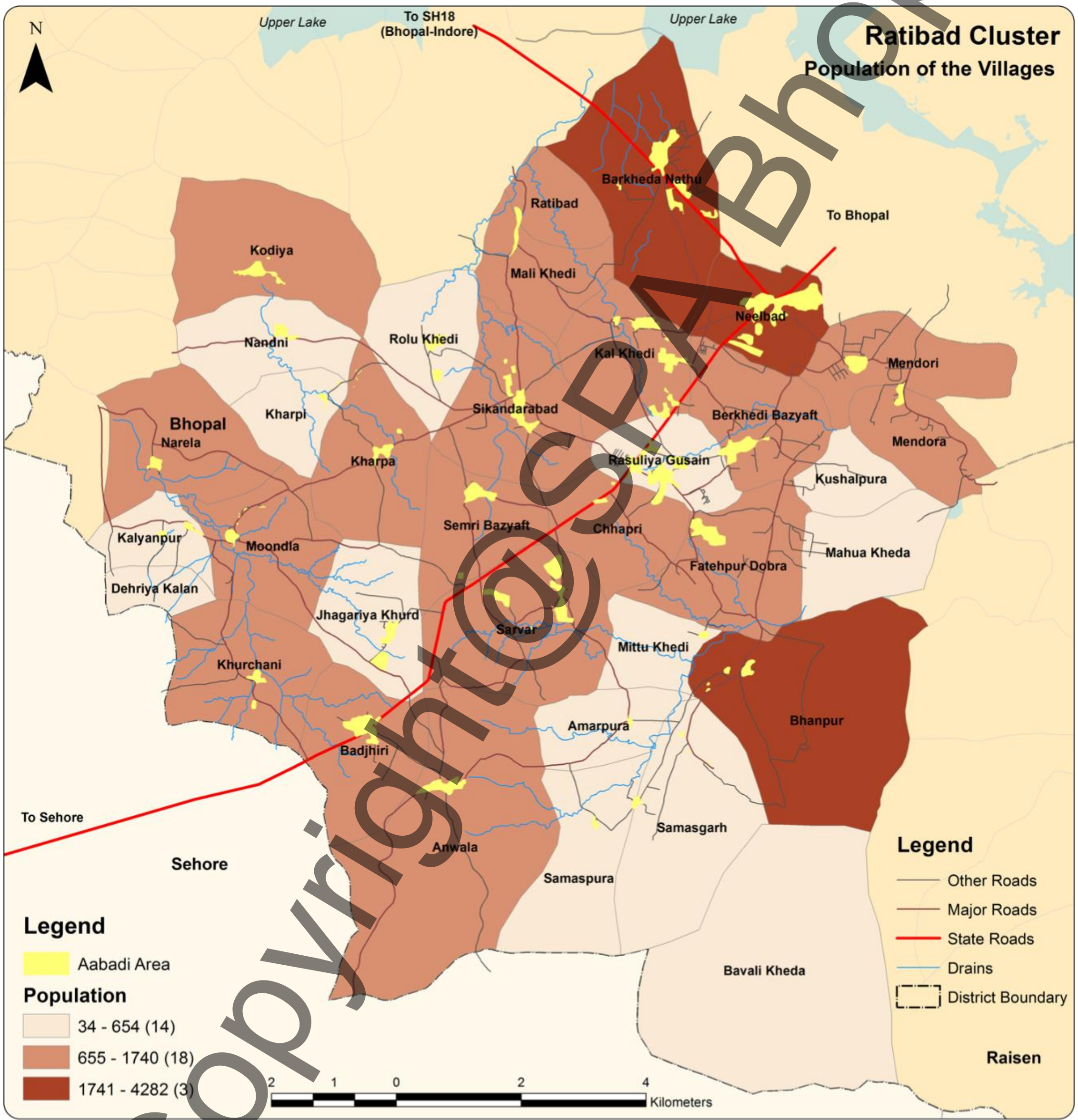

Figure 34: Population (Census of India, 2011)

As per Indian government, census accounting is done in every 10 years, and last was on 2011 which is six years earlier than now. In coming four years, national population survey will be conducted. Demand is always calculated for either present or future. This projections will be further discussed in page 57 There are many components which can be used for energy generation locally, so, following are the possible components available locally. Population as per 2011 census was 32193 with 6472 households, and average household size of 5.05 persons.

4.2 Agricultural land

As explained earlier in P43 that the area is majorly agricultural, few villages are very rich in agricultural area. Major agricultural products are wheat, rice for major seasons and other small vegetables are also grown here like guava, cauliflower, grapes etc. Following is a map shows agricultural land area of 10435 Hectare

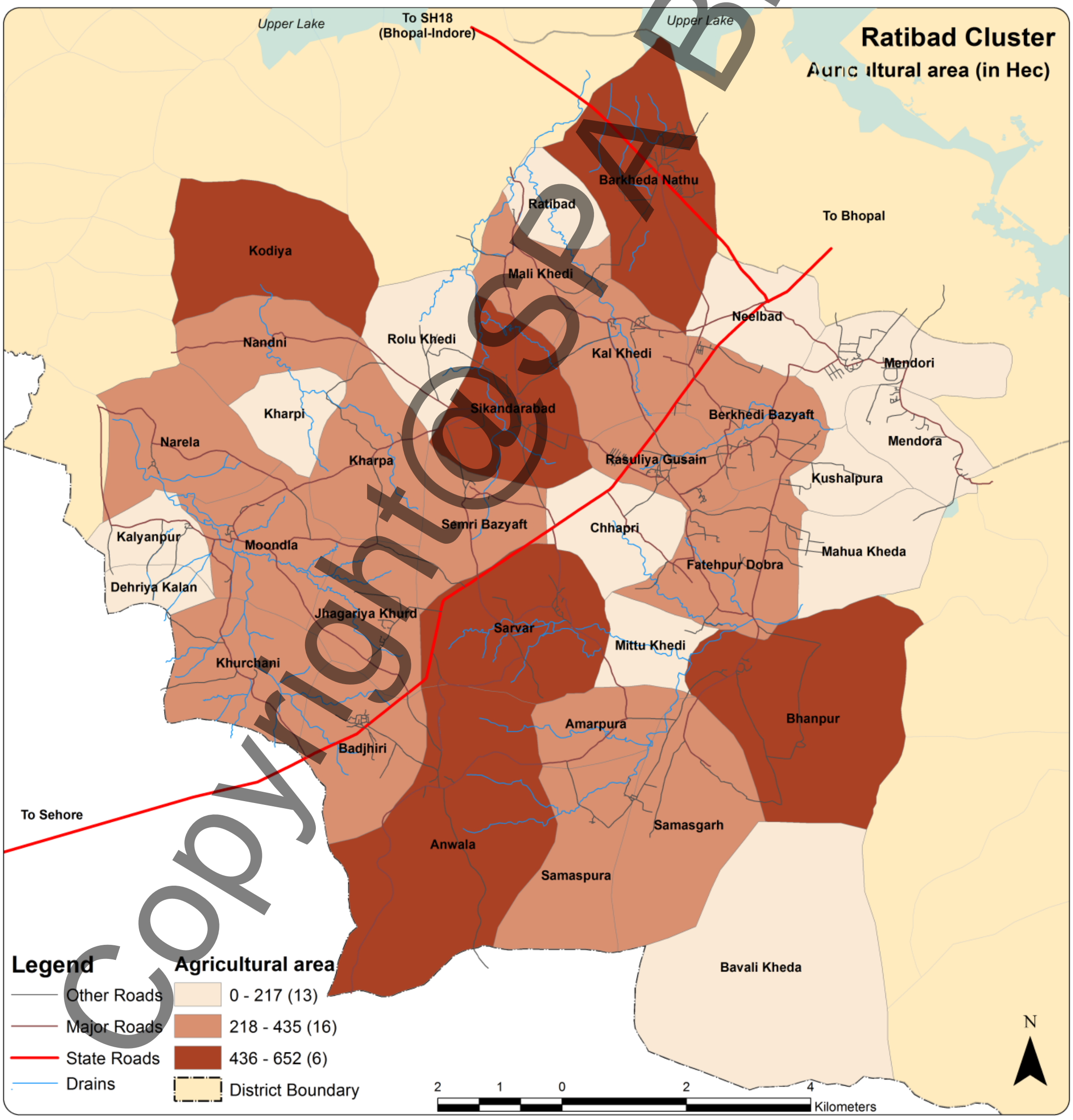

Figure 35: Agricultural area
Source: Author

Cropping is done over the year in different places. Although major area is cultivated with two seasons as shown in Figure 37. Following Figure 36 shows the cropping pattern. It is assumed that present fallow land is the land area used for other one season cropping only. The specific area for each type of cropping land is required to calculate the total crop waste which can be attained in whole year. This crop waste will act as one of the strength for the area because it is one of the organic waste used for biomass energy generation.

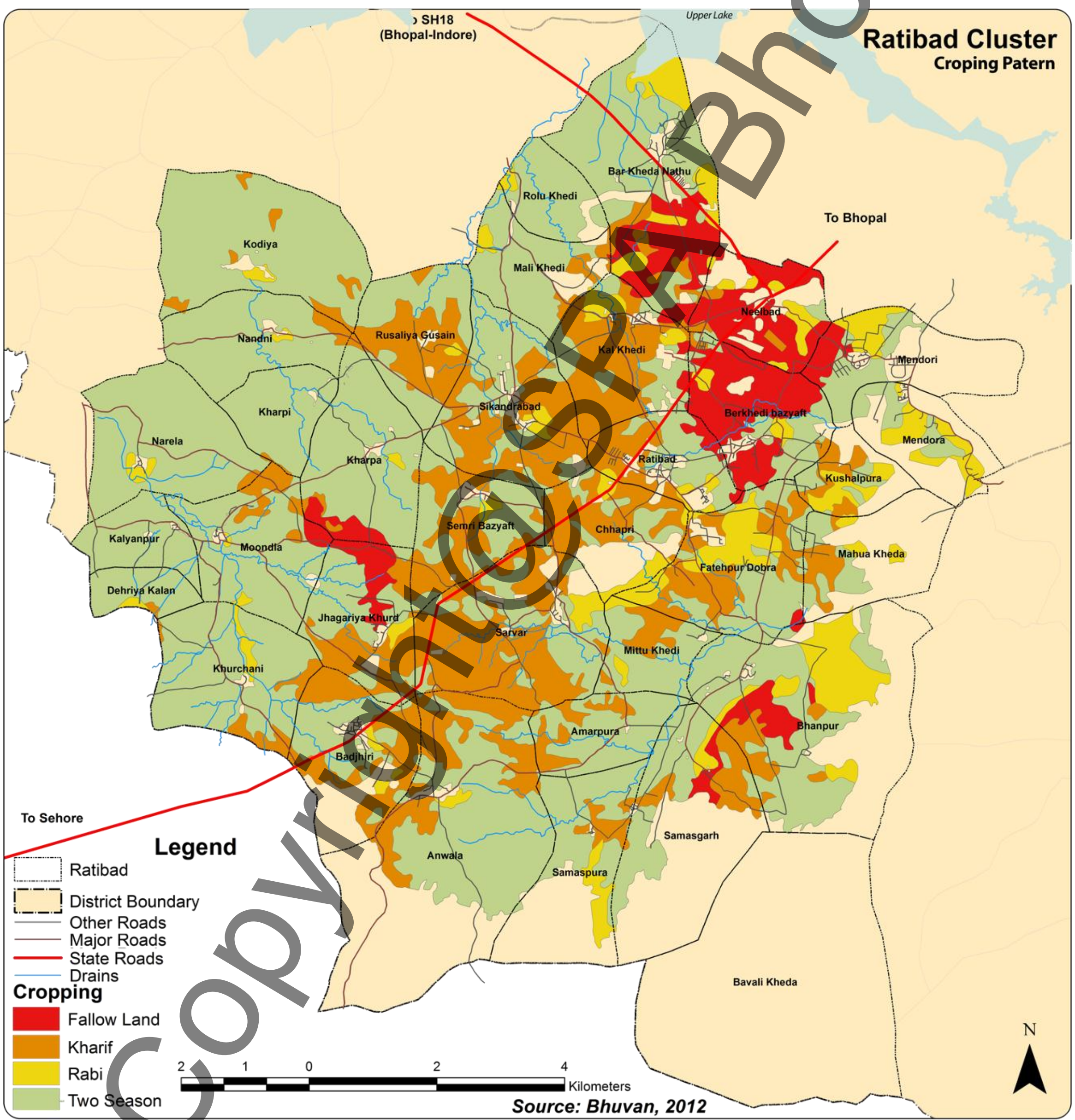

Figure 36: Cropping Pattern
Source: Bhuvan

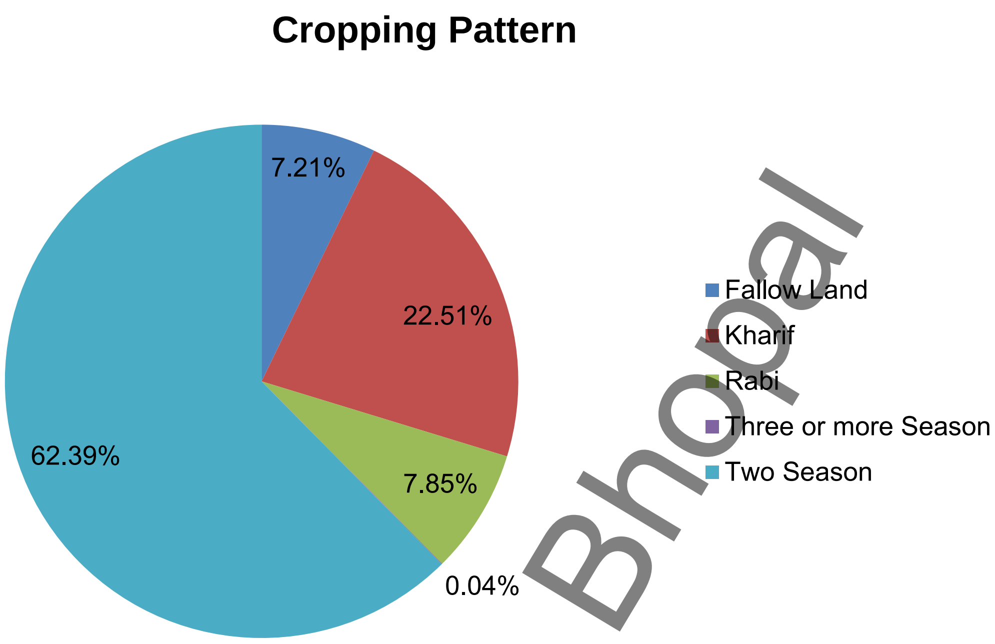

Figure 37: Cropping Pattern

4.3 Crop sown area

The gross area of cropping is known as the Crop Sown area. This implies that the total area which is used for cropping in the whole year. Multiple cropping increases the crop sown area. This increase the cropping area as well as crop production. More crop production will give us more residue for biomass. As per the discussion with local people it is derived that about "*one Hectare produces nearly 4 ton of crop*". Following Figure 38 shows the crop sown area. Therefore, if we compare the agricultural area and sown area, than sown area is almost 1.5 times the total agricultural area. Formula for Crop sown area calculation

