
**Addis Ababa University**

**School of Graduate Studies**

**College of Social Sciences**

**DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES**

# ENVIRONMENTAL AND SOCIOECONOMIC EFFECTS OF WIND ENERGY PRODUCTION; THE CASE OF ADAMA II WIND FARM.

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# Environmental and Socioeconomic Effects of Wind Energy production The Case of Adama II Wind Farm.

A Thesis Submitted to Department of Geography and Environmental Studies of Addis Ababa University, in Partial Fulfillment of the Requirements for the Degree of Master of Art ( Climate Change and Human Adaptation ).

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## Addis Ababa University

## School of Graduate Studies

This is to certify that the thesis entitled **Environmental and Socioeconomic Effects of Wind Energy Production The Case of Adama II Wind Farm.** is prepared by GetachewTafesse and submitted in partial fulfillment for the Degree of Master of Arts (Geography and Environmental Studies, Specialization: Climate Change and Adaptation) complies with the regulations of the university and meets the accepted standards with respect to originality and quality.

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**Signed by the examining committee**:

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_____

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## Statement of declaration

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***ACRONYMS AND ABBREVIATING***

| | |
|---|---|
| *CSE* | *Center of Sustainable Energy* |
| *EEP* | *Ethiopian Electric Power* |
| *EGII* | *Ethiopian Geospatial Information Institute* |
| *EMS* | *Ethiopian Metrological Society* |
| *EREDPC* | *Ethiopian Rural Energy Development and Promotion Center* |
| *EEA* | *Ethiopian Electric Agency* |
| *EPA* | *Environmental Protection Authority* |
| *FEWSN* | *Famine Early Warning Systems Network* |
| *FSRAIIWP* | *Feasibility Study Report for Aisha II Wind power Project* |
| *GHG* | *Green House Gas* |
| *GoE* | *Government of Ethiopia* |
| *HCC* | *Hydro China Corporation* |
| *IPP* | *Inter Dependence Power Producer* |
| *IPCC* | *Intergovernmental Panel on Climate Change.* |
| *KII* | *Key Informant Interview* |
| KPLCPDP | Kenya Power the Least Cost Power Development Plan 2009 – 2029(KLCPDP) |
| *LCA* | *Life Cycle Assessment* |
| *LU/LCC* | *Land-Use/Land-Cover Change* |
| *MESPRS* | *Ministry of Environment and Spatial Planning of the Republic of Serbia* |

| | |
|---|---|
| *MFAD* | *Ministry of Foreign Affairs of Denmark* |
| *NMA* | *National Meteorology Agency* |
| *PA* | *Peasant Association* |
| POST | Parliamentary Office of Science and Technology |
| *SWERA* | *Solar and Wind Energy Resource Assessment* |
| *WTGs* | *Wind Turbine Generator* |

# *ABSTRACT*

***Purpose of the study*** *is to assess environmental and socio economic effects of wind energy production of Adama II wind farm. The data used for the study were collected from 77 sample respondents who were randomly selected from 1576 households by simple random sampling technique by lottery method and feedback of key respondents like the wind farm managers and some farmers were used. In addition to this, production data from the beginning of the power plant (March 23, 2014) up to July 31st, 2018 and topographic map and remote sensing image of the study area which was obtained from Ethiopian Geospatial information institute and climatic data from National Meteorology Agency was used for data analysis. The main findings of the study are. As 2000-2016 Land use land cover change shows the wind farm plant contribution in altering the land use pattern particularly in shrub and forest clearing and sharing farm land is negligible except in aggravating soil erosion in some farm lands, The standard distance between two consecutive wind turbine is kept by 76%, .During dry season when there is shortage of power due to erratic water problem, wind energy is used to compensate energy supply, with the introduction of wind farm the local community have got the following economic benefit like accesses to public transport, employing as daily laborers and guard during the construction and operation phase, growing red onion as cash crop, they have got compensation for the farm land that used for wind farm even if they have complaint about the amount of compensation, wind farm contribute its own part in reducing the amount of carbon that will penetrate in to the atmosphere, the area ( foot print ) that is used for wind turbine is very small which does not affect the farming activity including grazing unlike hydro power which requires a huge area. The major social problem seen in relation to establishment of wind farm in the local community is noise created by wind turbine and flicker effect seen as minor problem, about 94% of the local community do not benefited with electric light. Wood and animal dung and charcoal is used as fuel for cooking food. About 50 (65%) used solar panel as source of light and 23 (30%) uses others like kerosene lumps as a source of light, consultative meeting was not carried with the local community before the introduction of wind farm .Therefore ,it is suggested that, among other soil conservation measure, reduction of noise of wind turbine near to residential area and social institution like churches, schools ,health station, resolving the grievance of the local community in relation to compensation payment , looking the way for supplying electric power to the local community must get police attention for sustainability of the wind farm in the study area.*



**Keywords:** wind, wind energy, wind farm, wind turbine

# CHAPTER ONE

## INTRODUCTION

### 1.1. Background of the study

Energy resources are the basic drive of development of entire mankind and growth of world economy. It is also basis of survival of mankind. The history of energy utilization is marked with the history of the mankind's recognition and conquering of nature. (Anderson,2015; Mentis,2013; Erin,2010; Hydro China Corporation ((HCC), 2012)**).**The history of the mankind's energy utilization can be leveled in five stages, including (1) Discovery and utilization of fire; (2) Utilization of animal power, wind power, hydropower and other natural powers; (3) Fossil fuel development and heat utilization; (4) Discovery, development and utilization of electricity; (5) Discovery, development and utilization of atomic energy**.**The discovery of steam engine speed up the industrial revolution as of the 1812 and promoted large scale coal mining. In the second half of the 19th Century, energy conversion appeared for the first time in the history of mankind. In 1870s, electric power substituted for steam engine, electrical industry developed rapidly, and the weight of coal in world energy consumption structure decreased gradually. In 1965, oil first ranked on the top instead of coal, and the world entered the "Age of Oil". In 1970s, oil accounted for 54% in world energy consumption structure((HCC), 2012)**.**

However, conventional sources of energy (oil, coal, natural gases and other fossil energy ) are finite and will someday be used up (EL-Fouly, 2007). On the other hand huge consumption of oil and coal causes serious energy shortage, in the meantime, triggers major environmental and social problems. The use of fossil fuel causes the emission of much carbon dioxide and other greenhouse gases global warming, sea level rise and other severe environmental problems, threatening the survival and development of mankind**.** It has been a primary common issue for energy utilization of entire mankind to secure energy supply, reduce greenhouse gas emission and promote sustainable development ((HCC), 2012; EL-Fouly, 2007; UN, 2018; Verma, 2010)

With the increase of world population and the rise of energy utilization level, global energy consumption will further increase, and it's foreseeable that the increase of energy consumption will be amazing in future. In order to secure energy supply, the scope of energy utilization must be extended, i.e. changing fossil energy consumption mode dominated by oil and coal to

diversifiedsustainable/renewable and zero-emission energy supply structure. In line with this, energy resources like wind energy, solar energy, tide, sea wave, sea current, and geothermal heat, shall be developed and enhanced. Likewise water energy development and utilization shall be enhanced. Therefore, renewable energy represented by wind and solar energy as well as water energy is the most promising development. Renewable energy development is important for every country to secure energy supply, respond to global climate change and reduce greenhouse gases. It is also major part of realizing sustainable energy supply and implementing environment and resource-friendly development strategy.. Wind energy resource is the most promising for large scale industrial development ((HCC), 2012)**.**The advancement of wind energy utilization technology, the anticipation of carbon taxes and reductions in carbon emissions, and an ever-increasing global demand for emissions-free power, make wind energy as the most promising solution and the fastest growing energy resourc es all over the world (EL-Fouly, 2007; Lei, 2017; Maynard, 2010; Verma, 2010) .Wind energy offers numerous advantages including clean fuel sources that do not produce atmospheric emissions that cause acidic rain or greenhouse gases. Its energy supply cannot be exhausted, and is one of the lowest-priced renewable energy technologies at 6 to 8 cents per kWh (EL-Fouly, 2007). The other advantage of this technology is that, it can be built on farms or ranches, benefiting the rural economy, where most of the best wind sites are found(EL-Fouly, 2007).Wind energy had local economic benefits that construction and operation wind farm can have a positive impact on the local economy ,especially during the construction period where a large proportion of the workers is likely to be recruited from areas local to the wind farm itself (CHEN, 2016) .In addition ,employment opportunities can also be generated during the operation period of the proposed .There is an economic contribution that will be derived through the proposed wind farm development at four stage of activity 1,the development phase including project design, environmental studies, legal agreements ,project funding and planning permission 2,the construction phase installation which include civil and project management , road and access, foundation and infra structure and grid connection 3, the operation phase -maintaining and operating the site over the life time of the proposed wind farm and decommission phase - removing the turbines and restoring the site over the life time of the proposed wind farm (CHEN, 2016) .

Ethiopia has historically focused largely on hydropower for electricity generation, but now wishes to diversify generation from other renewable sources to increase climate resilience.

Consequently, the Government of Ethiopia (GoE) has planned for an expansion of its wind power capacity to 5,200 MW by 2020 to be developed through the private sector, i.e. by Independent Power Producers (IPP) (Ministry of Foreign Affairs, 2016)**.** Nowadays electricity generation in Ethiopia is dominated by hydro power, while three wind farms are in operation with a total capacity of 324 MW (Ministry of Foreign Affairs, 2016).

Some studies, for example,((HCC), 2012; Ministry of Foreign Affairs, 2016). and Ethiopian Rural Energy Development and Promotion Center ((EREDPC), 2007).Have made assessments and identification of potential wind sites of the country. Since utilizing wind as source of electric energy in Ethiopia is new, very few researches are conducted for example, (CHEN, 2016; Yigzaw, 2014) . The study by (CHEN, 2016) was on the 'Sustainable Development Impact of wind farms in Ethiopia', while the study by (Yigzaw, 2014) was on 'Comparative Study of Electrical Power Output of Wind Turbine to Wind Power Estimated Using Wind Speed Measurement'. As to the knowledge of this researcher study on ' Assessment of Environmental and Socioeconomic effects of wind energy production in Ethiopia' is lacking. So that this paper contributes to the existing literature in the area of this study. The data used for the study was from 77 randomly selected farm households, monthly reports of Adama-II Wind power plant and Geospatial data obtained from Ethiopian Geospatial Information Institute. SPSS statistics software version 24 was used to analyze the data.

The rest of the paper deals with the background of the study area, literature review, methodological approaches used in the study, and results and discussion parts. Lastly, the paper presents conclusion and recommendation.

### 1.2. Statements of the Problem

Global climate appears to be changing at an alarming rate . Both urban and rural areas are experiencing warm temperature condition and it is increasing from time to time (Belete, 2017).The increase of population , industrialization, the expansion of urbanization and human activities during industrial revolution demand high energy consumption because of this fossil fuels like coal, natural gas ,petroleum used as a sole source of energy ((HCC), 2012; Belete, 2017). Continuous use of fossil fuels for a long time has caused emission of excess carbon dioxide and other greenhouse

gas to the atmosphere. Because of this, global warming, sea level rise and other severe environmental problem become a major challenge to human kind.

As a result of these now days most countries of the world use renewable energy like hydro power, wind and solar energy as a solution of the problem. Most recently the government of Ethiopia starts to use wind resource as means of energy production at some region of Ethiopia; for example the Adama wind mill project, Some studies, for example,((HCC), 2012; Ministry of Foreign Affairs, 2016). and Ethiopian Rural Energy Development and Promotion Center ((EREDPC), 2007).Have made assessments and identification of potential wind sites of the country. Since utilizing wind as source of electric energy in Ethiopia is new, very few researches are conducted for example, (CHEN, 2016; Yigzaw, 2014) . The study by (CHEN, 2016) was on the 'Sustainable Development Impact of wind farms in Ethiopia', while the study by (Yigzaw, 2014) was on 'Comparative Study of Electrical Power Output of Wind Turbine to Wind Power Estimated Using Wind Speed Measurement'. As to the knowledge of this researcher study on ' Assessment of environmental and socioeconomic effect on wind energy is lacking. . Therefore, this study values for policy makers to adjust additional remedies to problem and helps as baseline for those interested to study on similar issues in AdamaWoreda .

### 1.3. Research Question

1. What are the potential and actual temporal trends of electrical power of Adama II wind farm?
2. What is the role of wind generating power in substituting and supporting hydroelectric power in the country during dry season where there is shortage of power due to erratic water volume?
3. Does Adama wind farm had a significant negative effect (like deforestation, reducing farmland size) in the land use pattern of the study area ?
4. What are the socio-economic contribution of Adama II Wind farm to the local community and its role in mitigating problem of climate change by reducing the amount of carbon ?
5. Does the standard distance between two consecutive wind turbine either at crosswind direction or prevailing wind direction kept at Adama II wind farm?

## 1.3. Objective of the Study

### 1.3.1. General Objective

To assess environmental and socio economic effects of wind energy production the case of Adama II wind farm

### 1.3.2. Specific Objective

1. To assess the temporal (daily, monthly, seasonal, and annual) variability of wind power production at Adama II wind farm.

2. To assesses the effect of wind farm on land use pattern like forest, farmland, water body, bare land, bushes in the study area?

3. To assess the role of Adama II wind power project in substituting hydroelectric power during dry season where there is shortage of power.

4. To assess the socio-economic contribution of ofAdama II wind farm to the local community and its role in mitigating the problem of climate change in relation to its introduction in the area.

5. To assess the fulfillment of standard distance between two consecutive wind turbine either at crosswind direction or prevailing wind direction.

## 1.4. Significance of the Study

Using renewable resource like wind and solar energy as source of electrical energy, is new in Ethiopia because of this the number of research that is conducted so far with this topic are limited in number. Therefore, it is important to see the significance and limitation of the project for this case the Adama II wind farm conducting empirical research is necessary .This study was intended to see the environmental effect of wind energy production as well as to assess the socio economic contribution of wind farm project on socio economic condition of the local community in the study area so that concerned stake holders can use the finding as a feedback to make some corrective measures. Furthermore, this study can be used as a source material for further studies.

## 1.5. Scope of the study

Great effort is done to limit the scope of the studies to a manageable objective with available time. Therefore, this study attempts to investigate wind energy production like yearly monthly and daily energy production socio economic contribution like job opportunity, access to road introduction of public transport and its facilitation of market for agricultural production and impact of wind farm on the physical environment like soil, wild and domestic animals wind , potential of renewable energy that is wind and its ,variability distribution , the role of renewable wind energy in reduction of carbon emission, land use land cover change and its effect ,distribution of wind turbine, the standard distance between two consecutive wind turbine will be discussed at local level.

## 1.6. Limitation of the Study

One of the limitations was routine process to get data from different organizations . Hesitance and unwillingness of some selected respondents particularly at MokoyeHaro peasant association was another problem faced by the researcher while conducting household survey. However throughtolerance continual discussion and clarification of the research objective at the end the problem solved .

## 1.7. Organization of the paper

This paper is organized in five chapters. The first chapter deals with the introductory part that comprises background of the study, statement of the problem, objectives, research questions, significance and limitation of the study, Chapter two includes reviews of some relevant literature. The third chapter describes the research methodology and sampling techniques, description of the study area, chapter four deals with data analysis, discussions and results. Following this the last chapter contains conclusion and recommendation. The data collection tools and other information are attached as appendices.

## CHAPTER TWO

# LITERATURE REVIEW

### 2.1. Renewable Energy in Ethiopia

Ethiopia has vast hydro, wind, solar, and geothermal renewable energy potential. It has the second largest hydropower potential in Africa after the Democratic Republic of Congo. the total exploitable reserve of hydro and wind energy are 45GW and 10GW respectively. Only about 5percent of Ethiopians hydro resource and less than 1 percent of Ethiopia's wind resources have been developed thus far .As of 2014,hydropwer accounted for88 percent of Ethiopians total installed electricity capacity ,while wind power contributed just 8 percent. Although Ethiopia doesn't envision wind power being its primary source in the future, it will undoubtedly be a crucial component . First wind farms are less controversial and can be built more quickly than hydropower plants ,which usually take many years to construct and often cause irreversible damage to the surrounding environment and local communities. Reservoir may have net positive greenhouse emissions if large area of vegetation and trees are submerged, and studies have found that impounded water can contribute to methane emissions. (CHEN, 2016).

One strategy of reducing the effect of climate change is using renewable energy like wind, solar energy and hydropower as a source of power. The rationale for the Renewable Energy Strategy (and solar and wind energy) is that renewable will contribute directly and significantly to five of the six policy goals: poverty reduction, energy security, sustainability, good governance, and economic efficiency (Ethiopian Rural Energy Development Promotion Center ((EREDPC), 2007). In recent years, global renewable energy industry has developed rapidly. Many countries have taken developing wind energy, solar energy and other renewable energy as important opportunity and means for responding to future dual challenges of energy and climate change. In order to promote the development of domestic energy industry and guarantee domestic energy security, Ethiopian government determined a new national energy development strategy to encourage the development of domestic renewable energy resources (especially wind energy, solar energy and other new energy resources) and realize its development objective of “Energy Diversification”.((HCC), 2012)

The use of wind power has a light environmental foot print compared to the much more serious efects of conventional electricity generation, which affects climate change and disturbs the na tural balance. Wind power does not produce harmful emissions or hazardous waste, it do es not deplete natural recourses, or does it cause environmental through resource extraction, transport & waste management Ministry of Environment and Spatial Planning of the Republic of Serbia ((MESPRS), (2010).). Wind power seems an attractive way of producing energy-it is nonpolluting and, unlike solar power, is not restricted to daytime use (Aherens, 2012).

.In addition ,employment opportunities can also be generated during the operation period of the proposed .There is an economic contribution that will be derived through the proposed wind farm development at four stage of activity 1,the development phase including project design, environmental studies, legal agreements ,project funding and planning permission 2,the construction phase installation which include civil and project management , road and access, foundation and infra structure and grid connection 3, the operation phase -maintaining and operating the site over the life time of the proposed wind farm and decommission phase - removing the turbines and restoring the site over the life time of the proposed wind farm (CHEN, 2016)

In Ethiopia, depending mainly on hydro-power has made the energy sector vulnerable to climate change, especially in relation to recurring droughts. Hence, the Government of Ethiopia (GoE) has decided to diversify the source of energy to solar, geothermal, and wind energy, in order to achieve its ambition to become a leader in light manufacturing and become a hub of electric power exports. As a result, the generation from hydro, wind, solar, geothermal, and biomass is expected to reach 17,000 MW by the end of the GTP-2 period (Ministry of Foreign Affairs, 2016).

**2.2. Hydro Power and Wind Complement each other**

Annual electricity demand in Ethiopia increased from 1.6 Terawatt- hour ( TWh )in 2000 to 9.5 TWh in 2014/2015 (Ministry of Foreign Affairs, 2016). While 55% of the population resides in areas covered by the network, less than 25% is connected to the grid. Sustained economic growth in Ethiopia will increase electricity demand, which is predicted to increase at about 10% per annum in the medium term, from the current daily peak demand of 1,900 MW.

Today electricity generation in Ethiopia is dominated by hydro power, while three wind farms are in operation with a total capacity of 324 MW (Ministry of Foreign Affairs, 2016).

Although wind power is more environmental and social friendly, the construction of wind farms still have social and environmental challenges like land clearing, which requires relocation or compensation for local farmers. Yet studies have shown that once wind farms are operational, the land can still be used for farming and grazing in many cases (CHEN, 2016).Second the development of hydropower in Ethiopia has broad regional security implications ever all major rivers in Africa originate in the Ethiopian highlands (CHEN, 2016; Tesfaye, 2001). Damming these rivers may reduce downstream water flows, sparking conflict between Ethiopia and its neighbors. Thirdly the wind power complements hydropower in Ethiopia has a distinct dry-wet season climate .Water flow is lower during the dry season from October to March which happens to be the windiest period in Ethiopia (CHEN, 2016) .While the generating capacity of Adama wind farm accounts for less than 10 percent of the total generating capacity in Ethiopia, it provides over 15percent of electricity for the country in the dry season. Generation from Ethiopian energy power, the nation state-owned power company revels that drought is impeding hydropower electricity production. In line to this the environmental and socio economic studies conducted in Kenya Lake Turkana Wind Power Project stated that "The situation is aggravated by the over reliance (approximately 50%) on hydropower which has been often unreliable in the dry seasons. The1999 - 2002 drought in the region is an example of periods where lack of water supply greatly affected the power production of the hydroelectric dams that had a crippling effect on the economy. This experience underscores the need to increase power production and associated facilities in order to diversify power sources (Kenya Power the Least Cost Power Development Plan 2009–2029) ((KLCPDP), 2011 ).

The technical potentials for harnessing renewable energy sources are substantial and exceed tho se of all other already available sources. Climate change, reduction of emissions, depleted fos sil fuel reserves and soaring fuel prices have led to increased governments suppose through ado ption of laws and regulations, stimulation and commercialization of renewable energy sources. Wind energy is booming worldwide and installed capacities are increasing significantly year by year, because wind power is a competitive and cost efficient energy source(((MESPRS),

(2010).)Finally the cost of electricity generated from wind power is cheaper than existing diesel power products (CHEN, 2016).

### 2.3. Prospect of Renewable Resource as A Source of Energy

Most of the developing countries are suffering from what many call the energy crisis, which is characterized by depletion of locally available bio-fuel energy resources and dependence on imported fuel. In fact, the energy crisis is believed to be the second most serious problem in these countries next to the food crisis. What is more, the energy crisis is exacerbating the food crisis by increasing the rate of deforestation and thereby causing degradation of farmlands (Aklilu, 2010) .The Ethiopian government mitigation part is aimed at promoting conditions that reduce the greenhouse gas emissions due to various types of development activities. The focus in this respect concerns 1) improvement of crop and animal production practices, 2) development of forestry and agro-forestry activities, 3)development of electric power generation through renewable energy sources and 4) expanding the use of modern and energy efficient technologies (Kebede, 2016).

In line with this Ethiopian Government recently issued national energy development strategy to encourage the development of domestic renewable energy resources inclusive of wind and solar energy, so as to realize the objective of "Energy Diversification" and guarantee energy security ((HCC), 2012).In recent years, with global warming and frequent appearance of extreme drought, sometimes reservoirs can't normally store water and generate power at full load in rainy season seriously affects Ethiopian energy supply dominated by hydropower, causes power shortage at many places and hampers social and economic development ((HCC), 2012) . On the other hand, wind energy resources and hydropower resources are very complementary, seasons without rainfall (i.e. drought seasons) have high natural wind speed and very strong solar radiation, and the alternation between drought season and rainy season form the good complementation among hydropower, wind power and solar power. Therefore, wind and solar power generation projects have very strong resource advantage and actual demand in Ethiopia (CHEN, 2016) .

## 2.4. Wind

Wind is the movement of air caused by pressure differences within the atmosphere. This pressure differences exert a force that causes air mass movement from a region of high pressure to region of low pressure. That movement of air is referred to as wind (Aherens, 2012; Lei, 2017; Minina, 2015; Yigzaw, 2014). Such pressure differences are caused primarily by uneven heating effects of the sun on the Earth's surface. Thus, wind energy is form of solar energy (Lei, 2017; Yigzaw, 2014). Winds are very much influenced by the ground surface at altitudes up to 100 meters. The wind will be slowed down by the earth's surface roughness and obstacles (Minina, 2015; Yigzaw, 2014) .

