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GIS-based analysis of renewable fuel production from biomass energy in Algeria

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Abstract

The world coming to an end, what’s popular is not what is important , the oil prices are getting cheaper and a lot of greenhouse effecting the world and our country in particular we have no choice than taking the lead and going for the renewable energies ,one of them is biomass which is capable of covering a significant part of the energy consumption of a country like Algeria in a sustainable way. In our work, we carried out an estimation of the potential of biomass and selecting the suitable sites to produce bio-fuel by using multi-criteria decision analysis and geographic information system in Algeria.

Keywords: Renewable energy; Biomass; MCDA; GIS; best site selection; Algeria.

Résumé

Le monde touche à sa fin, ce qui est populaire, ce n’est pas l’important, les prix du pétrole sont en train de baisser et beaucoup de gaz à effet de serre affectent le monde et notre pays en particulier, nous n’avons pas d’autre choix que de prendre les devants et de passer aux énergies renouvelables. Parmi eux, la biomasse est capable de couvrir de manière durable une part importante de la consommation d'énergie d'un pays comme l'Algérie. Dans notre travail, nous avons effectué une estimation du potentiel de la biomasse et sélectionné les sites appropriés pour la production de biocarburant en utilisant une analyse de décision multicritère et un système d’information géographique en Algérie.

Mots clés: Énergie renouvelable; biomasse; MCDA; GIS ; sélection les meilleurs sites ; Algérie

ملخص

إن العالم يقترب من نهايته ، وما هو شائع ، ليس بالضرورة إنه مهم ، وأسعار النفط آخذة في الانخفاض ، والعديد من غازات الدفيئة تؤثر على العالم والبلد بشكل خاص. لا خيار أمامنا سوى خيار أخذ زمام المبادرة في الطاقات المتجددة والكتلة الحيوية هي واحدة من تلك الطاقات التي يمكن أن تغطي جزء كبير من استهلاك الطاقة في بلد مثل الجزائر استدامة. في عملنا ، قمنا بإجراء تقدير لإمكانات الكتلة الحيوية واختيار المواقع المناسبة لإنتاج الوقود الحيوي باستخدام تحليل القرار متعدد المعايير ونظام المعلومات الجغرافية في الجزائر.

الكلمات المفتاحية: الطاقة المتجددة، الكتلة الحيوية، نظم المعلومات الجغرافية، دليل القرار متعدد المعايير،تحديد افضل موقع،الجزائر.

Summary

Chapter III: Multi-criteria analysis based on geographic information system

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Abbreviation List

Abbreviation	Definition
OPEC	The Organization of the Petroleum Exporting Countries
LPG	Liquefied Petroleum Gas
Mtoe	Million tons oi lequivalent
LNG	Liquefied natural gas
CSP	Concentrated Solar power Plant
PV	Photovoltaic
UNFCCC	United Nations Framework Convention on Climate Change
NREP	National Renewable energies program
IEA	International Energy Agency
EU	European Union
MSW	Municipal solid waste
UFO	Using fryin goil
FBD	Full biomass demand
IBD	The incremental biomass demand
GIS	geographic information system
MCDA	Multiple Criteria Decision Analysis
MSW	Municipal solid waste
MTBE	Methyl tertiary butyl ether
PROGDEM	The National Program for Integrated Management of Household Waste
ONS	National Organization of statistics

General introduction

The world population project by world data lab has shown that the world contain + 7 billion of person and it increase every single moment , more people means more consumption of energies , but let see our realities, we're living in a world who use fossil energies which produce a lot of greenhouse gases ,pollution moreover they are limited . According to the International Energy Agency, the world CO_2 emissions from fuel combustion rose 108% from 1973 to 2015 . In 2014, by economic sector, the transportation accounts for a significant share of the global fossil fuel combustion-related CO_2 emissions, which is responsible for over 23%. Almost all (95%) of the world's transportation energy comes from petroleum-based fuels, largely gasoline and diesel which was shown in the IEA.

We can notice also that we have different resources so how can the countries meet their needs based on their resources . The solution is having a technical production marriage between the renewable energies and the fossil ones . In our Study we will be trying to get the possibilities of applying the biomass energy in Algeria and having a clear idea about the favourable sites

The development of biomass can be considered as one of the best solutions to the implementation of renewable energies in Algeria.

The rich atmosphere we have in Algeria make the use of biomass as type of energy production very possible.

Our main objective is to give the potential of biomass in Algeria and the possibilities of produce bio fuel, this evaluation will be based on the GIS system to geographically locate the accumulated biomass.

So we determine the potential energy generated by biomass. The present work has three main parts:

- A bibliographic overview: about the energy reality of Algeria   where will take a look about the production , consumption and some other energy realities in Algeria .

-An overview: prospects of bio-energy production potential from biomass in Algeria by seeing the current technologies of biomass conversion the waste production , our Algerian possibilities and biomass potential .

-A study of the biomass potential in Algeria using GIS-MCDA in order to obtain the favourable sites. Electer I is one of MCDA methods which was used this study to obtain the suitable sites in Algeria.

And finally we finish our work by conclusion and some perspectives .

Chapter I

Litterateur review

1.1 Introduction:

The distribution of energy resources affect directly the energy trade all over the world, the other important major in trade is the domestic levels. Because if one of the countries has rich resources and high consumption this means that the country has no energy to save, however you may find a country with a small quantity of energies with a small consumption which made her succeed in the energy part. All these factors plus other control the world energy consumption and production. In this chapter we will be taking a look on our current energies and the possibilities of the renewable energies in Algeria.

1.2 Energy context

Conventional primary energies include oil, coal and natural gas. These are available energies, easy to transport, store and use. Their mastery has allowed industrial and economic development. But the uneven distribution of resources on the surface of the Earth, the fluctuation of the costs and their foreseeable exhaustion pose the question of their preservation today [1].

1.2. Energy production

Commercial production of primary energy registered a virtual stability (-0.2%) compared to 2016 achievements, reaching 165.9 M toe. Thus, the increase in natural gas production partially offset the decline in production of liquids (petroleum and LPG) due in particular to the application of the agreement reduction of OPEC production[2]. It should be noted that the doubling of primary electricity production (including of 336 to 63 GWh in 2017, following the completion of new renewable electricity generation capacity.

Thus, the year 2017 saw the entry into production of 5 photovoltaic power plants, a combined capacity of nearly 125 MW; which brought the original production share solar and wind in the total production of primary electricity to more than 90%. In contrast, hydropower production decreased (-22%) to 56 GWh, given the low rainfall, reducing its share to less than 10% of primary electricity.[1]

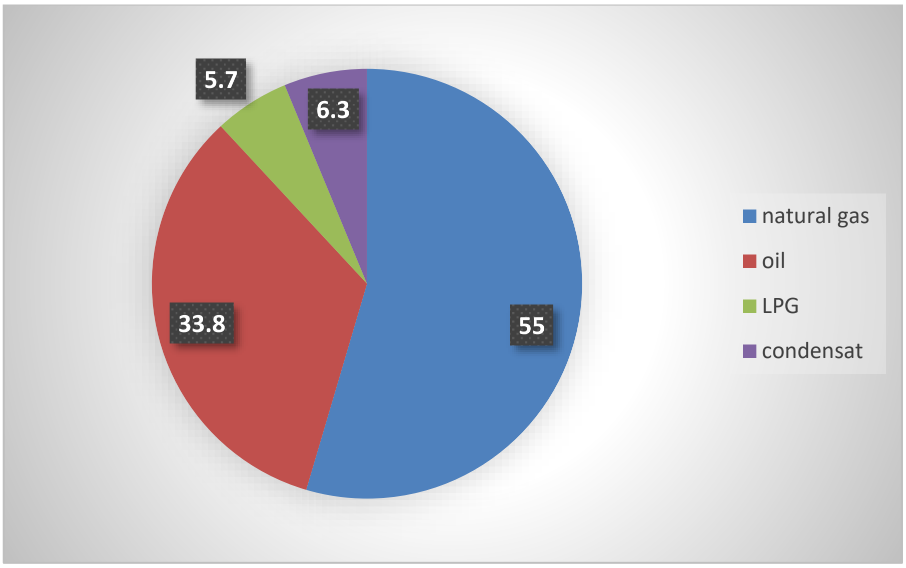


Figure I.1: Primary energy production

As overall production for the year 2017 is close 166.18 Mtoe. The distribution of primary energy production as follows:

- Natural Gas: with a 55% production.
- Oil: with a production of 33.8%
- LPG in the fields: 5.7 %
- Condensate: 6.3 %

Secondary energy production reached 64.2 Mtoe, up 1.8% from 2016 achievements, following the increase (+ 6.0%) in natural gas production liquefied natural gas (LNG), thermal electricity (5.2%) and LPG (5.3%). This increase has more than offset the decline in production of petroleum products (-2.7%) [2].