Equation 2: Crop sown area claculation

$$\boldsymbol{Cropsownarea} = \boldsymbol{Sumof}\ (\boldsymbol{areaundertypeofcropping} \times \boldsymbol{timesofcroppingannually})$$

Furthermore, the calculation of total crop residue is done using following equation

Equation 3: Crop amount calculation

$$\boldsymbol{Gross\ agricultural\ area} \times \boldsymbol{amount\ of\ crop\ per\ unit\ area} = \boldsymbol{aggrigate\ amount\ of\ crop}$$

Hence, total agricultural area is as follows

1. Kharif - 2349 Ha
2. Rabi - 819 Ha
3. Three Season - 4 Ha
4. Two Season - 6510 Ha
5. Other One season - 753 Ha
6. Total agricultural area is - 10435 Ha
7. Total sown area - 16953 Ha

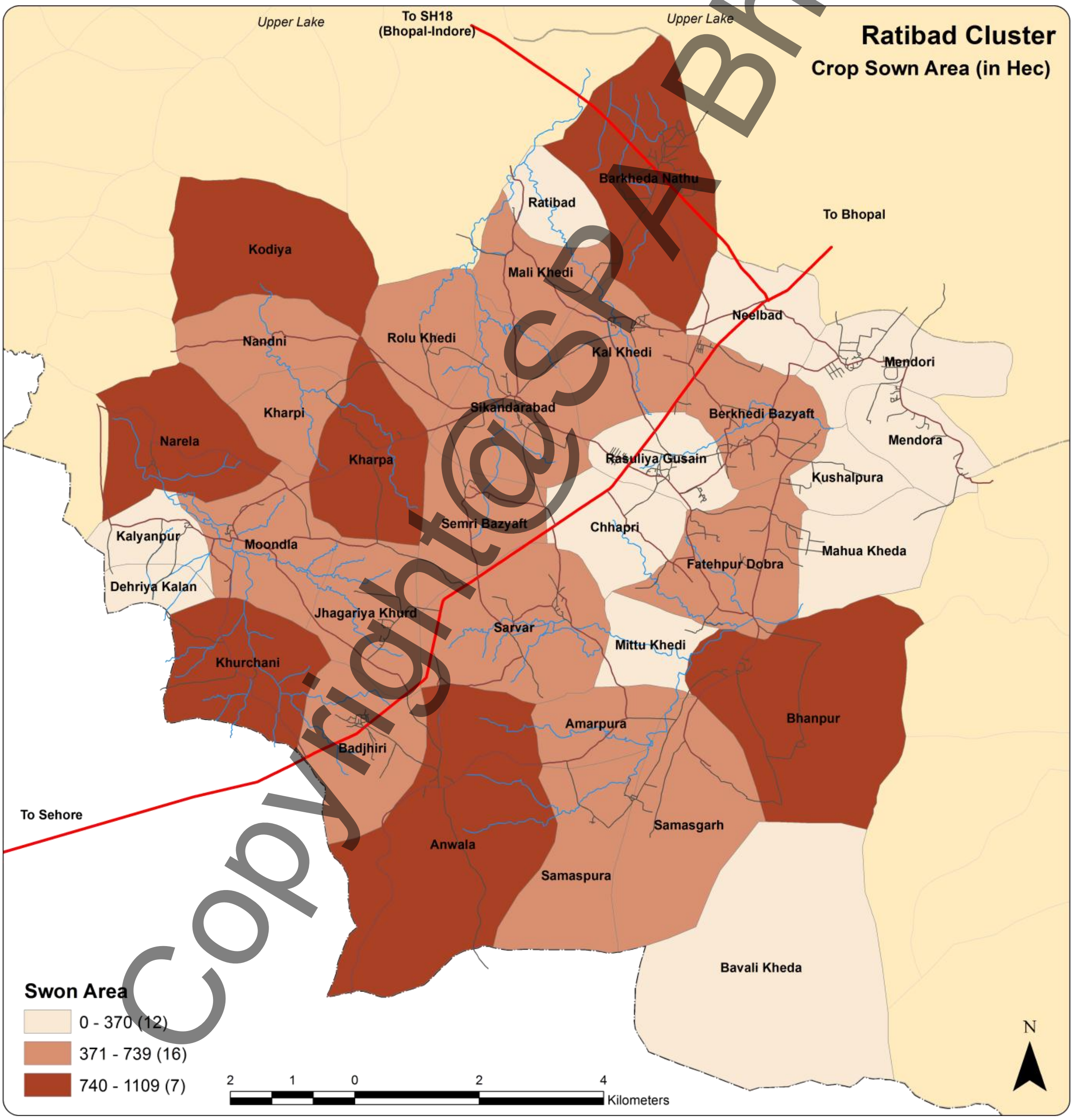

Figure 38: Village wise Crop Sown Area

Hence, considering 4 ton of crop generation per Ha as basis, we can calculate that total generation of crop is **67,812 ton** per annum "*(16,953 X 4 = 67,812)*".

Considering average residue production ration as **1.5**

RPR = 1.5 or 3/2

Equation 4: Crop residue calculation

$$\boldsymbol{Residue\ Production = 3 \times (67812 \div (3\ + 2)\ ) =\ 40,687\ ton}$$

4.4 Cattle

In rural areas, cattle are used in various works as helping hands for humans. This started long back when humans used horses for running, buffalo for agriculture, pigs for livelihood, cows for milk and many more. Cattle dung cake was also used for cooking in small rural households. Although use of cattle were limited to certain activities only before the invention of biogas energy. This opened a new gate for gases generation in which, CO_2, H_2, N_2 and other gases too. However, to calculate the total amount of gases output, total input is according to the adult cattle population. This number of cattle also needs to have sufficient amount of fodder and water to survive. This implies that total crop residue which we get from cropping cannot be used as raw material or biomass is as follows. As well as total amount of required raw material to make the cattle population survive. Figure 39 shows the village wise total adult cattle population.

Equation 5: Annual cattle dung generation

$$\boldsymbol{Annual\ Cattle\ dung = (ACU \times 27 \times 365)kg}$$

Total cattle units in the cluster is	=	10148
Dung generation per ACU	=	27 kg per day
Hence, total cattle dung per day	=	10148 X 27
	=	2,37,996 kg
therefore, annual cattle dung	=	2,37,996 X 365
	=	10,30,65,050 kg

On the other hand, as per explained earlier, cattle need sufficient amount of food and water to survive. Therefore, total requirement of fodder is 40kg wet and 10kg dry fodder per adult cattle unit. As cattle need dry fodder, another form of crop residue. Considering that the crop residue is total dry, than that can directly be used as dry fodder for the cattle population.

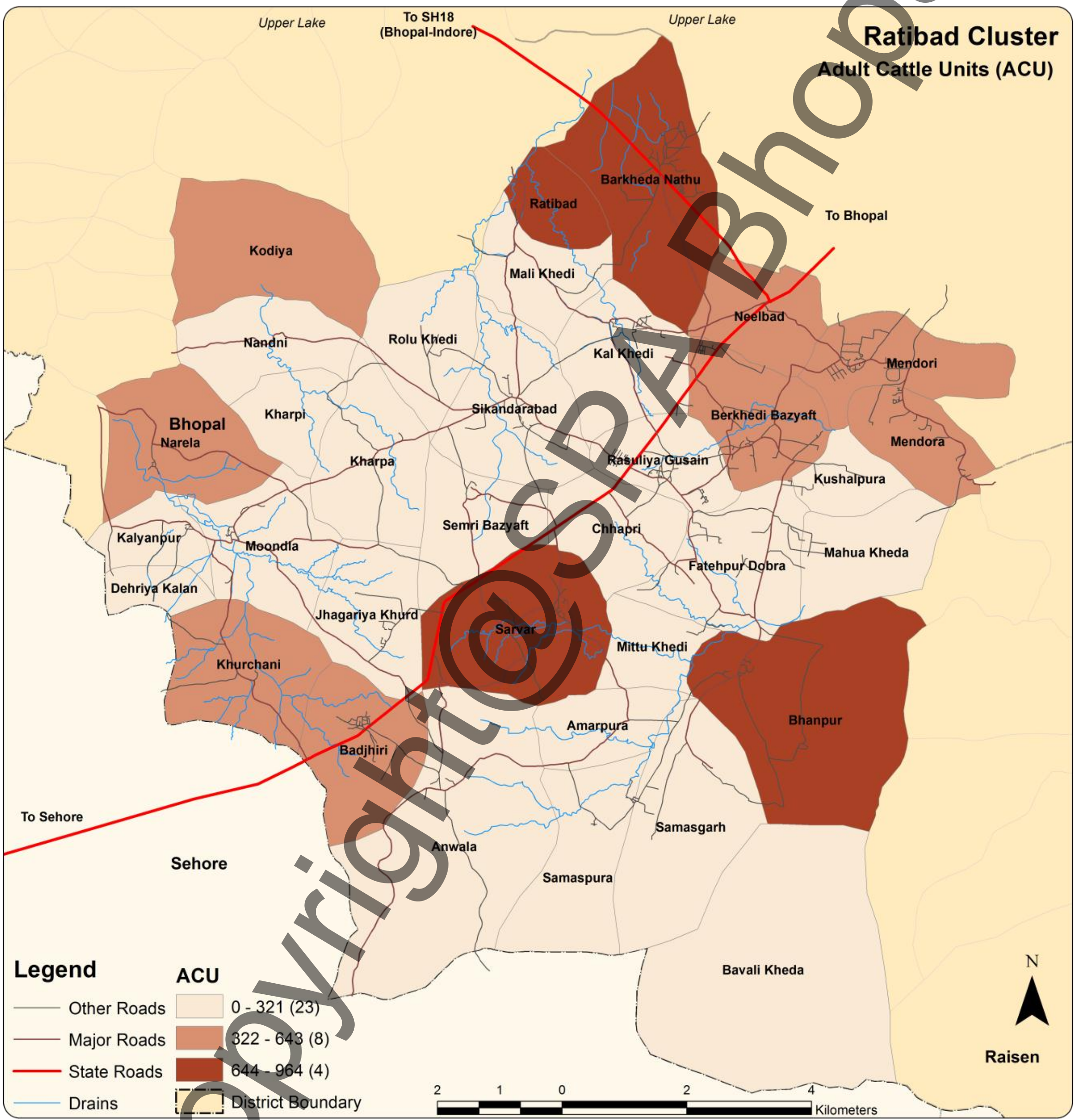

Figure 39: Village wise ACU Distribution

Calculation of total water requirement and total fodder requirement is as follows. This also gives the rest amount of crop residue left as raw material for biogas and biomass energy generation.

Equation 6: Annual water requirement for cattle population

$$\boldsymbol{Annual\ total\ water\ requirement = (ACU \times 40l) \times 365}$$

Annual water requirement = (10148 × 40) × 365 = 148,160,800 l

Equation 7: Annual fodder requirement for cattle population

$$\boldsymbol{Annual\ fodder\ requirement = (ACU \times 10) \times 365}$$

Annual fodder requirement = (10148 × 10) × 365 = 3,40,40,200 kg

4.5 Household organic waste

In all the components, households waste is also considered to be one of the reusable material. The organic waste from households are now a day used as one of the source of compost for agricultural use. This can also be used as the raw material for biomass and biogas generation. Household organic waste generally acts as the wet part share of raw material for biogas plant. The details is explained later in chapter 5. The amount of household organic waste depends on the number of households. This generally counts the amount of kitchen waste generated from each household. Although rural areas are sparsely developed compared to urban areas, which makes it difficult to collection and transportation. However, calculation can be done irrespective of these threats for estimation of total amount of organic waste can be obtained for biomass or biogas generation. Indian average kitchen waste generation for rural areas is about 1.3 kg per day (Central Statistics Organization, 2007). According to census, Every household has kitchen, irrespective of inside of house or outside. Hence, following is the calculation for household waste calculation:

Equation 8: Annual household waste estimateion

$$\boldsymbol{Total\ Household\ annual\ waste = (Waste\ from\ individual\ HH \times 1.3) \times 365}$$

Total household waste per day = 6472 × 1.3 = 8,413.6 kg

Annual HH waste generation = 8413.6 × 365 = 30,70,964 kg

Following Figure 40 shows the total household waste generation with respect to villages. This gives an idea about the spatial distribution of the concentration of waste generation for better collection system (only if feasible).