### 2.4.1. Energy in the wind

A wind turbine obtains its power input by converting the force of the wind into a torque (turning force) acting on the rotor blades. The amount of energy which the wind transfers to the rotor depends on **the density of the air ,the rotor area, and the wind speed((HCC), 2012; Yigzaw, 2014)**.

### 2.4.2. Density of Air.

The kinetic energy of a moving body is proportional to its mass (or weight). The kinetic energy in the wind thus depends on the density of the air, i.e. its mass per unit of volume .In other words, the "heavier" the air, the more energy is received by the turbine. At normal atmospheric pressure and at 15° Celsius air weighs some 1.225 kilograms per cubic meter, but the density decreases slightly with increasing humidity. Also, the air is denser when it is cold than when it is warm. At high altitudes, (in mountains) the air pressure is lower, and the air is less dense(Lei, 2017; Minina, 2015; Yigzaw, 2014).

### 2.4.3. Rotor Area

A typical 1,500 kW wind turbine has a rotor diameter of 77 meters, i.e. a rotor area of some 4654.26 square meters (Rotor area=$2\pi r^2$ (2*3.14*38.5*38.5*/2=4654.26).The rotor area determines how much energy a wind turbine is able to harvest from the wind(Minina, 2015; Yigzaw, 2014).

Power production from a wind turbine is proportional to the rotor disk area, and varies as the cube of wind speed. Doubling the diameter of the rotor leads to a four-time increase in power output(Yigzaw, 2014).

### 2.4.4. Wind Speeds and Variability

The wind speed is extremely important for the amount of energy that a wind turbine can convert to electricity. The energy content of the wind varies with the cube (the third power) of the average wind speed, e.g. if the wind speed is twice as high it contains 2 3 = 2 x 2 x 2 = eight times as much energy (Yigzaw, 2014).

Wind speed varies over the course of time. In the majority of regions considerable seasonal changes of wind streams are observed. In the winter months wind speed is usually higher than in the summer (Yigzaw, 2014).The wind is highly variable, both geographically and temporally. Moreover, this variability exists over a very wide range of scales, both in space and time. This is important because extractable energy from wind varies with the cube of wind velocity. This variability is due to different climatic conditions in the world. The tilt of earth on its axis and its own spinning results in different wind distributions across the world (Patnaik, 2010; Yigzaw, 2014).

For any location there is variation of wind pattern, wind speed may vary from year to year and wind distribution will change from decade to decade. Such long-term variations are not well understood, and thus make it difficult to make predictions of the economic viability of wind-farm projects. Wind distribution is more predictable over shorter time spans like a year, but on shorter time frame like few days the wind energy is difficult to predict. These variations are due to the weather systems. Depending on location, there may also be considerable variations with the time of day (diurnal variations), which are fairly predictable. These variations are important to be considered because they can affect production of large scale wind energy and consequent integration into grid and associated power generation systems must be prepared for these variations (Patnaik, 2010; Yigzaw, 2014).

In most locations around the globe it is windier during the daytime than at night . This variation is largely due to the fact that temperature differences e.g. between the sea surface and the land surface tend to be larger during the day than at night.

The wind is also more turbulent and tends to change direction more frequently during the day than at night. From the point of view of wind turbine owners, it is an advantage that most of the wind energy is produced during the daytime, since electricity consumption is higher than at night. Many power companies pay more for the electricity produced during the peak load hours of the day (when there is a shortage of cheap generating capacity) (Minina, 2015; Yigzaw, 2014).

Geographical conditions and character of a terrestrial surface, including various natural and artificial obstacles, such as hills , trees and buildings, have considerable influence on wind speed. For this reason wind turbine dispose, whenever possible, in open space and remove from high trees, apartment houses and other constructions places since such obstacles reduce speed of a wind and lead to the turbulences of a stream complicating transformation of a wind power (Minina, 2015) .

### 2.4.5. Wind Speed Levels

Variability of wind speed affects the amount of electricity which is generated from wind turbine. There are three wind speed levels that are important in electrical energy generation. These are cut-in, rated and cut-out wind speeds as shown in Figure 1. Cut-in wind speed is the minimum wind speed at which wind turbine begins to produce electrical power. Rated wind speed is wind speed at which wind turbine achieves the nominal electrical power. In general, rated wind speed is the speed between cut-in and cut-out wind speed. Rated wind speed value is approximately 10m/s-12m/s. Cut-out wind speed is the maximum wind speed at which wind turbine stops to produce power. Cut-out wind speed value is about 23.5 m/s (Yigzaw, 2014). When wind speed is above the cut-out wind speed, the wind turbine automatically stops so that wind turbine does not suffer overloads during stormy wind. Storm wind speed is one characteristic value (Yigzaw, 2014).

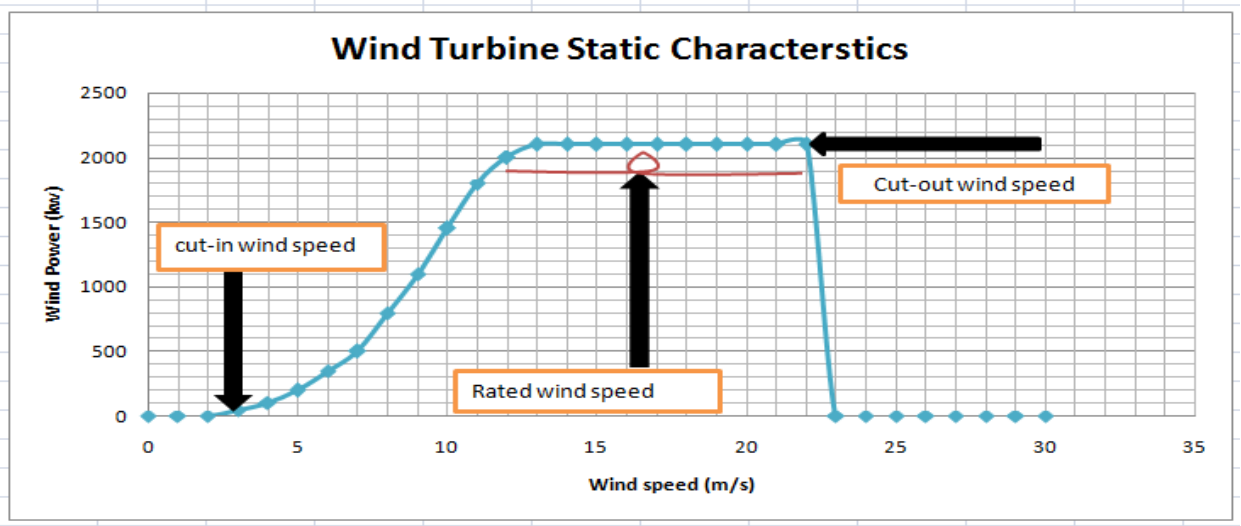



**Fig. 1 Wind speed levels (Yigzaw, 2014).**

### 2.4.6. Wind Rose

The prevailing wind can be represented by a wind rose, which indicates the percentage of time the wind blows from different directions (Aherens, 2012).Wind rose is a diagram drawn to show the information about the distributions of wind speeds, and the frequency of the varying wind directions. The compass divided into 12 sectors, one for each 30 degrees of the horizon. (A wind rose may also be drawn for 8 or 16 sectors, but 12 sectors tend to be the standard set by the European Wind(Aherens, 2012). The radius of the 12 outermost, wide wedges gives the relative frequency of each of the 12 wind directions, i.e. how many per cent of the time is the wind blowing from that direction. A wind rose gives you information on the relative wind speeds in different directions (Aherens, 2012). A look at the wind rose is extremely useful for sitting wind turbines. If a large share of the energy in the wind comes from a particular direction, then you will need to have as few obstacles as possible, and as smooth a terrain as possible in that direction, when you place wind turbines in the landscape. Planners of large wind parks will usually rely on one year of local measurements, and then use long-term meteorological observations from nearby weather stations to adjust their measurements to obtain a reliable long term average. The Wind Frequency is the percentage of the time the wind is coming from a particular direction (Aherens, 2012).

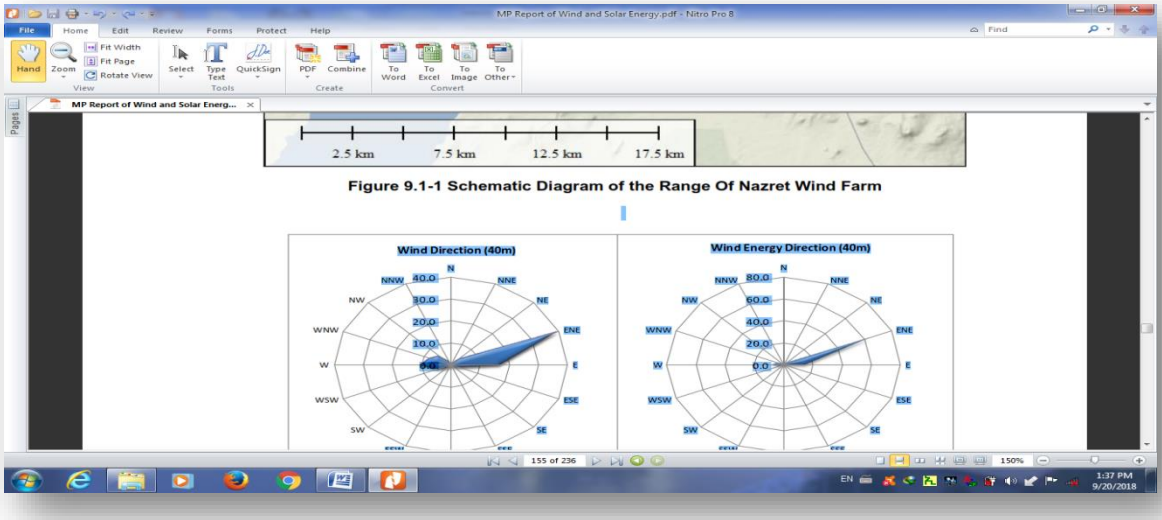



**Fig.2 Wind rose diagram source (CORPORATION,2012).**

### 2.4.7. Wind Energy and the Environment

The use of wind power has a light environmental footprint compared to the much more serious effects of conventional electricity generation, which affects climate change and disturbs the natural balance. Wind power does not produce harmful emissions or hazardous waste, it does not deplete natural recourses, nor does it cause environmental damage through resource extraction, transport and waste management. Wind turbines occupy less than 1% of the land area. Once up and running, existing activities, such as agriculture and ease of access to the site, can continue around them((MESPRS), (2010).).

### 2.4.8. Some Problems of Wind Turbine

A region dotted with large wind machines is unaesthetic. (Probably, though, it is no more of an eyesore than the parades of huge electrical towers marching across many open areas.). Unfortunately, each year the blades of spinning turbines kill countless birds. To help remedy this problem many wind turbine companies hire avian specialists to study bird behavior, and some turbines are actually shut down during nesting time. And the blades of modern high-capacity turbines turn more slowly,thereby allowing birds to avoid them (Aherens, 2012).

Studies conducted in the United States of America (USA) estimates that less than one-tenth of unnatural bird deaths in the USA are caused by wind turbines. In fact, studies show that wind farms currently kill far fewer birds than the estimated 550 million that fly into glass buildings, or up to 100 million killed yearly by cats. According to the United Kingdom Centre of Sustainable Energy (CSE),"for every bird killed by a turbine, 5,820, on average, are killed striking buildings, typically glass windows." Wind turbine blade designs are another contributing factor to bird mortality rates. Older wind turbines have smaller blades that rotate frequently over the period of a minute. These design features have increased the risk of collision for birds as most are clipped while attempting to fly across wind farms. With modern changes to wind turbine designs, blades are being built larger and have fewer rotations per minute compared to smaller turbine ((MESPRS), (2010).).

### 2.4.9. Shadow Flicker

Wind turbines, like other tall structures, can cast long shadows when the sun is low in the sky. The effect known as shadow flicker occurs where the blades of a wind turbine cast a shadow over a window in a nearby house and the rotation of the blades causes the shadow to flick on and off. This effect lasts only for a short period and happens only in certain specific combined circumstances, such as when the sun is shining at a low angle (at dawn and before dusk), when the turbine is positioned directly between the sun and the affected property upon which the shadow is cast and there is enough wind to ensure that the turbine blades are moving. Careful site selection, design and planning, as well as use of relevant software for calculating the shadow effect, can help avoid the effect completely. It is recommended that the duration of shadow flicker at neighboring offices and dwellings within a 500m range should not exceed 30 hours per year or 30 minutes per day. At distances from a turbine that are greater than 10 rotor diameters, the potential for shadow flicker is very low. Where shadow flicker could be a problem, developers should provide calculations to quantify the effect and where appropriate take measures to prevent or mitigate the potential effect, such as by turning off a particular turbine at certain times.((MESPRS), (2010).)

### 2.4.10. Ethiopian Wind Energy Resource

The renewable resource assessment done by Solar and Wind Energy Resource Assessment (SWERA) for relevant countries in early stage included Ethiopian systematically analyzed the distribution characteristics and gross amount of Ethiopian wind energy resources by GIS technique and in combination with distribution of local terrains, forests and lakes, roads and other conditions. Moreover it classified different wind resource regions of the country (. According to the wind energy resource analysis of SWERA, regions rich in wind energy resources are basically centralized along the Great Rift Valley, i.e. from capital Addis Ababa to Mek'ele in the north and from Addis Ababa to Mega in the south. Major regions rich in wind energy resources are centralized on east and west sides of the Great Rift Valley, inclusive of the large mountainous region from the capital to the east till to Harar and Jijiga. According to the estimate of SWERA, the total utilizable area, regions suitable for wind energy development in Ethiopia include mechanical energy utilization and grid connection regions, is about 166,000 km2, inclusive of about 20,000 km2 suitable for grid-connected power generation. According to preliminary estimate, annual power output potential is about 890TWh.((HCC), 2012).

Wind energy is the kinetic energy contained in horizontal air flow. A common way of wind energy utilization is to convert the horizontal kinetic energy of air into electric energy by wind turbine generator ((HCC), 2012).Ethiopia has one of the most ample wind resources in Eastern Africa, with velocities ranging from 7 to 9 m/s ((EEA), 2012). Ethiopia also has exploitable reserve of 10,000 MW wind energy.

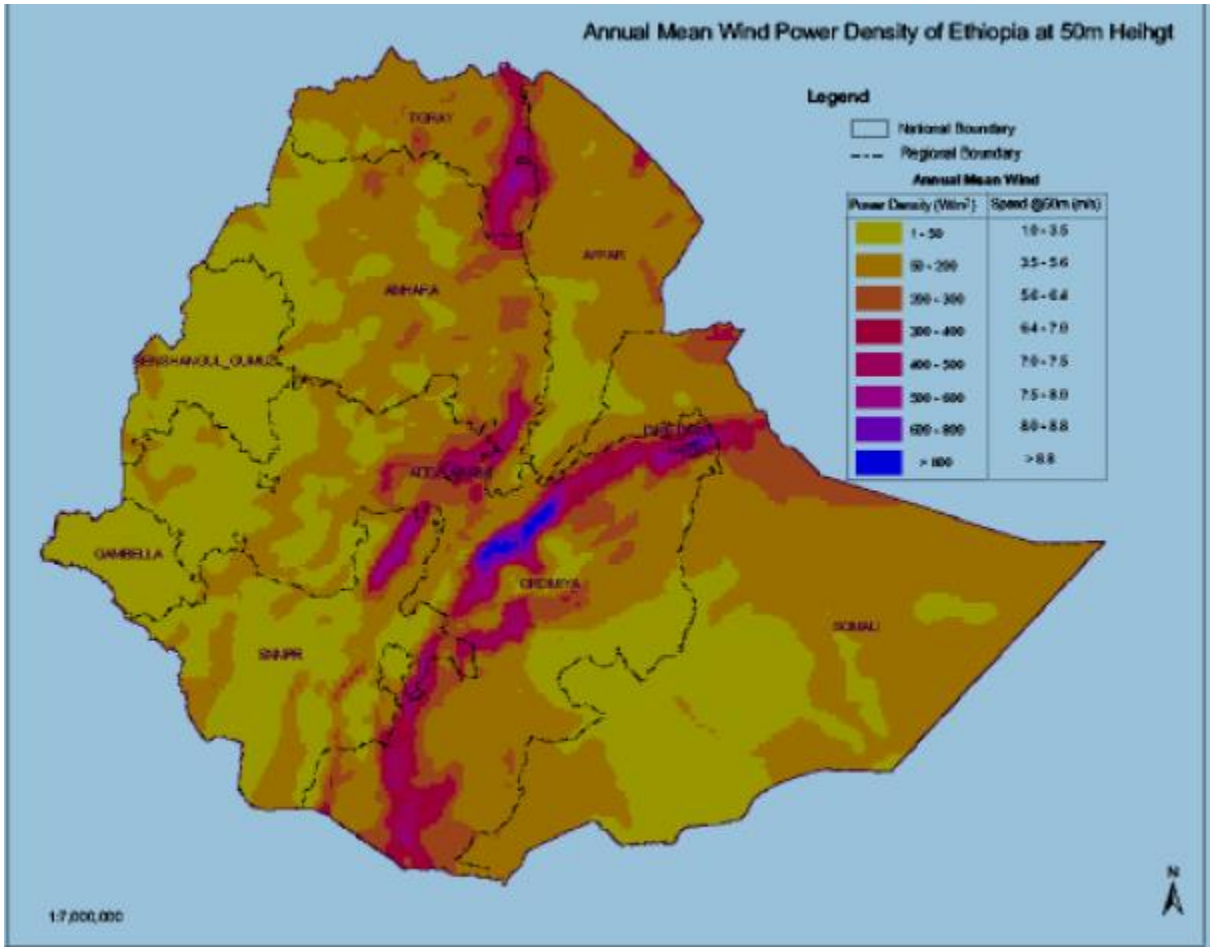



**Figure 3 Ethiopian Wind Energy Resource Distribution Map by SWERA ((HCC), 2012)**

As we can see from the Ethiopian wind energy resource distribution map the greatest wind distribution potential is seen at rift valley around Adama that is the one reason for establishment of wind farm in the area by the government of Ethiopia in addition to nearest distance to the capital City (Addis) availability of grid and the presence of Koka dam.

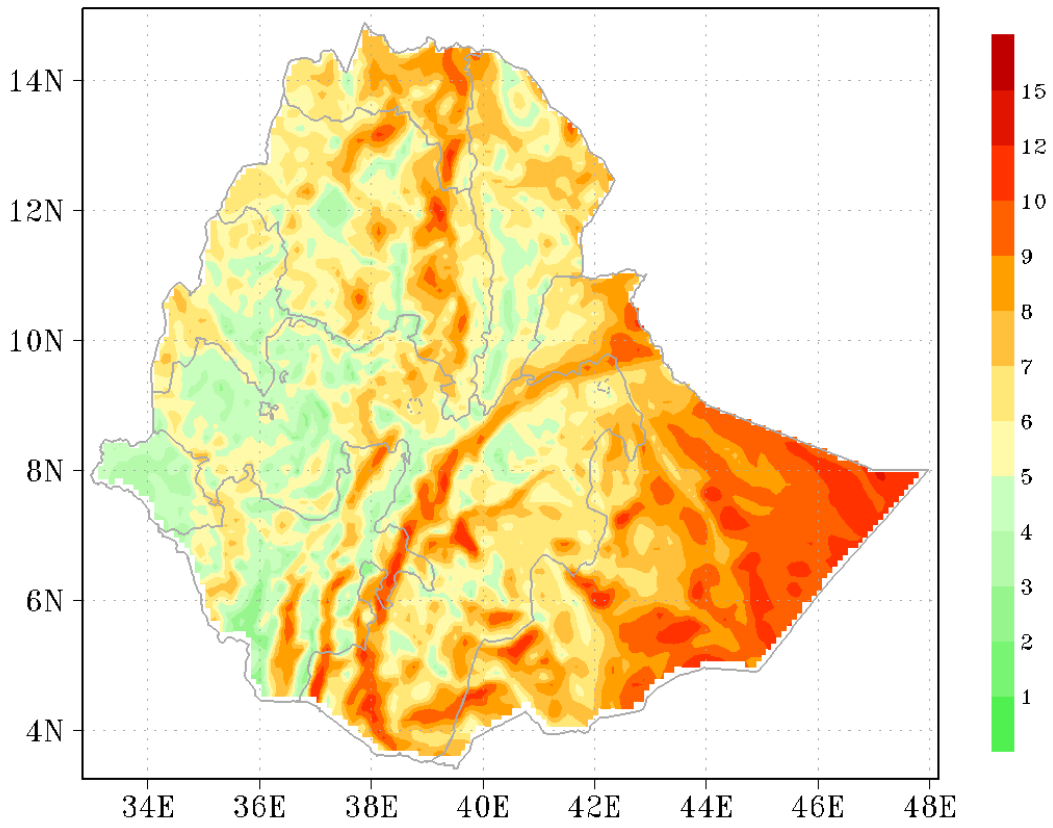



**Figure 4 Distribution of Average Wind Speed, m/s (Height: 50m, 1980~2009) ((HCC), 2012)**

As we can see from the map that show distribution of average wind speed high wind speed more than 9m/s abundantly observed at Eastern Ethiopia Somali region and to some extent at the rift valley Adama surrounding and North Ethiopia and South Ethiopia .