1.3. Energy consumption

National energy consumption (including losses) reached 59.6 Mtoe in 2017, reflecting an increase of 2.1% compared to 2016, driven mainly by final consumption (+ 4.1%). Conversely, non-energy consumption and energy industries have respective declines of (-19.5%) and (-5.1%)[2]. Final consumption increased from 42.9 Mtoe in 2016 to 44.6 Mtoe in 2017, reflecting 1.8 million toe (+ 4.1%), driven by natural gas, electricity and LPGs more than offset the decline in petroleum products[3].

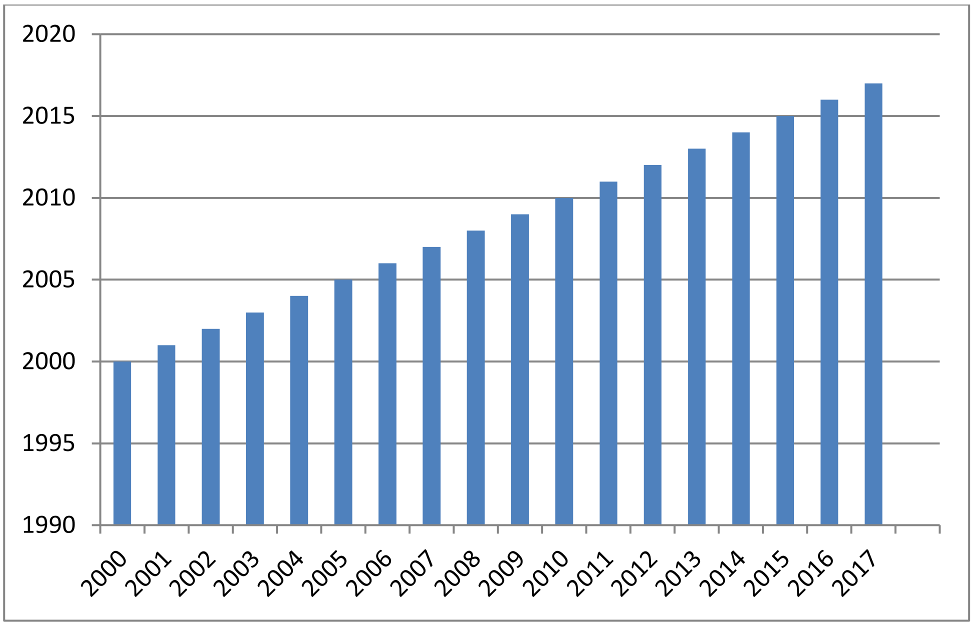


Figure I.2: Final energy consumption

Figure I.2 shows that Algeria's final energy consumption increases in the years 2000-2017. The final energy consumption by sector of activity is presented by 3 sectors in Algeria, it is industry and construction, transport, households and others.

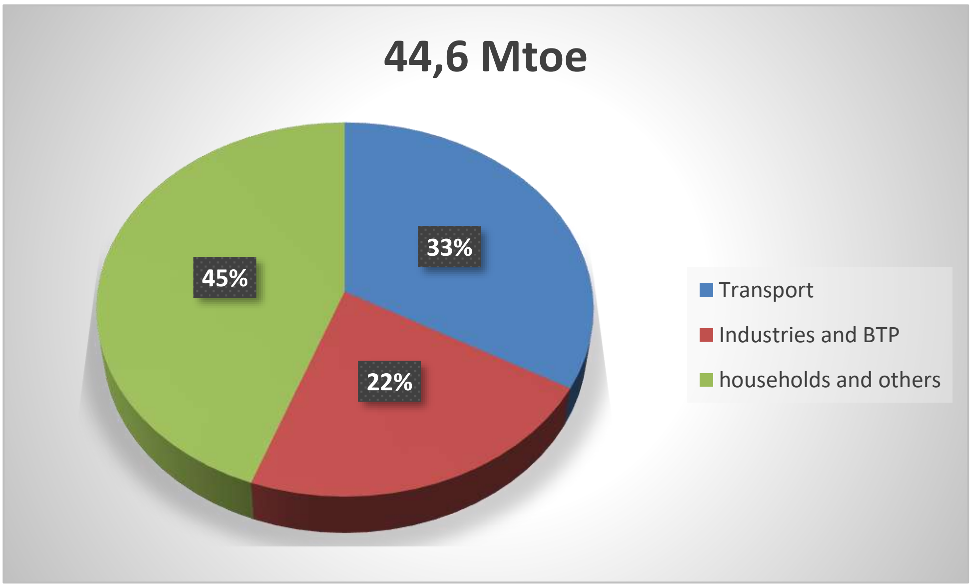


Figure I.3: Final energy consumption 2017 [2]

The figure I.3 illustrates that the sector of residential consumes the most final energy which is about 45%, then the transport with value of33% and finally the industry with 22%.

1.4. Renewable energies

Algeria is considered as top 10 of counties of OPEC which explains the strategy implemented now by using fossil energies, however we can't ignore its emissions and how polluted they are . Since these fossil energies are limited ,this what can push us to think more about the green energies which are familiar to earth , those what we called the renewable energies.

1.4.1. Solar energy

Algeria first introduced solar energy, in 1988, into the Southern project. Algeria started preparing larger cities, like Skikda and Oran, with the adequate equipment to improve the potential of solar energy as all. Solar energy can be generated either through the installation of CSP (Concentrated Solar power Plant) system, or the PV (Photovoltaic) system.

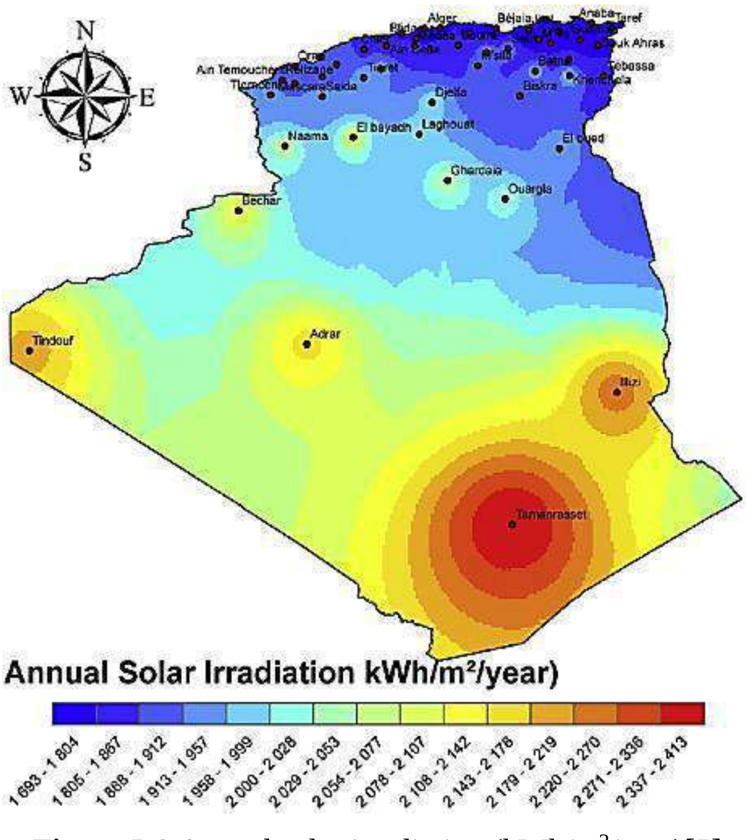


Figure I.4: Annual solar irradiation (kWh/m^2/year)[5]

View of its geographical location, Algeria has one of the most raised in the world. The duration of insulations on almost the entire national territory exceeds 2000 hours annually and can reach 3900 hours (highlands and Sahara). The energy received annually on a horizontal surface of 1m² is close to 3 kWh/m² at north and exceeds 5.6 kWh/m in the South TAMENRASSET) [4].