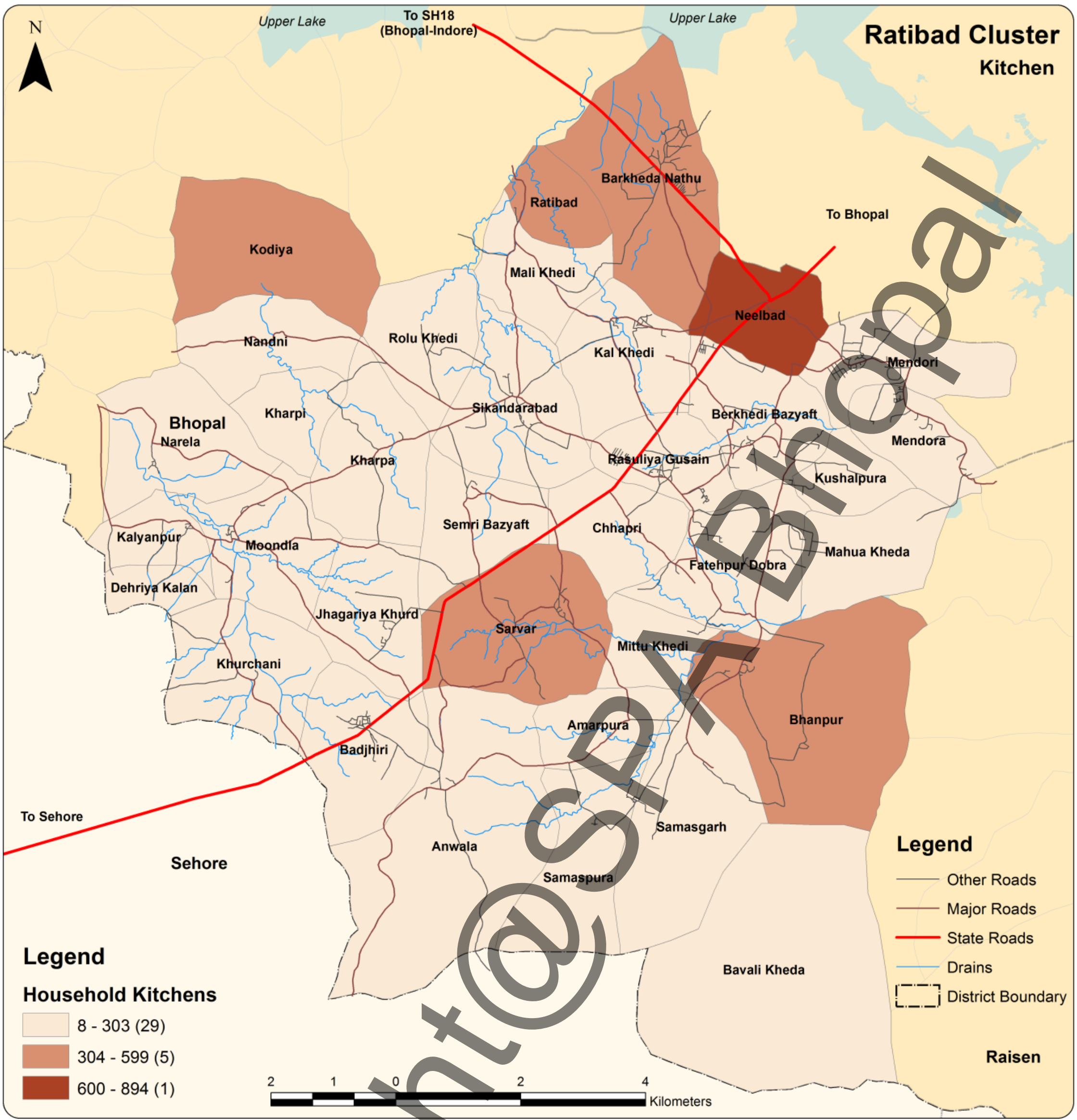

Figure 40: Village wise HH Organic Waste

4.6 Rooftop and waste land

The two major components from where solar energy can be harnessed are roof top area and waste land. This waste land includes those areas which are not utilized, areas which have undulations in slope, areas which are covered with rocks and hills etc. These areas can be used for other useful purposes like generation of solar energy. This is because, after studying all the technologies and renewable resources, it is understood that the area do not have huge running water bodies, no tidal condition, no canals, not much wind flow for wind mills and others. Hence, only solar energy can be harnessed as a source of lighting in the area. The study area is capable of generating 5.6 kWh/day/m^2.

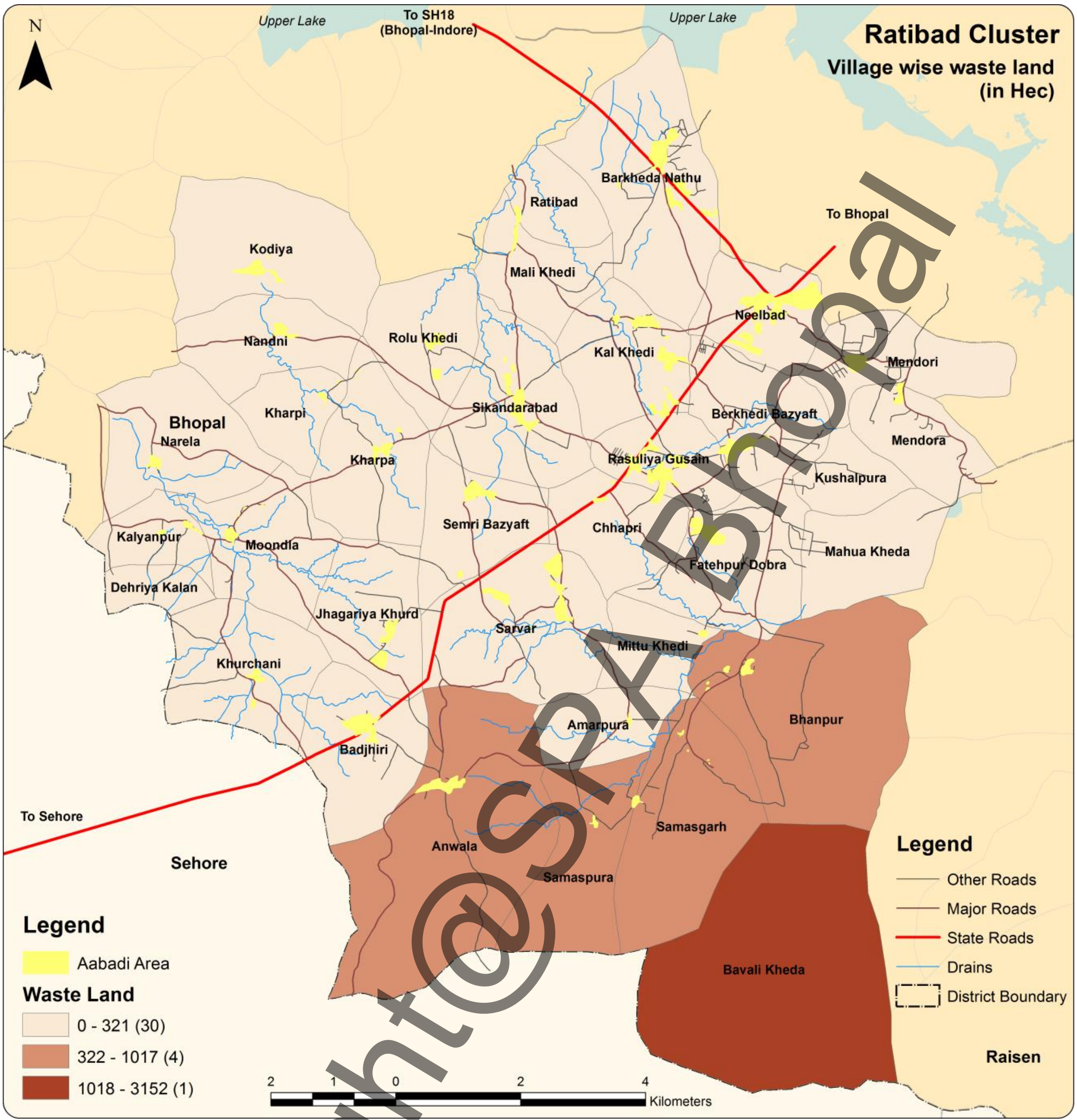

Figure 41: Village wise waste land

4.7 Population Projection

To have any kind of estimation, it is necessary to have the present demand as well as the future demand. This is because, any kind of infrastructure is made to serve a certain magnitude for a certain time. This magnitude can be population, standard units, or time. Such as battery's life is calculated as per the usage. This usage is with respect of the current being drawn from it in certain rate. This determines the lifecycle of battery. Best example of this is laptop batteries, they are made to have about 300 cycle of charges. With time, the capacity of battery decreases. The time when the capacity reaches 70% of the total capacity, these cycles are complete, and the cells needed to be replaced. Other example of magnitude is any kind of services being provided to settlement, such as water supply system or sewage system. These infrastructure are made to cater certain number of population for certain time only. Afterwards the system needs repairing. Another example being the roads. This infrastructure, is designed to cater certain PCU (Passenger Car Unit) for certain number of years. If we consider two roads which are constructed similar, but on one road only cars are running while on the other one trucks in same number. The road which running trucks will require repair sooner compared to the road which is running only cars. This is because PCU value of truck is more than car.

This manifests that any infrastructure is designed to serve certain magnitude for certain time duration. Hence, any kind of intervention or changes in infrastructure with respect to energy distribution, will need to have an clear idea about the population which it will serve for next years. According to Census of India, every 10th year is census year, and next one is 2021. Considering 2021 as first census from this year, second one will be 2031. However, projections are also required for two decades from now. This study will go forward with respect to projection for second census year from now. There are three types of projections which are followed for this irrespective of any kind of external factors. Following

Table 5: Population Projections

Year	**1991**	**2001**	**2011**	***2017***	**2021**	**2031**	**2037**	**2041**
Arithmetic Growth	16619	24137	32193	*36776*	39890	**47677**	52350	55464
Exponential Growth	16619	24137	32193	*39818*	45447	**63254**	77131	88037
Logarithmic Growth	16619	24137	32193	*36738*	39825	**47516**	52112	55169

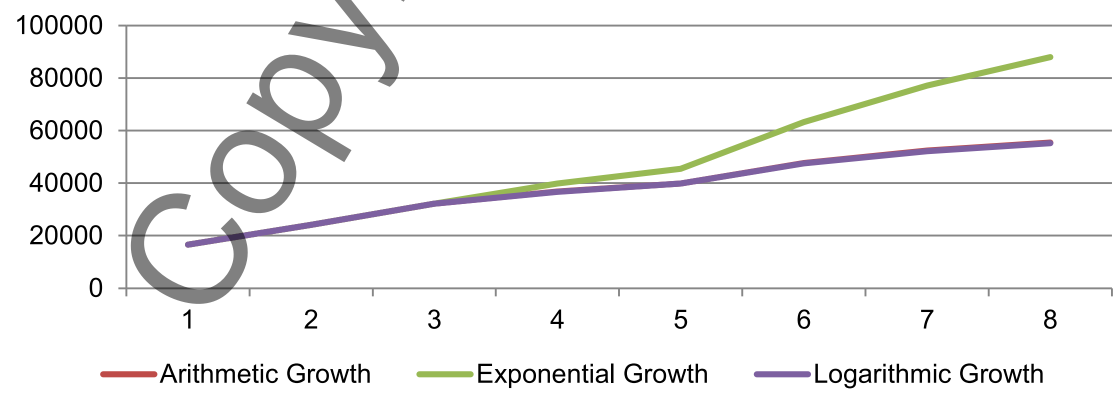

Figure 42: Population Projections

Source: Author

Among all this projections, exponential is giving way too much population, whereas arithmetic and logarithmic growth is giving approximately the similar values. However, logarithmic growth is little less than the other arithmetic growth. Hence, considering arithmetic growth as the base of population projections, further calculations area done.

4.8 Source of Lighting

Above paragraphs explained about the potential of generation. However, it is also necessary to observe the amount of resource being used for different purposes. This section will explain the sources used for lighting. There are two major sources of lighting, which are as electricity and kerosene. Other sources are like other oils, solar electricity and no lighting at all. Following paragraphs explains the context of sources being used for lighting.