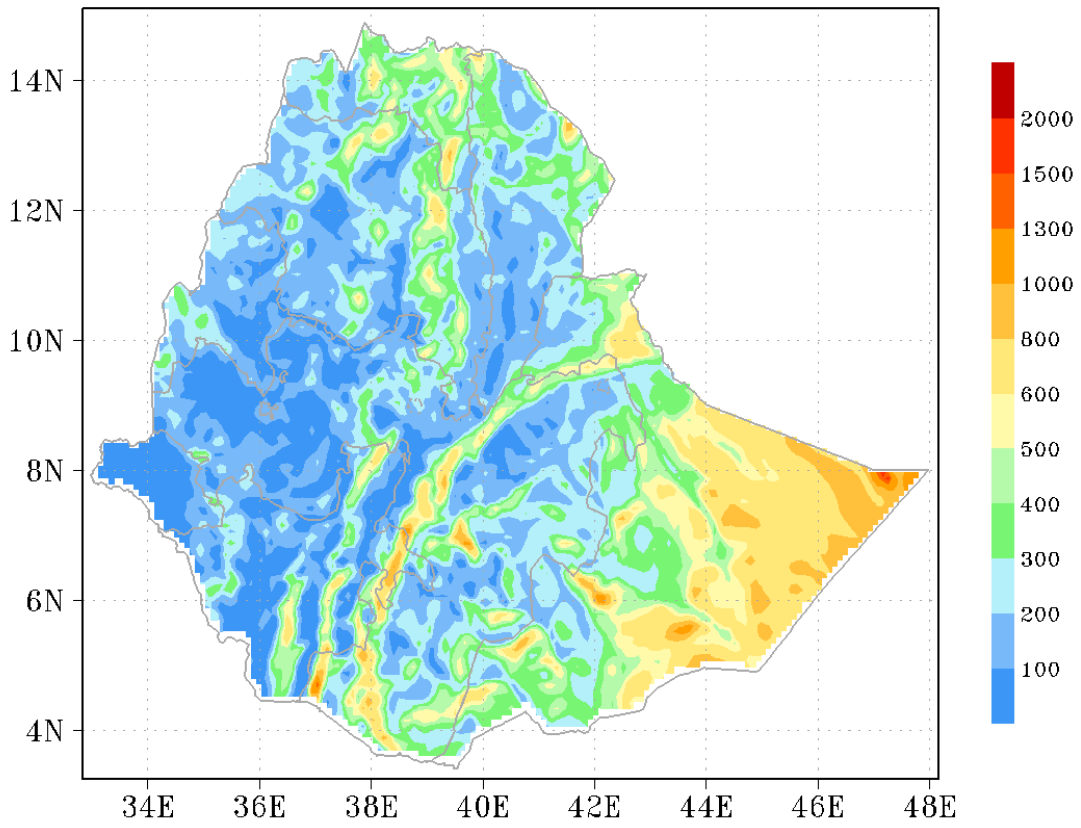



**Figure 5 Distribution of Wind Power Density, W/m2 (Height: 50m, 1990~1999) ((HCC), 2012)**

As we can see from the Distribution of Wind Power density map of Ethiopia still more wind power density is observed at Eastern Ethiopia ,Rift valley inclusive of Adama , South and North Ethiopia**.** Wind power densities in many parts of both long and narrow zones in Central Ethiopia, the area bordering Djibouti and Somali Region exceed 200 W/m2 in height of 10m and exceed 400 W/m2 in height of 50m, indicating rich wind energy resource. Regardless of restrictions, wind energy can be full used for power generation in these parts ((HCC), 2012) .

### 2.4.11. Carbon Reduction Potential

All electricity generation technologies generate carbon dioxide (CO2) and other greenhouse gas emissions. To compare the impacts of these different technologies accurately, the total CO2 amounts emitted throughout a system's life must be calculated. Emissions can be both direct – arising during operation of the power plant, and indirect – arising during other non-operational phases of the life cycle. Fossil fuelled technologies (coal, oil, gas) have the largest carbon footprints, because they burn these fuels during operation. Non-fossil fuel based technologies such as wind, photovoltaic's (solar), hydro, biomass, wave/tidal and nuclear are often referred to as 'low carbon' or 'carbon neutral' because they do not emit CO2 during their operation. However, they are not 'carbon free' forms of generation since CO2 emissions do arise in other phases of their life cycle such as during extraction, construction, maintenance and decommissioning. Parliamentary Office of Science and Technology ((POST), 2006) . A 'carbon footprint' is the total amount of CO2 and other greenhouse gases, emitted over the full life cycle of a process or product. It is expressed as grams of CO2 *equivalent* per kilowatt hour of generation (gCO2eq/kWh), which accounts for the different global warming effects of other greenhouse gases ((POST), 2006). Carbon footprints are calculated using a method called life cycle assessment (LCA), and is also referred to as the '*cradle-to-grave*' approach. This method is used to analyze the cumulative environmental impacts of a process or product through all the stages of its life. It takes into account energy inputs and emission outputs throughout the whole production chain from exploration and extraction of raw materials to processing, transport and final use. The LCA method is internationally accredited by ISO 14000 standards ((POST), 2006).

### 2.4.12.Land Use Land Cover Change

In developing countries where a large proportion of the human population depends almost entirely on natural resources for their livelihoods, there are competing demands for utilization, development and sustainable management of the land resources (e.g. natural vegetation), resulting in land-use and cover changes (Birhan, 2017) . Land use/land cover (LULC) change has important impacts on the functioning of socioeconomic and environmental systems with tradeoffs for sustainability, food security, biodiversity and the vulnerability of people and global ecosystem impacts. Studies on LULC showed that socio-economic and biophysical variables act as the driving forces of land use changes. Driving forces are generally subdivided into two groups: proximate causes and underlying causes. Proximate causes are the activities and actions that directly affect land use, e.g. wood extraction or road building. Underlying causes are the 'fundamental forces' that underpin the proximate causes, including demographic, economic, technological, institutional and cultural factors (Birhan, 2017) .

# CHAPTER THREE

## DISCRIPTION OF THE STUDY AREA METHODS AND MATERIALS

## 3.1 Description of the Study Area

### 3.1.1. Location

AdamaZuriaWoreda (Adama and surrounding Woreda) is one of the Woredas in the East Shewa Zone of the Oromia, Regional State of Ethiopia. The Administrative center of the Woreda is Adama, which is located southeast of Addis Ababa the capital city of Ethiopia approximately about 90 km at latitude and longitude of 8° 14′ 0″−8° 43′ 0″N and 39° 6′ 0″−39° 25′ 0″ E, covering a total area of 901.5 $km^2$ (Fig.3.1). Altitude of the area range from 1621 to 2567 m above sea level and it is located within the Great Ethiopian Rift Valley.The study area Adama is one of the districts, or woredas, in the Oromia Regional state. Part of the MisraqShewa Zone located in the Great Rift Valley. Adama is bordered on the south by the Arsi Zone, in the southwest by Koka Reservoir which separates it from Dugda Bora, on the west by Lome, on the north by the Amhara Region, and on the east by Boset; the Awash River, the only important river in this woreda, defines the woreda boundaries on the east and south(Belete, 2017).

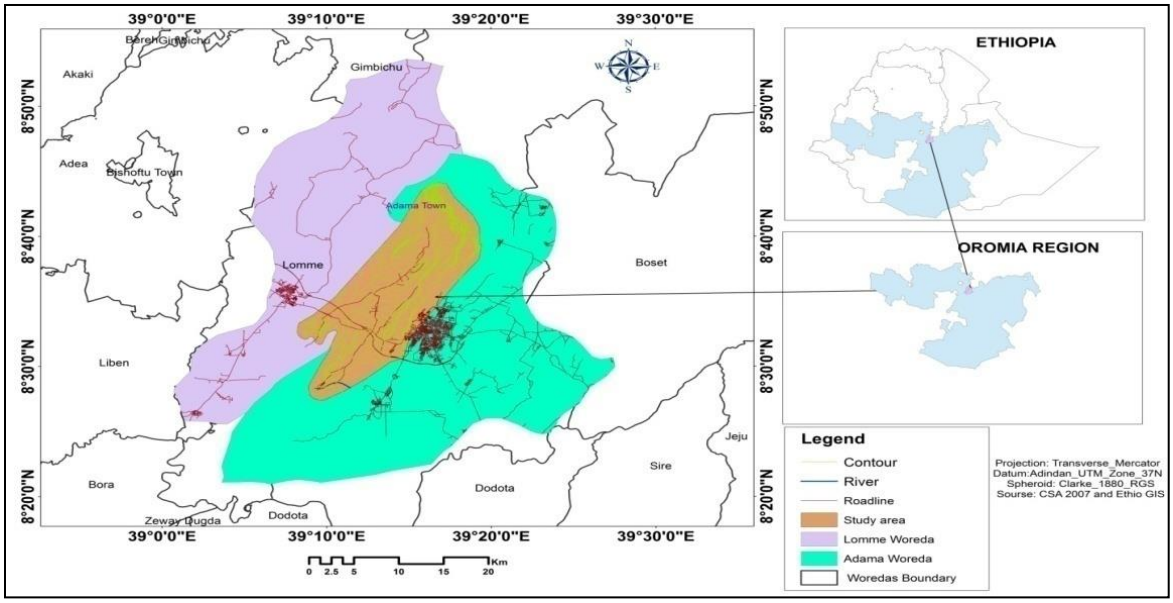



**Fig 6.** Location map of study areaSource EGII (2019)

### 3.1.2. Topography

Topography is the study of the shape and feature of the surface of the earth and other related phenomenon or it is an integral part of the land surface. It includes such as landforms, elevation, latitude, longitude and topographic maps (Belete, 2017). As we can see from the elevation map the study area lowest elevation is 1621-1764 m and the highest elevation from 2206-2567 m.The highland that ranges from 2034 m-2567 mainly covered by forest. The AdamaZuriaWoreda has a broad flat area. However, in its northwest part there is relatively rugged topography. It also bordered on the south by the Arsi Zone, on the Southwest by Koka reservoir, which separates it from Dugda Bora on the west by Lome on the north by the Amhara Region, and on the East by Boset; the Awash River, the only important river in this Woreda, defines the Woreda boundaries on the east and south . The elevation of the study area is indicated in (Fig. 3.2 a). Slope of AdamaZuriaWoreda shows that, roughly 85% of the area is between 0 and 13 º. About 10% of the area is between 13 and 28 º, <5%% is more than 28% of the slope. Slope of the area with greater than 28 º is located in the northern, northeast, southeast ridge part of the area. The slope of the area is indicated in fig 8

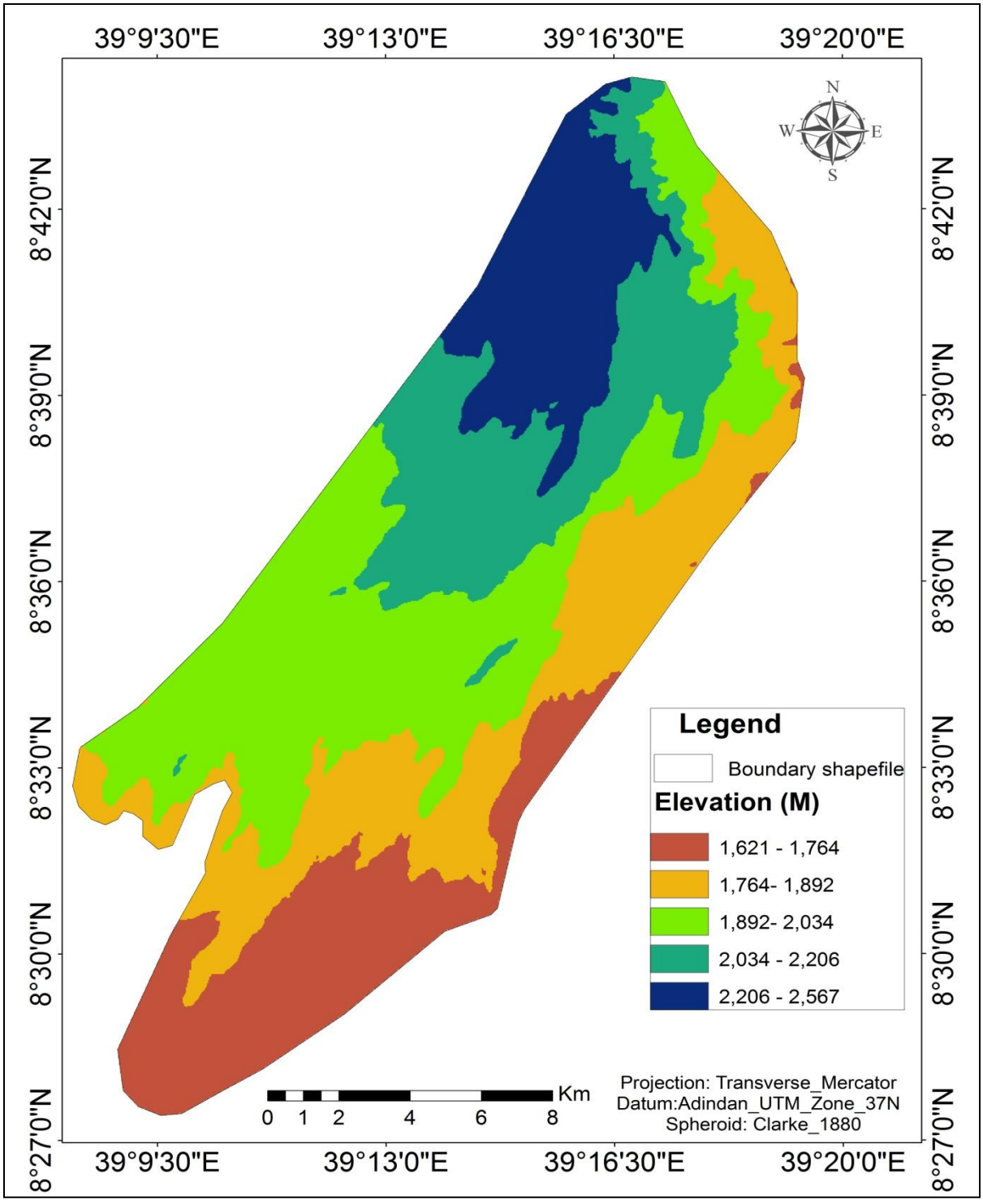



**Fig 7. Elevation map of the Study Area Source Ethio GIS (2019)**

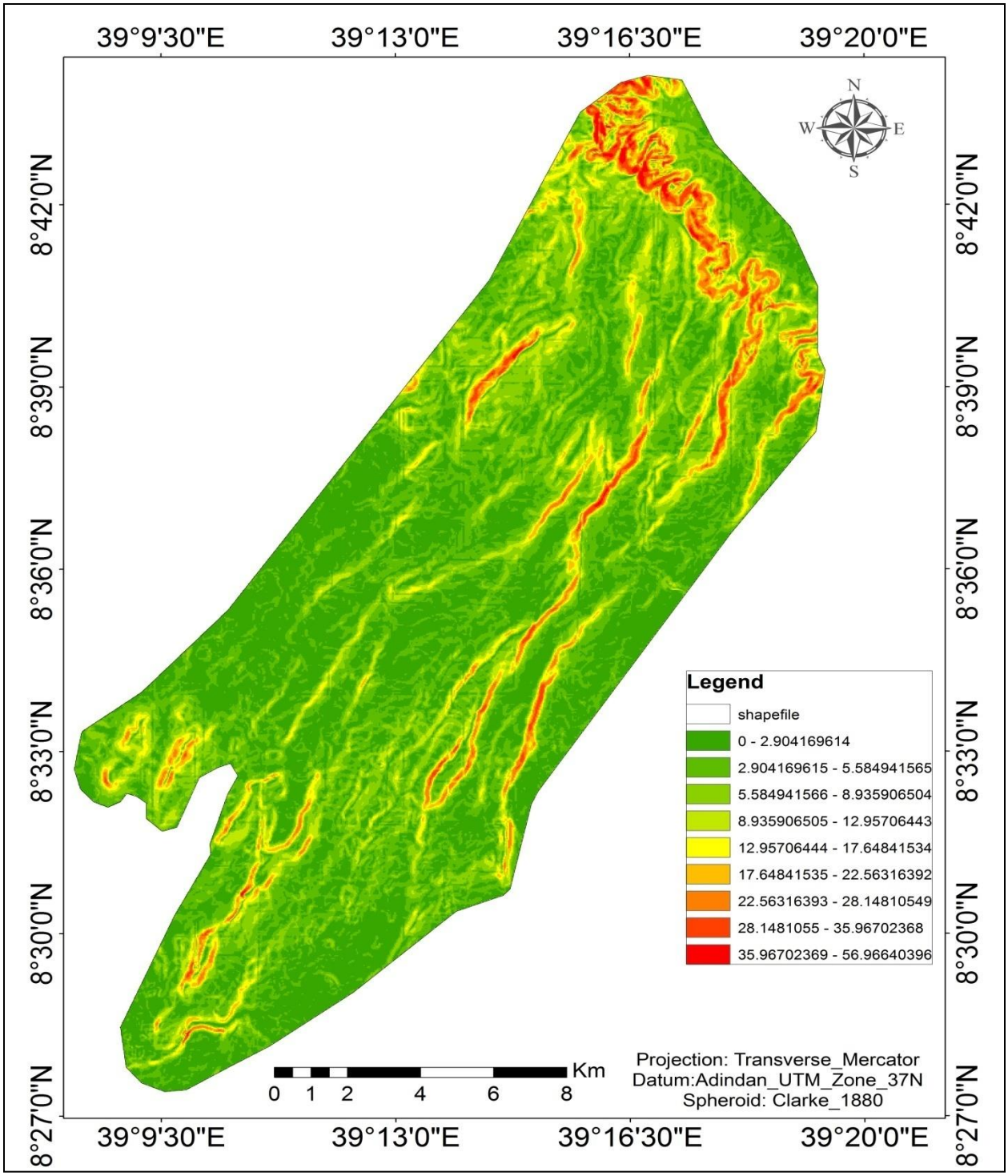



**Fig 8. Slope Map of the Study Area in degree Source Ethi GIS (2019)**

### 3.1.3 Climate and Vegetation of the Study Area

## A. Rain fall

A long-term rainfall record from1998 to 2017 at the Adama meteorological station shows an average annual rainfall of 851.45 mm and the maximum monthly average rainfall was 259.8 mm in the month of July (Fig.3.3). On the average, most rainfall or rainy season is June, July, August and September. Whereas, the dry month is in January, October, November and December. On average, the warmest month is May and coolest month is July. Among all month, the driest month is December .

## B. Temperature

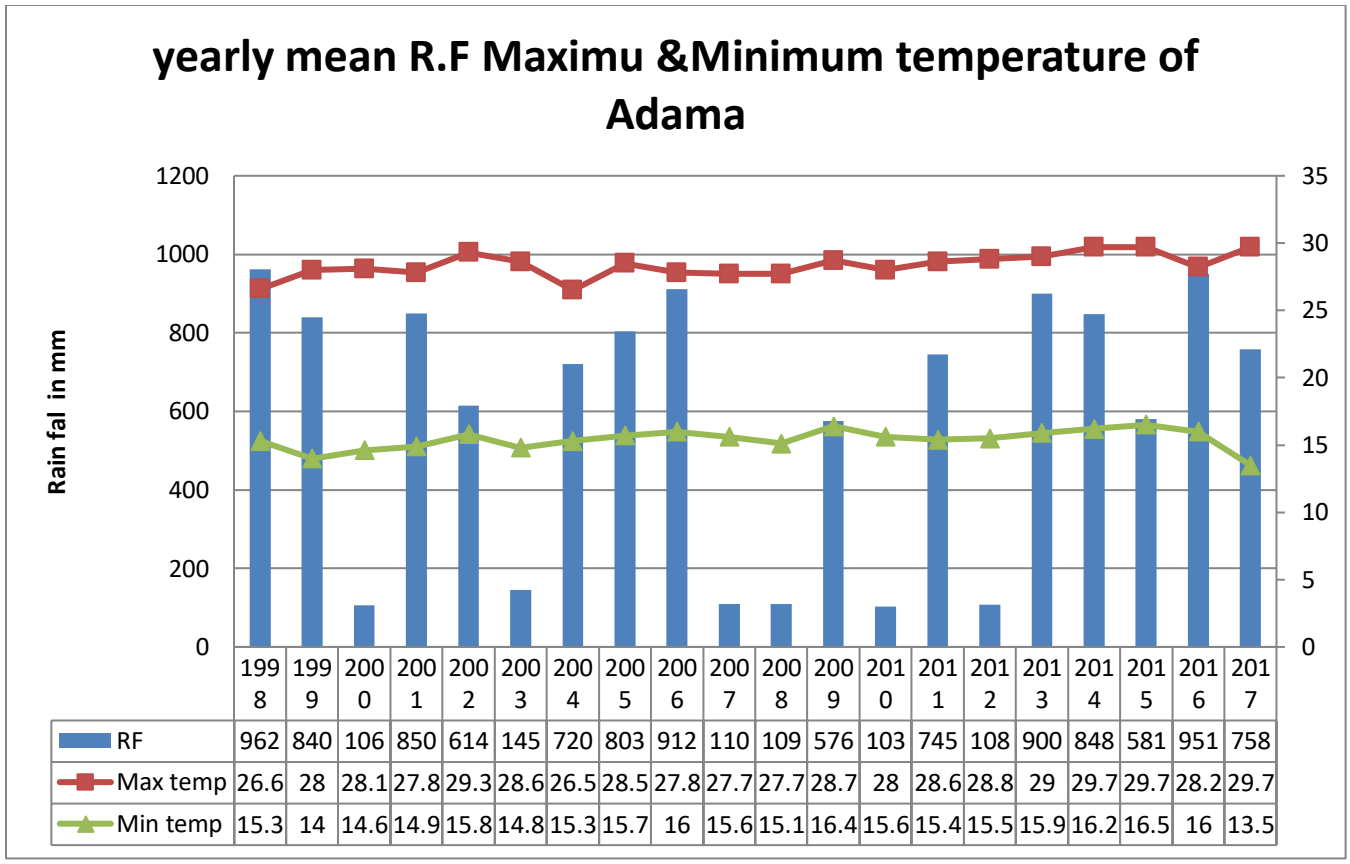
The mean annual temperature of the AdamaZuriaWoreda is 27.8 . It can be classified as semi-humid to semi-arid climate, which characterizes the altitude range between 1,500–2,400 m above mean sea level. In the study area, the hottest month with maximum mean temperature of 30.7ºC was May. The detail information of rain fall and temperature indicated in fig 5.

## C. Vegetation

The vegetation distribution of the area is mainly dependent on the climate condition of the area. The climate condition of the study area is characterized as tropical. On these types of climate, vegetation is scarce and typical example that is found in the area is shrub, Acacia and scattered trees of Eucalyptus. Eucalyptus trees, which is, grown by local communities in soil conservation program that is applied in the Main Ethiopian rift to protect soil from erosion. The local people cultivate, some types of crops cultivated in the area are Teff, wheat, Barley, maize and sorghum. The harvesting season is between October and December at which the rain is very low (Belete, 2017).

## D. Population

According to CSA (2007), the total human population of AdamaZuriaWoreda including Adama Town is about 375,561. Out of this, 187,676 are women and 187,885 are men. While in 2014 CSA projected data (estimated population) the total population is about 473,385. From this, about 237,541 are women and 237844 are men (Belete, 2017).




| | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RF | 962 | 840 | 106 | 850 | 614 | 145 | 720 | 803 | 912 | 110 | 109 | 576 | 103 | 745 | 108 | 900 | 848 | 581 | 951 | 758 |
| Max temp | 26.6 | 28 | 28.1 | 27.8 | 29.3 | 28.6 | 26.5 | 28.5 | 27.8 | 27.7 | 27.7 | 28.7 | 28 | 28.6 | 28.8 | 29 | 29.7 | 29.7 | 28.2 | 29.7 |
| Min temp | 15.3 | 14 | 14.6 | 14.9 | 15.8 | 14.8 | 15.3 | 15.7 | 16 | 15.6 | 15.1 | 16.4 | 15.6 | 15.4 | 15.5 | 15.9 | 16.2 | 16.5 | 16 | 13.5 |

**Fig 9.Adama average Rain fall, maxi & min. temperature**

Source EMA(2018).