1.4.2. Wind power

Usually ranges from a topographic area to another, also it depends on the climate too. Algeria's climate ranges greatly between the northern and the southern halves of Algeria. Northern half, is unique because it acquires an ideal location on the Mediterranean, it has the Atlas mountains and other high plains. But the northern winds aren't as strong as the southern ones. The southern winds speeds range from 4m/s - 6m/s, but most southern lands are lower in latitude than the northern region, whereas desert represents more the 70% of the total Algerian surface area. Adrar is considered to be the most suitable place as it's famous for operating, and providing strong winds. Having strong winds around a high hill or ridge can provide a good power plant.

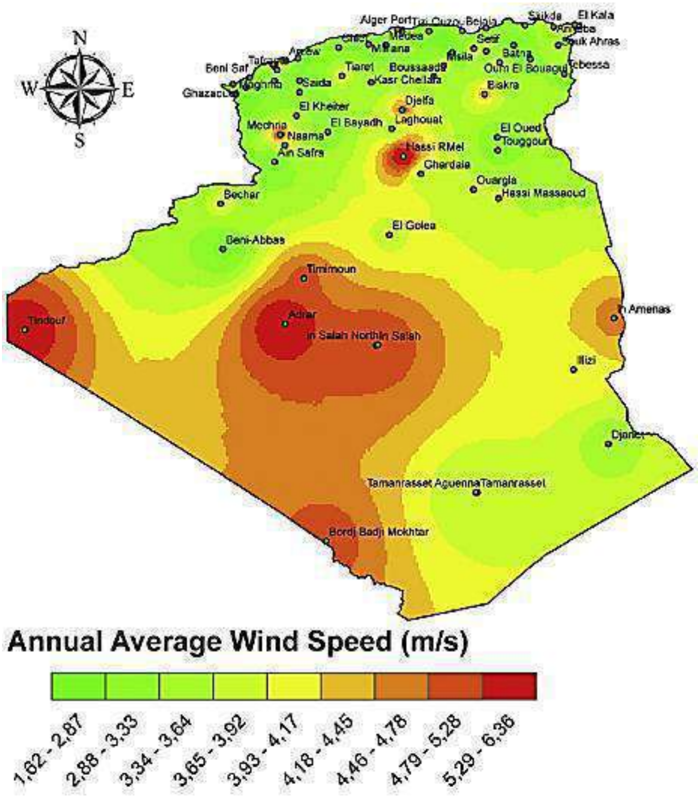


Figure I.5: Annual Average wind speed (m/s) [5]

Mainly due to a very diverse topography and climate. Indeed, our vast country, subdivides into two major geographical areas. The northern Mediterranean is characterized by a coastline of 1200 km and a mountainous terrain, represented by the two chains of the

Tellien Atlas and the Saharan Atlas. Between them are interspersed plains and highlands of continental climate. The South, meanwhile, is characterized by a Saharan climate.

The map shown below shows that the South is characterized by higher speeds North, particularly in the Southeast, with speeds above 7 m/s and exceeding the value of 8 m/s in the Tamanrasset region (In Amguel). Regarding the North, it is generally noted that the average speed is low. However, the existence of microclimates on the coastal sites of Oran, Bejaïa and Annaba, on the highlands of Tebessa, Biskra, M'sila and Elbayadh (6 to 7 m/s), and the Great South (> 8 m/s)[4].

1.4.3. Geothermal

The compilation of the geological, geochemical and geophysical data contributed to layout a preliminary geothermal chart. More than two hundred (200) hot springs have been recorded in the Northern part of the country [7]. Approximately a third of these hot spring (33%) show temperatures exceeding 45° C. High temperature springs exist in Biskra region reaching 118°C. These natural outflows which are generally leakages from existing reservoirs have a flow of more than 2m3/sof hot water. This represents only a very small part of the production possibilities of the reservoirs.

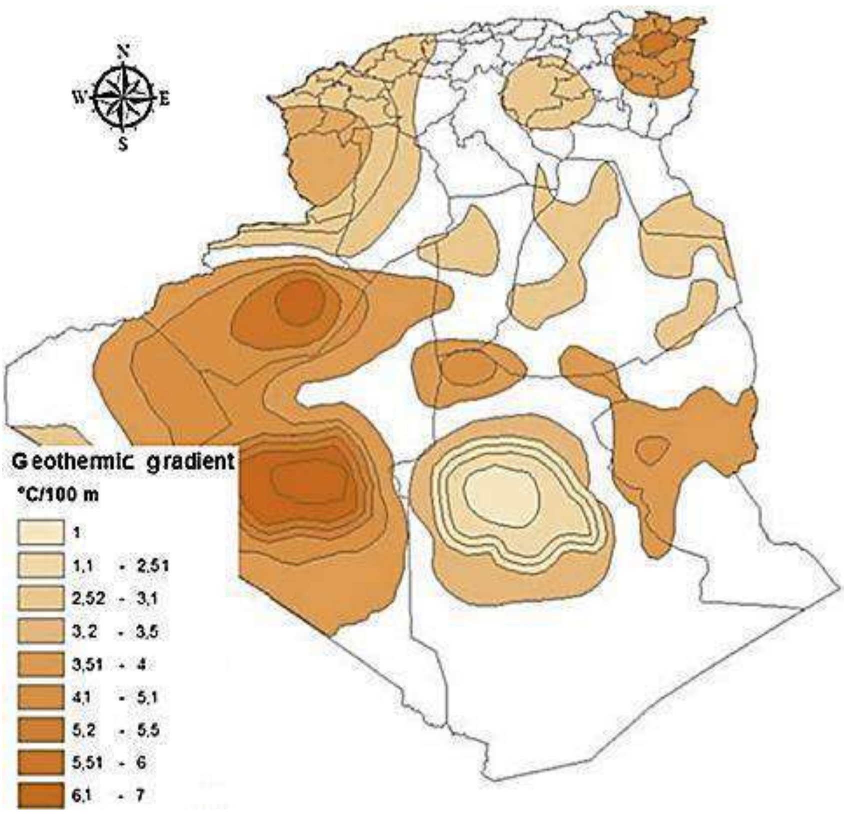


Figure I.6: Distribution map of geothermic gradient in Algeria[5].