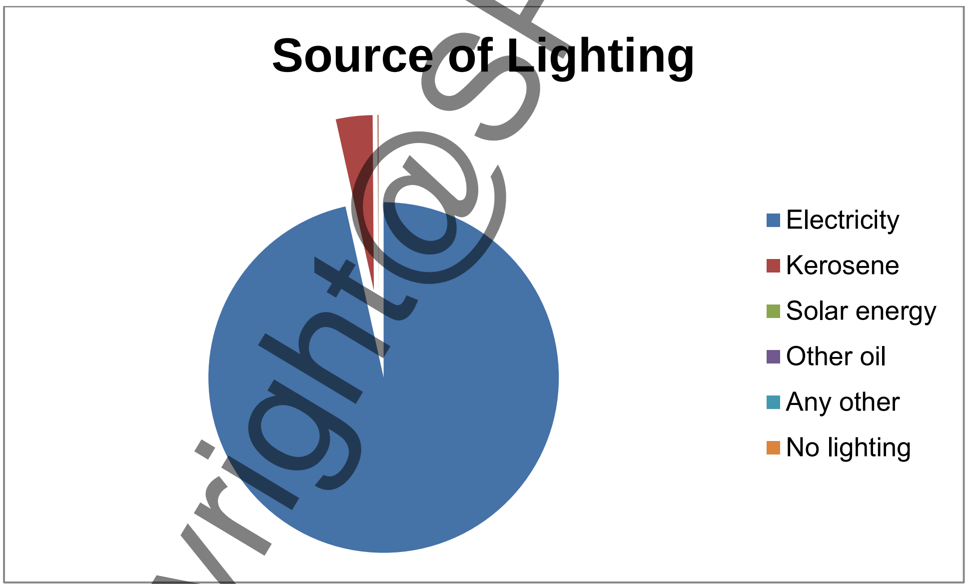

Figure 43: Share of Household lighting source

Source: Census, 2011

4.8.1 Electricity

As the village cluster lies adjacent to capital city Bhopal Municipal Corporation, and is well developed. All the villages in the cluster is electrified. According to MPSEDC, each connection in the area pays around Rs.660/- – Rs.930/-. This price do not include agricultural supply. Almost more than 50% of the villages have 90% or more share of households using electricity as their primary source of lighting. This area also suffers power cuts, due to load distribution between the cluster and other surrounding areas. According to Chief Engg. of MPSEDC, the area suffers power cuts about 2.5 to 3 hrs a day during summer, and the timings are somewhere from afternoon ~3:00 pm to ~4:00 pm with addition to night time from ~9:00 pm to ~10:30 pm. Figure 44 shows village wise household share of usage of electricity as primary source for lighting. Although according to standards and past experiences, per capita rural electricity usage is about 635 kW in annual basis and India's average is 805 kW (The World Bank, 2015). Hence, estimated demand of electricity by year 2031 considering 635 kW being per capita annual demand:

Equation 9: Annual electricity demand

$$\boldsymbol{Annual\ Electricity\ demand = Per\ capita\ demand \times 2031\ population}$$

Annual average demand = 635 × 47677 = 33,02,74,895 kW or 3,30,274 MW

Daily average demand is around 82.9 MW (3,30,274 ÷ 365) and 3.45 MW is average hourly demand. Considering 3.45 MW as designed capacity of power supply system, than considering $\boldsymbol{x}$ as 100% capacity of the plant then:

$$\boldsymbol{80 = \frac{3.45}{x} \times 100}$$

Hence $\boldsymbol{x}$ is about 4.32 MW.

∴ A power supply plant of about 4.5 MWh is enough to supply 24×7 electricity to the village cluster till 2031.

Although the population projections is done irrespective of any external growth factors. And this is also not confirm that it will only increase. However, it can also be assumed as the population might decrease. Considering a positive notion of increase in population, 4.5 MW plant can run till 2031. A buffer of 0.5 MW can be added to cater any kind of fluctuations. Hence, total 5 MW plant will probably be enough for provision of power to the village cluster.

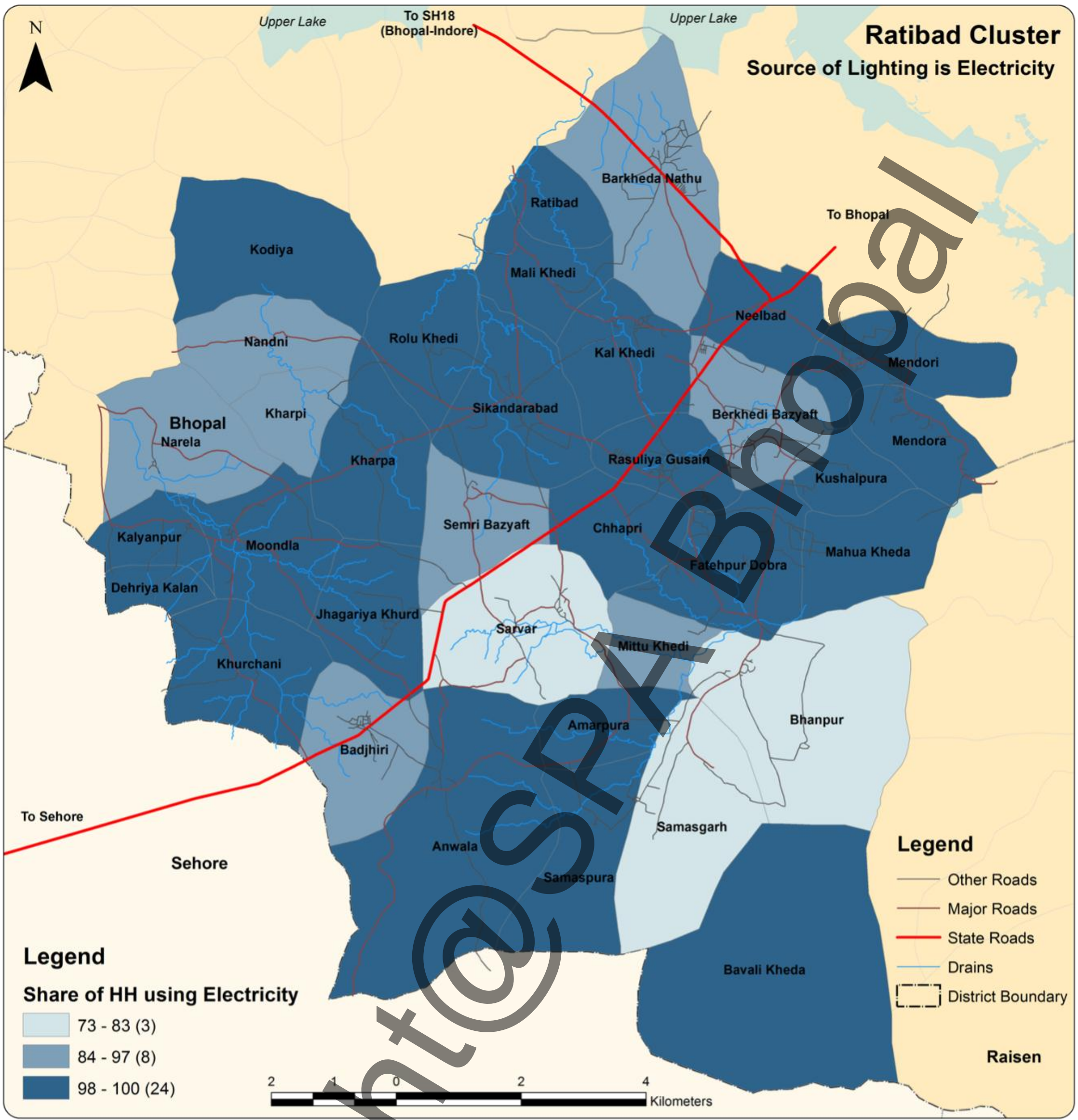

Figure 44: Map of village wise electricity usage at HH level

4.8.1 Kerosene

Kerosene is the second important fuel source used for lighting in the cluster. According to primary survey, it is identified that kerosene is only used for emergency use. Only in few cases, where household electricity connection is not there, kerosene is used as primary source of lighting. Although, following Figure 45 shows village wise percentage of household usage of kerosene as source of lighting. Kerosene is only used to understand the pattern of fuel consumed for lighting.

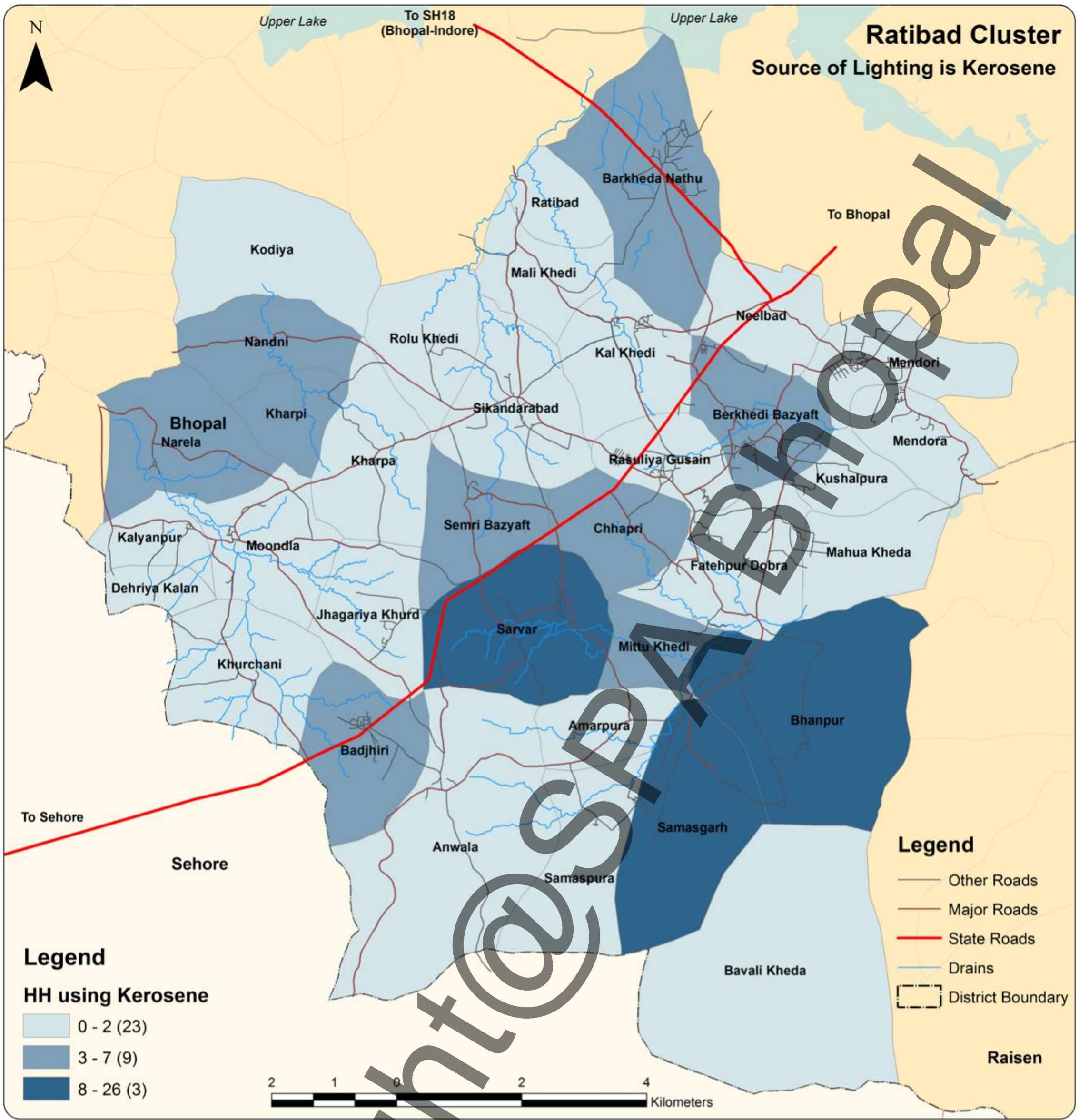

Figure 45: Village wise HH lighting source is Kerosene

4.9 Cooking Fuel

As it is explained earlier, that electricity is the basic source for lighting in the study area followed by kerosene, similarly; for cooking fuel, firewood and LPG are major sources. However, other sources are also there like crop residue, cow dung cake, coal, lignite, charcoal, kerosene, electricity and biogas. The next most used fuel for cooking is cow dung cake. This is due to availability of huge number of cattle in the area. This is necessary to understand for any kind of fuel shifting. Although, villagers get subsidy in only kerosene and LPG. This is explained later in detail. There are three biogas plant within the area, which are at Mendori, Kodia and and Jhagariya Khud.

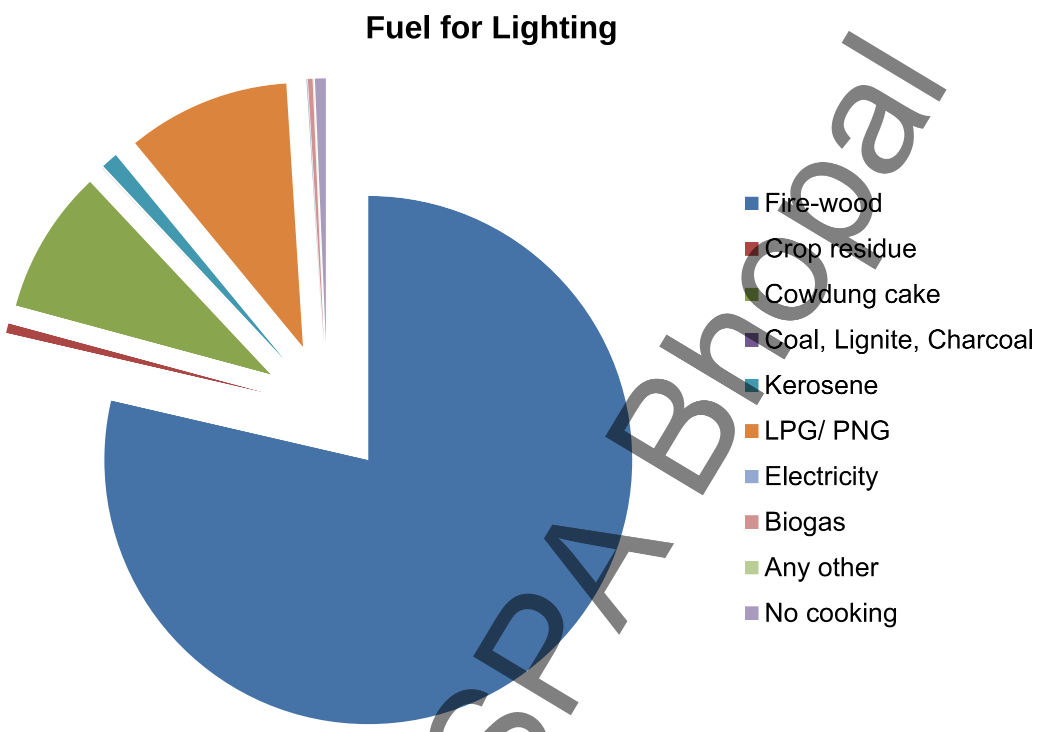

Figure 46: Source for Cooking fuel

Source: Census 2011

4.9.1 Firewood as cooking fuel

As per the above Figure 46 it is identified that firewood is the major source of fuel used for cooking. Firewood can be considered as one of the renewable fuel for cooking. However, wood is a living material and killing them for cooking purpose. This is also cleaner than coal and other traditional fuels but not clean enough to be recommended as mass use. This is because those living organisms will emit gases is any condition but in slower rate. Burning them makes this process quicker. This is why it is clean compared to other fuels. However, regeneration of that much wood will take few years unless they are hybrid and generated in few months. According to discussion with the local people, reason of using firewood as cooking fuel is that they do not have so much to cook for which they would spent huge money for LPG or Kerosene. Whereas firewood is almost free to them. Following Figure 47 shows village wise share of household usage for firewood as cooking fuel.