### 3.2. Sample Survey and Sampling Methods

### 3.2.1. Selection of the study villages

About 80% of Adama wind II farm is located at Adamawereda ( there are three kebele farmers association namely, Kechemo, Bubusakusaye,MekoyeHaro and the remaining 20% is located in Mojo limo wereda .The selection of the four study village was entirely based on the availability of wind turbine. Total no of house hold of the study area are 1560 Of which 1075 are male and 501 are female .From the total house hold population MukoyeHaro had 491 and out of these 341 are male and 150 female, BubusaKusaye had 495 and among these number of males are 330 and number of females are 165, Kechemo had 263 among these number of males are 174 and number of females are 89 and Limo had a total population of 327 among these number of males are 230 and number of females are 97. Five percent of population is taken as sample house hold from each total of population. Accordingly a total of 77 households have been randomly selected by simple random sampling technique (lottery method) from the lists of the households of the four villages. Out of 77 randomly selected households 51 are male and 26 are female.

**Table1.Profile of Sampe house hold of the Study Area**

| Sn | Kebele peasant association | No of house hold | | | Sample house hold | | |
|---|---|---|---|---|---|---|---|
| | | | M | F | | Male | Female |
| 1 | MukoyeHaro | 491 | 341 | 150 | 24 | 17 | 7 |
| 2 | BubusaKusaye | 495 | 330 | 165 | 24 | 15 | 9 |
| 3 | Kechemo | 263 | 174 | 89 | 13 | 8 | 5 |
| 4 | Limo | 327 | 230 | 97 | 16 | 11 | 5 |
| 5 | Total | 1576 | 1075 | 501 | 77 | 51 | 26 |

Source Own observation( 2018).

### 3.2.2. Selection of Sample Households and Questionnaire Administration

Sample survey method was applied to collect primary data from sampled households/farmers through structured questionnaire with closed ended and open option questions. The information collected included farmers' perception of the effect before and after the introduction of wind farm in their locality like its effect on climate like trend of temperature and precipitation ,fertility of their farm land , increase or decrease of number of livestock, wildlife like birds ,environment and their economic and social life like job opportunity accessibility to road ,potable water social service like schooling ,health. The questionnaire also included information about the households' socio economic status.

To make the data collection processes effective and to control the quality of the data which has been collected, the researcher employed different methods throughout the data collection process. Firstly, the researcher repeatedly traveled to farm site and tried to have a good understanding of the area under study and this helped him to develop proxy and understandable questionnaire to the local people. Questioner used as data collection instrument and these were administered by the researcher and trained enumerator the questioner were translated into Amharic .The enumerators were selected on the base of their fluency in speaking Oromifa and Amharic.Before the implementation of survey enumerators were trained and tested for their clarity and understanding the question.The data collection process was through face-to-face contact and interviewing heads of the samples households. The heads were oriented by the kebele administrator about the purpose of the survey. To enhance the chance of meeting the household's heads in their villages and homes, early mornings and late afternoon were found to be an appropriate time.

### 3.3. Key Informant Interview and Field Observation

Interview method is suitable for intensive investigation issues. The researcher prepared both structured and semi structured interview guide and conducted interview with 15 informants from different authorities /experts/ professionals like (1) high experts from Ethiopian Electric Power (2) Adama II wind farm plant managers (1) Adama II wind farm production manager,(1) agents of administrative office ,(1) forest and environment protection office ,(1) water resource office , (3) Developmental agents,(4) kebele peasant association chair person (1) health officer.

In general 8 KII interviewed from four keble and the rest 7 experts interviewed from different offices that has clue in the issue. The researcher repeatedly traveled to farm site and tried to have a good understanding of the area under study and this helped him to develop proxy and understandable questionnaire to the local people.

### 3.4. Secondary Data

In order to see production of Adama II wind farm different statistical data like daily, monthly energy production was obtained from Adama II wind farm office more over to see the potential wind energy and the overall climatic condition of the study area statistical data like temperature, precipitation and wind (direction and speed) obtained from National Meteorology Agency and to see the change of land use land cover of the study area 2000, and 2016 topographic map and remote sensing imagery which obtained from Ethiopian Geospatial institute used as secondary data.

### 3.5. Data Analysis

Qualitative data from various sources was examined and presented in different forms. It was discussed under different headings. Quantitative data also were edited, coded and entered in a SPSS and Microsoft Excel spread sheets and analyzed.To see the distance between each turbine and to study Land Use Land Cover Change of the study area with data that obtained from Ethiopia Spatial Information Institution (ESII) Arc GIS version 10.4.1 and ERDAS Imagery 2014 employed . Descriptive statistics were run to give frequencies and percentage . Multiple response questions were analyzed so as to give frequencies and percentages. Tables and graphs were abundantly used to present different variables. Daily and monthly energy production data which obtained from Adama II wind farm and temperature and rainfall data from meteorological stations were analyzed using Microsoft Office Excel 2007 and SPSS 24 version.

### 3.6. Daily energy production

Daily energy production for the year 2015 computed .The purpose is to see in which hour of the day energy production is high and to suggest the best time for production. Energy production at every 15 minutes interval were obtained from 2014-03 0915:00 up to 2016-03-25 15:45:00 from Adama II wind farm .For convenience year 2015 taken and from the whole year by employing random systematic sampling (three days from each months ,twelve days from each season and 36 days from the whole year ) selected and converted into average three hours (1/8days) .1/8 daily average power production is obtained by summing 12 successive 15 minutes interval for each class group. In this way the day is grouped as follow 0-2h,3-5h,6- 8h,9-11h,12-14h.15-17h,18-20h,21-23h.In the same way seasonal average energy production obtained by summing the no of successive days of the fourth months and dividing by the number of the days of each season . Finally daily year 2015 average wind energy production is computed by summing 36 successive days and divided by 36 .As of Bedasa& Swenson the year is divided in two three seasons based on rain in the country . These are Kiremt (June, Julay, August, September),Bega (October, November , December, January) Belge (February, March, April, May) (Swensoon, 2015) .

# CHAPTER FOUR

## 4. RESULT AND DISCUSSION

This chapter deals with the analysis and interpretation of the collected data. An attempt has been made to discuss perception of farmers, concerning individuals and experts about the effect before and after the introduction of wind farm in their locality like its effect on climate like trend of temperature and precipitation ,fertility of their farm land , increase or decrease of number of livestock, wildlife like birds ,environment and their economic and social life like job opportunity accessibility to road ,potable water social service like schooling ,health. The questionnaire also included information about the households' socio economic status. The result and discussion consist general demographic characteristics of sample households, daily, ,monthly yearly wind energy production land use pattern of the study area ,wind farm station and distribution of wind turbine ,standard distance between two consecutive wind turbine based on 2000 and 2016 remote sense imagery and finally negative and positive socio economic and environmental effect of wind farm on the local community discussed based on the data collected.

### 4.1. General Demographic Characteristics of Sample Household

The following table indicates the age groups of sample respondents in the study area

**Table 2 Age groups of sample respondents in the study area.**

| Age | Frequency | percent | Sex and Frequency | | Percent | |
|---|---|---|---|---|---|---|
| | | | M | F | M | F |
| 15-30 | 13 | 16.88 | 7 | 6 | 9.1 | 7.8 |
| 31-60 | 46 | 62.33 | 28 | 18 | 36.36 | 23.37 |
| >60 | 18 | 20.78 | 16 | 2 | 20.8 | 2.6 |
| Total | 77 | 100 | 51 | 26 | 66.23 | 33.76 |

Source Own Survey (2018).

Based on the sample the age of the house hold is categorized in to three categories .These are 15-30 years young , 31-60 years Adults and >60 years old .Accordingly out of the total house hold population 16.9% is young ,59.74% adult and 23.37% old age. This revel that the majority 59.7% are adult group.

**Table 3 Educational status of the house hold**

| | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| Illiterate | 13 | 16.9 | 16.9 | 16.9 |
| Read and Write | 14 | 18.2 | 18.2 | 35.1 |
| Grade 1-6 | 33 | 42.9 | 42.9 | 77.9 |
| Grade7-8 | 8 | 10.4 | 10.4 | 88.3 |
| Grade 9-12 | 8 | 10.4 | 10.4 | 98.7 |
| Degree, diploma | 1 | 1.3 | 1.3 | 100.0 |
| Total | 77 | 100.0 | 100.0 | |

Source Field survey (2018).

As we have seen from the graph out of 77 respondent 33 or 43% are between grade 1 to 6 14(18.2%) read and right and 13(17%) .In general 80% of the respondent are grade 6 and below so that the concerned body must take this into consideration and give attention for the expansion of education service to the local community.

**Table 4. Marriage status of the house hold**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Married | 63 | 81.8 | 81.8 | 81.8 |
| | Not married | 3 | 3.9 | 3.9 | 85.7 |
| | Widowed | 5 | 6.5 | 6.5 | 92.2 |
| | Divorce | 2 | 2.6 | 2.6 | 94.8 |
| | Separated | 4 | 5.2 | 5.2 | 100.0 |
| | Total | 77 | 100.0 | 100.0 | |

**Source**: Field Survey (2018).

Most of the respond ants are married number of respondents that is divorced, widowed and not married is very small .This show there is good social coherence in the rural area than commonly observed urban area where divorced is very high.

## Land Use Land Cover Change of the Study Area in Relation to Wind Farm.

> "The KII confirmed that wind farm project had insignificant impact in altering the land use pattern of the study area as KII from Ethiopian Electric power about 80% wind turbine ,wind turbine generator ,33KV and 230 KV tower installed at Adama wereda (Bubusakusay, Kechemo&Mukoyeharo peasant association village in farm land the remaining 20% wind turbine 33KV and 230 KV tower installed at Lemo wereda peasant association in bare land and moreover the foot print of wind turbine is very small as compared to Hydro power and grid solar installation .KII from Adama wereda Agriculture office and environmental office share the same idea .

Socio-economic and biophysical variables act as the driving forces of land use changes (Birhan, 2017) .When we compare the land use land cover change of the study area based on 2000 and 2016 of remote sensing imagery bare land decrease from 15.4 km2 to 6.05km2 and forest decrease from 27.05 km2 to 17.84km2 shrub land from 77.65km2 to 44.72 km2 in 2016 and farm land increase from 155.98 km2 to 205.74 km2 and settlement increase from 3.2km2 to 4.84km2 in 2016 .Since most wind turbine installed in farm land the possibility of cutting trees in relation to installation of the wind turbine, wind turbine generator,33& 230KV tower is very minimal. In the study area farm land area increase from 155.98km2 to 205.74 km2 if wind turbine had significant effect on the farm land the farm land would have not been increased in such large rate despite the decrease of bare land ,bush land and forest can be taken as a reason for increment of farmland). Wind farm can be built on farms or ranches and studies have shown that once wind farms are operational, The wind farm site boundary will not be fenced, hence the land can still be used for farming and grazing in many cases (CHEN, 2016; EL-Fouly, 2007)**.** From this we can conclude the wind farm had insignificant effect in altering the land use pattern of the study area particularly forest, shrub land and farmland . Of course indirectly it can have an effect in changing pattern of settlement.

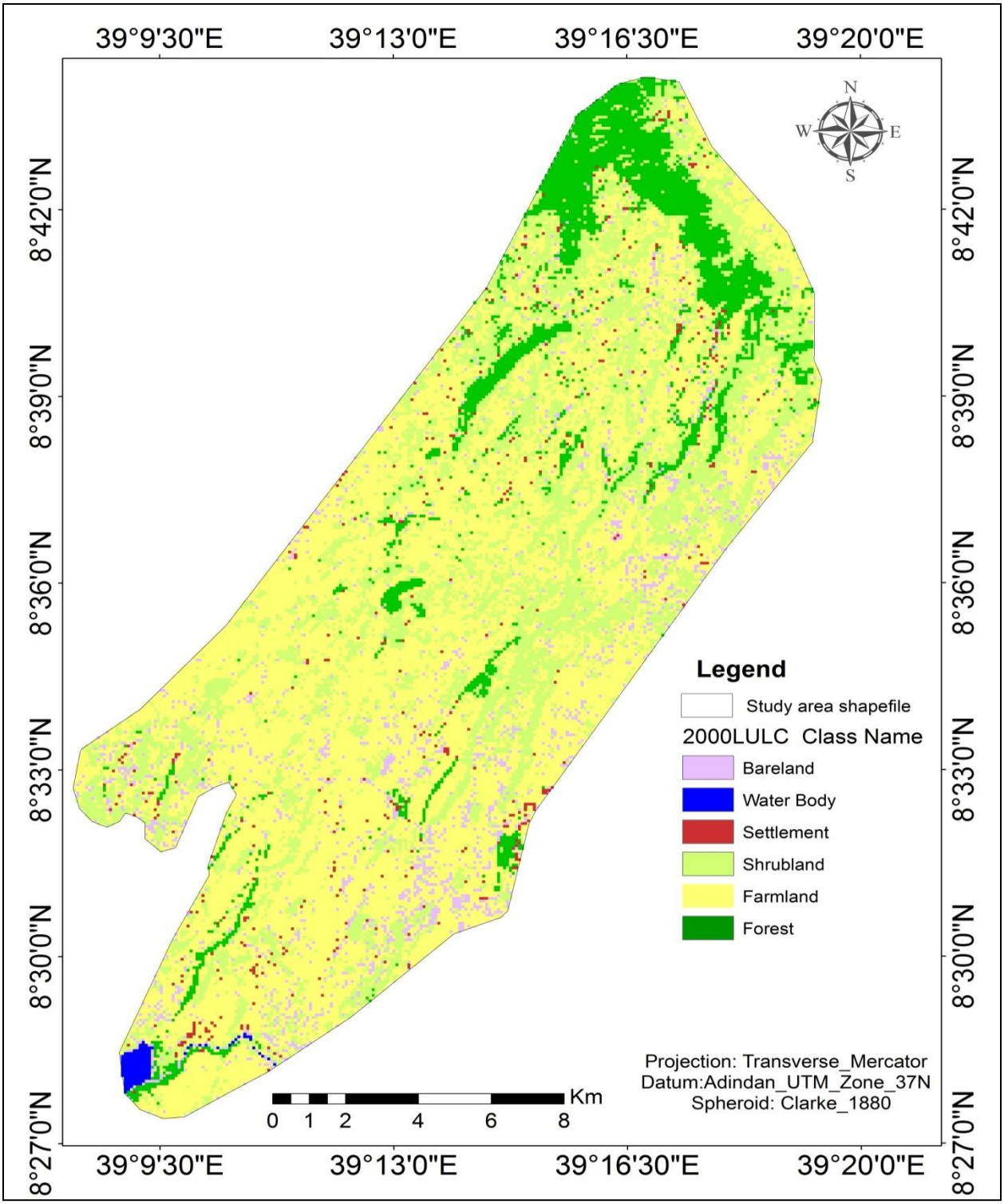



Fig 10 map of Land Use Land Classification of study area for year 2000
Source EGII (2019).

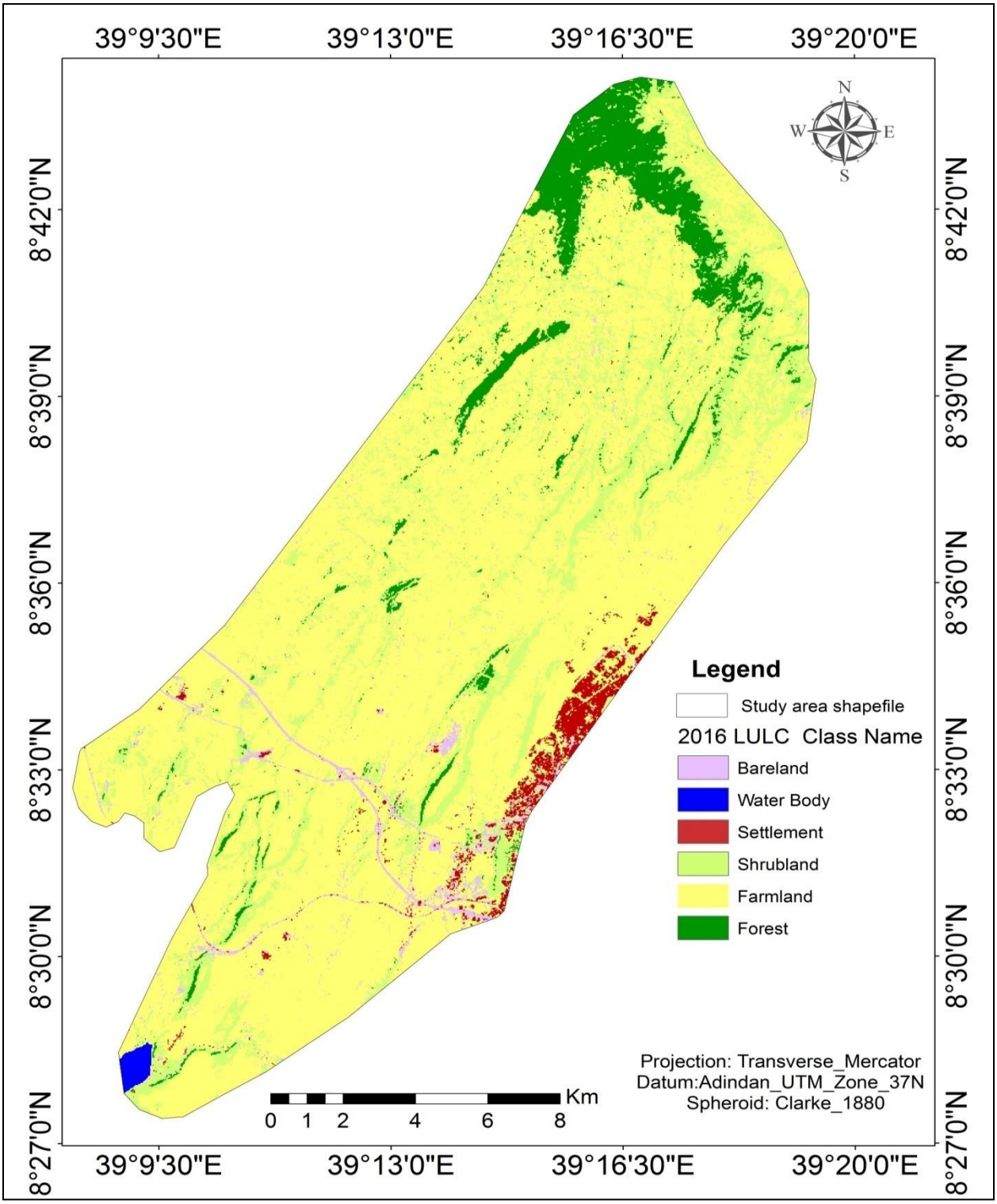


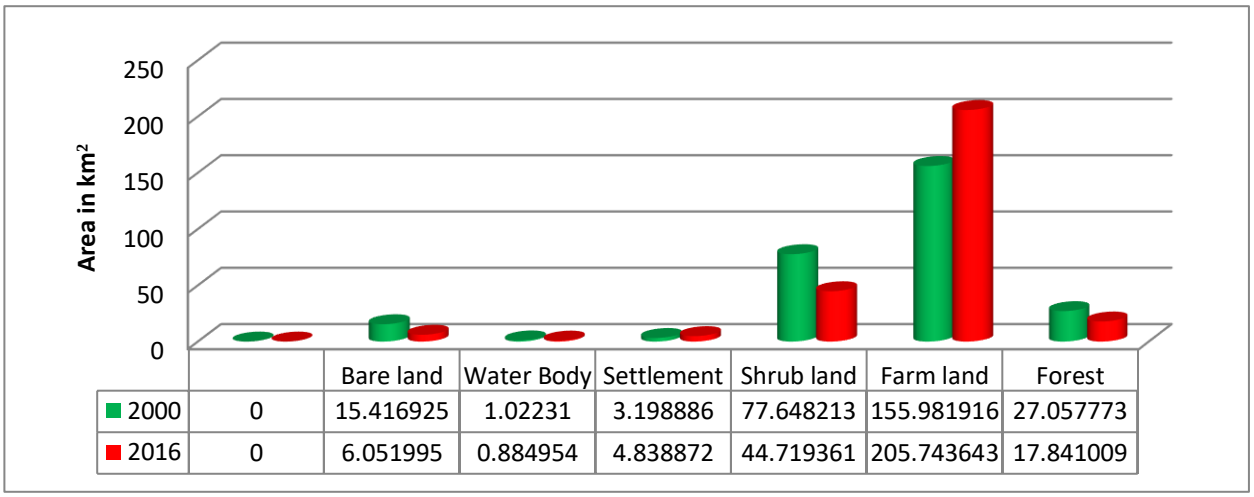

Fig 11.Map of Land Use Land Cover of the study area for the year 2016 Source EGII (2016).

The following table shows Land Use Land Cover Change of the study area for the year 2000 and 2016 .As we can see from the table bare land decrease from 15.42km2 to 6.05km2 and water body decrease from 1.02km2 to 0.88km2 ,shrub land from 77.64km2 to 27.7km2 ,forest from 27.05km2 to 17.84km2 in 2016 and Settlement increase from 3.2km2 to 4.83km2 and farm land from 155.98km2 to 205.74km2.Net change during 2000-2016 bare land, shrub land, water body and forest shows - sign that means decrease and Settlement and farmland show +sign that means increase through time.

**Table5. Land Use Land Cover Change for the year 2000 and 2016.**

| **No** | **LULCC** | **2000** | | **2016** | | **Net changes during 2000-2016** |
|---|---|---|---|---|---|---|
| | | **Area in $km^2$** | **Area in %** | **Area in $km^2$** | **Area in %** | in $km^2$ |
| 1 | Bare land | 15.416925 | 5.49964 | 6.051995 | 2.158913 | -9.36493 |
| 2 | Water Body | 1.02231 | 0.36468 | 0.884954 | 0.315687 | -0.137356 |
| 3 | Settlement | 3.198886 | 1.14113 | 4.838872 | 1.726158 | +1.639986 |
| 4 | Shrub land | 77.648213 | 27.6992 | 44.719361 | 15.95262 | -32.928852 |
| 5 | Farm land | 155.981916 | 55.6430 | 205.743643 | 73.39441 | +49.761727 |
| 6 | Forest | 27.057773 | 9.65225 | 17.841009 | 6.364378 | -9.216764 |
| Total | | 280.326022 | 100 | 280.326022 | 100 | |

**Source EGII (2019)**




| | | Bare land | Water Body | Settlement | Shrub land | Farm land | Forest |
|---|---|---|---|---|---|---|---|
| 2000 | 0 | 15.416925 | 1.02231 | 3.198886 | 77.648213 | 155.981916 | 27.057773 |
| 2016 | 0 | 6.051995 | 0.884954 | 4.838872 | 44.719361 | 205.743643 | 17.841009 |

Fig.12 shows Land Use Land Cover Change of the study area during 2000-2016 source (EGII).