Deeper in the South, the continental rock formation constitutes a great geothermal reservoir extending over several thousand km2. This reservoir commonly called the ‘‘albian platform’’ is exploited through drilling, at a flow rate of over 4 m^3/s. This water has an average temperature of 57 °C [6]. Studies on the thermal gradient have identified three zones whose gradient exceeds 5 °C/100 m[4]:

- Relizane and Mascara area;
- Area of Ain Boucif and Sidi Aïssa;
- Guelma and Jebel El Onk area

1.4.4. Biomass

To generate fuel through biological processes may require a couple of restrictions. To succeed in generating biofuel, you have to have vast areas of Greenland and not just that, but also to be ready to use them in your generation process. Luckily, Algeria has plenty of agricultural lands and a high quality of unpolluted soil fully rich with minerals, making it a good call to plant soybeans, corn and wheat... for energy purposes. “To each his own biofuel feedstock” - that is what Nakheel, an Algerian biotech company must have thought when it took decision to research and invest in bioethanol production using dates from the abundantly growing palm trees in North Africa and the Near East as a raw material.

The biomass potentially offers great promise, with 37 Mtoe (tons oil equivalent), coming from forests, with a rate of recovery around 10%. Moreover 5 million tons of urban and agricultural waste (365 kg of urban waste per Algerian). This potential represents a deposit approximately of 1.33 Mtoe / year; however this potential is not enhanced and consumed yet. In addition, the harnessing of organic wastes, mainly animal wastes, for biogas production could be considered as an economic solution: it is decentralized and ecological since it delivers energy autonomy, and allows sustainable development of rural areas [6]. It is composed of two major types which are the forest and household and similar waste.

a)Potential of the forest

The current potential is estimated at around 37 Mtoe**.** The recoverable potential is of the order of 3.7 Mtoes. The current recovery rate is of the order of 10%. The potential of biomass is relatively limited. The wooded area covers about 250 million hectares and represents 10% of the total area of the country where the Sahara covers almost 90% of the territory. Forests occupy an area of about 4.2 million hectares, representing 1.8% of this area, while alfatier zones occupy only about 2.5 million hectares, that is to say a little more than 1% of the extent of the territory. On the other hand, so-called unproductive lands cover more than 188 million hectares, representing 79% of the total area [8].

b) Household and similar waste

05 million tons of urban and agricultural waste is not recycled. This potential represents a deposit of the order of 1.33 Mtoe / year [9].

1.4.5. Hydraulic Power

One of the main forms of energy comes after oil and natural gas in terms of popularity and business in Algeria, by generating 5% of the total energy consumed. Ever since, Algeria has managed to generate itself a considerate amount of hydroelectric energy through the making of power plants. These are usually built into large bodies of water, such as lakes, rivers; Hydro-electric is one of the most efficient sources of energy, at about 90% effectiveness. Algeria uses mostly the traditional hydropower method, which is suited only to large dams. While the new technology, is the concentrated reduced flow of water, but it's most effective in the generation process [6].

The global quantities falling on the Algerian territory are important and estimated at 65 billion m^3, but finally benefit little to the country: reduced number of days of precipitation, concentration on limited spaces, strong evaporation, and fast evacuation towards the sea. Schematically, the surface resources decrease from north to south. Current resources are estimated at 25 billion m^3, of which about 2/3 for surface resources.103 dam areas were identified. More than 50 dam are currently in operation [4].

1.5. Environmental context

1.5.1. CO_2 emissions

In recent years, the polluting effects relating to the use of fossil fuels in the means of transport 47.2 million tones, industries with a value up to 36.7 Mt and then residential up to 34.6 Mt and other causes with a value 11.8 Mt has been the subject of particular attention. Indeed, it has been proven time and time again that pollutant emissions from vehicle tailpipes are largely responsible for the greenhouse effect, and emissions from air conditioners contribute to the thinning of the ozone layer [10].

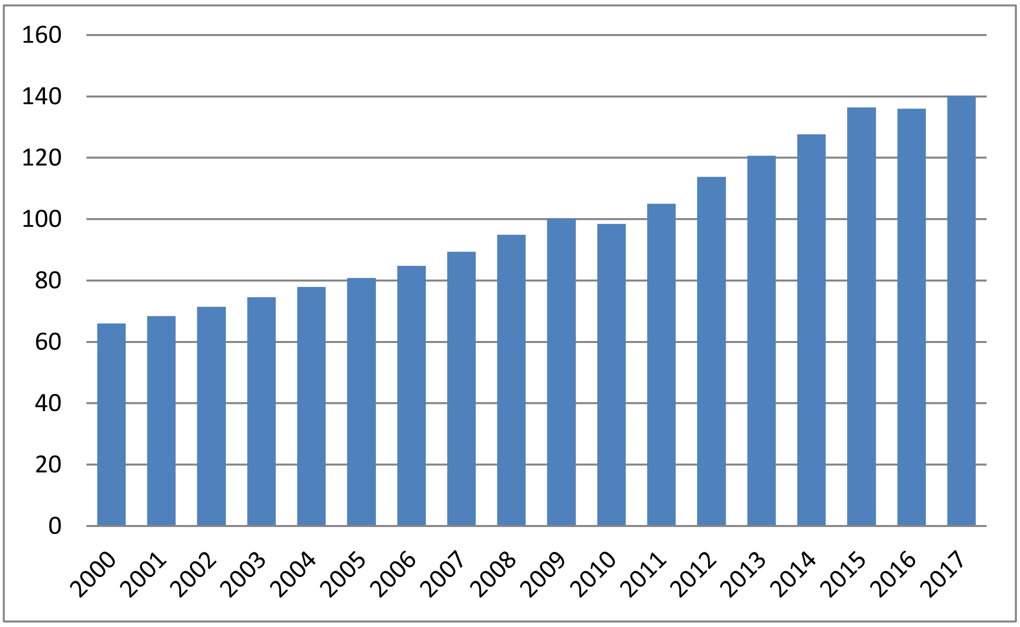


Figure I.7: CO_2 emissions (Mt).

Note that the value of CO_2 emissions is increasing every year, from about 62 Mt in 2000 to 140.22 Mt in 2017 due to the use of fossil fuels.

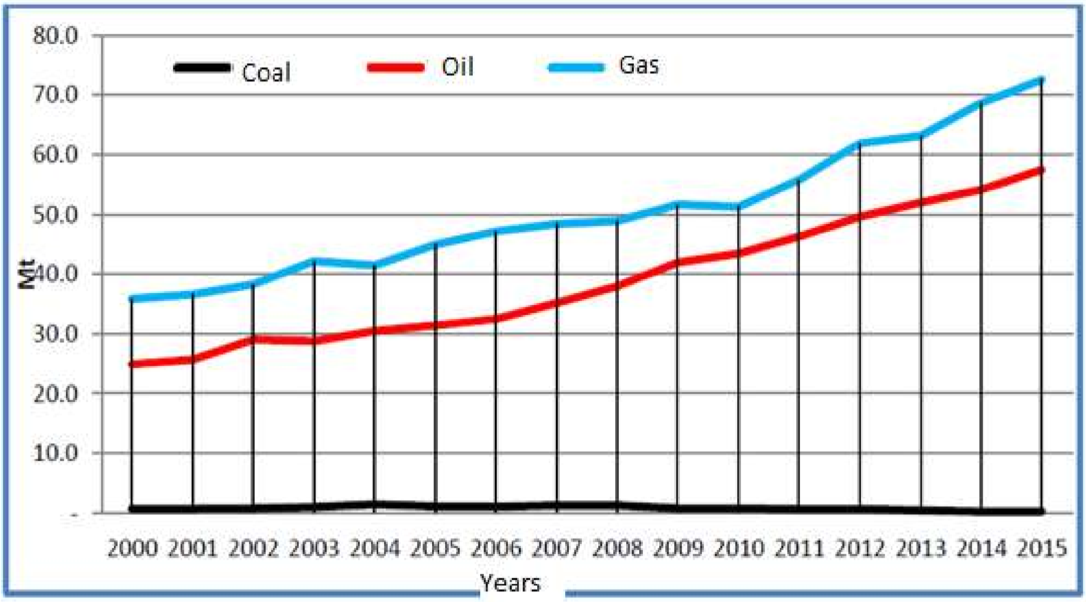


Figure I.8: Annual CO_2 emissions per product.