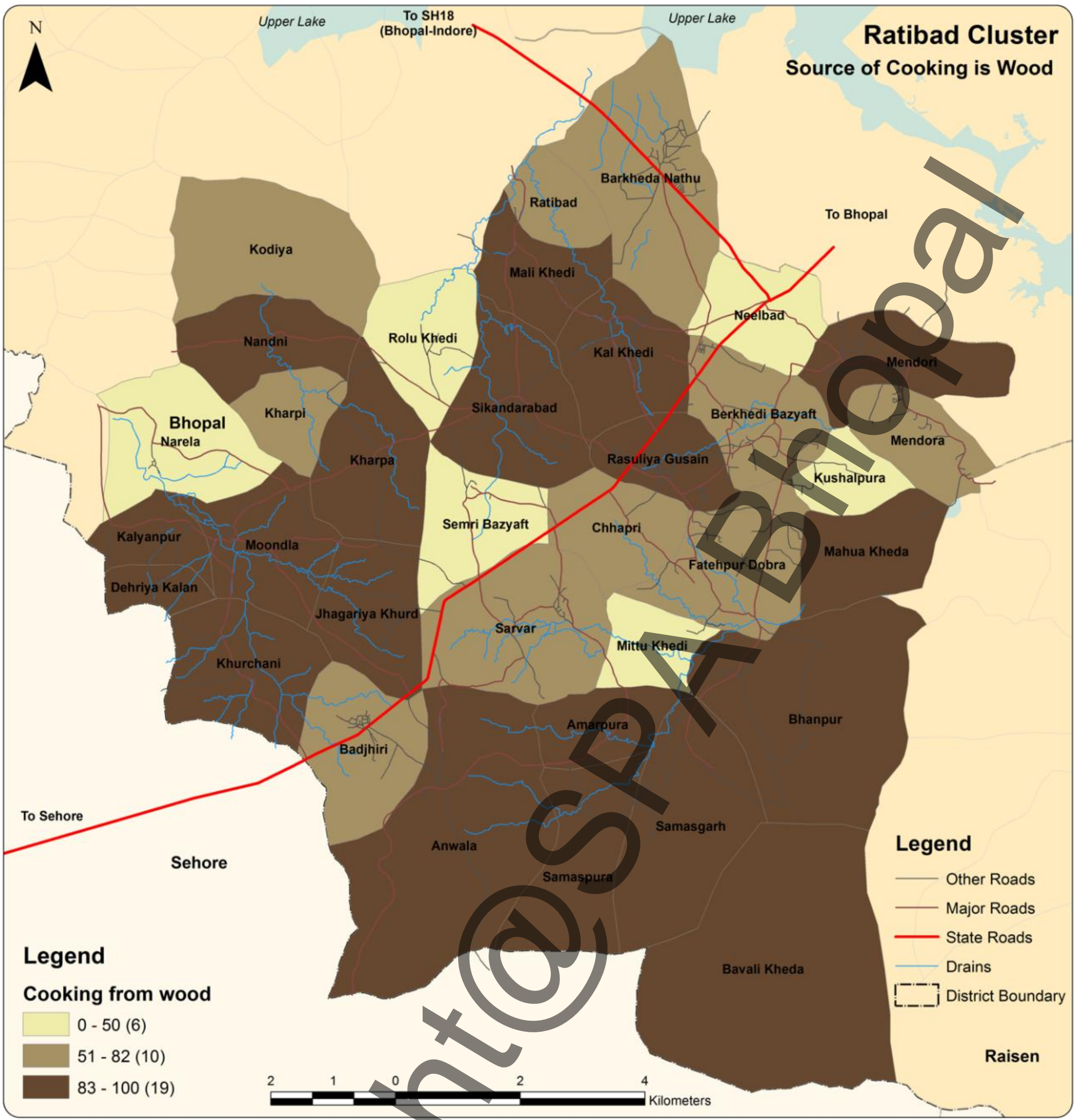

Figure 47: Village wise HH cooking fuel is Firewood

4.9.2 LPG as Cooking Fuel

LPG is the second most used fuel for cooking within the cluster. Availing LPG at urban areas is very easy. Here comes the similar point of distribution which says that more the distribution area, more will be the cost and more emissions. Although there aren't any kind of losses observed in distribution of LGP unless some accident occur. The distribution of LPG has to be made very carefully because it is counted as one of the most flammable fuels. After availing subsidy residents buy a tank of LPG (15.6 kg) in Rs.362/- and Rs.433/- depending upon the subsidy card. Whereas kerosene costs around Rs.10/- per litre after subsidy.

Following Figure 48 shows the village wise share of household using LPG as cooking fuel.

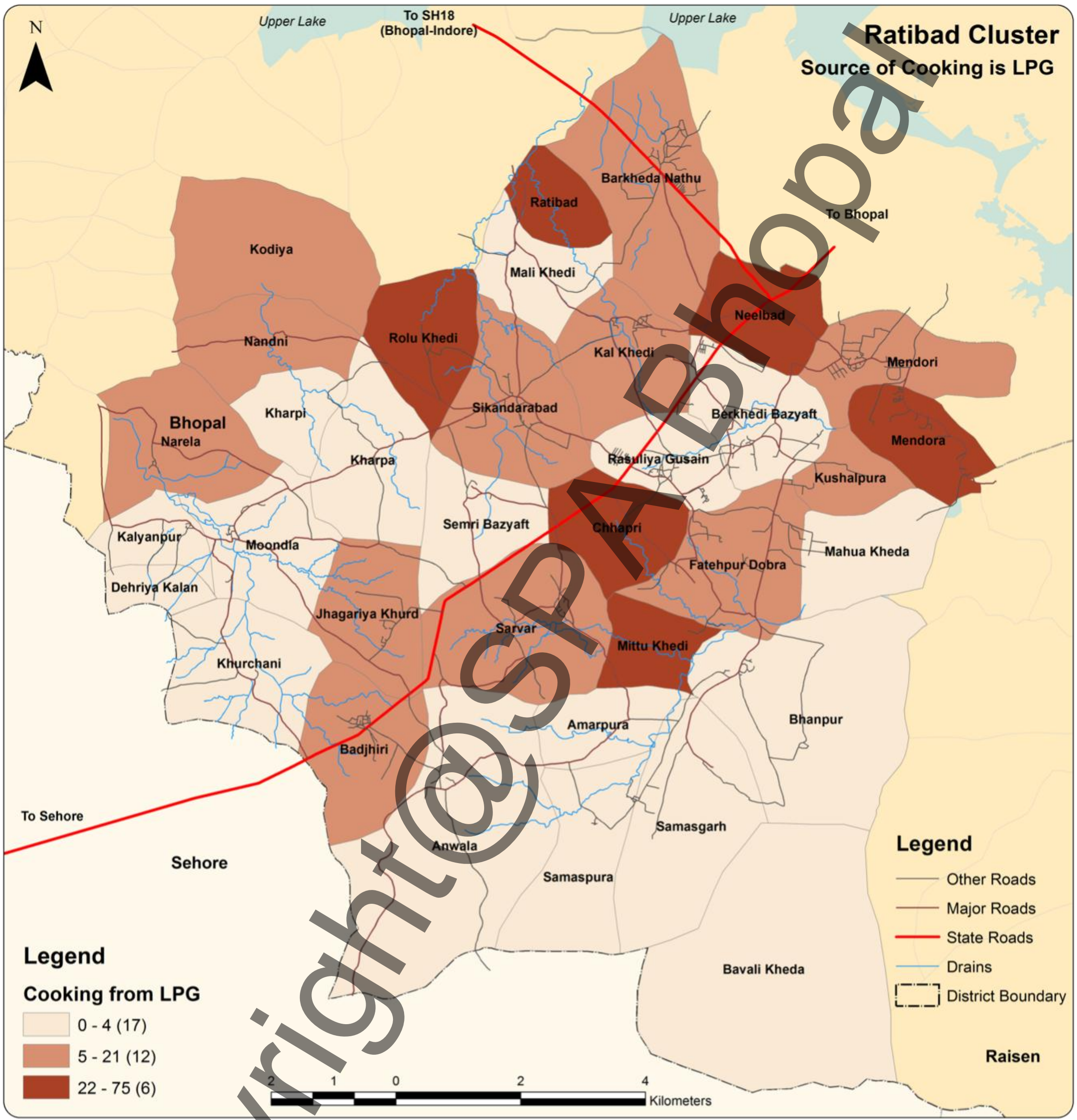

Figure 48:Village wise HH cooking fuel is LPG

Above discussion gives a picture, that the area might look urban in northern area and rural in south area, and it is the same according to the fuel usage and supply. Furthermore, to sum up and understand the strengths, weakness, opportunities and threats. This will help in finding out the possibilities and scope of intervention of new mechanism to use renewable resources present within the area locally. This is to demonstrate the way of usage of different fuels for different purposes.

4.10 SWOT

4.10.1 Strengths

1. Area is well connected with electricity line. As discussed in page 59, all villages are electrified. Transportation of electricity can be made quick and reliable.
2. State highway is there and connectivity is good. However, only the villages which are adjacent to the road are connected quite good.
3. Few of the villages have LED street lighting with solar panel. Narela village has the maximum share of household lighting source as solar

4.10.2 Weakness

1. Poor available infrastructure. Villages are connected with roads, but the quality of those roads are not very good.
2. Required raw materials for feeding cattle population
3. Water scarcity. Water is not only abundant in few villages like north most village, Berkheda Nathu, Mendori, Mendori, Kushalpura, Neelbad and Berkhedi Bezyaft.
4. Present power supply system is three stage transformer system, which might led to replacement of the supply system.

4.10.3 Opportunities

1. Presence of waste land. This can be used for any kind of physical intervention.
2. Seasonal crop production is possible for fodder generation as well as raw biomass
3. Promise of 40% of renewable energy sources by 2030 by Government of India will subsidize any kind of intervention.

4.10.4 Threats

1. Future unplanned development and demand. Bhopal city is developing in an unplanned manner. The development of the city is mostly towards the Kolar road. In some of the news and public discussions it was said that to attract the development towards north, land use are being transformed.

2. Unwanted pricing difference. Price of land is one major component while any kind of proposal, but the price of equipments are also important for

This is understood that to fulfil the energy requirement might be cater using the local resources. However, the calculations of its feasibility is explained in next chapter.

Chapter 5. Possible Interventions

This chapter will discuss about possible interventions that can be done to fill the gap. This intends to fulfil the requirement of energy for different purposes by using local resources.

5.1 Concept

The area already has enough power supply and cooking fuel supply to sustain, but they are all traditional sources. Such as for cooking still coal, firewood, cow dung cakes etc. are being used and for lighting electricity and kerosene are used. That also kerosene being the second preference during power cuts. As there are only two needs which needed to be catered using local resources, and there are about 5 types of resources which are available and can be used. A conceptual diagram is shown below that how the sources will cater the needs.

Figure 49: Conceptual Framework

5.2 Household Electricity

The need of household electricity can be catered directly from solar power. This system at least require 40% generation of the total demand. However, 100% use of the total waste land would generate more than enough power which is useless. If at all the system runs for at least 8 hours, this can cater day demand of the area. Day demand of 8 hours would be about 18 MW. Following is the calculation:

Total Population	= 32193
Per capita demand	= 635 kW (annual)
	= 1.7 kW (daily)
Total daily demand	= 56007 kW (24 hrs)
Demand for 8 hrs	= 2333.625 kW (8 hrs)

Hence, a power plant which can generate 3 MW daily, can cater the day time demand of the area.

Area requirement for power plant.

Potential of Solar energy generation	= 5.6 kW/day/m^2
Efficiency of PV cells	= 15%
One square meter will generate	= 5.6 × 0.15 = 0.84 kW/day/m^2

Hence, to generate 3 MW per day, total area requirement:

= 3000 ÷ 0.84

= 3,574 m^2

Total available waste land is about = 2,82,62,471 m^2

Generation of electricity using smart-flower

Per unit generation capacity	= 12 kW/day
Average HH size	= 5.05
Per capita demand	= 1.7 kW/day

Generation unit required to power one Household is

= (5.05 × 1.7) ÷ 12

= 0.7 units

However, if only 40% demand is needed to be catered than

= (5.05 × 0.68) ÷ 12

= 0.3 units

Hence, electricity demand of approximately 3 HH can be catered by only 1 smart flower unit. This do not include the inbuilt battery supply.

These panels costs about Rs.3,00,000/- per unit. To supply total area around 2157 units would be required. This makes the total cost of Rs.64.72 Cr. Which do not require any kind of repairing in natural condition for next 25 years. However, rooftop can also be used as installation of solar panels but this might lack the standard requirement of roof, which is concrete roof.