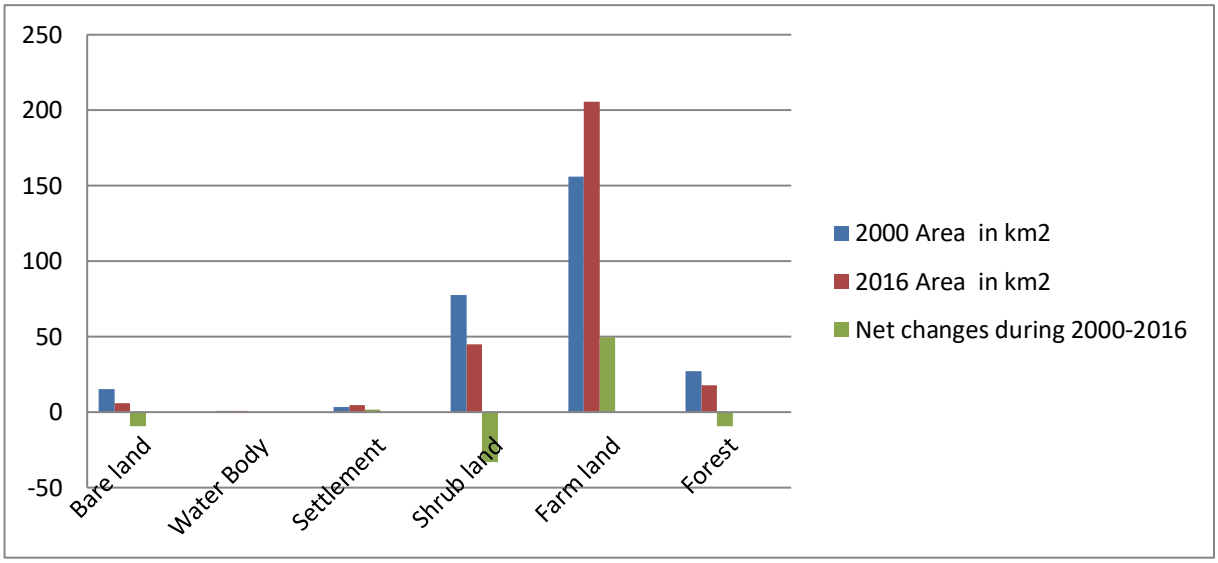
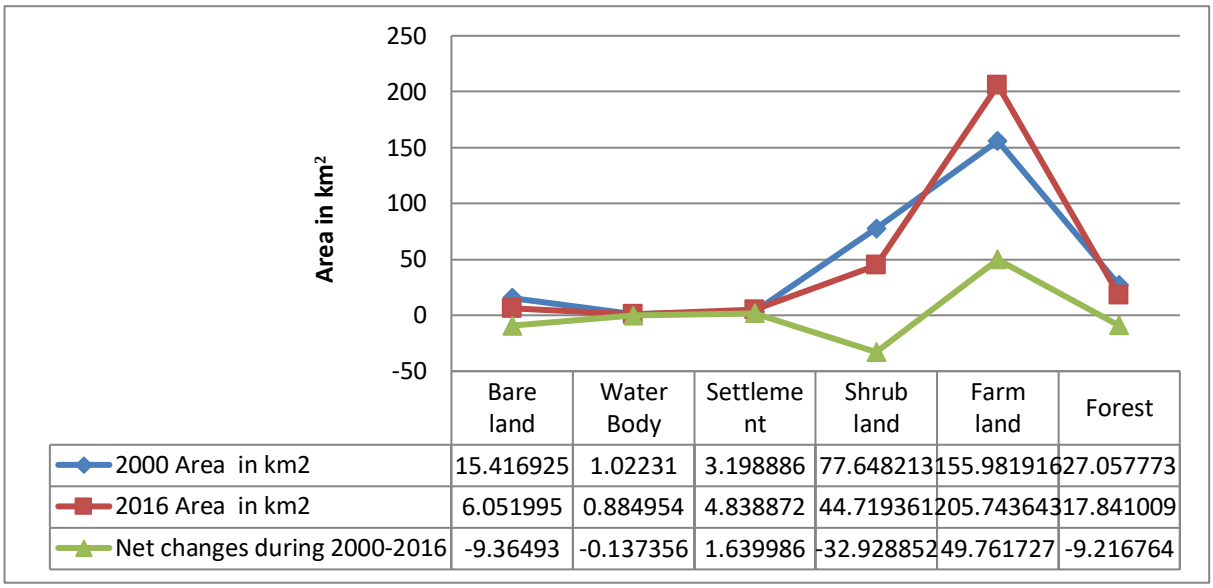



Fig13. shows Land use Land Cover Net Change during 2000-2016




| | Bare land | Water Body | Settlement | Shrub land | Farm land | Forest |
|---|---|---|---|---|---|---|
| 2000 Area in km2 | 15.416925 | 1.02231 | 3.198886 | 77.648213 | 155.98191 | 27.057773 |
| 2016 Area in km2 | 6.051995 | 0.884954 | 4.838872 | 44.719361 | 205.74364 | 17.841009 |
| Net changes during 2000-2016 | -9.36493 | -0.137356 | 1.639986 | -32.92885 | 49.761727 | -9.216764 |

Figure14.Land Use Land Cover class Area in km2.

When we see the above figure in 2000 the area coverd by the bare land was 15.41km2 and this reduced into 6.05km2 in 2016 and the land that was coverd by water was 1.02 km2 in 2016 it redced to 0.88km2 .In 2000 the area of the settlement was 3.2km2 this increse into 4.84km2 in 2016 and shurb land in 2000 was 77.65km2 but it reduce into 44.72km2 in 2016 .The land that was coverd by farmland in 2000 was 155.98 km2 in 2016 the area of the farm land coverd by farmland increas significantly to 205.74km2 and the land that was covered by forest in 2000 was 27.06km2 this decline to 17.84km2.In general when we see the change of the land use pattern bare land water body,forest and shurbland reduced on the otherhand settlement and farm land significantly increase in 2016 as copare to 2000 .The main reason for the increament of farm land and settlement could be population growth due to internal and external factor (birthrate and migration) because of this bare land shurbland and forest area converted into farmland and settlement .The establishment of wind farm had also certain ammont of contribution in inicrement of settlement particularly during the constraction phase of the wind farm at Kechemo near to the sub-station of the wind farm .

### 4.2. Distance Between Wind Turbine

The question of wind take should be dealt with at planning stage, to ensure that any proposed layout of wind turbines takes into account the development potential of an adjoining site for a similar development. In general, to ensure optimal performance and to account for turbulence effects, the minimum distance (the standard distance) betwwen the two consecutive wind turbines will generally be three times the rotor diameter (=3d) in the crosswind direction and six times the rotor diameter (=6d) in the prevailing direction (downwind). If wind turbine installed closed to each other can act as an obstacle and create turbulence. Bearing in mind the requirements for optimal performance, a distance of not less than two rotor blades from adjoining property boundaries will generally be acceptable. Unless, permission for wind energy development has been granted on an adjacent site, the principle of the minimum separation distances between turbines in crosswind and downwind directions indicated above should be respected.((HCC), 2012; (MESPRS), (2010).)

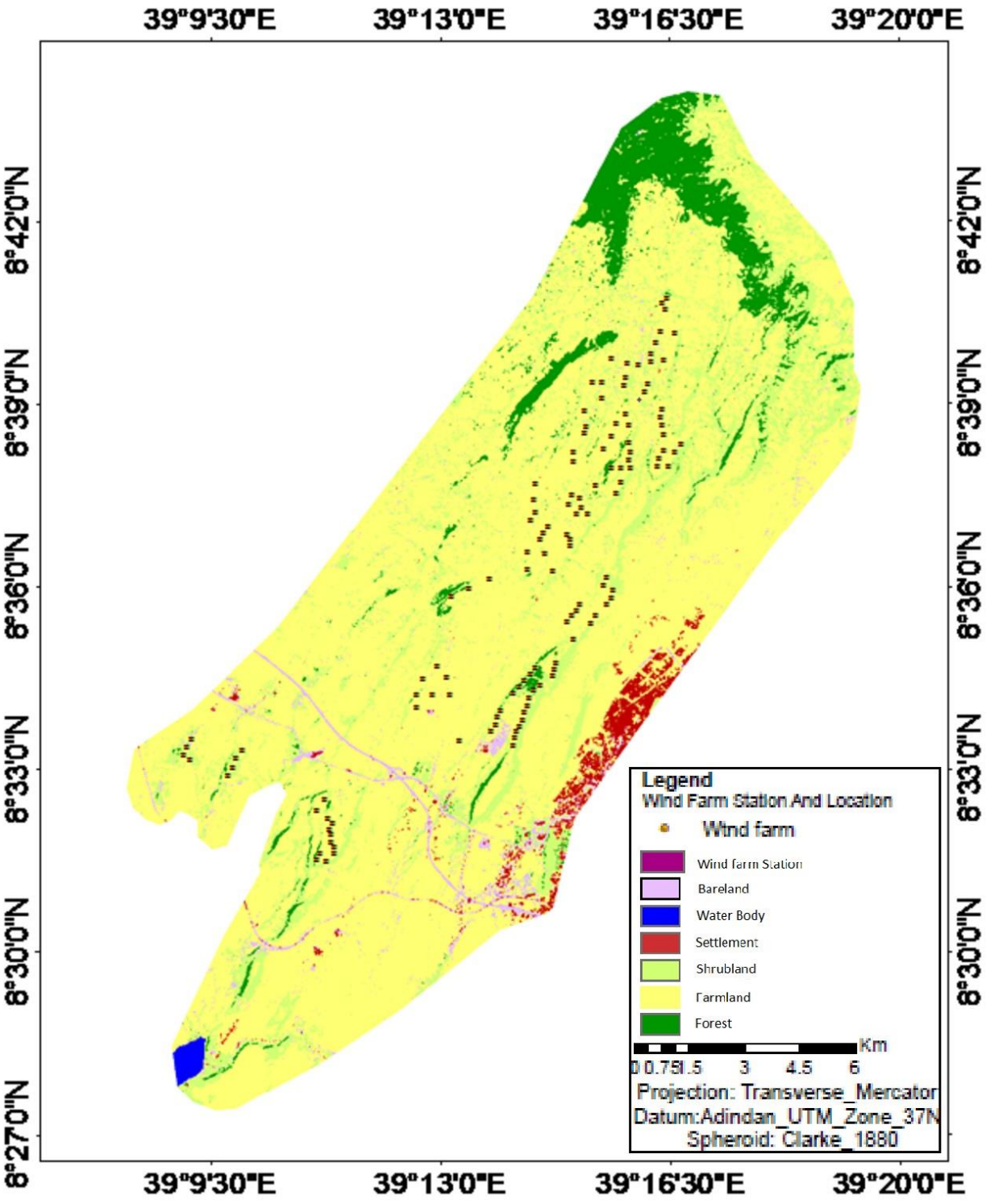



Fig 15 Wind Farm Station and Location

The above map show the distribution of 102 wind turbine and substation of AdamaII wind farm .When we see the distribution the wind turbines they are more closer at the south Mojo Limuwereda and near to substation Kechemo peasant association and wind turbine are far apart at north of the study area particularly at BubusaKusaye and MekoyeHaro peasant association .More over the wind turbine are completely located at farmland in Adamawereda and they are far away from forest bush land and settlement .Out of 102 wind turbine 20 located at Mojo Limo wereda at hilly land where settlement are very scattered and the land is barren and covered with thin grass and the remaining 82 wind turbine located at Adamawereda in cultivated farm land.

## The distance between two consecutive wind turbine

The distance between two consecutive wind turbine

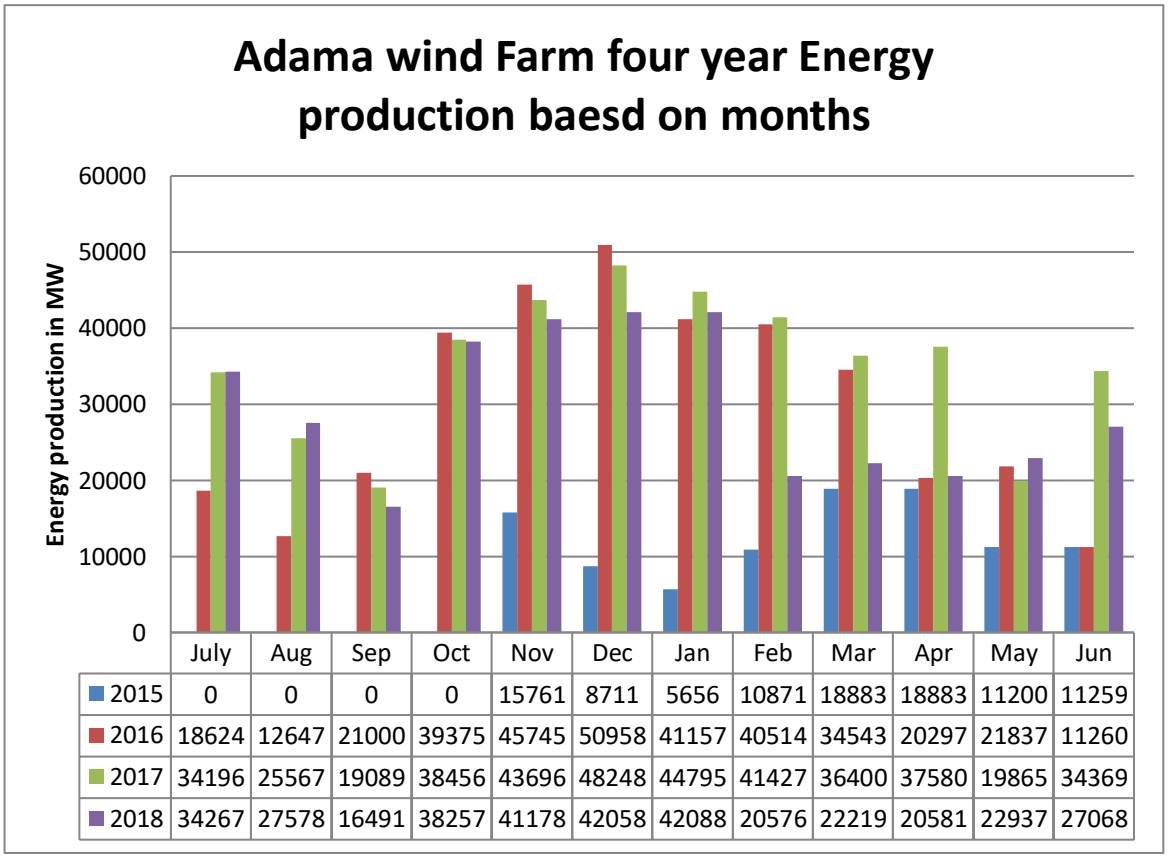
The minimum distance (the standard distance) betwwen the two consecutive wind turbines will generally be three times the rotor diameter (234m) in the crosswind direction and six times the rotor diameter (468m) in the prevailing direction (downwind) ((HCC), 2012).As we can see from the map that shows distribution of wind turbine there is no any consecutive wind turbines along the prevailing direction instead almost all consecutive wind turbines located along crosswind direction. Therefore, to see distance between two consecutive wind turbines along cross wind direction from the map" I" select those wind turbines that are more closer from the study area and by employing Arc GIS 10.4.1 measurement conduct. The result of the measurement show that, the distance between 27 consecutive turbine is below the standard for instance the lowest distance is measured between wind turbine FID 114 & 116 is 167m at Mojo Limo wereda. The number 0f two consecutive wind turbine that their distance is below the standard at Mojo Limowereda are five and their mean distance is 193.8 meter At kechemo peasant association there total number are 13 and mean distance 213.3 at BubusaKusay there total number are 6 and mean distance 195.33 and at MukuyeHaro their number are three and mean distance 134.33.In general total number of wind turbine that their distance is below the standard between two consecutive wind turbine are 27 (24%) .The remaining 75 (76%) consecutive wind turbine fulfilled the minimum standard distance. From this we can conclude the standard distance between two consecutive wind turbines along cross wind direction at the study area fulfilled by 76%.Therefore it doesn't have that much negative effect in energy production. The following table show distance between two consecutive wind turbine in meter.

**Table 6 the distance between two consecutive wind turbine (EGII,2019).**

| The distance between two consecutive wind turbine at selected point in Limo Peasant Associ (PA) | | |
|---|---|---|
| FID | Distance between two consecutive wind turbine | Length in meter |
| | 110&111 | 210 |
| | 111&112 | 187 |
| | 112&113 | 201 |
| | 113&114 | 204 |
| | 114&116 | 167 |
| | Mean Distance | 193.8 |
| The distance between two consecutive wind turbine at selected point in Kechemo P. Association | | |
| FID | 82 & 83 | 212 |
| | 83&94 | 216 |
| | 96&97 | 230 |
| | 102&103 | 195 |
| | 103&104 | 197 |
| | 104&105 | 190 |
| | 105&106 | 224 |
| | 86&90 | 230 |
| | 99&100 | 219 |
| | 100&101 | 223 |
| | 80&79 | 217 |
| | 79&78 | 206 |
| | 78&77 | 214 |
| | Mean Distance | 213.3 |
| The distance between two consecutive wind turbine at selected point in BubusaKusayeP.Asso(PA) | | |
| FID | 80&79 | 201 |
| | 79&78 | 222 |
| | 78&77 | 195 |
| | 61&62 | 174 |
| | 62&124 | 179 |
| | 49&54 | 201 |
| | Mean Distance | 195.33 |
| The distance between two consecutive wind turbine at selected point in MekoyeHaroP.Associat | | |
| | 0&1 | 198 |
| | 1&2 | 180 |
| | 25&26 | 205 |
| | Mean Distance | 134.33 |

### 4.3. Adama II Energy production

As of the feasibility study of Adama II wind power the yearly electric production is (when the plant start to implement with its full capacity is 476.665 GWH or 476665 MWH per year ). Since wind blow is an arbitrary we can't get wind 24 hours but from the 24 hours we can get about 8.83 hours about 3115 hours yearly .When we compare the electric production from the outset of the project that is year 2007 the production is very low the reason is the project is on the process of the construction .But when we see year 2008,2009 and 2010 the production is promising because the plant start to implement with its full capacity.




| | July | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2015 | 0 | 0 | 0 | 0 | 15761 | 8711 | 5656 | 10871 | 18883 | 18883 | 11200 | 11259 |
| 2016 | 18624 | 12647 | 21000 | 39375 | 45745 | 50958 | 41157 | 40514 | 34543 | 20297 | 21837 | 11260 |
| 2017 | 34196 | 25567 | 19089 | 38456 | 43696 | 48248 | 44795 | 41427 | 36400 | 37580 | 19865 | 34369 |
| 2018 | 34267 | 27578 | 16491 | 38257 | 41178 | 42058 | 42088 | 20576 | 22219 | 20581 | 22937 | 27068 |

Fig16 AdamaII wind farm Monthly Energy Production 2007-2010

Source Adama wind farm( 2018).

From the above graph we can observe that energy production is good at the months of October,, November, December ,January , February and to some extent at April when there is low rain fall in most part of the country and on the other hand during the rainy season except July the wind energy production is low. In line to this one KII Ethiopian Electric Power Corporation's electromechanical supervisor in charge of the Adama wind farm stated that: "As compared to wind and solar we have plenty of hydroelectric energy sources, but during the dry season and when droughts happen the level of the dam decreases but the wind turbines were immune to the dry spells."At that time the wind will complement the hydro dam. The wind is especially strong during the dry season, so wind and hydro power complement each other." In line to this the environmental and socio economic studies conducted in Kenya Lake Turkana Wind Power Project stated that "The situation is aggravated by the over reliance (approximately 50%) on hydropower which has been often unreliable in the dry seasons.The1999 - 2002 drought in the region is an example of periods where lack of water supply greatly affected the power production of the hydroelectric dams that had a crippling effect on the economy. This experience underscores the need to increase power production and associated facilities in order to diversify power sources like wind and solar ((KLCPDP), 2011 ) .

From this we can conclude that wind energy complement electric power to the nation when there is power scarcity production of hydro power during dry season.

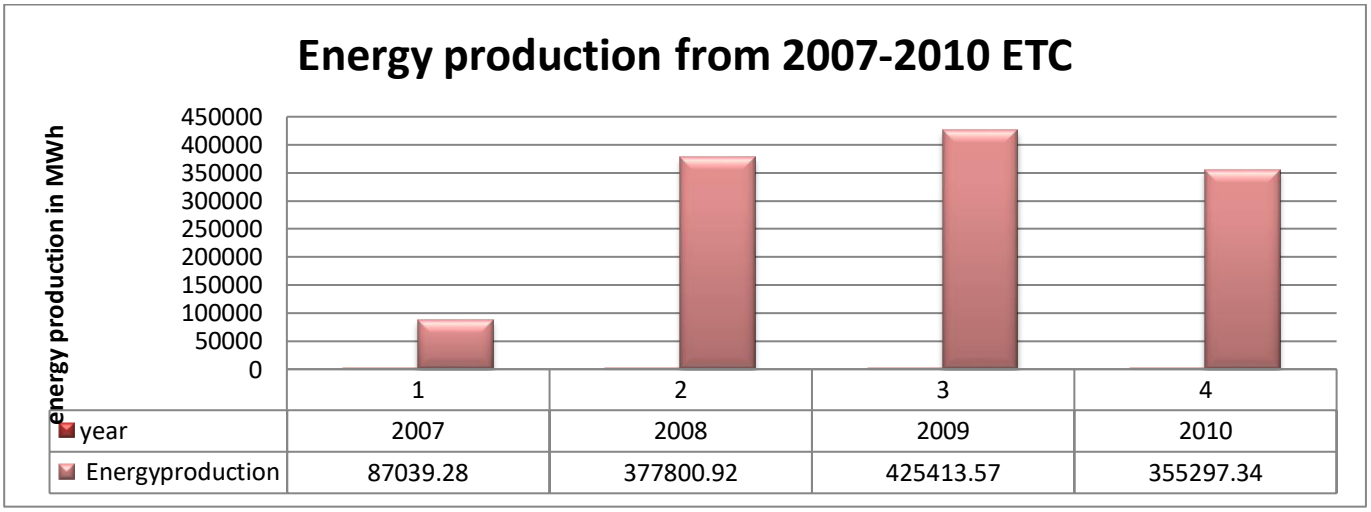



Fig17:- Adama II wind energy production from year 2007- 2010 ETC.

**source :-Adama II wind farm (2018)**

### 4.4. Daily Energy Production

Daily energy production for the year 2015 computed .The purpose is to see in which hour of the day energy production is high and to suggest the best time for production.

**Table: 7 winter season daily energy production**

| No | Class interval | Daily energy production with 3hr interval in MWh |
|---|---|---|
| 1 | 0-2h | 261.1 |
| 2 | 3-5h | 232.8 |
| 3 | 6-8h | 274.4 |
| 4 | 9-11h | 280.1 |
| 5 | 12-14h | 160.2 |
| 6 | 15-17h | 98 |
| 7 | 18-20 | 146.9 |
| 8 | 21-23h | 276 |

As indicated in table 3 the highest daily energy production in the winter season is from 6 to 8 hour and next 9 to 11 hours and the least energy production 18 to 12 hours.