This figure shows that the CO_2 emissions rise from 2000 till 2015 with an increase in Oil and gas while the coal was a bit stable .

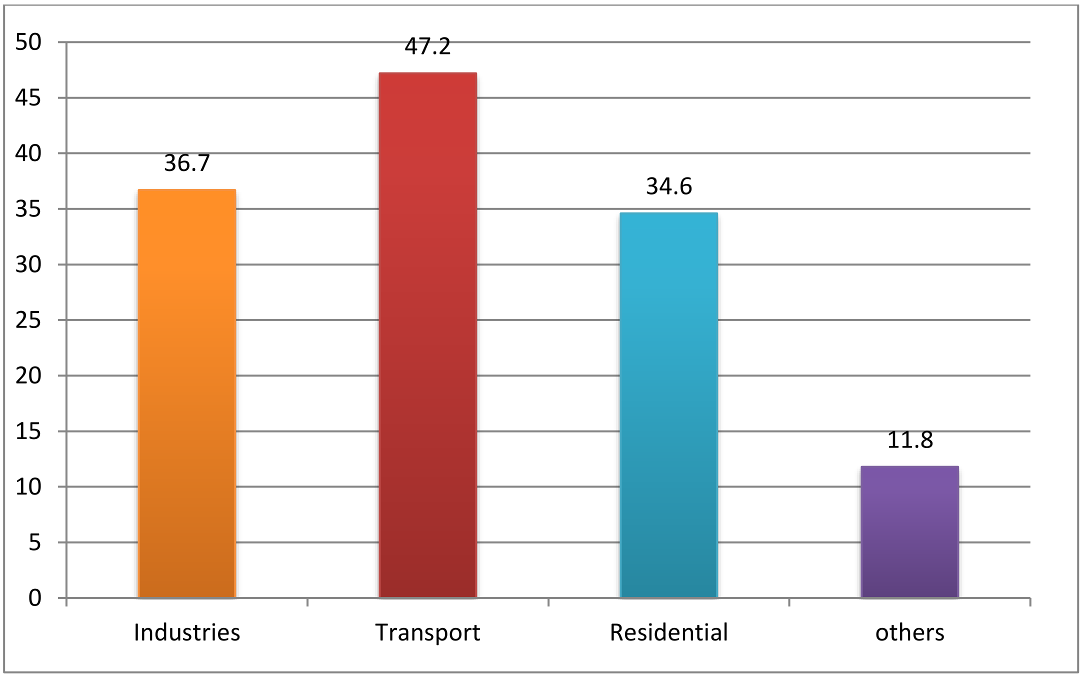


Figure I.9: CO_2 emissions by sector

This figure shows that the co_2 emissions per sectors while the transportation is the dominate followed by industries and residential and finally the other sectors with only 11.8

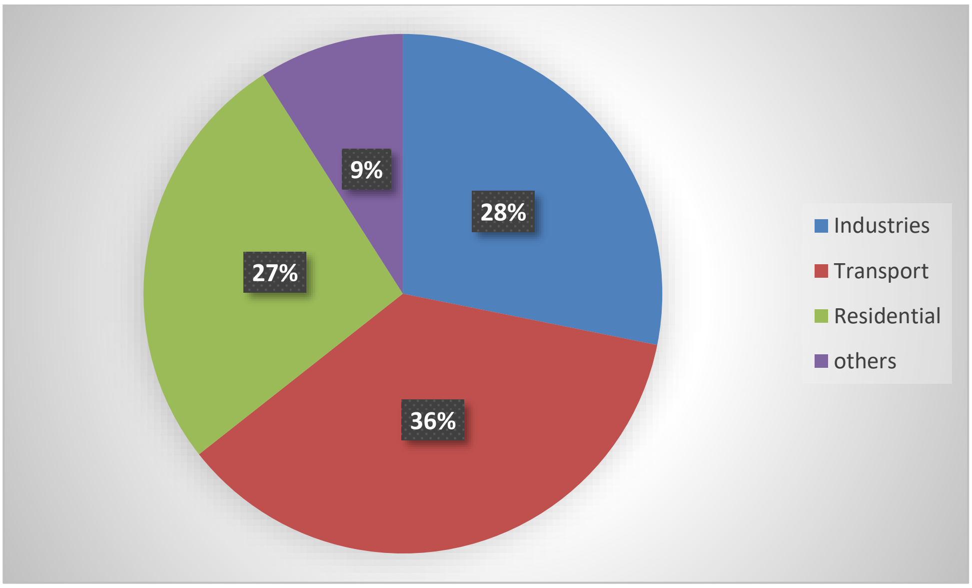


Figure I.10: CO_2 emissions by sector 2017 [1]

This figure illustrate what was already presented in the pervious pictures and gives the percentage of each sector .

1. 5. 2. National commitment to Climate change

Some global environmental problems such as global warming or thinning of the ozone layer required the application of international measures such as the Kyoto Protocol in 1997 to reduce anthropogenic greenhouse gas emissions [10]. This protocol sets a goal for the 38 most industrialized countries in the world to reduce their global greenhouse gas emissions by 5% from levels observed in 1990 [11].

Algeria has been among the countries to be submitted to the UNFCCC Secretariat (United Nations Framework Convention on Climate Change). It plans to reduce, by 2030, its greenhouse gas emissions between 7% (with its own funds) to 22% (conditioned with international aid) [12]. To coordinate the national effort to combat climate change, the government recently adopted a renewable energy development program.

1. 5. 3. National Renewable energies program (NREP)

The National Program for the Development of New and Renewable Energy (RE) and Energy Efficiency for the period 2011-2030 aims to produce 40% of national electricity consumption from the solar and wind sectors. This program provides for the installation of a power of nearly 22,000 MW, with 12,000 MW to meet domestic demand and 10,000 MW for export [13].

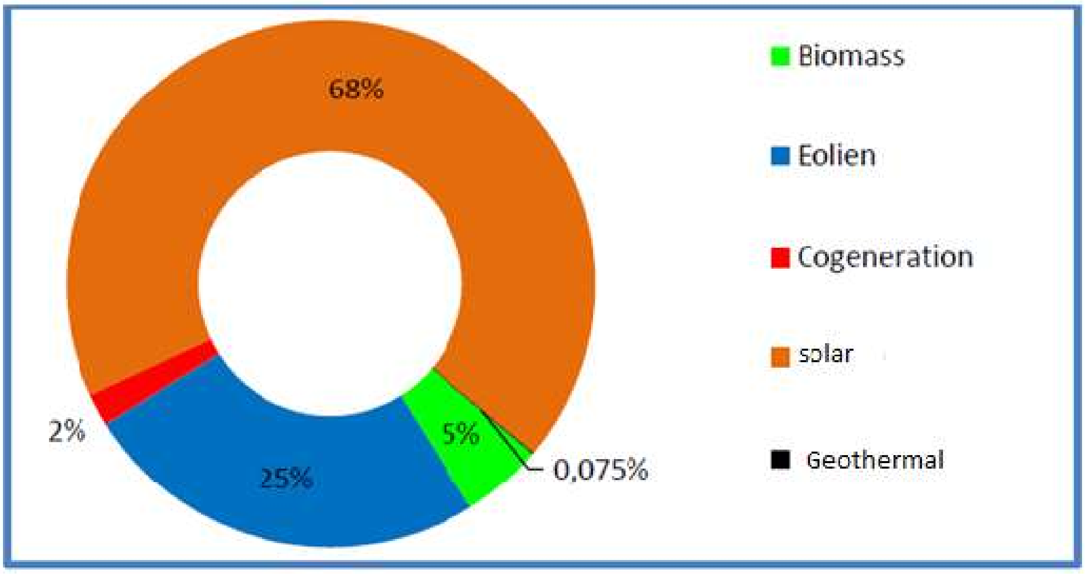


Figure I.11: Distribution of renewable energies 2017.