Roof Materials

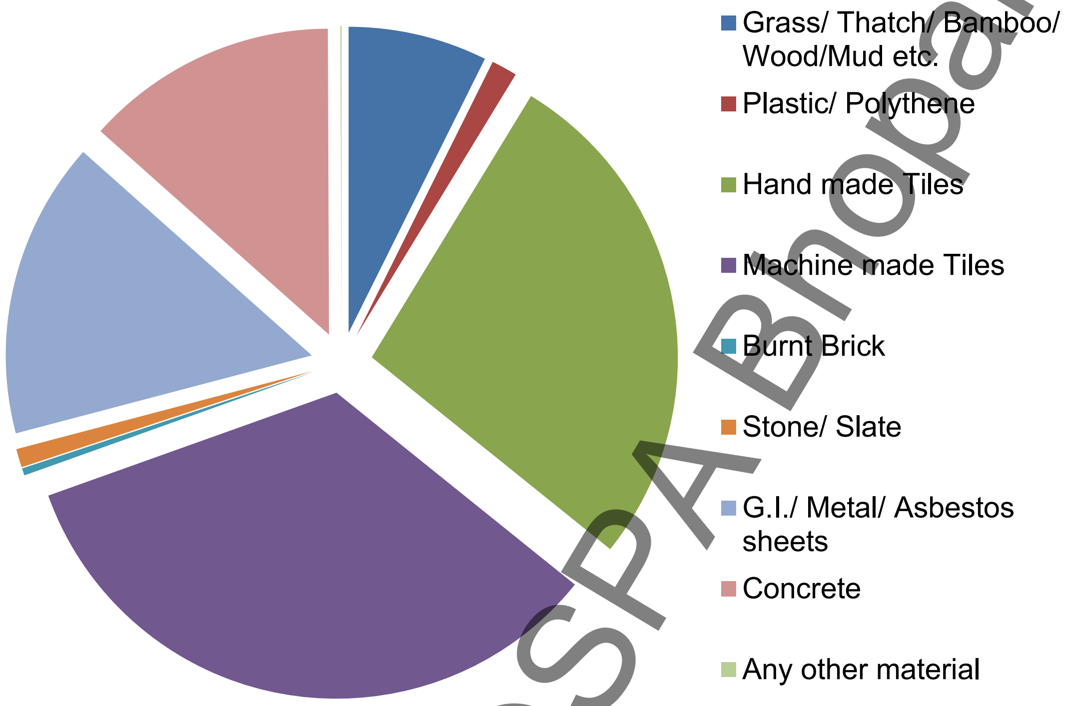

Figure 50: Household Share of roof materials

Source: Census, 2011

5.3 Household cooking fuel

Cooking fuel demand can be catered using three different sources. These are cattle dung, crop residue and kitchen waste.

Annual cattle dung	= 10,30,65,050 kg	
Annual crop residue	= 4,06,87,000 kg	(a)
Annual fodder requirement	= 3,40,40,200 kg	(b)
Remaining crop residue	= 66,46,800 kg	{(a)-(b)}
Annual kitchen waste	= 30,70,964 kg	

Typical biogas system requires about following amount

Table 6: Biogas plant requirements

Size (cu m.)	Required dung (kg/day)	Required cattle (no's)	Cooking for no. of persons
15	375	35-40	50-60
25	625	60-70	90-100
35	875	70-80	140-200
45	1125	100-110	180-200
60	1500	140-160	240-250
85	2125	200-220	340-350

Source: Vattenfall, 2016

Hence, biogas plants can be proposed with respect to villages locally to reduce transportation charges and viability of dung, quick water requirement

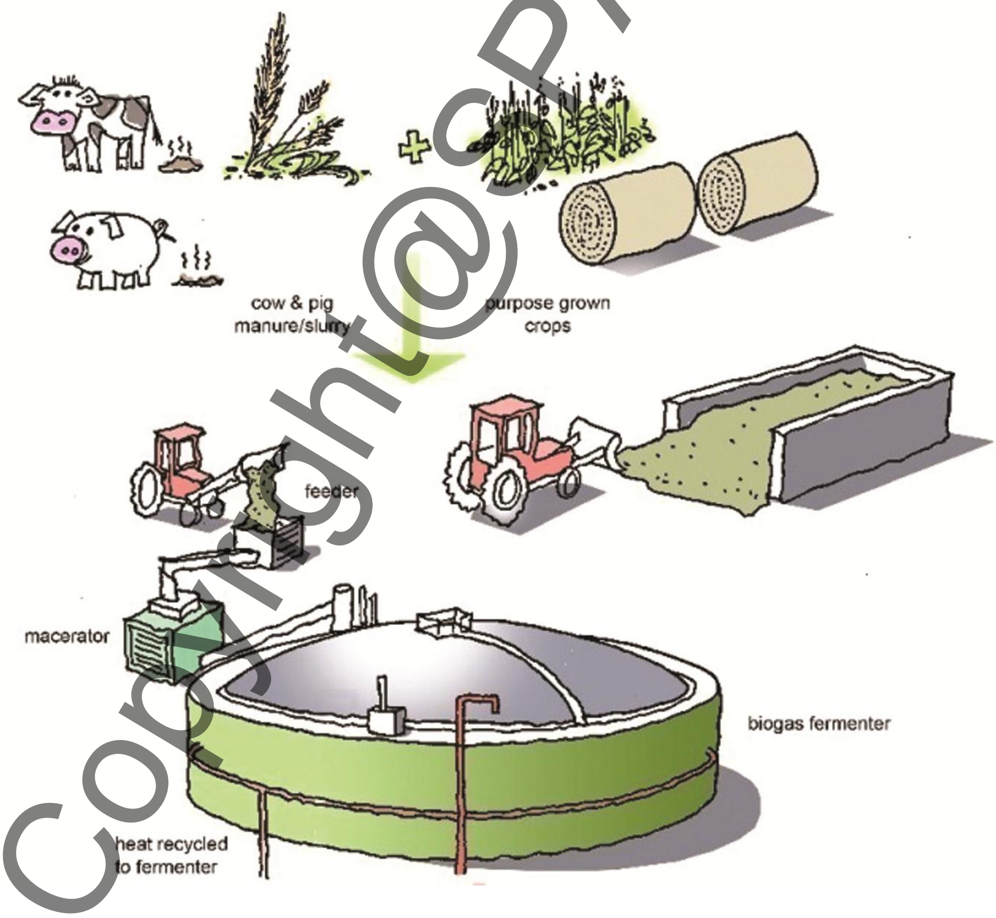

Figure 51: Raw materials for biogas plant

Source: Vattenfall, 2016

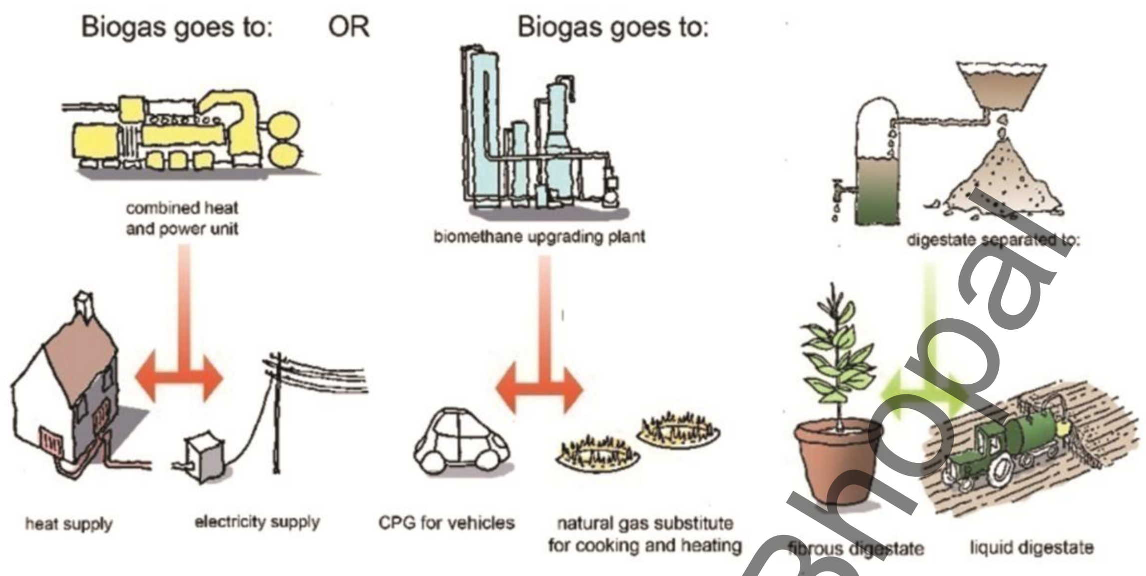

Figure 52: Outputs of Biogas plant

Source: Vattenfall, 2016

Table 7: Comparison of Possible interventions

Factors	Biomass plant	Smart Flower	Solar Panel	Solar Tree
Land	10 Acre for 7.5-12 MW	4 sq.ft for 12kW	4.5-7.5 acre per MW	4 sq.ft per unit
Capital cost	Rs 3-4.5 cr for 10 MW unit	8 Lakhs for 12kW	691.09 Lakh/MW, Capital cost for non Battery based system costs about Rs 90-100 / W and Rs170-210 / W for battery based system	3 to 4.5 lakh per unit (with 30 panels)
Generation Cost	Rs 3.25-3.75 / kWh	NIL		NIL
Maintenance cost			12-13 Lakh /year/MW	
CO_2 Release	20.29% out of total output	NIL	NIL	NIL

Factors	Biomass plant	Smart Flower	Solar Panel	Solar Tree
Funding	IREDA and other banks	Bank Loans	IREDA, Third Party Loans and Bank Loans	Bank Loans
Service time	24 Hrs	9 Hrs	8 Hrs	8 Hrs
Raw Materials	Organic waste, water	Sunlight	Sunlight	Sunlight
lifetime without repairs	20 years	20 years	25 years	15 years
Subsidy	Capital Cost can be paid by Govt, Maintainance and operation charges are covered by the system revenue		10 years of tax holiday and afterwards 19.9305% tax, 30% subsidy is available for only upto 100kW power plant, No subsidy is applicable for over 500kW power plant	

References

3TIER. (2017). *What is Global Horizontal Irradiance?* Vaisala.

Abhishek, S. (2015, June 19). *Biogas Production in India*. Retrieved March 03, 2017, from Faculty: https://faculty.in/biogas-production-in-india-is-about-5-percent-of-total-lpg-consumption/

Arouri, M. E., Youssef, A. B., M'henni, H., & Rault, C. (2012). *Energy Consumption, Economic Growth, and CO2 emission.* IZA.

Bendigo Bank. (n.d.). *Calculating green house gas emissions - gas application.* Cool Australia Organization.

Bright Source Limitless. (2015). *IVANPAH Project Facts.* Oakland: Bright Source Limitless.

Briglio, T., Galvan, J., Ivan, K., Mun, D., Pullen, B., Schneider, E., & Verhines, A. (2014). *A Feasibility Analysis of Installing Solar Photovoltaic Panels Over California Water Canals.* Los Angeles: University of California.

Bushehri, F. (2012). *Green Economy in the Arab Region.* Beirut, Lebanon: United Nations Environment Programme.

Census. (2015). *Current status of rural electrification and electricity service delivery in rural areas of India.* Government of India.

Census of India. (2011). *Primary Census Abstract.* Government of India.

Census of India. (2011). *Primary Census Abstract.* Retrieved December 2016, from Census of India: www.censusindia.gov.in/2011census/hlo/pca/pca_data.html

Census of India. (2012). *Housing Household Amenities and Assets - Madhya Pradesh source of lighting.* Bhopal: Government of India.

Center for Climate and Energy Solutions. (2013). *Environmental Protection Agency*. Retrieved 02 22, 2017, from Reducing carbon di oxide emission:

https://www.c2es.org/federal/executive/epa/reducing-aircraft-carbon-emissions

Central Statistics Organization. (2007). Estimation of Rural and Urban Income. In *Natioal Accounts Statistics - Sources and Methods* (pp. 301-305).

City and County of Swansea Council. (2012). *Open Space Assessment Report.* Dinas A Sin Abertawe.

Couture, R., & Aures, J. (2013, November 12). *You make me feel like a Na-tur-al*. Retrieved February 02, 2017, from Tuner, Mason & Company: http://www.turnermason.com/index.php/youmakemefeellikeanaturalgasvehiclepart2/

Creative Commons Attribution. (2015). *Solar power plant in the Mojave Desert.* Nellis Solar Power Plant.

Dabrowski, M., Dewulf, L., Paczynski, W., & Bergasse, E. (2013). *The Relation Between ENergy and Socio Economic Development in Southern and Eastern Mediterranean.* Seventh Framework Programme. European Comission.

Dash, P. (2012). *Consumption Pattern of Electricity in Rural and Urban Areas.* National Institute of Technology, Department of Humanities and Social Science. Rourkela: National Institute of Technology.

Davulis, J. (2010). *Maine's Green Economy.* Augusta: Center for Workforce Research and Information.

Defra. (2003). *Livestock units and Stocking rates*. Retrieved March 21, 2017, from Department of Environment Food and Rural Affairs: http://adlib.everysite.co.uk/adlib/defra/content.aspx?id=000IL3890W.198AWLDOHJ69F3#nix

Denholm, P., O'Connell, M., Brinkman, G., & Jorgenson, J. (2015). *Overgeneration from Solar Energy in California.* National Renewable Energy Laboratory.

Department of Transport. (2010). *Federal Register Rules and Regulations.* Environmental Protection Agency.

Dutta, P., & Kumar, P. (2012). *Towards cleaner, cheaper and more efficient power generation.* Bangalore: Indian Institute of Science.

Dzioubinski, O., & Chipman, R. (1999). *Trends in Consumption and Production: Household Energy Consumption.* UN: Economic & Cocial Affairs.

Electropedia. (2015). *Nuclear Energy The*. Retrieved February 07, 2017, from Battery and Energy Technologies: http://www.mpoweruk.com/nuclear_theory.htm#dt_energy

Energy Atlas. (2005). *Atlas of Household Energy.* Government of India.

Energy Department, U. S. (Director). (2015). *Tidal Power 101* [Motion Picture].

Energy Economics. (2007, September 21). *Hostage to Oil*. Retrieved February 07, 2017, from Green Economics: http://greenecon.net/hostagetooil/

Energy Lens. (2014). *kW and kWh Explained*. Retrieved February 07, 2017, from Understand and Convert Between Power and Energy: http://www.energylens.com/articles/kwandkwh

Energy, U. S. (Director). (2016). *Energy 101 Geothermal Energy* [Motion Picture].