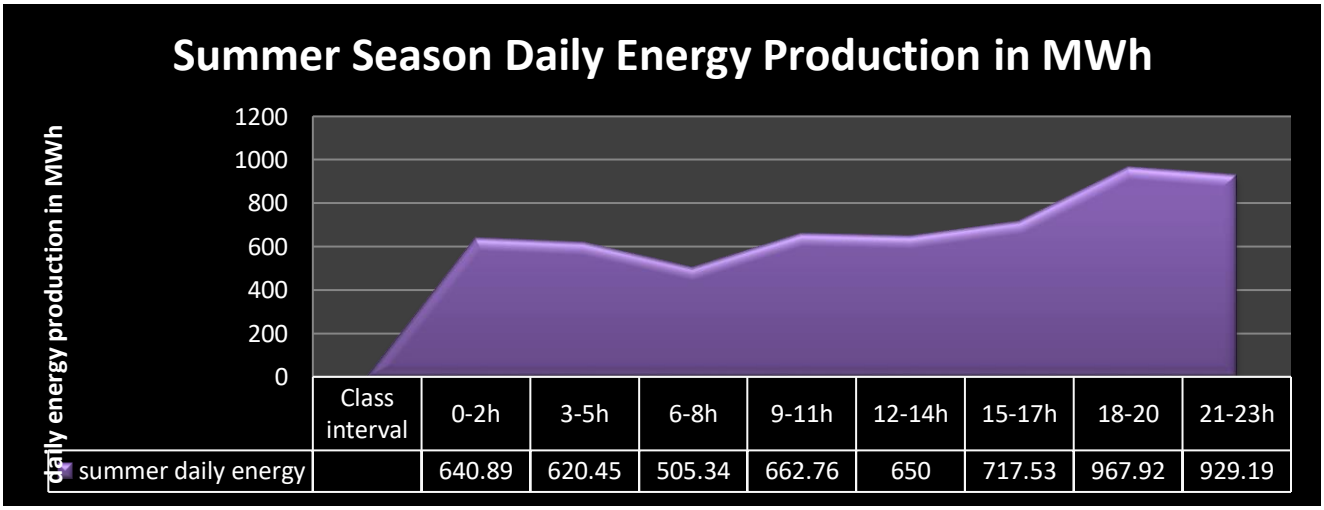



Fig 18:-Adama II summer season daily energy production for year 2015.

sourceAdama II wind farm (2018)

As shown in the graph during the summer season the highest energy production is at night particularly around midnight rather than day .For the remaining hour's production is moderate.

As we can see from below graph during the Belge (autumn) season daily energy production has a similar pattern as of summer season. Energy production is very high during the night time than the day .The highest energy production during the day time is observed from 15 to 17 hours.

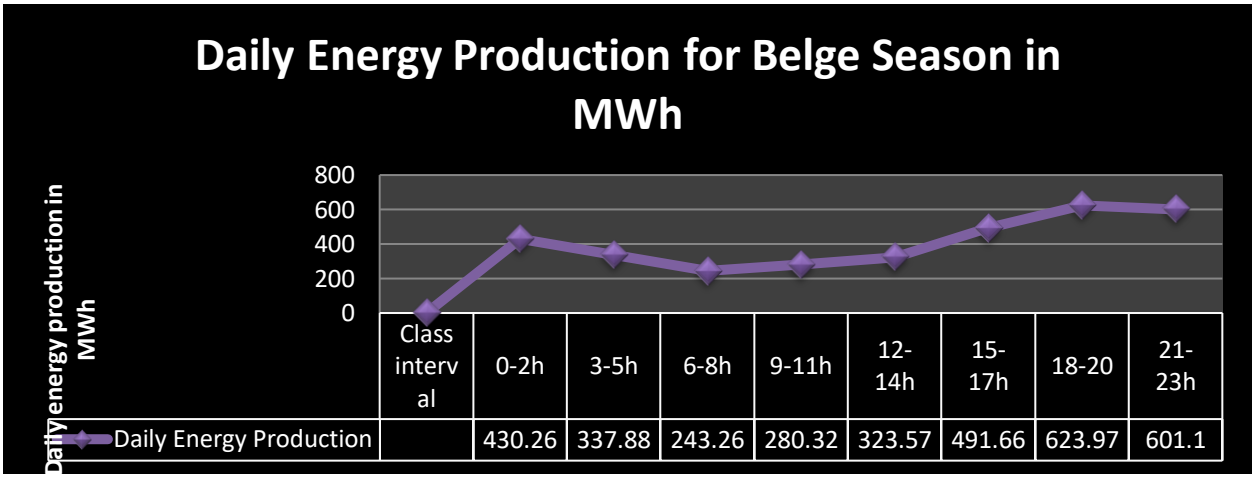



**Fig 19:-**Adama II Belge season daily energy production for year 2015.

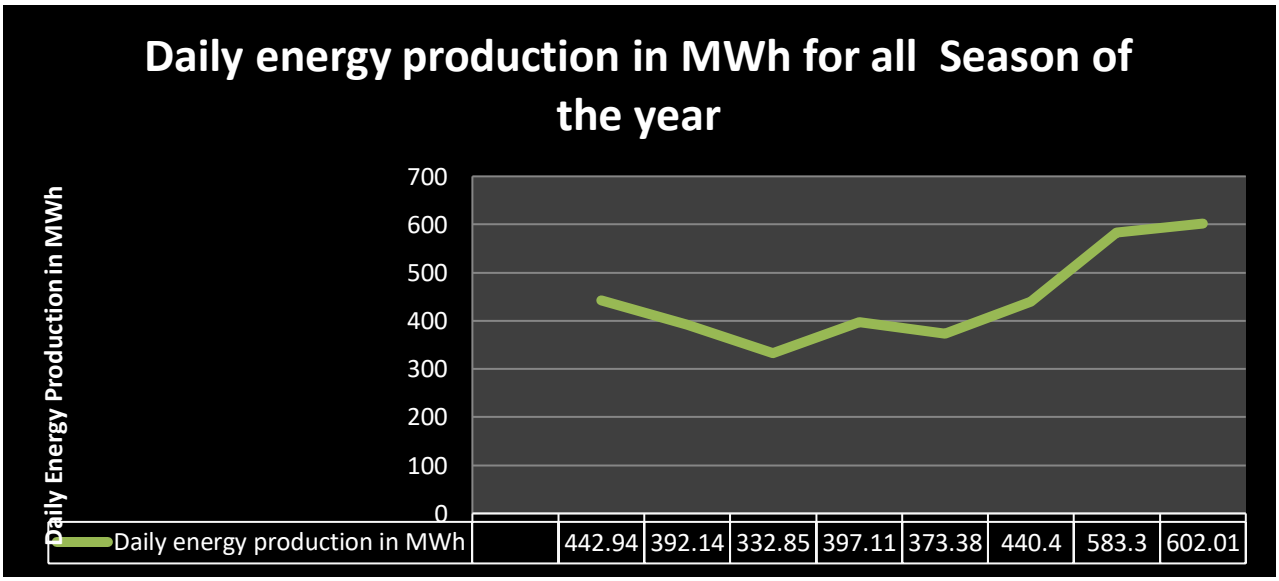



Fig 20:-AdamaII daily energy production for year 2015.

Source: AdamaII wind farm

As it is clearly seen from the above table year daily energy product relatively the highest energy production is observed during the night time than the day .So that we can conclude that at

Adamasurrounding relatively wind is more available at night time than day time particularly at 18-20 hours and during the midnight.

## Planned verse production

To evaluate the productivity of wind power plant I think it is better to see production verse plan so that attempts has been done to compare year 2009 and 2010 power production against plan .As we can see from table 4 .In the year 2009 the wind plant plan to produce 378,238.7595 MW but the actual production in the given year is 423457.973 MW(111.95%). In year 2009 the wind plant produce above 12 % of the plan, On the other hand in year 2010 the wind plant plan to produce 364,713.4426 MW but actual production is 339827.402 MW that means 93.17% of the plan .This means production is very high in the year 2009 than 2010 .For this the following two factors are responsible .These are availability of plants and speed of wind .For instance, availability of plants for the year 2009 is 98.25% while for the year 2010 is 85.34% and average wind speed for year 2009 is 7.9 meter per second and for the year 2010 7.4 meter per second. In year 2009 we can say plants or the wind turbine work with their full capacity than the year 2010 and at the same time relatively there is a little bit wind availability with better speed in the year 2009 than 2010 .That is why there is power production variation against plan in the two production period. This goes in line with the explanation of plant production manager as of his explanation the main reason for the variation to power production between the year 2009& 2010 is technical faults in switch breaker and power transmission in some power unit.

## Table 8 plan verses energy production for the year 2009 and 2010

| NO. | MONTH (LOCAL) | PRODUCTION (MWH) | AVERAGE WIND SPEED (M/S) | Plant AVAILABILITY (%) | PLANNED ENERGY(MWH) | PRODUCTION (MWH) | AVERAGE WIND SPEED (M/S) | Plant AVAILABILITY (%) | PLANNED ENERGY(MWH) |
|---|---|---|---|---|---|---|---|---|---|
| **1** | HAMLE2008 | 34196.859 | 7.55 | 98.18 | 29,068.9514 | 34297.037 | 7.62 | 98.18 | 29,068.9514 |
| **2** | NEHASSE2008 | 25566.986 | 6.68 | 98.48 | 30,226.9026 | 27577.688 | 6.94 | 97.68 | 32,624.0170 |
| **4** | MESKEREM2009 | 19089.795 | 5.71 | 98.75 | 29,395.0792 | 14561.085 | 5.33 | 98.34 | 31,726.2270 |
| **5** | TIKIMT 2009 | 38456 | 8.3 | 98.56 | 30,883.0993 | 38257.122 | 8.64 | 97.06 | 33332..253 |
| **6** | HIDAR 2009 | 43696.818 | 8.8 | 98.57 | 32,073.8785 | 41178.387 | 9.75 | 96.34 | 34,403.2640 |
| **7** | TAHISSAS 2009 | 48248.116 | 9.31 | 97.69 | 31,035.8456 | 42057.602 | 8.79 | 96.56 | 33,497.1130 |
| **8** | TIR 2009 | 44795.842 | 9.17 | 97.69 | 31,510.0355 | 42085.707 | 9.51 | 94.77 | 34,008.9080 |
| **9** | YEKATIT 2009 | 41421.931 | 8.46 | 98.13 | 32,144.2135 | 20576.274 | 8 | 60.22 | 34,008.9080 |
| **10** | MEGABIT 2009 | 36400.342 | 7.78 | 98.14 | 32,577.6752 | 22218.856 | 8.59 | 60.22 | 32,577.6752 |
| **11** | MIAZIA 2009 | 37350.237 | 7.97 | 97.92 | 32,629.0933 | 20580.749 | 6.01 | 91.51 | 35,216.2160 |
| **12** | GUENBOT 2009 | 19865.506 | 7.39 | 98.46 | 31,836.2934 | 9368.895 | 2.54 | 45.01 | 34,361.0390 |
| **13** | SENE 2009 | 34369.541 | 7.39 | 98.4 | 34,857.6919 | 27068 | 7.1 | 88.54 | 33,221.1240 |
| | **TOTAL** | **423457.973** | **7.9** | **98.25** | **378,238.7595** | **339827.402** | **7.4** | **85.34** | **364,713.4426** |
| | | **Plant actual Production(MWH) For 2009 E.C** | **average wind speed(m/s) for 2009 E.C** | **Plant Availability (%) for 2009 E.C** | **Planned Energy(MWH) for 2009 E.C** | **Plant actual Production(MWH) For 2010 E.C** | **average wind speed(m/s) for 2010 E.C** | **Plant Availability (%) for 2010 E.C** | **Planned Energy(MWH) for 20010E.C** |

**source** :-AdamaII wind farm (2018)

**Table 9.Trend of livestock population and wind farm**

| | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| Decreasing | 7 | 9.1 | 9.1 | 9.1 |
| The same | 60 | 77.9 | 77.9 | 87.0 |
| Increasing | 3 | 3.9 | 3.9 | 90.9 |
| No of livestock increase or decreases based on season | 7 | 9.1 | 9.1 | 100.0 |
| Total | 77 | 100.0 | 100.0 | |

**Source**: Field Survey (2018).

### 4.5. Wind Farm Establishment and Trend of Livestock Population

The establishment of wind farm doesn't have any effect on the trend of livestock population this match with the respondents response out of 77 respondants 60 (77.9%) report the trend of population is the same 7 or 9.1% report decreasing and 7 or 9.1% say no of livestock increase or decrease based on season 3( 3.9%) report increasing this indicate that that the introduction of wind farm in the area doesn't affect the trend of livestock population.

**Table.10 SampleHouseholds land holding size .**

| | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| yes | 75 | 97.4 | 97.4 | 97.4 |
| no | 2 | 2.6 | 2.6 | 100.0 |
| Total | 77 | 100.0 | 100.0 | |

Source: Field Survey (2018).

Out of 77 respond ants 75 or 97% owned their own land only 2 or 3% of the respond ant does not owned their own land.

**Monthly income of the household**

Out of 77 respond ants about 34 (44.2%)report their monthly income is with the range of 1001-2000 birr and 23 (29.9%) with the range of 2001-3000 birr and 13 (16.9%) 1000 and below 1000birr and only 7(9.1%)above 3000 birr.

From the data we can see that the monthly income of the majority 57(74%) fall between 1001 and 3000 birr .Average family size of the house hold is six and the monthly income is low.

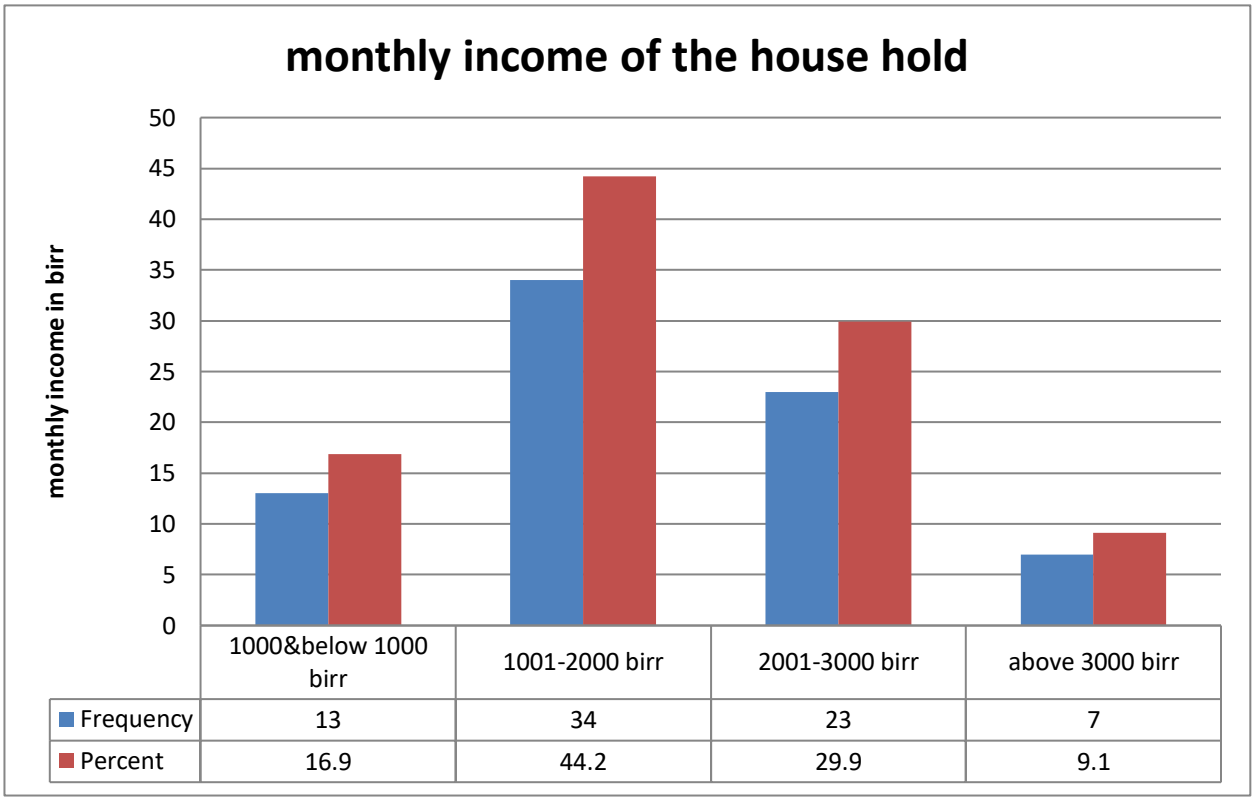



Fig.21 Monthly income of the house hold

source :field survey (2018).

## Main source of Income

Out of 77 respondents 63 (81.8%) report that the main source of their income is crop production the remaining 12(15.6%) in addition to crop production they used petty trade ,daily labor and guard as side business .In general almost 99% of the respondents used crop production as their main source of income .From this we can conclude that most of the respondents engaged with agricultural activities that are sensitive to climate change but fortunately the introduction of wind energy production project in the area does not have any climatic effect on the farmers life or on their environment.

**Table 11: Perception of the respondents about the fertility of their land.**

| | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| Improving | 10 | 13.0 | 13.0 | 13.0 |
| Constant | 58 | 75.3 | 75.3 | 88.3 |
| Declining | 9 | 11.7 | 11.7 | 100.0 |
| Total | 77 | 100.0 | 100.0 | |

Source: Field survey (2018).

### 4.7. Respondents Perception about fertility of their farm land

Attempt has been done to assess the perception of the farmers that the introduction of the wind turbine had effect on fertility of the land. According to the respond ants response 58 (75.3%) say the land is constant 9 (11.7%) the fertility of the land decline and 10 (13%) said improved. From this we can conclude the introduction of wind farm (wind energy generating project ) in the area doesn't have a significant effect on the diminishing of fertility of the land.

### 4.8. Compensation Paid for Farmer that their Land Used for Wind Farm Purpose

Out of 77 respond ant 39 (50.6%) report that they have got compensation for the land that is used for the wind farm project but most of them do not satisfied with amount of compensation they obtained. The amount of compensation vary depend on the purpose it is used if the land is used for road they will get 20 birr perm2 and if the land is used for installation of wind turbine they paid 40 birr per m2 and if the farm land is used for installation of 33KV or 230KV tower the government paid 6000 birr per tower .Total amount of money paid for compensation is 30,000,000 birr .Moreover during the construction phase farmers land was used temporarily for storing wind turbine accessories the amount of compensation paid was 12 birr per m2 .The highest compensation paid is for those farmers that their land used for wind turbine and wind turbine generator is 60,000 birr. The amount of land needed for wind turbine and wind turbine generator is 1500m2.

Though farmers received compensation for the land that they received most of the farmers except those their land used for road, plough the land that they get compensation and let their cattle grazing the farm land even near to turbine .From my field observation they let only six to seven meter radius of the turbine. The footprint of the wind turbines is very small in comparison to other power plants of similar magnitude, hence minimal vegetation loss .Wind farm can be built on farms or ranches and studies have shown that once wind farms are operational, The wind farm site boundary will not be fenced, hence the land can still be used for farming and grazing in many cases **((KLCPDP), 2011 ; CHEN, 2016; EL-Fouly, 2007)**. Actually they do not support by law but the local government let them knowingly since they don't have an effect on the turbine.


Fig 22. Farmers Land get Compensation but still cultivated by farmers

Source field survey (2018).

**Table 12.** Farmers land used for wind farm

| | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| yes | 39 | 50.6 | 50.6 | 50.6 |
| no | 38 | 49.4 | 49.4 | 100.0 |
| Total | 77 | 100.0 | 100.0 | |

**Source**: Field survey (2018).

Out of 77 respond ant 39(50.6%) report that their farm land is used for wind farm like installation of wind turbine, 230kv & 33kv power line, road etc...

**Table.13** Respondent that get compensation

| | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| yes | 39 | 50.6 | 50.6 | 50.6 |
| no | 38 | 49.4 | 49.4 | 100.0 |
| Total | 77 | 100.0 | 100.0 | |

**Source:** Field survey (2018).

**Table 14**.Perception of farmers about the amount of compensation

| | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| .00 | 38 | 49.4 | 49.4 | 49.4 |
| enough | 1 | 1.3 | 1.3 | 50.6 |
| not enough | 38 | 49.4 | 49.4 | 100.0 |
| Total | 77 | 100.0 | 100.0 | |

**Source:** Field survey (2018).

Out of 77 respond ant 39 (50.6%) report that they have got compensation for the land that is used for the wind farm project but most of them do not satisfied with amount of compensation they obtained. The amount of compensation vary depend on the purpose it is used.

**Table 15.**Consultative meeting with the stake holders

| | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| yes | 4 | 5.2 | 5.2 | 5.2 |
| no | 73 | 94.8 | 94.8 | 100.0 |
| Total | 77 | 100.0 | 100.0 | |

**Source**: Field survey (2018).

About 73 (95%) report that consultative meeting do not take place with the local community (farmers ) before the introduction wind farm but about 4 (5%) report that there was consultative meeting but they don't attend the meeting. From this we can see that the majority 95% report that there was no consultative meeting with the local community .To create owner ship sense and for sustainability of the project participation of the local community is indispensible but in the case of the wind farm there is main gap so that the government must take lesson from this for the other project he planned to conduct in the future.

### 4.9. Local Communities Accesses to Motor able Road Before the Introduction of Wind Farm.

All residents of MukoyeHaro and Bubusakusaye and some residents of Kechemo that dwell to the north of the study area travel long distance to reach moterable road before to the introduction of wind farm in their localities. For example out of 77 respond ants 45(58.4%) report they travel more than 3 hours to reach motor able road and 7(9.1%) report they travel 2hr to 3 hours to reach motor able road and 11(14.3%) travel 1hr to 2hr before the introduction of wind farm in their localities .Only 7 (9.1%) travel less than half hour to reach motor able road .This indicate that the majority 63(81.81%) travel more than 1 hour to reach motor able road .As most of respondents mainly that dwells in mkuyeharo and bubusakusaye report before the introduction of the wind farm in their localities they travel more than three hours in foot and animal backs to reach motor able roads but now in relation to the introduction wind farm they can able to get public transport to their locality with short distance from their residence.