By technology, solar photovoltaic will participate in the implementation of this program to the tune of 13575 MW, wind to 5010 MW, biomass to 1000 MW, cogeneration to 400 MW and geothermal to 15 MW.

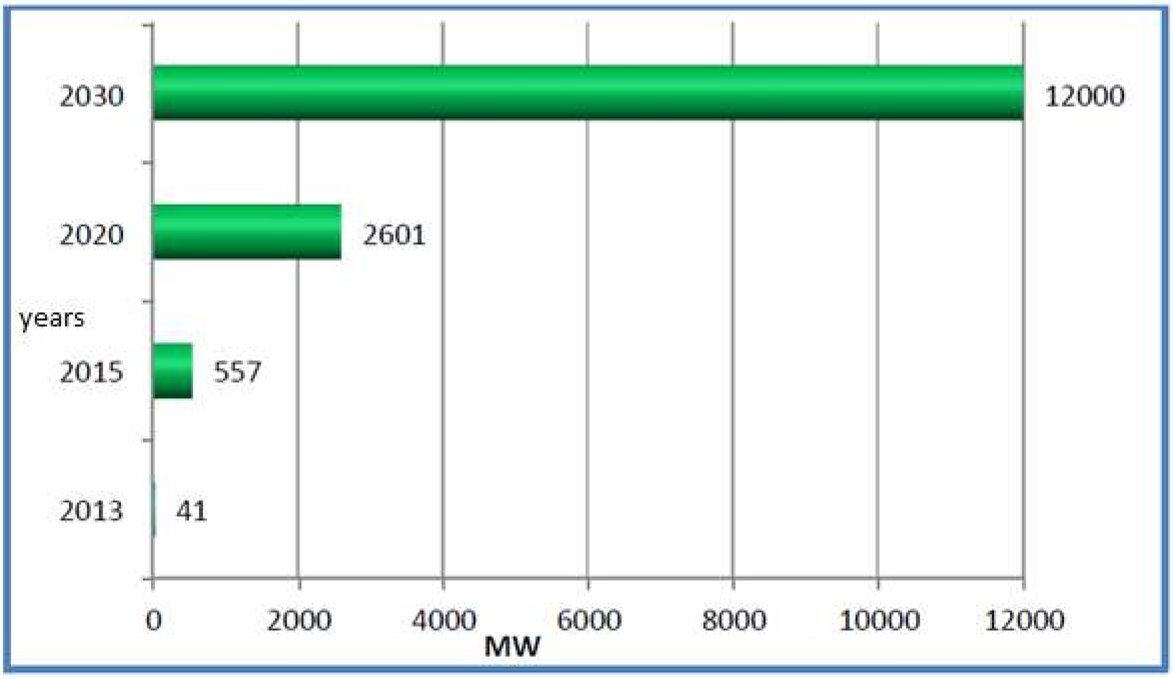


Figure I.12: Prospective evolution of the production of renewable energies.

The completion of this program will achieve, by 2030, a renewable share of nearly 27% in the national electricity generation balance sheet [1].

1.6. Conclusion

After reviewing the realities of energies in Algeria e can notice that the renewable energies are one of the best solutions in the future one of this is biomass which can be produced from organic rubbish and Algeria is one of the best places for this.

Chapter II

Biomass Potential in Algeria

2.1. Introduction

We saw in the last chapter that the renewable energies and the biomass in practically important so we can say that the change in Algeria's energies resources is a must now, in order to go for it we need also to study the methods, ways and knowing the availabilities here in our large country .In this chapter we'll analyze the biomass in Algeria and its future based on our resources.

2.2. Biomass

2.2.1. Definition and classification

Biomass is organic, non-fossilized material made from plants and animals wood and wood waste are the largest sources of biomass energy, followed by energy from municipal solid waste (MSW) and alcohol fuels. Biomass is largely composed of organic material and water [14].

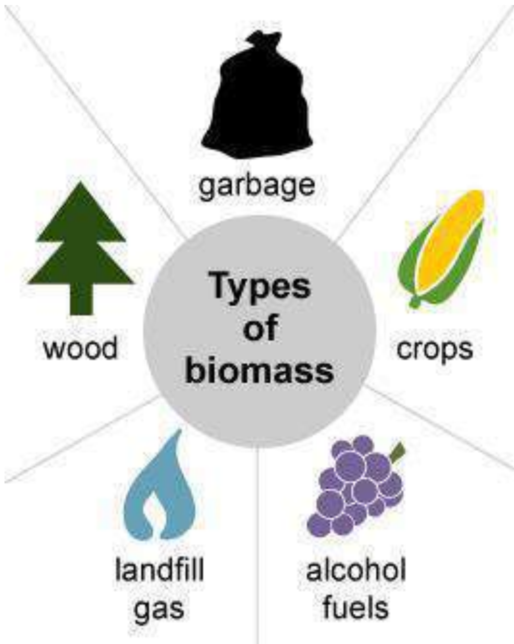


Figure II.1: Biomass types

2.2.2. Biomass to energy conversion

Combustion deriving from biomass, such as burning wood, has been used from prehistoric times to the present. However, it is not very efficient. Converting solid biomass to a gaseous or liquid fuel by heating it with limited oxygen prior to combustion greatly increase the heating value and overall efficiency, making it possible to convert the biomass to other valuable chemicals or materials. For example the gasification of biomass is developing energy among various systems for the energetic utilisation of biomass [15].

Biomass contains stored energy from the sun. Plants absorb the sun's energy in a process called photosynthesis. The chemical energy in plants gets passed on to animals and people that eat them. Biomass is are new able energy source because we can always grow more trees and crops, and waste will always exist. Some examples of biomass fuels are wood, crops, manure, and some garbage. When burned, the chemical energy in biomass is released as heat, than the water is heating to produce steam which is using for making electricity, or to provide heat to industries and homes.