(2016). *Environmental and Social Assessment Report.* Urja Bhawan Mega Solar Limited. Rewa District: AECOM India.

Environmental Protection Agency. (2017, January). *GHG Annual Output Emission Rates*. Retrieved March 21, 2017, from Envronmental Protection Agency: https://www.epa.gov/energy/egrid

EPA. (2012). Energy and CO2 Emissions. In *Energy and CO2 Emissions* (p. 24).

Epp, D. C., Rutz, D., Kottner, M., & Finsterwalder, T. (2008). *Guidlines for Selecting Suitable Site for Biogas Plant.* Biogas for Eastern Europe. Europe: WIP Renewable Energies.

ESRI. (2017). *ESRI*. Retrieved 2017, from ESRI: www.esri.com/

Government of India. (2005). *Atlas of House Energy.* GoI.

Government of India. (2010). *Indian Solar Resource.* National Renewable Energy Laboratory.

Government of India. (2012). *Livestock Census.* Delhi: Census of India.

Government of India. (2015). *India in Figures.* New Delhi: Ministry of Statistics and Programme Implementation Central Statistics Office Research & Publicaiton unit.

Government of India. (2015). *India in Numbers.* Government of India.

Government of India. (2015, October 01). *Un-electrified Villages as on 21-05-2015*. Retrieved January 01, 2017, from A Digital India Initiative: https://community.data.gov.in/un-electrified-villages-as-on-31-05-2015/

Government of India. (2017). *Commissioning Status of Solar Power Projects.* Government of India.

Government of India. (n.d.). *Frequently Asked Questions on Biomass Power Generation*. Retrieved April 03, 2017, from Ministry of New and Renewable Energy: http://mnre.gov.in/file-manager/UserFiles/faq_biomass.htm

Hacker, J., Mattingly, J., & Caputo, J. (2009). *Food and Crop Waste: A Viable Biomass Feedstock.* Washington DC: Environment and Energy Study Institute.

Hecht, L. (2009, January 31). *The Astounding High Cost of 'Free' Energy*. Retrieved February 07, 2017, from Larouche Pac Archive: http://archive.larouchepac.com/node/7908

Hiloidhari, M., & Baruah, D. C. (2011). Crop residue biomass for decentralized electrical power generation in rural areas. *Renewable and Sustainable Energy Reviews*, 28. Retrieved from Research Gate.

IBGeography-Lancaster. (2015). *Solar Energy Generation.* Solar Energy Generation.

International Energy Agency. (2012). *CO2 Emissions from Fuel Combustion.* International Energy Agency.

International Energy Agency. (2015). *CO2 Emissions from Fuel Compustion Highlights.* International Energy Agency.

International Energy Agency. (2016). *Energy, Climate Change & Environment 2016 Insights.* Australia, Austria, Belgium, Canada, Czech, Denmark, Finland, France, Greece, Germany, Hungary, India, Ireland, Italy, Japan, Korea, Luxembourg, Netherlands, New Zealand, Norway, Poland, Protugal, Slovak, Spain, Sweden, Switzerland, Turkey, UK & US: IEA.

IPCC. (2011, August 24). *Glossary - Climate Change.* NSIDC. Retrieved February 13, 2017, from Wikipedia: https://en.wikipedia.org/wiki/Climate_change

IPCC. (2014). *Global Greenhouse Gas Emissions Data.* US Environmental Protection Agency.

(2016). *Ivanpah Solar Power Facility.* Ivanpah: May 2016 Industrial Accident.

Jain, A., Ray, S., Ganeshan, K., Aklin, M., Cheng, C.-y., & Urpelainen, J. (2015). *Access to clean cooking energy and electricity.* Council on Energy, Environment and Water. Delhi: Columbia University.

JNNSM. (2014). *Solar Energy Corporation of India*. Retrieved February 15, 2017, from Jawaharlal Nehru National Solar Mission: http://www.seci.gov.in/content/innerinitiative/jnnsm.php

K.O, A., & E.F., U. (2015). Production of biogas from kitchen waste and cow dung. *National Journal of Innovation Scientific and Engineering Technologies Research*, 13.

Kumar, P., Kumar, S., & Joshi, L. (2015). The Extent and Management of Crop Stubble. In *Socioeconomic and Environmental Implications of Agriculture Residue Burning* (Vol. XIX, pp. 13-34). Panjab, India: Springer Briefs.

Kumar, U., & Kumar, R. (2016). *Bio medical waste awareness in health care professional.* Ranchi: International journal of advance research in science and engineering.

LEEDs. (2013). Energy and CO2 Emission. In LEEDs. LEEDs.

Legacy Management. (2011). *Annual Assessment of Effectiveness of site-wide Institute Controls.* United States Department of Energy.

Mallapur, C. (2015, October 1). *96% Villages Electrified. Yet (In 6 States) 31% Homes Lack Electricity*. Retrieved January 1, 2017, from India Spend: http://www.indiaspend.com/cover-story/96-villages-electrified-yet-in-6-states-31-homes-lack-electricity-85393

MEP2015. (2016). *Water Sensitive Development Plan.* Kutch: School of Planning and Architecture.

Ministry of Agriculture. (2014). *19th Livestock Census - 2012 All India Report.* New Delhi: Government of India.

Ministry of Home Affairs. (2011). *Census Implications.* Delhi: Government of India.

Ministry of Statistics and Programme Implementation. (2015, August 20). *Indian states by GDP per capita*. Retrieved September 18, 2016, from Statistics Times: http://statisticstimes.com/economy/gdp-capita-of-indian-states.php

Mittal, M. L., Sharma, C., & Singh, R. (2012). *Estimates of Emissions from Coal Fired Thermal Power Plants in India.* New Delhi: Department of Environmental and Occupational Health, University of South Florida.

NASA. (2017, Fevruary 07). *Nasa Earth Observatory*. Retrieved February 22, 2017, from Heat Wave Breaks Records in Australia: http://earthobservatory.nasa.gov/IOTD/view.php?id=89683

National Energy Eduation Development. (n.d.). *Biomass at a glance.* National Energy Eduation Development.

National Sample Survey 66th. (2012). *Energy Sources of Indian Households for Cooking and Lighting.* Ministry of Statistical and Programme Implementation. Government of India.

NCERT. (2009). *Physics.* NCERT.

OECD/IEA. (2006). Energy for Cooking in Developing Countries. In *World Energy Ourlook* (pp. 419-445). OECD.

Ogn., S., Campbell, C., Denholm, P., Margolis, R., & Heath, G. (2013). *Land-Use Requirements for Solar Power Plant in the US.* National Renewable Energy Laboratory.

Parliament office of Science and Technology. (2011). *Carbon Footprint of Electricity Generation.* London: House of Parliament.

Patel, D. (2016, September 14). *All villages electrified, but darkness pervades*. Retrieved January 11, 2017, from Indian Express: http://indianexpress.com/article/india/india-news-india/electricity-in-india-villages-problems-still-no-light-poverty-3030107/

Patil, K., & Chattopadhyay, A. (2012). *Household Energy use and CO2 Emission: Differential and Determinants in India.* Mumbai: International Institute for Population Sciences.

PTI. (2016, January 19). *About 25% of 18 thousand unelectrified villages get power since August*. Retrieved January 1, 2016, from Indian Express: http://indianexpress.com/article/india/india-news-india/about-25-of-18-thousand-unelectrified-villages-get-power-since-august/

Rajvinshi, A., Patil, S., & Mendonca, B. (2007). Low Concentration Ethanol Stove for Rural areas in India. *Energy for Sustainable Development*, 63-68.

Ramji, A., Soni, A., Sehjpal, R., Das, S., & Singh, R. (2012). *Rural energy access and inequalities.* TERI.

Renewable Energy is Market leader of PFSE. (2016, September 23). *Sasakt Bharat*, p. 14.

Royal Society and US NAS. (2013). *Climate Change Evidence & Causes.* (T. R. Society, Ed., & C. C. Causes, Trans.) United States of America: National Acadamy of Sciences.

Shah, A. (2015, February 02). *Global Issues*. Retrieved January 21, 2017, from Climate Change and Global Warming: http://www.globalissues.org/issue/178/climate-change-and-global-warming

Shah, A. (2015). *Humans and energy consumption.*

Smart Cities. (2016). *What is Smart City.* Governement of India.

Solar Energy Conservation Office. (2008). *Chapter 3 - Solar Energy*. Retrieved March 16, 2017, from Texas Renewable Energy Resource Assessment: https://www.seco.cpa.state.tx.us/publications/renewenergy/solarenergy.php

Solar Energy Industries Association. (2014). *Solar Energy Technologies - Solutions for today's energy needs.* Solar Energy Industries Association.

Spring. (2005). Energy in Natural Process and Human Consumption. *ENVIR*, 10.

TARU. (2016). *Road to Resilience.* TARU.

TERI. (2013/14). Energy Demand (Domestic). In TERI, *TERI Energy $ Environment Data Directory and Yearbook* (pp. 263-285).

The Energy Toolbox. (n.d.). *Summary of the Important oned for Gassification*. Retrieved February 16, 2017, from Densities of Common Gasses: http://www.engineeringtoolbox.com/gasdensityd_158.html

The Engineering Toolbox. (2014). *Liquids - Density*. Retrieved February 16, 2017, from The Engineering Toolbox: http://www.engineeringtoolbox.com/liquids-densities-d_743.html

The Geography of Transport System. (2016). Retrieved February 07, 2017, from Energy Content of some Combustibles: https://people.hofstra.edu/geotrans/eng/ch8en/conc8en/energycontent.html

The World Bank. (2008). *Residential Consumption of Electricity in India.* Government of India.

The World Bank. (2015). *Per capital Electricity consumption*. (T. W. Bank, Producer, & The World Bank) Retrieved March 10, 2017, from Use Public Data by World Bank: http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC

(2014). *Thermal Energy Storage with Solar Power Generation.* Navada.

Tiwari. (2015). *Energy, Carbon emission and Economic growth.* IIT.

TIWARI, & Kumar, A. (2011). Energy Consumption, CO2 Emissions and Economic Growth: A revisit of the evidence from India. *Applied Economictrics and International Development, II-2*, 165-189.

Trina Solar. (2011). *Ground-Mount system using Trina Solar's Multicrystaline Modules.* Porteville: Trina Solar Smart Energy Together.

United Kingdom Physical Laboratories. (2005). *Battery and Energy Technology*. Retrieved February 07, 2017, from Energy Resources and Energy Content of Fuels: https://www.mpoweruk.com/energy_resources.html

United States Environmental Protection Agency. (2015). *About the U.S. Electricity System and its Impact on the Environment*. Retrieved January 24, 2017, from Energy and the Environment: https://www.epa.gov/energy/about-us-electricity-system-and-its-impact-environment

United States Environmental Protection Agency. (2016, January 17). *GHG Equivalencies Calculator - Calculations and References*. Retrieved January 24, 2017, from Energy and the Environment: https://www.epa.gov/energy/ghg-equivalencies-calculator-calculations-and-references

Urja Vikas Nigam Limited. (2015). *Sanctioned Projects of Solar Street Light.* Bhopal: State Government of Madhya Pradesh.

US Environmental Protection Agency. (2015, August 24). *Causes of Climate Change*. Retrieved February 13, 2017, from Climate Change: https://www3.epa.gov/climatechange/science/causes.html

US EPA. (2013). *Overview of Greenhouse Gases*. Retrieved August 24, 2016, from Greenhouse Gas Emission: https://www.epa.gov/ghgemissions/overview-greenhouse-gases

USEIA. (2015). Electricity supply, disposition, prices, and emissions. In *Annual Energy Outlook* (p. A18). United States Energy Information Administration.

USEIA. (2015). Residential sector key indicators and consumption. In *Annual Energy Outlook* (pp. A9-A10). United States Energy Information Administration.

USEIA. (2016). Approximate Heat Content of Natural Gas. In *Monthly Energy Review December* (p. 194). United States Energy Information Administration.

USEIA. (2017). *How much carbon dioxide is produced per kilowatthour when generating electricity with fossil fuels?* Retrieved January 24, 2017, from United States Environmental Information Administration: https://www.eia.gov/tools/faqs/faq.cfm?id=74&t=11

Vattenfall. (2016, August 24). *Biomass Plant ~ How it Works*. Retrieved March 4, 2017, from Vattenfall: https://corporate.vattenfall.com/about-vattenfall/

Waitz, L., Twonsend, J., Cutcher-Gershenfeld, J., Greitzer, E., & Kerrebrock, J. (2004). *Aviation and the Environment.* Massachusetts Institute of Technology. Massachusetts: United States Congress.

WELTEC Bio Power. (n.d.). *How does a Biogas Plant Works?* Retrieved April 03, 2017, from WELTEC Bio Power: http://www.weltec-biopower.com/How-does-a-biogas-plant-work.1080.0.html

Wikipedia. (2016, August 24). *Carbon Footprint*. Retrieved February 14, 2017, from Wikipedia: https://en.wikipedia.org/wiki/Carbon_footprint

Woodbridge, R., Sharma, M., & Fuente, D. (2005). *Atlas of Household Energy Consumption and Expenditure in India.* (www.householdenergy.in, Ed.) Chennai, Tamil Nadu, India: Center for Development Finance, Institute for Financial and Management Research.

Young, J. (2016). *5 Powerful ways to Harness Solar Energy*. Retrieved March 14, 2017, from United States Renewable Energy Association: https://usrea.org/5-powerful-ways-to-harness-solar-energy/

Zafar, S. (2015, July 27). Importance of Biomass. p. 12.