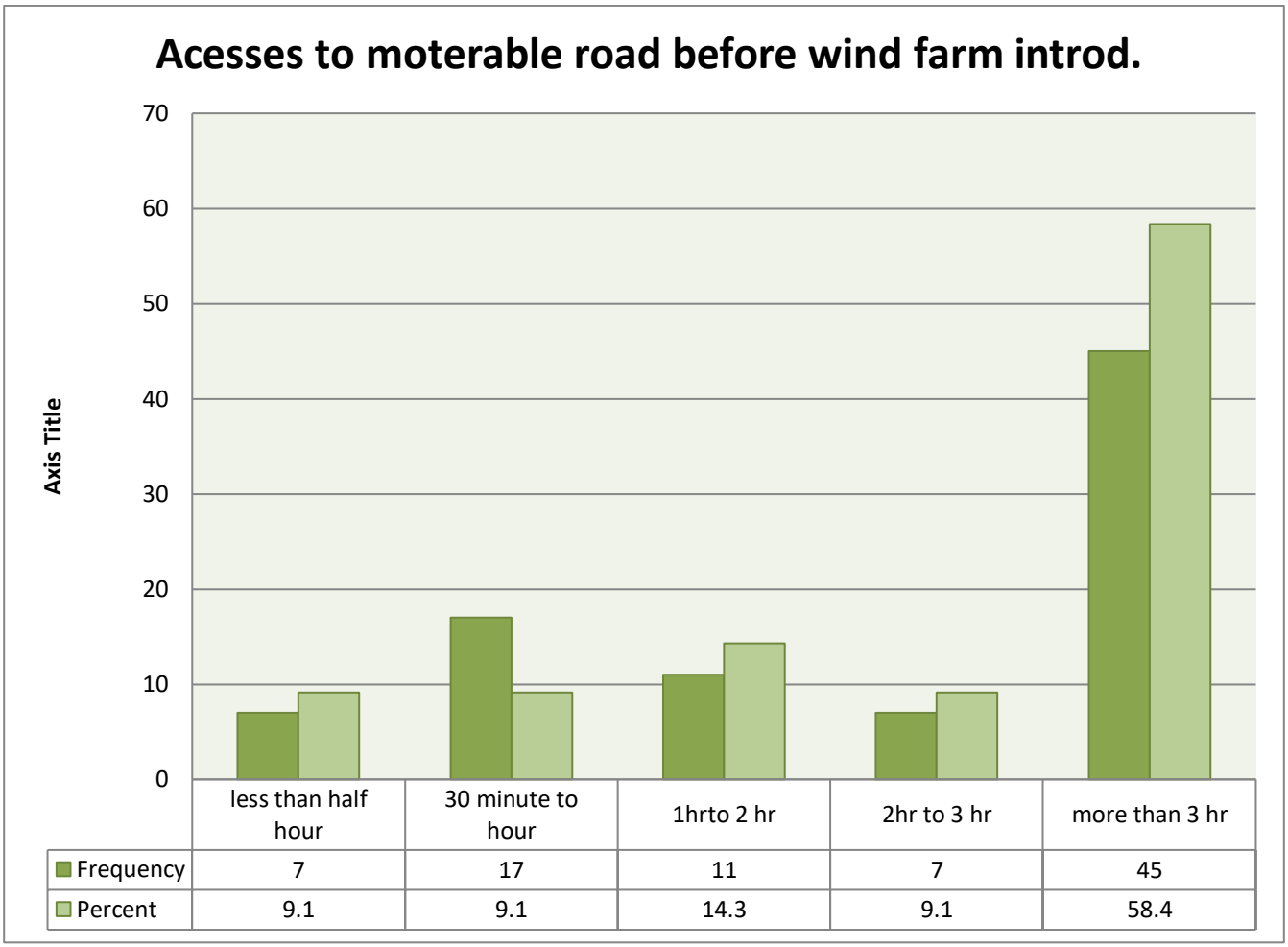



Fig.23 .Accessible to motor able road before the introduction of wind farm

**Source:** Field survey (2018).

**Table 16.Access to motor able road after the introduction of wind farm**

| | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| 30 minut | 68 | 88.3 | 88.3 | 88.3 |
| 30 -1hour | 9 | 11.7 | 11.7 | 100.0 |
| Total | 77 | 100.0 | 100.0 | |

**Sourc**e: Field survey (2018).

Out of 77 respond ants 68 (88.3%) report that after the introduction of wind farm in their locality they travel 30 minute or less to reach motor able road ,9 (11.7%) report that they travel 30 to 1 hour to reach motor able road after the introduction of wind farm in their localities and some respond ants report that during summer (dray) season we will get home to home public transport .In addition to become a means for the construction of road in their localities introduction of wind farm project brought change in their crop grown pattern for example most of the farmer lives in MokoyeHaro and BubusaKusaye grow onion only for their home consumption but now after the introduction of wind farm in their locality create conducive environment for road access and as a result most of the farmers start to grow onion for market rather than as they do earlier only for their own consumption.

Table. 17:- Water accessibility

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | River | 1 | 1.3 | 1.3 | 1.3 |
| | Unprotected spring | 2 | 2.6 | 2.6 | 3.9 |
| | Hand dug well | 6 | 7.8 | 7.8 | 11.7 |
| | Pond | 51 | 66.2 | 66.2 | 77.9 |
| | Water pipe | 7 | 9.1 | 9.1 | 87.0 |
| | Communal water point | 9 | 11.7 | 11.7 | 98.7 |
| | 6&8 | 1 | 1.3 | 1.3 | 100.0 |
| | Total | 77 | 100.0 | 100.0 | |

**Source:Field survey (2018).**

### 4.10. Accessibility of Potable Water

Accesses of potable water is one of the challenge of the local community. Out of 77 respondants 51 (66.2%) report that they get water from ponds .As pointed out by the peasant association chair persons and some local residents the water in the pond that accumulated during the winter season (rainy season) will dry up during the months of February and March unless the area get the rain of the Belge season therefore , during the year when there is scarcity of rain they will

suffer with shortage of water and they will travel more than three hours to fetch water .So that, the concerned local government body should seek immediate solution how the local community get permanent water supply.

### 4.11. Accesses to Electric light Service

Out of 77 respondents 71 (92.2%) report that they didn't get electric light,6 (7.8%) respond ant report they get electricity. But all respondents (6 house hold ) that report they get the electric service before the introduction of wind power generating project to their locality .In this regard UN secretary stated that Today, nearly one in every seven people lacks access to electricity (UN, 2018)**.**So that we can conclude that the local community directly do not benefited from the power production of the project .There for the government should look for the way that the local community benefited from the electric power .

**Table 18:- Accesses to electric light service**

| | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| **yes** | 6 | 7.8 | 7.8 | 7.8 |
| **no** | 71 | 92.2 | 92.2 | 100.0 |
| **Total** | 77 | 100.0 | 100.0 | |

**Source:** Field survey (2018).

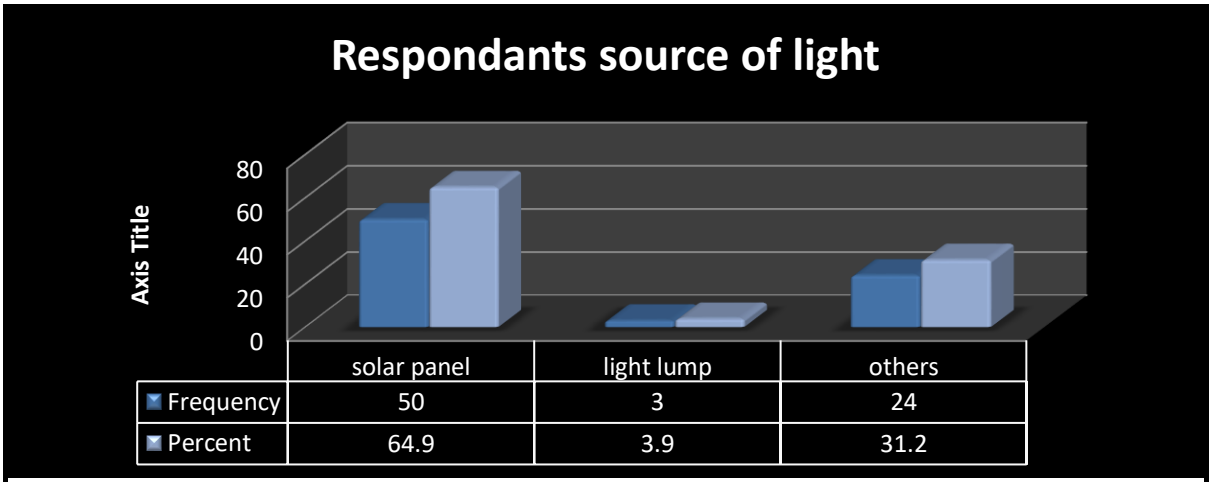



**Fig .24.**Respondents accessible to kind of source of light.

**Source**: Field survey (2018).

Out of 77 respond ants 50(64.9%) report that they used solar panel as the main source of light during night and they also used for charging their mobile phone in addition to this some respond ants used solar panel for lessening radio and tape but using for other electronics apparatus like television is unthinkable. In relation to this the health station of MikoyeHaro used a solar panel that can generate 4050 watt electric power.About 24 (31.2%) report that they used others like mainly kerosene which is dangerous for their health specially for their sight. Indoor air pollution kills some 4 million people a year, most of them are women and children inhaling toxic smoke (UN,2018). So that this problem seeks immediate solution from concerned stake holders .

Fig.25.Solar panel 4050 watt that used as source of power for MukoyeHaro health station

Source field survey (2018).

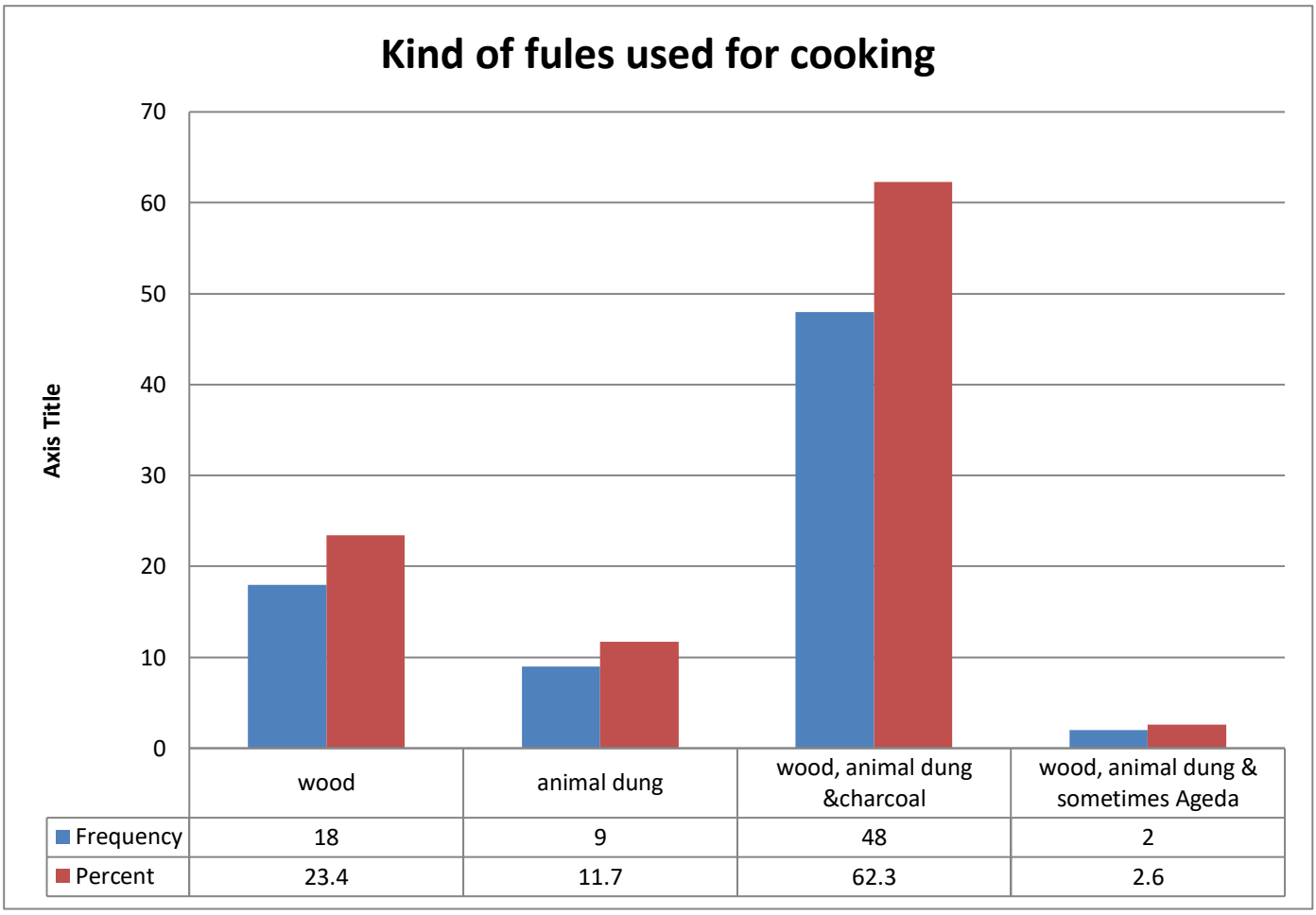



Fig 26. Kinds of fuels used by local community for cooking food

Source.Field survey (2018).

**4.12. Kinds of fuels used by local community for cooking food**

Among 77 respond ant in the wind farm area 18 (23.4%) used wood for cooking 9 (11.7%) used animal dung and 48 (62.3%) used wood ,animal dung and charcoal used for cooking 2 (2.6%) used animal dung and sometimes maize Ageda for cooking food .This indicate that the majority used agricultural by products like animal dung and crop waste like Ageda used for cooking that can be used as organic fertilizer for increment of agricultural productivity .More than 3 billion people rely on wood, charcoal, animal and crop waste or other solid fuels to cook their food and heat their homes.

That’s 40 per cent of all our people (UN, 2018)**.**In other word if the farmer have got an opportunity to use electric power or other alternative means of energy which don't generate greenhouse gases like solar energy for cooking and source of light subsequently bio products like animal dung crop residue can be used as soil fertilizers and conservation of natural resources like forest and a huge amount foreign currency that is used for buying chemical fertilizers can be saved and the farmer can harvest genuine organic products . In addition to this at least we can have a farming land that not adopt chemical fertilizers.

**Table. 19.** School health service

| | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| yes | 77 | 100.0 | 100.0 | 100.0 |

Source: Field survey (2018).

### 4.13. Social Service Like School and Health Service in Study Area

All 77 respond ant report that there are school and health service in there locality but all respond ant report that they get these social service (school and health service) before the introduction of wind farm in their localities. From this we can see that with the introduction of wind farm the local community don't get any social service more over most of the respond ant do not satisfy with the service delivered particularly with the education given for example the school that give education service to the children of the community couldn't get any electric service .In my field visit even solar panel with about 60 watt become out of use .So that the school children couldn't get audiovisual lesson. But relatively the health service is better there is one health officer four nurses including midwife there is also one laboratory technician and laboratory equipment according to the report of the health officer the major health problem to the local community is water born diseases .The health station used solar panel with the capacity of 4050 watt to power the health station .

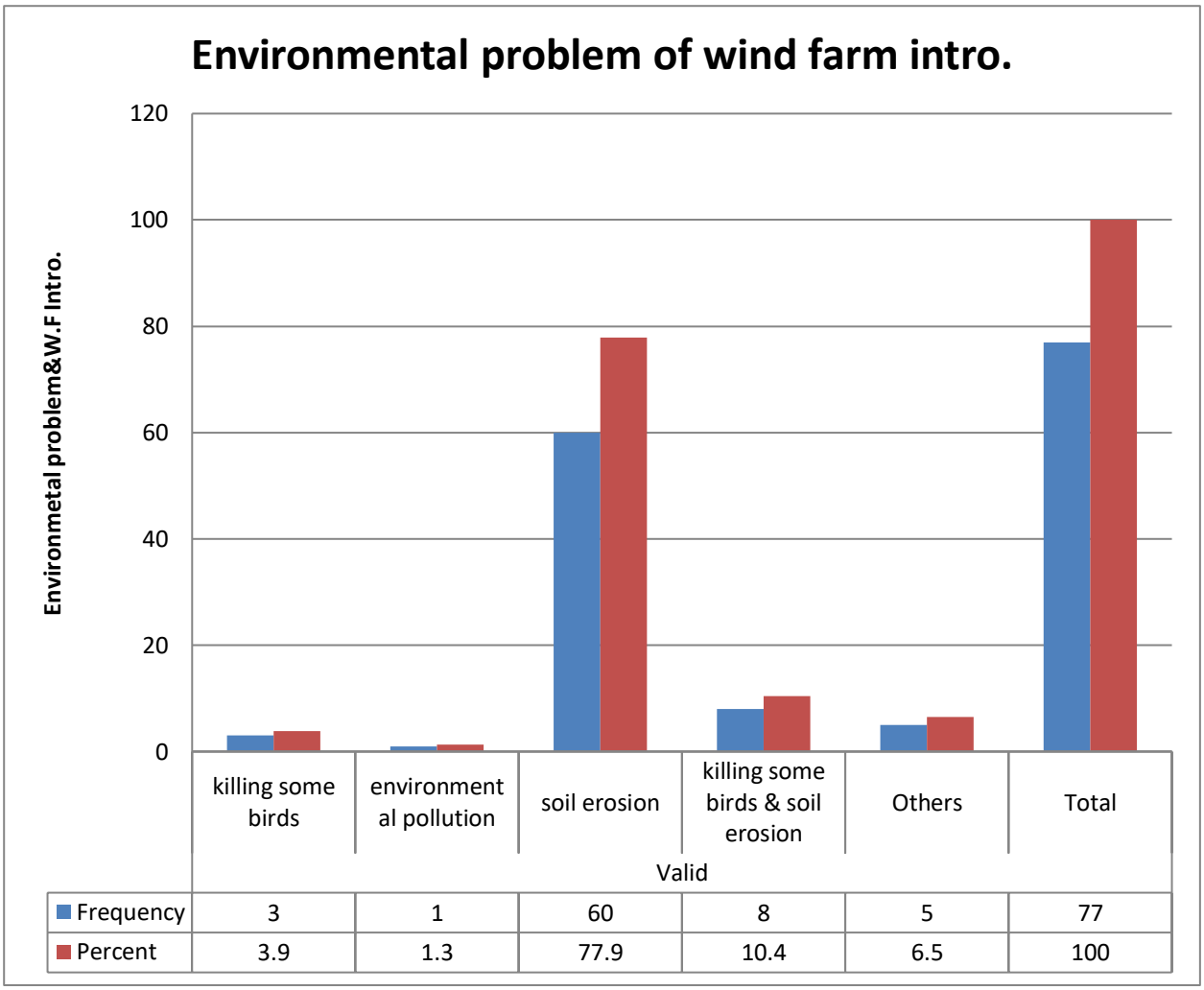



Fig .27. Environmental problem of wind farm introduction

Source: Field survey 2018.

### 4.14. Wind Farm Introduction and Environmental Problem

Among 77 respond ants 60 (77.9%) report that because of the introduction of wind farm their farming land is highly affect by soil erosion, 3(4%) killing some birds 8(10.4%) introduction of wind farm had an effect on the environment by killing birds and eroding soil. From this we can understand that the majority about 80% of respond ants had complaint about the introduction of wind farm in their area because it cause soil erosion in the area. At the beginning of the project with the purpose of installing the wind turbine and then for maintenance purpose the Chinese company construct road that can access to each turbine but the waterway do not properly done because of this during the rainy season the water divert to the farm land and highly erode the

farm. I also observe this during my field visit and I take a picture. According to one young farmer and his friends before the construction of the road the run of flow over the large surface of the earth it forms sheet erosion so that it couldn't cut the soil deeply until it make a gorge, but after the construction of the road the company make a channel for the run of and let it to flow to the farm land at this time the run of which once dispersed over a large area to form sheet erosion now get chance to collect in the narrow canal and get power and rushes down and cutting deep grooves into the land .The grove become deepened and widened and forms gully which finally cut up the land to form bad land as seen in the picture.

One KII the previous Adama II wind farm plant manager and other senior expert from head office (EEP) also agree with problem of the land erosion . The farmers continuously report the problem to the concerned body like Adama administrative bureau, Agricultural bureau ,soil and conservation office and AdamaII wind farm office but they don't get satisfactory response. One KII and his friends say that almost all The farmers including them are happy and benefited with the construction of road but what they complain is that the Chinese company do not make proper water way to the right and left of the road .As my observation and response of the respond ant before the introduction of the wind farm the run of crated by rain flow over large surface and make a sheet erosion but after the construction of the road it converted to gully erosion and formed bad land. Rough measurement is done for eroded land that seen in the picture it has length of 35 meter and width at the top is 5 meter and depth 3 meter as we go down the width and depth gradually decline and at the bottom the width become about 1 meter and the depth about 0.75 meter from this we can imagine some amount of metric soil will be washed away yearly .There for the concerned stake holder should take some corrective measures like long practiced soil conservation methods such as soil and stone bunds, tied ridges, check dams, grass strips before it become sever and out of control (Dereje, 2015) .


Fig 28.Land eroded in relation to the introduction of wind farm.


Fig. 29.The land that erode by diverted waterway

**Table 20.Economic Advantage of wind farm introduction to the local community.**

| | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| Increased employment | 4 | 5.2 | 5.2 | 5.2 |
| Introduction of roads | 62 | 80.5 | 80.5 | 85.7 |
| Increased employment & road building | 9 | 11.7 | 11.7 | 97.4 |
| Increase employ, road building, electric service | 2 | 2.6 | 2.6 | 100.0 |
| Total | 77 | 100.0 | 100.0 | |

**Source: Field survey (2018).**

According to response of the respond ant 62 (80.5%) say that the economic advantage they get in relation to introduction of wind farm give them a chance for access of road.9 (11.7%) says increase employment and road service .One KII and his friends also agree with this they say that the most important economic activity that we get along the Introduction of wind farm is access of road for example say one young farmer the local community grow onion at the back of his house garden (□□□□□□□) only for his consumption but after the introduction of wind farm there village is connected to Adama town with road as a result of this lorries like Isusu have got accesses to their farm land so that most of the farmer start to produce onion for market or as cash crops .

**Table.21 Wind farm introductions and its social impact to the community.**

| | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| Visual intrusion | 2 | 2.6 | 2.6 | 2.6 |
| Increase in noise level | 37 | 48.1 | 48.1 | 50.6 |
| Increase incidence of disease | 1 | 1.3 | 1.3 | 51.9 |
| Increase risk of accident | 3 | 3.9 | 3.9 | 55.8 |
| Disturbance to livestock | 5 | 6.5 | 6.5 | 62.3 |
| No effect | 19 | 24.7 | 24.7 | 87.0 |
| Others like flicker effect | 10 | 13.0 | 13.0 | 100.0 |
| Total | 77 | 100.0 | 100.0 | |

**Source: Field survey (2018).**

### 4.15. Wind Farm Introduction and Its Social Impact To Local Community

About 37(48.1%) of respond ant report that increase in noise level is the major social problem particularly those respond ant that their home is near to the turbine will mostly affected by the noise of the turbine during the night time but during the day time they adopt it and do not perceive it .In the study area there are social institution like churches, health station and schools for instance four churches one health station and one elementary schools are located within less than 400 meter radios to wind turbine in other word the wind turbine is located closer to some social institution like school, health station and churches below the standard distance ,19(24.7%) report that no effect and about 10(13%) report that the major social problem that they faced are flicker effect (effect caused shadow by wind turbine mostly during the sun rise and sun set).So that the noise created by the wind turbine should be taken into consideration by concerned body particularly by the Ethiopian Electric Power and action of measurement should be taken. As of KII from EEP senior expert and plant manager of Adama wind farm Concerning displacement of farmer partially there is displacement if their residential area is needed for installation of turbine ,33KV & 230KV tower and to make them safe from noise and shadow created by the turbine (shadow flicker) .In addition to this about 30 people that live near the entrance of Koka dam displaced and settled in other place after they get compensation because 230 KV tower pass over their residence .Farmer also get compensation for the land that they lost .Farmer lost their fertile land for founding or locating of 102 wind turbine,403 tower of 33KV and 43 tower of 230KV .The area are totally fertile farm land .Amount of compensation paid is more than 30 million birr.