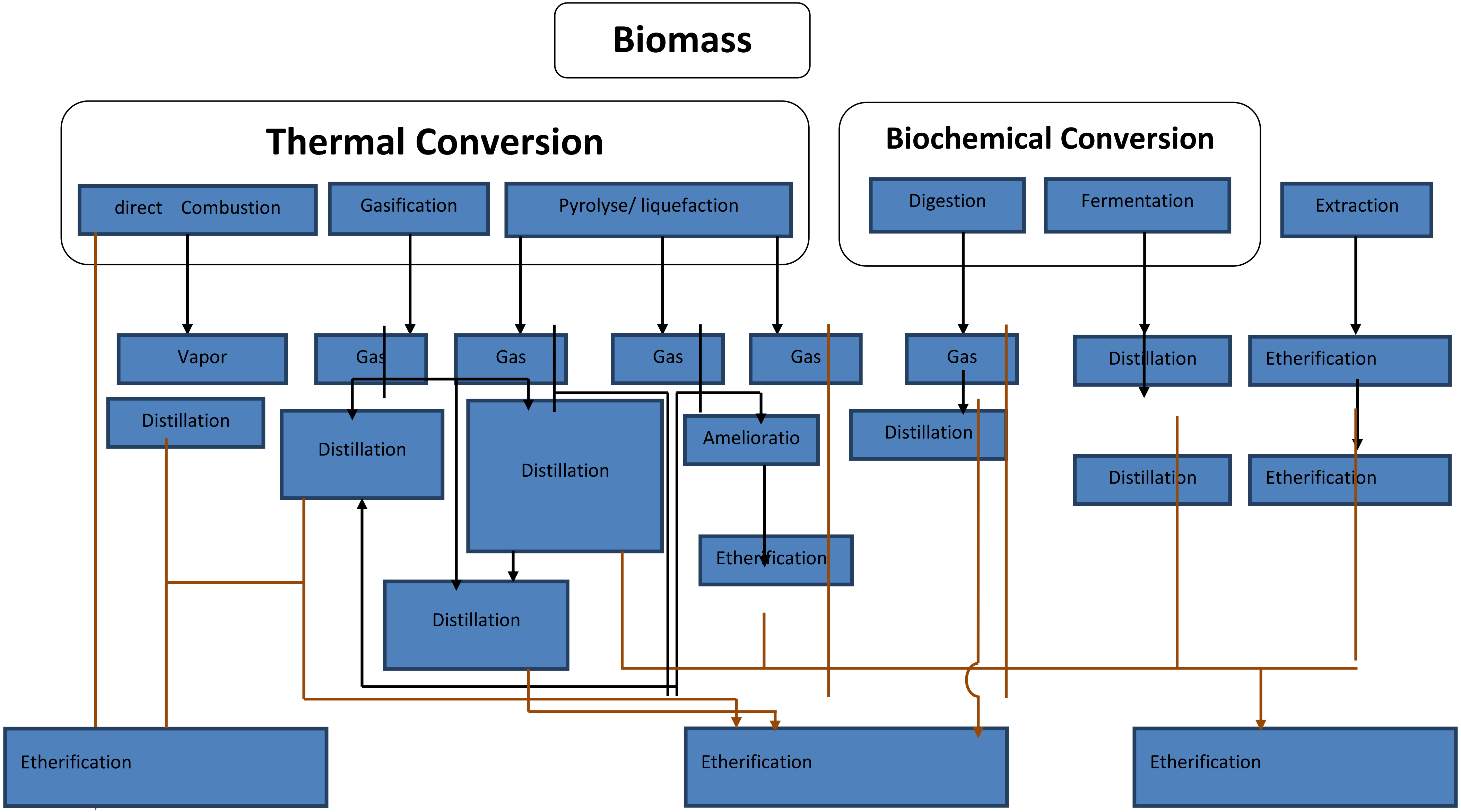


Figure II.2: Biomass to energy conversion routes.[26]

Biomass seems to be the only renewable alternative for liquid transportation fuel. Biomass use strengthens rural economies, decreases countries dependence on imported oil, avoids use the methyl tertiary butyl ether (MTBE) or other highly toxic fuel additives, reduces air and water pollution, and reduces greenhouse gas emissions. Fuel from biomass is related to ethanol, biodiesel, biomass power and industrial process energy [16].

It is important to consider the use of biomass, in that most of the electricity, heat and steam produced by industry in consumed on site. However, some manufacturers sell excess power to the grid. Wider use of biomass resources will directly benefit many companies whose growth generates more residues, such as wood or animal wastes, that they can use internally. New markets for these excess materials will also support business expansion [16].

2.2.3. Biofuels

Biofuels are transportation fuels like ethanol and biodiesel that are made from biomass materials. These fuels are usually blended with the petroleum fuels — gasoline and diesel fuel, but they can also be used on their own. Using ethanol or biodiesel means we don't burn quite as much fossil fuel. Ethanol and biodiesel are usually more expensive than the fossil fuels that they replace, but they are also cleaner-burning fuels, producing fewer air pollutants.

Ethanol is an alcohol fuel made from the sugars found in grains, such as:

• Corn, sorghum, barley

Other sources of sugars to produce ethanol include:

• potato skins, rice, sugar canes, sugar beets, yard clippings, bark, switch grass

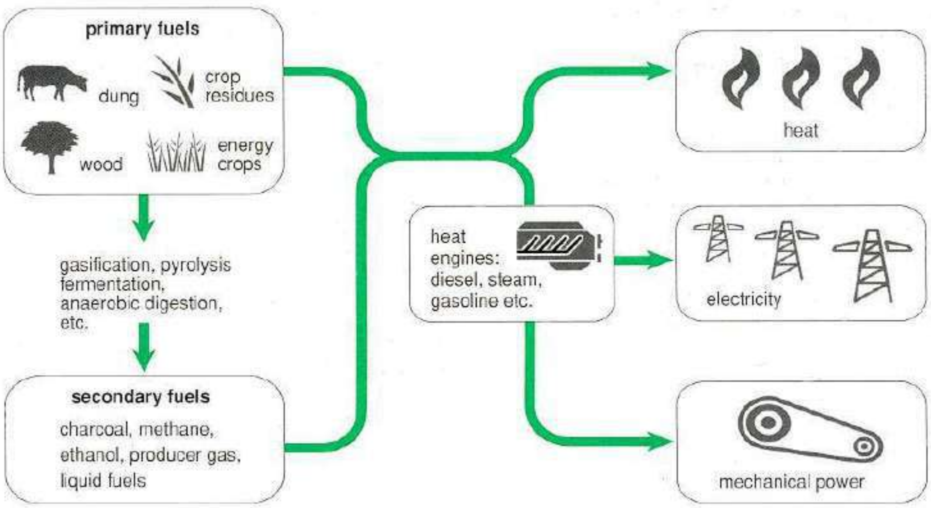


Figure II.3: Biomass Cycle.

Most of the ethanol used in the United States today is distilled from corn. Scientists are working on cheaper ways to make ethanol by using all parts of plants and trees rather than just the grain. Farmers are experimenting with "woody crops," mostly small poplar trees and switch grass, to see if they can be grown cheaply and abundantly.

About 99% of the ethanol produced in the United States is used to make "E10" or "gasohol," a mixture of 10% ethanol and 90% gasoline. Any gasoline powered engine can use E10, but only specially made vehicles can run on E85, a fuel that is 85% ethanol and 15% gasoline.

Biodiesel is a fuel made from vegetable oils, fats, or greases - such as recycled restaurant grease. Biodiesel fuel can be used in diesel engines without changing them. It is the fastest growing alternative fuel in the United States. Biodiesel, a renewable fuel, is safe, biodegradable, and produces lower levels of most air pollutants than petroleum-based products.

2.2.4. Biomass potential in the world

Today, there are 1.4 billion people around the world that lack access to electricity, some 85%of them in rural areas. Without additional dedicated policies, by 2030 the number of people drops, but only to 1.2 billion. Some 15% of the world’s population still lack Son the traditional use of biomass is projected to rise from 2.7 billion today to 2.8 billion in 2030 . Bioenergy technologies have applications in centralized and decentralized settings, with the traditional use of biomass in developing countries being the most widespread current application. Bioenergy typically offers constant or controllable output. Figure.3 shows the share of bioenergy in the world energy mix.

Biomass, mainly, now represents only 5% of primary energy consumption in industrialized countries. However, much of the rural population in developing countries, which represents about 50% of the world’s population, is reliant on biomass, mainly in the form of wood, for fuel, Biomass accounts for 35% of primary energy consumption in developing countries, raising the world total to 14% of primary energy consumption.

2.3. Municipal waste in Algeria

2.3.1. Definition and classification

According to the law n ° 01-19 of 12-12-2001, the "domestic and assimilated waste" or "municipal waste "are all household waste (consumer waste),as well as similar waste from industrial, commercial and craft activities and others which by their nature and composition are comparable to household waste.

As regards classification and definitions of the different categories of waste, the far ° 01-19 of 12-12-2001 divides waste into three categories:

1. Household and similar waste;
2. Special waste including hazardous waste;
3. Bulky waste.

2.3.2. Composition

Composition of Municipal Solid Waste (MSW) knowledge of the composition of the waste is essential in order to appreciate the valorisation possibilities such as composting or anaerobic digestion, recovery of metals or other recyclable materials (paper, cardboard, glass, plastic) and to the capacity of the facilities (Koledzi, 2011).