Annexure

Annexure 1: Village wise Arithmetic growth of population

Year								
Name	1991	2001	2011	2017	2021	2031	2037	2041
Rural Population	16619	24137	32193	36776	39890	47677	52350	55464
Kodiya	956	691	1454	1432	1532	1781	1930	2030
Nandni	416	547	654	729	777	896	967	1015
Kharpi	351	435	542	595	634	729	786	825
Narela	696	835	959	1040	1093	1225	1303	1356
Kalyanpur	82	89	138	148	159	187	204	215
Moondla	567	727	875	969	1031	1185	1277	1339
Dehriya Kalan	377	453	496	537	561	620	656	680
Khurchani	633	883	978	1107	1176	1349	1452	1521
Jhagariya Khurd	276	476	580	687	748	900	991	1052
Sarvar	471	1011	1265	1551	1710	2107	2345	2504
Badjhiri	917	1156	1351	1489	1575	1792	1923	2009
Anwala	737	983	1200	1344	1436	1668	1807	1899
Rasuliya Gusain	321	329	532	563	605	711	774	816
Sikandarabad	689	926	1316	1479	1604	1918	2106	2231
Kharpa	498	562	712	762	805	912	976	1019
Barkheda Nathu	1403	1863	2324	2600	2784	3245	3521	3705
Neelbad	778	1328	4282	4933	5633	7385	8437	9137
Rolu Khedi	26	63	45	60	64	73	79	83
Mali Khedi	325	452	710	804	881	1073	1189	1266
Kal Khedi	659	886	1261	1417	1537	1838	2019	2139
Mittu Khedi	49	73	112	128	141	173	191	204
Kushalpura	28	31	198	222	256	341	392	426
Berkhedi Bazyaft	847	1107	985	1090	1118	1187	1228	1256
Ratibad	969	1409	1740	1989	2144	2529	2760	2915
Semri Bazyaft	633	761	877	952	1001	1123	1196	1245
Chhapri	19	1009	767	1197	1346	1720	1945	2094
Mahua Kheda	10	119	34	74	78	90	98	102
Fatehpur Dobra	440	628	743	846	907	1058	1149	1210
Amarpura	147	168	194	207	217	240	254	264
Bhanpur	1084	1508	2120	2399	2607	3125	3435	3643
Samasgarh	240	383	387	454	484	557	601	631

Year								
Name	1991	2001	2011	2017	2021	2031	2037	2041
Samaspura	136	222	257	302	326	387	423	447
Mendora	302	707	899	1114	1233	1532	1711	1830
Mendori	479	1232	1070	1400	1518	1813	1991	2109
Bavali Kheda	58	85	136	155	171	210	233	249
Total	16619	24137	32193	36776	39890	47677	52350	55464

Annexure 2: Village wise Exponential growth of population

Year								
Name	1991	2001	2011	2017	2021	2031	2037	2041
Rural Population	16619	24137	32193	39818	45447	63254	77131	88037
Kodiya	956	691	1454	1380	1501	1851	2099	2282
Nandni	416	547	654	761	833	1045	1196	1310
Kharpi	351	435	542	617	673	836	953	1039
Narela	696	835	959	1064	1134	1331	1465	1562
Kalyanpur	82	89	138	152	169	219	256	284
Moondla	567	727	875	1007	1099	1365	1554	1695
Dehriya Kalan	377	453	496	547	578	663	720	760
Khurchani	633	883	978	1158	1263	1570	1789	1952
Jhagariya Khurd	276	476	580	768	891	1291	1614	1872
Sarvar	471	1011	1265	1862	2268	3717	5000	6092
Badjhiri	917	1156	1351	1537	1661	2016	2264	2447
Anwala	737	983	1200	1410	1554	1983	2295	2530
Rasuliya Gusain	321	329	532	574	635	817	951	1052
Sikandarabad	689	926	1316	1583	1802	2490	3024	3442
Kharpa	498	562	712	777	835	999	1112	1194
Barkheda Nathu	1403	1863	2324	2732	3022	3890	4526	5006
Neelbad	778	1328	4282	6424	9035	21197	35357	49729
Rolu Khedi	26	63	45	65	73	95	113	126
Mali Khedi	325	452	710	880	1028	1520	1921	2247
Kal Khedi	659	886	1261	1518	1728	2390	2904	3306
Mittu Khedi	49	73	112	143	169	255	326	385
Kushalpura	28	31	198	266	393	1045	1880	2780
Berkhedi Bazyaft	847	1107	985	1099	1133	1221	1278	1317

Year								
Name	1991	2001	2011	2017	2021	2031	2037	2041
Ratibad	969	1409	1740	2131	2396	3211	3827	4302
Semri Bazyaft	633	761	877	974	1040	1224	1349	1440
Chhapri	19	1009	767	4720	9890	62836	190556	399236
Mahua Kheda	10	119	34	91	117	215	311	397
Fatehpur Dobra	440	628	743	897	996	1295	1515	1682
Amarpura	147	168	194	210	222	256	278	294
Bhanpur	1084	1508	2120	2588	2960	4139	5061	5788
Samasgarh	240	383	387	482	530	673	777	855
Samaspura	136	222	257	329	374	514	622	707
Mendora	302	707	899	1381	1717	2963	4110	5112
Mendori	479	1232	1070	1632	1916	2864	3645	4281
Bavali Kheda	58	85	136	173	205	314	406	481
Total	16619	24137	32193	43931	55839	134310	287054	518985

Annexure 3: Village wise Logarithmic Growth of population

Year								
Name	1991	2001	2011	2017	2021	2031	2037	2041
Rural Population	16619	24137	32193	36738	39825	47516	52112	55169
Kodiya	956	691	1454	1430	1529	1774	1921	2019
Nandni	416	547	654	729	776	894	964	1011
Kharpi	351	435	542	595	633	727	784	821
Narela	696	835	959	1040	1092	1222	1299	1351
Kalyanpur	82	89	138	148	159	186	203	214
Moondla	567	727	875	969	1030	1182	1273	1333
Dehriya Kalan	377	453	496	537	561	619	654	678
Khurchani	633	883	978	1107	1175	1345	1447	1515
Jhagariya Khurd	276	476	580	687	747	897	987	1046
Sarvar	471	1011	1265	1549	1707	2099	2333	2489
Badjhiri	917	1156	1351	1488	1574	1788	1916	2001
Anwala	737	983	1200	1343	1434	1663	1800	1891
Rasuliya Gusain	321	329	532	562	604	708	770	812
Sikandarabad	689	926	1316	1477	1601	1911	2096	2219
Kharpa	498	562	712	761	804	909	972	1014

Barkheda Nathu	1403	1863	2324	2598	2781	3235	3507	3688
Neelbad	778	1328	4282	4923	5617	7346	8380	9067
Rolu Khedi	26	63	45	60	64	73	79	82
Mali Khedi	325	452	710	803	879	1069	1183	1258
Kal Khedi	659	886	1261	1415	1535	1832	2010	2128
Mittu Khedi	49	73	112	128	141	172	190	203
Kushalpura	28	31	198	221	255	339	389	422
Berkhedi Bazyaft	847	1107	985	1090	1117	1186	1227	1254
Ratibad	969	1409	1740	1988	2141	2521	2749	2900
Semri Bazyaft	633	761	877	952	1000	1120	1193	1240
Chhapri	19	1009	767	1196	1344	1714	1935	2082
Mahua Kheda	10	119	34	74	78	90	97	102
Fatehpur Dobra	440	628	743	845	905	1055	1145	1204
Amarpura	147	168	194	207	216	240	254	263
Bhanpur	1084	1508	2120	2397	2602	3114	3419	3623
Samasgarh	240	383	387	454	483	556	599	628
Samaspura	136	222	257	302	326	385	421	445
Mendora	302	707	899	1112	1231	1526	1702	1819
Mendori	479	1232	1070	1399	1516	1809	1983	2099
Bavali Kheda	58	85	136	155	171	209	232	247
Total	16619	24137	32193	36738	39825	47516	52112	55169

Annexure 4: Village wise source of lighting in percentage household

Area Name	Main Source of lighting					
	Electricity	Kerosene	Solar energy	Other oil	Any other	No lighting
Ratibad	100	0	0	0	0	0
Kalyanpur	99.4	0.6	0	0	0	0
Jhagariya Khurd	34.4	65.6	0	0	0	0
Neelbad	5.9	94.1	0	0	0	0
Kodiya	97.9	1.4	0	0.4	0	0.4
Nandni	97.1	2.9	0	0	0	0
Kharpi	94.5	5.5	0	0	0	0
Narela	95.8	3.6	0	0.6	0	0
Kalyanpur	100	0	0	0	0	0

Area Name	Main Source of lighting					
	Electricity	Kerosene	Solar energy	Other oil	Any other	No lighting
Moondla	98.1	1.9	0	0	0	0
Dehriya Kalan	100	0	0	0	0	0
Khurchani	98.9	1.1	0	0	0	0
Jhagariya Khurd	98.4	1.6	0	0	0	0
Sarvar	79.7	19.9	0	0	0	0.3
Badjhiri	95.9	4.1	0	0	0	0
Anwala	99.5	0.5	0	0	0	0
Rasuliya Gusain	98.2	1.8	0	0	0	0
Sikandarabad	98.7	1.3	0	0	0	0
Kharpa	98.9	1.1	0	0	0	0
Barkheda Nathu	95.4	3.9	0.5	0.2	0	0
Neelbad	98.7	1.2	0.1	0	0	0
Rolu Khedi	100	0	0	0	0	0
Mali Khedi	99.2	0.8	0	0	0	0
Kal Khedi	98	2	0	0	0	0
Mittu Khedi	92.9	7.1	0	0	0	0
Kushalpura	100	0	0	0	0	0
Berkhedi Bazyaft	96.7	3.3	0	0	0	0
Ratibad	97.9	1.8	0	0	0	0.3
Semri Bazyaft	96.3	3.7	0	0	0	0
Chhapri	97.4	2.6	0	0	0	0
Mahua Kheda	100	0	0	0	0	0
Fatehpur Dobra	98.7	1.3	0	0	0	0
Amarpura	100	0	0	0	0	0
Bhanpur	73.2	25.7	0	0.8	0	0.3
Samasgarh	82.9	17.1	0	0	0	0
Samaspura	100	0	0	0	0	0
Mendora	100	0	0	0	0	0
Mendori	98.8	1.2	0	0	0	0
Bavali Kheda	100	0	0	0	0	0

Annexure 5: Village wise share of household of cooking fuel

Area Name	Type of Fuel used for Cooking									
	Fire-wood	Crop residue	Cow dung cake	Coal, Lignite, Charcoal	Kerosene	LPG/PNG	Electricity	Biogas	Any other	No cooking
Ratibad	98.8	1.2	0	0	0	0	0	0	0	0
Kalyanpur	97.6	1.8	0	0	0	0.6	0	0	0	0
Jhagariya Khurd	100	0	0	0	0	0	0	0	0	0
Neelbad	72.4	1.8	25.9	0	0	0	0	0	0	0
Kodiya	67.8	0	0	0	23.7	8.1	0.4	0	0	0
Nandni	95.1	0	0	0	0	4.9	0	0	0	0
Kharpi	81.8	2.7	15.5	0	0	0	0	0	0	0
Narela	30.5	0.6	59.3	0	0	4.8	0	4.8	0	0
Kalyanpur	100	0	0	0	0	0	0	0	0	0
Moondla	94.4	0	0	0	1.9	3.7	0	0	0	0
Dehriya Kalan	97.6	0	0	0	0	1.2	0	1.2	0	0
Khurchani	99.5	0	0	0	0	0	0	0.5	0	0
Jhagariya Khurd	88.7	0.8	0	0	0	8.1	0.8	1.6	0	0
Sarvar	80.4	0	14.3	0	0	5.3	0	0	0	0
Badjhiri	68.8	0	26.1	0	0	5	0	0	0	0
Anwala	98	1	0	0	0	1	0	0	0	0
Rasuliya Gusain	99.1	0.9	0	0	0	0	0	0	0	0
Sikandarabad	94.1	0	0.4	0	0	5.1	0	0	0	0.4
Kharpa	97.2	2.8	0	0	0	0	0	0	0	0
Barkheda Nathu	77.6	3.7	7.4	0	0	10.6	0	0.5	0	0.2
Neelbad	30.3	4.9	15.5	0	4	45.4	0	0	0	0
Rolu Khedi	50	0	0	0	0	33.3	0	0	0	16.7
Mali Khedi	99.2	0	0	0	0	0	0	0	0	0.8
Kal Khedi	91.3	0	0	0	0	7.1	0	0	0	1.6
Mittu Khedi	25	0	0	0	0	75	0	0	0	0
Kushalpura	46.3	0	46.3	0	0	4.9	0	0	0	2.4
Berkhedi Bazyaft	76.5	0	20.2	0	0	2.2	0	1.1	0	0
Ratibad	63.1	1.2	1.2	0.3	3	29.6	0	0.3	0.6	0.6
Semri Bazyaft	0	0.5	97.4	0	0	2.1	0	0	0	0

Area Name	Type of Fuel used for Cooking									
	Fire-wood	Crop residue	Cow dung cake	Coal, Lignite, Charcoal	Kerosene	LPG/PNG	Electricity	Biogas	Any other	No cooking
Chhapri	69.3	0	0	0	2	28.8	0	0	0	0
Mahua Kheda	100	0	0	0	0	0	0	0	0	0
Fatehpur Dobra	78.7	0	0.7	0	0	20.7	0	0	0	0
Amarpura	100	0	0	0	0	0	0	0	0	0
Bhanpur	97.9	0	0.5	0	0	1.3	0.3	0	0	0
Samasgarh	94.3	0	2.9	0	0	2.9	0	0	0	0
Samaspura	100	0	0	0	0	0	0	0	0	0
Mendora	71.9	1.4	0.5	0	0.5	25.2	0	0	0	0.5
Mendori	87.3	0	0	0	0.4	12.3	0	0	0	0
Bavali Kheda	100	0	0	0	0	0	0	0	0	0

Questionnaire

Other tables

:::Sheets:::