Table 22. Family members that benefit economically with the introduction wind farm

| Frequency | | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| Yes | 18 | 23.4 | 23.4 | 23.4 |
| No | 59 | 76.6 | 76.6 | 100.0 |
| Total | 77 | 100.0 | 100.0 | |

**Source**: Field survey (2018).

About 59 (76.6%) respond ants report that there is no person that benefited economically from their family with the introduction of wind farm project in their locality and 18 (23.4%) report that in one way or another person from their family benefited economically with the introduction of wind farm in their locality. Although the introduction of wind energy project do not benefit local community as source of power it become a means to access of road transport and provision of public service moreover it job opportunity particularly during project and operation phase for the local people and migrant from other area . In relation to this KII said that "Concerning economic importance. Most of the local people engaged in employment during construction time as daily laborer and guard about 300 guard was employed as a guard for keeping the turbine for each turbine 2-3 guard employed. 60km gravel road constructed by the project and now community guard employed through safety-net program by EEP".

**4.16. Carbon Reduction Potential.**

The carbon footprint of fossil fuelled power plants is dominated by emissions during their operation. Indirect emissions during other life cycle phases such as raw material extraction and plant construction are relatively minor. Coal burning power systems have the largest carbon footprint of all the electricity generation systems analyzed here. Conventional coal combustion systems result in emissions of the order of >1,000 gCO2eq/kWh. Lower emissions can be achieved using newer gasification plants (<800gCO2eq/kWh), but this is still an emerging technology so is not as widespread as proven combustion technologies .The average carbon footprint of oil-fired electricity generation plants in the UK is ~650gCO2eq/kWh Parliamentary Office of Science and Technology((POST), 2006). Electricity generated from wind energy has one of the lowest carbon footprints. As with other low carbon technologies, nearly all the emissions occur during the manufacturing and construction phases, arising from the production of steel for the tower, concrete for the foundations and epoxy/fiberglass for the rotor blades .These account for 98% of the total life cycle CO2 emissions. Emissions generated during operation of wind turbines arise from routine maintenance inspection trips. This includes use of lubricants and transport. Onshore wind turbines are accessed by vehicle, while offshore turbines are maintained using boats and helicopters. The manufacturing process for both onshore and offshore wind plant is very similar, so life cycle assessment shows that there is little difference between the carbon footprint of onshore (4.64gCO2eq/kWh) versus offshore (5.25gCO2eq/kWh) wind generation ((POST), 2006) .

### 4.17. Comparative Analysis of Carbon Foot Print of Fossils fuel and wind

Practically for the last four years 1225655.6MW electric energy is produced at Adama II wind farm for the sake of comparison let us assume these 1225655.6 MWH electric energy is produced by conventional coal combustion ,oil fired and wind.

**Table 23 Comparative Analysis of Carbon Foot print for Fossil Fuel and Wind**

| Carbon foot print of conventional coal 1000 $gCO_2eq/kWh$ | Carbon foot print of oil fired 650 $gCO_2eq/kWh$ | Carbon foot print of wind 5.25 $gCO_2eq/kWh$ | Carbon foot print difference b/n coal and wind energy production | Carbon foot print difference b/n oil-fired and wind energy production |
|---|---|---|---|---|
| Amount of carbon that will be released or carbon footprint will be 1225658600 kg or 1225658.6 tone carbon | Amount of carbon that will be released or carbon footprint will be 766036625 kg or 766036.6 tons of carbon | Amount of carbon that will be released or carbon footprint will be 6434707 kg or 6434.7tons of carbon | 1000g-5.25g=944.75g 1157940.96 tons. | 650g-5.25g=644.75g 790243.38 tons. |

**Source :-((POST), 2006) .**

Adama wind farm Project achieves CO2 emission reduction by replacing electricity generated by fossil fuel fired power plant connected to the national grid. For example from the Adama wind II plant the government of Ethiopia produce 1225685.6 MWH or 1225.69 GWH from November 2015 up to July 2018 .If these amount of energy generated by conventional coal power plant 1157940.96 tons carbon will be released into the atmosphere and also if these amount of energy generated by oil-fired then 790243.38 tons will be released in to the atmosphere this will contribute its own part in aggravating climate change and global warming .So that energy produced by renewable energy like wind ,solar and hydro power plays a vital role in reduction of carbon emission to the atmosphere.

# CHAPTER FIVE

## 5. Conclusion and Recommendation

This study attempted to see the environmental and socio economic effect of wind farm. In addition to respondents report ,Key Informant Interview and land use land cover change of the study area 2000 &2016 used.

### 5.1. Conclusion

An attempt is done to evaluate the effect of wind farm project before and after the establishments of wind farm in the study area. The result show that there are positive and negative effect on the environment and socio economy of the study area .The positive effect are as the land use land change study and respondants and KII report show the wind farm plant contribution in altering the land use pattern particularly in shrub and forest clearing and sharing farm land is negligible except in aggravating soil erosion in some farm lands. It doesn't have any effect on the trend of livestock like ox, cow and donkey. The number of domestic animals also doesn't affect by the wind farm project .The study also shows that most of the residents .About 45(58.4%)respond ant report they travel more than 3 hours to reach motor able road and 7 (9.1%) report they travel 1 to 2 hours to reach motor able road only 7 (9.1%) travel less than half hour to reach motor able road before the introduction of wind farm in their localities. But after the introduction of wind farm about 68 (88.3%) respond ants travel 30 minute or less than 30 minute to reach motor able road because of this the majority of the residents particularly those who live far away from Adama city like mikoyeharo,Bubusakusaye and majority of Kechemo residence highly benefited with road introduce along wind farm project .Now the majority of the residence properly benefited with public transport service. The introduction of wind farm brought economic benefit for local peasants like help them to diversify crop grow like growing red onion as cash crop, create job opportunity for many residential as well as new comers during construction phase. During operation phase more than 250 local people benefited being employed as a guard through safety net program, payment of compensation for those farmers whose land used for purpose of wind farm despite there is complaint in relation to amount of compensation payment.

The standard distance between two consecutive wind turbine is kept by 76%. Relatively at Mojo Limuwereda and AdamaKechemo peasant association the wind turbine are closer to each other so that the standard distance between the two consecutive wind turbine do not kept .As the land use land cover change 2000 and 2016 remote sense imagery shows the contribution of wind farm plant for altering the land use pattern of the study area like clearing shrub land and forest is insignificant .Even if 80 present of Adama II wind farm turbines ,33KV and 230 KV tower ,wind turbine generator installed in farm land their effect on farming activity of the peasant is very minimal .Relatively the highest energy generated during 2009 than 2007,2008 &2010.The highest daily energy production is during the night than the day. From this we can conclude that at Adamazuria night time is windy than day time particularly at the time of 18 to 20 and 21to 23hrs Wind farm is environmental user-friendly and it contributes its own part in reducing the amount of carbon that will penetrate into the atmosphere .For example if we use carbon emitting conventional coal instead of wind for generating electric energy within 10 years about 3 million metric tons carbon will enter into the atmosphere, and if we use oil-fired for electric energy production about 2 million tons carbon will be released in to the atmosphere in 10 years so that we can conclude that generating electric power using renewable energy like wind plays vital role in making insignificant the amount of carbon that will be enter in to the atmosphere.

The negative effect . The major social problem seen in relation to establishment of wind farm in the local community is noise created by wind turbine and flicker effect (shadow caused by the wind turbine during sunrise and sunset) seen as minor problem .About half of the respondents land is used for wind farm project and they have got compensation but the majority or 98,5% respondents doesn't satisfy with the compensation that they obtain so that Ethiopian Electric Power Authority must take this into consideration and should take corrective measure. Wood and animal dung and charcoal is used as fuel for cooking food. Majority of the local community do not get electricity out of the 77 respond ant only 6(7.8%) get electric service .All respond ant that get electricity live nearby Adama city. Those who are far away from the city never get electric service. About 50 (65%) used solar panel as source of light and 23 (30%) uses others like kerosene lumps as a source of light **.**Out of 77 respond ants 51(66.2%) report that they get water from ponds and 22(28.6%) respond ants report they get water from water pipe, communal water point and hand dug well. Almost all residence get water from ponds the water is not safe for health.

As reported by health officer of MikoyeHaro health station waterborne disease is the major problem for the local community. About 60 (70.9%) respond ant report that their farm is affected by erosion .The other finding is on the environmental impact in which farm lands were eroded in connection with improper water drainage built by the wind farm project.Consultative meeting doesn't take place with the local community before the introduction of wind farm in the study area .

## 5.2. Recommendation

- Climate change increasing at alarming rate all over the world so that the government of Ethiopia should intensify to use renewable resource as a source of power.
- To keep the minimum distance (the standard distance ) between two consecutive wind turbine plays vital role for efficient and effective wind power production so that the concerned body particularly Ethiopian Electric Power should take these into consideration during planning and realization of wind farm project.
- Side by side with the introduction of mega project like Adama wind farm II it should be mandatory to provide or at least improving the existing social service like schooling, health service, providing sufficient potable water for the local community.
- One of the major problem of the wind farm is its effect of erosion on their farm land in relation to improper water way of the road. So that the concerned body particularly Ethiopian Electric power ,Agriculture burro and Natural Resource Conservation office should apply long practiced soil conservation methods such as soil and stone bunds, tied ridges, check dams, grass strips.
- one of the major social problem is noise created and flicker effect by the wind turbine so that Ethiopian Electric Power should take some corrective measures on wind turbine installed near to social institution like churches schools, health station and near residential areas .

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**Questioner for Adama wind II impact assessment**

**Questionnaires filled by farmers**

Dear respondents,

This questionnaire is designed to obtain or gather data to develop a thesis for academic purpose and so, that are intended to investigate the farmers perception about the impact of Adama wind farm II on socio economic and environment impact on Adamawereda (where wind farm located). The success of this academic research depends on your honest answer and, thus you are kindly requested to respond clearly and genuinely. You do not need write your name and you may not respond if you are not comfortable with the questionnaires.

**Thank you in advance!**

**Socio economic and demographic profile of HH heads**

**A.Demographic profile**

1Age of the household head _____

2. Sex of the household head

1. Male _____ 2. Female _____total--------

3. Size of the Family, 1, under 15 years old _____

2, 16 to 35 years____, 3, 36 to 64 ------4, 65+ Years----

2. Marital status

1. Married 2. Single 3.Widowed 4.Divorced

3. Separated

4. Family size_____

**Livelihoods of the households**

6. Monthly income _____

7. How much money you earn per-year (approximately?) ----------

1. Enough 2. More than enough 3.Not enough

8. What are the main sources of income for the house hold?

1. Crop production 2. Cattle rearing 3.petty trade

4. Weaving 5. Daily laborer 6.Others specify _____

9,Do you have livestock? 1,yes 2,no If you answer yes,

10 What is the trend of livestock population in the area in relation to the construction of wind farm ?

1. Decreasing 2. The same 3.Increasing 4. I do not know

11,Do you have your own land? 1, Yes 2,no------- If your answer is yes, how many hectares do you have before the wind farm introduction?

1 < 0.5 ha 2. 0.5 Ha 3. 1 ha 4. 1.5 ha 5. 2.0 ha 6. >2 ha

12,How many hectors do you have after the wind farm introduce in your locality?

1 < 0.5 ha 2. 0.5 ha 3. 1 ha 4. 1.5 ha 5. 2.0 ha 6. >2 ha

13,. How did you get the land you have currently? (More than one choice is possible)

1. through renting 2. Through share cropping

3,Inherited from parent 4. Allocated by Kebele

14,How do you perceive the fertility of your farm land before the introduction of wind farm?

1. Improving 1. Constant 3.Declining 4. Do not know

15,How do you perceive the fertility of your farm land after the introduction of wind farm in your locality ?

1. Improving 1. Constant 3.Declining 4. Do not know

16,Did you have get compensation for the land that used for the wind farm? 1,yes 2,no if your answer for question no 16 is yes

17,Do you think the compensation is ? 1,enough 2,more than enough 3, not enough----

18 ,Is there special benefit you get from the introduction of wind farm in your locality? 1,Yes

2, no if your answer is yes what are these?----------

19,Are you vulnerable to climate change related problems? 1. Yes 2. No

If you say yes, which of the following affects your life please? put in order of severity?

1. Drought _____ 6. Shortage of animal "feed_____

2. Food inadequacy _____ 7. Poor grazing land ----------

3. Flood _____ 8. Malnutrition

4. Price fluctuations for agricultural products _____9. Migration_____

5. Shortage of water supply_____

10. Poor health_____

11 .Others, specify _____

20, Do you think vulnerability to climate change aggravated with The introduction of wind farm to your locality ? 1yes 2,no---------

If your answer is yes in what way ?----------

21, Is there consultative meeting with the local community before the introduction of wind farm? 1,Yes 2,no if your answer is yes do you participate in the consultative meeting

1, yes 2,no if your answer for the above question is yes how do you participate?----------

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22, Do the household get sufficient water for the whole years?

1. Yes------2,no----------

23. from where the house hold get water?

1. River 2. Unprotected spring 3.Protected spring 4. Hand dug well 5. Pond

6. Open wells 7. Others,

Specifying _____

24, the walking distance to water source is _____hr?

25, how long would you travel to reach motor able road before the introduction of wind farm?

---

1, less than half hour 2, 30 minute to 1 hour

3,1hr to 2 hr 4,2hr to 3 hr 5 more than 3 hr

26, how long do you travel to reach motor able road after the introduction of wind farm?

1, less than half hour 2,30 minute to 60 minute

3,1hr to 2 hr 4,2hr to 3 hr 5 more than 3 hr

27. Do you have access to mobile telephone?

1. Yes 2. No

28. Did you get electric lightning service ?

1,Yes 2,no--- if your answer is yes when did you get the electric service

1, before the introduction of wind farm ,

2 after the introduction of wind farm

If your answer for question no 27 is not what are the source

of power for your home?

1, solar panel 2, light lump 3, others like kerosene lump

29, what types of energy do you used commonly as a fuel at home?

1,wood 2,charcol

3, wood, animal dung &charcoal 4 wood, animal dung & sometimes Ageda

30, is there school service in your locality for your children?

1, Yes 2, no if your answer is yes

31, when the school starts to give service?

1, before the introduction of wind farm in your locality

2, after the introduction of wind farm in your locality

32, Is there health service in your locality?

1, Yes 2,no .If your answer is yes when the service start

1, Before the introduction of wind farm

2,After the introduction of the wind farm

33,As of your perception the introduction of wind farm does

have some environmental problem in your locality?

1. like killing some birds 2.displacement of some wild animals

3.environmental pollution 4. Disturbance of flora and fauna

5. Soil erosion 6. 1,2&3 7.4&5

34, What happen to the no of wild animals with the introduction of wind farm?

1, Increase 2, decline 3, no significant change observed with the introduction of wind farm

35, what are economic importance in relation to the introduction of wind farm in your locality?

1. electric service 2. contribution to the government revenue

3. increased employment 4. introduction of roads

5.1&4 6.1,3&4

36, What are social impacts in relation to introduction of wind farm?

1.visual intrusion 2. Increase in noise levels

3.Increased incidence of diseases, 4. Increased risk of accidents

5. Disturbance to livestock 6.no effect 7.others

37. Is there a person from your family that benefit economically with the introduction of wind farm in your locality?

1. Yes 2. No

38. If your answer for question no 37 is yes in what way

1. Employed in the wind farm

2. Selling some goods and items for workers that engaged in wind farm

5. Providing transport service that work in the wind farm

6. During the project construction time rent houses

5. As daily laborer during project construction time

6. Employed as a guard 7 others specify ----------

Thank you !

**Checklist for Key Informant Interview**

For experts from Ethiopian Electric power authority(head office ) and Adama wind farm II plant manager and project manager

**Dear respondents;**

My name is GetachewTafesse. I am a postgraduate student at Addis Ababa University colleague of social sciences, department of geography and environmental studies in a stream of climate change and adaptation. Currently, I am writing my thesis entitled ENVIRONMENTAL AND SOCIOECONOMIC EFFECTS OF WIND ENERGY PRODUCTION THE CASE OF ADAMA II WIND FARM.

You have been selected purposely from different experts as a respond ant . The responses you give are valuable and will be held in utmost confidentiality and will be used only for the analysis of this research. You are honestly requested to respond to any of the following questions.

Thank you in advance for your cooperation!!

1. Name _____

2. Position/profession _____

3. In your view, do you think introduction of wind farm in

Adama have environmental and socio economic impact? If yes, please tell me the impact----------

---

4,Does the establishment of Adama wind farm had an effect on the land use pattern (forest, farmland, shrub land, water body, bare land settlement ) in the study area?

4, Is there any economic importance that the local community gain with the introduction of wind farm ?.....

5,Is there any person or community displaced from their locality in relation to establishment of wind farm? if your answer is yes

How many ?

6, Does your organization paid compensation for those farmers that their land used for wind farm? if your answer is yes do you think the compensation is sufficient?----------How many people have got compensation ?----------

7,Does consultative meeting was carried out with the local community before the introduction of wind farm .If your answer

Is yes please tell me the step that carried out..... If the answer is not why?.....

# Appendix

| Daily energy production for winter season | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | June | | | July | | | August | | | September | | | |
| | DY1 | DY2 | DY3 | DY1 | DY2 | DY3 | DY1 | DY2 | DY3 | DY1 | DY2 | Sum | Mean |
| 0-2 | 1.9 | 371.6 | 277.1 | 241.04 | 472.54 | 702.83 | 342.7 | 420.78 | 0 | 42 | 0 | 2872.49 | 261.13 |
| 3-05 | 0 | 262.14 | 229 | 276.4 | 510.7 | 282.5 | 348.54 | 424.65 | 0 | 227.8 | 0 | 2561.73 | 232.88 |
| 6-08 | 19.7 | 194.8 | 246.03 | 355.5 | 473.36 | 508.4 | 496.1 | 351.1 | 0 | 288.43 | 85 | 3018.42 | 274.4 |
| 9-11 | 17.8 | 182 | 373.76 | 290.93 | 382.2 | 446.94 | 408 | 204.29 | 0 | 157.61 | 617.6 | 3081.13 | 280.1 |
| 12-14 | 246.83 | 369.3 | 110.1 | 117.68 | 228.39 | 191.59 | 267.02 | 9.86 | 61.8 | 47 | 112.6 | 1762.17 | 160.2 |
| 15-17 | 519.8 | 38.9 | 124.65 | 29.8 | 39.81 | 65.1 | 21.12 | 0 | 0 | 207.39 | 32 | 1078.57 | 98 |
| 18-20 | 422.73 | 8.64 | 226.23 | 10.4 | 250.92 | 170.38 | 1.94 | 11.69 | 0 | 190.75 | 322.63 | 1616.31 | 146.9 |
| 21-23 | 229 | 212.04 | 341.95 | 154.5 | 590.55 | 544.24 | 323.24 | 172.13 | 1.43 | 139.93 | 327 | 3036.01 | 276 |
| | | | | | | | | | | | | | |
| Daily energy production for Bega season | | | | | | | | | | | | | |
| | October | | | November | | | December | | | January | | | |
| | DY1 | DY2 | DY3 | DY1 | DY2 | DY3 | DY1 | DY2 | DY3 | DY1 | DY2 | Sum | Mean |
| 0-2 | 736 | 1035.4 | | 218.87 | 558.88 | 1010.75 | 799 | 1015.73 | 347.4 | 331.8 | 996 | 7049.83 | 640.89 |
| 3-05 | 592.8 | 695.84 | 687.9 | 44.2 | 585.6 | 585.6 | 1035.9 | 1313.9 | 70.7 | 292.2 | 920.3 | 6824.94 | 620.45 |
| 6-08 | 229.2 | 504.34 | 687.9 | 57.3 | 490 | 502.4 | 954.51 | 1188.1 | 1 | 330.54 | 613.5 | 5558.79 | 505.34 |
| 9-11 | 1146.3 | 569.63 | 860.1 | 45.7 | 519.37 | 519.34 | 1089.86 | 1242.74 | 56.3 | 435.1 | 806 | 7290.44 | 662.77 |
| 12-14 | 895 | 715.07 | 967.74 | 335.8 | 493.68 | 836.03 | 643.68 | 1093.87 | 96.7 | 355.6 | 716.72 | 7149.89 | 649.99 |
| 15-17 | 731.6 | 809.6 | 802.54 | 493.98 | 584.58 | 1052.25 | 796.69 | 813.7 | 400.4 | 549.5 | 858 | 7892.84 | 717.53 |
| 18-20 | 692 | 747.66 | 1007.1 | 1187.7 | 792.1 | 1115.74 | 1086.7 | 1105.3 | 703.4 | 1051.6 | 1157.9 | 10647.2 | 967.93 |
| 21-23 | 623.4 | 786.5 | 887.7 | 558.33 | 768.2 | 1251.14 | 1161.9 | 1362.97 | 999.1 | 776 | 1045.88 | 10221.1 | 929.19 |
| | | | | | | | | | | | | | |

Daily energy production for the belge season and The sum of all seasons

| | February | | | | | March | | | | April | | | May | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DY1 | DY2 | DY3 | DY4 | DY5 | DY1 | DY2 | DY3 | DY4 | DY5 | DY1 | DY2 | DY1 | DY2 | Sum | Mean | Year sum | Mean |
| 0-2 | 664.5 | 1179.2 | 577.18 | 132.7 | 664.5 | 394.9 | 86.2 | 411.8 | 320.5 | 320.5 | 538.8 | 418.8 | 311 | 3.1 | 6023.68 | 430.26 | 15946 | 442.94 |
| 3-05 | 544.3 | 1058.4 | 459.3 | 125.6 | 544.3 | 403.7 | 71 | 416.4 | 189.9 | 189.9 | 420.89 | 169.4 | 137.2 | 0 | 4730.29 | 337.88 | 14117 | 392.14 |
| 6-08 | 415.24 | 1022.9 | 338.3 | 100.7 | 415.24 | 394.45 | 261.8 | 191.74 | 32.5 | 32.5 | 102.12 | 98.2 | 0 | 0 | 3405.69 | 243.26 | 11983 | 332.86 |
| 9-11 | 816.03 | 977.9 | 102.13 | 75.5 | 816.03 | 365.29 | 252.7 | 268.14 | 58.07 | 58.07 | 113.35 | 13.5 | 7.8 | 0 | 3924.51 | 280.32 | 14296 | 397.11 |
| 12-14 | 1203.6 | 486.5 | 18.04 | 26.8 | 1203.6 | 362.64 | 167.89 | 256.34 | 63.1 | 63.1 | 146 | 200 | 332.3 | 0 | 4529.91 | 323.57 | 13442 | 373.39 |
| 15-17 | 1452.8 | 604.4 | 520 | 31.9 | 1452.8 | 344.4 | 370.94 | | 357.5 | 357.5 | 382.8 | 606.6 | 37.8 | 363.8 | 6883.24 | 491.66 | 15855 | 440.41 |
| 18-20 | 1496.83 | 1307.5 | 924.33 | 65.05 | 1496.83 | 406.55 | 218.9 | | 454.55 | 454.55 | 579.4 | 712.25 | 47.4 | 571.5 | 8735.64 | 623.97 | 20999 | 583.31 |
| 21-23 | 1366.48 | 1359.49 | 999 | 96.45 | 1366.48 | 411.2 | 211.2 | 274.9 | 411.4 | 411.4 | 589.75 | 545.3 | 52.5 | 319.8 | 8415.35 | 601.1 | 21672 | 602.01 |