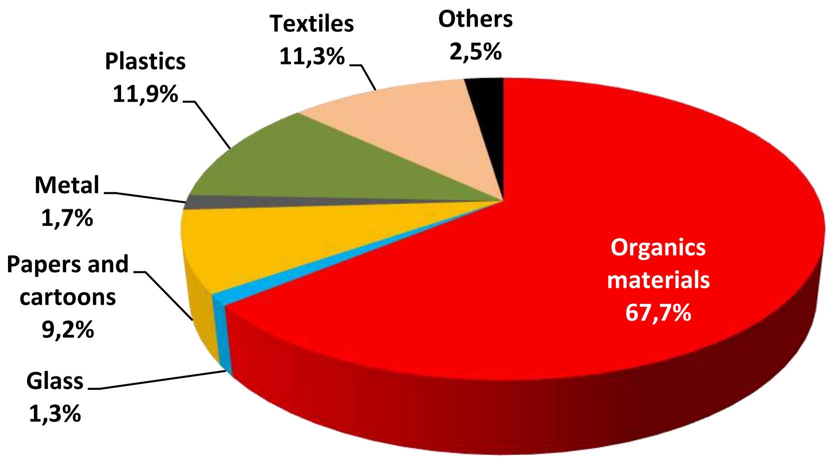


Figure II.4: DSM composition.

The organic fraction of waste is mainly dominant in developing countries. Development, exceeding 55% compared with 35% in the industrialized countries. Conversely, the share of paper, glass and plastics is increasing in the industrialized countries, reflecting and the new ways of consuming the population. The proportion of glasses is low in the developing countries (between 5 to 8%) as well as the proportion of potentially polluting metals.

Indeed, organic fractions are valued within households as feeding for animals. The use of waste as resources - through the energy production, recycling and reuse - could be a solution to limit the impact of man on the planet. The recovery of waste offers them a second life. To ensure management of this waste, it will be necessary to reduce their volume at the source, improve their sorting, reinforce their recycling and recovery and promote better supervised landfills.

Rapid urban development in developing countries has become one of the most serious environmental challenges as it is synonymous with increased production of urban waste. Overall, the waste management policy is based on three types of instruments: legislative or regulatory instruments, economic instruments (incentive, taxation) and awareness and training instruments.

2.3.3. Solid Urban Waste Management Program (PROGDEM)

The National Program for Integrated Management of Household Waste (PROGDEM), been implemented by the Ministry of Regional Planning and Environment in 2001, whose objectives include the improvement of the living environment of the citizen, the preservation of public health and the protection of health, as well as healthy elimination and environmentally sound waste by recovering recyclable waste. The main actions concerned by PROGDEM are the following:

- The development and implementation of municipal waste management plans;
- Development of controlled landfill sites;
- Promotion of recycling and waste recovery activities;

The introduction of new forms of management;

- The gradual adaptation of the household waste collection tax and the improvement its recovery rate;
- Awareness-raising, training and education through the creation of CNFE for the training of state executives in the field of the environment.[26]

2.3.4. Treatment and recovery of municipal waste

The importance of waste treatment is specified in Law No. 01-19 of 12December 2001 on the management, control and disposal of waste.

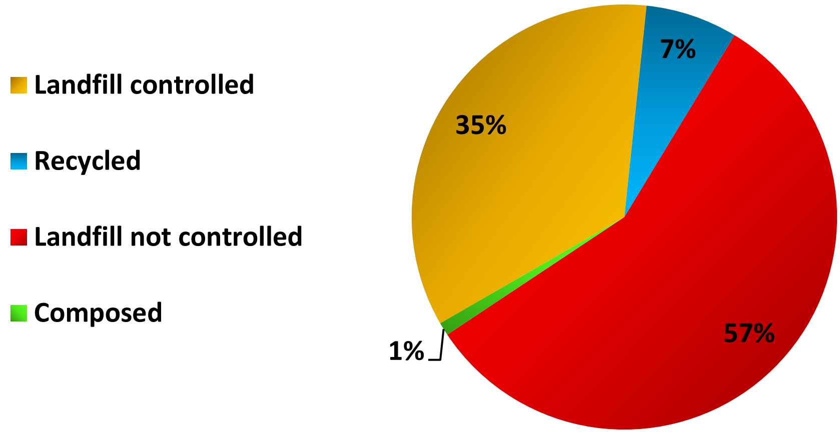


Figure II.5. Mode of disposal of waste in Algeria[26].

In general, disposal remains the solution applied to 97% of the waste produced in Algeria (Djemaci, 2012). The intended for disposal are put in public dumps or uncontrolled municipal (57%), controlled landfill and CET (35%). By cons quantities for recovery are too low, of which only 7% per recycling and 1% composting (Kehile, 2014).

2.3.5. Waste production

The territory is divided into three (03) distinct sets; the Sahara represents 87% of territory, the highlands 9% and the north (Tellian complex), barely 4%. According to the Office National Statistics (ONS), the number of inhabitants for the year 2012 is estimated at 37.5million with a population growth rate of about 1.43%. This population is concentrated mainly in the north, which represents about 65% of global population. Hence a very high rate of urbanization in this region and a density occupancy exceeding 300 h / km2 (ONS, 2012).

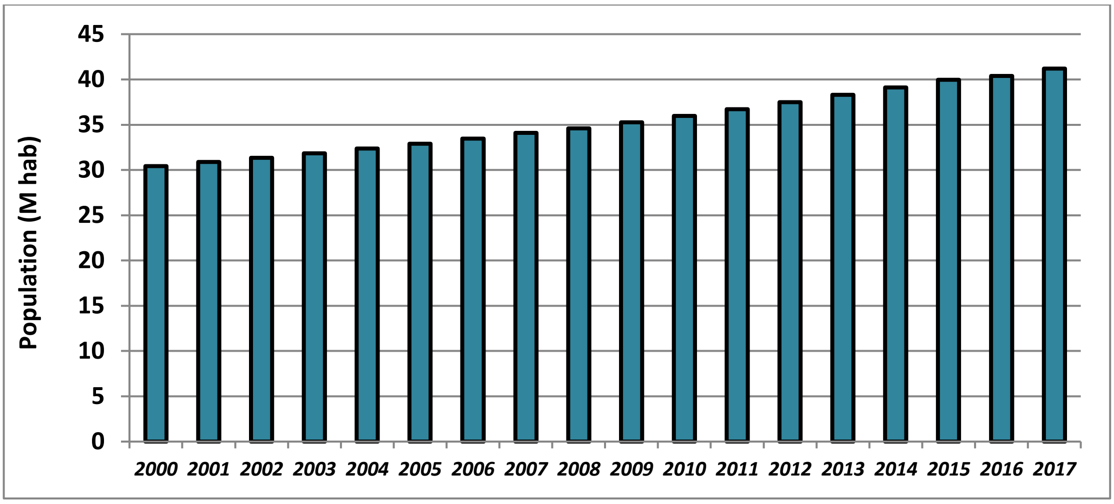


Figure II.6: Retrospective evolution of the population (ONS, 2017).

Between 1980 and 2014, the Algerian population increased from 18.6 to 39.11 million inhabitants, at the same time leading to an increase in the quantities of waste. He is at emphasizing that the cities of the Algerian littoral, denser in population generate quantities of waste far superior to that of the Highlands and the Great South. About the capital, it produced more than 0.87 million tonnes in 2008. A dozen cities emit between 200 and 300,000 tonnes of municipal solid waste (MSW) per year: this is the case cities like Oran in the West, Constantine in the East and TiziOuzou in Center. About twenty medium-sized cities produce between 100 and 190,000 tons a year.

Finally, some cities produce DSM quantities of less than 50,000 tons per year; these are generally concentrated in the Great South (Sahara) and are characterized by low population densities (Djemaci, 2012).

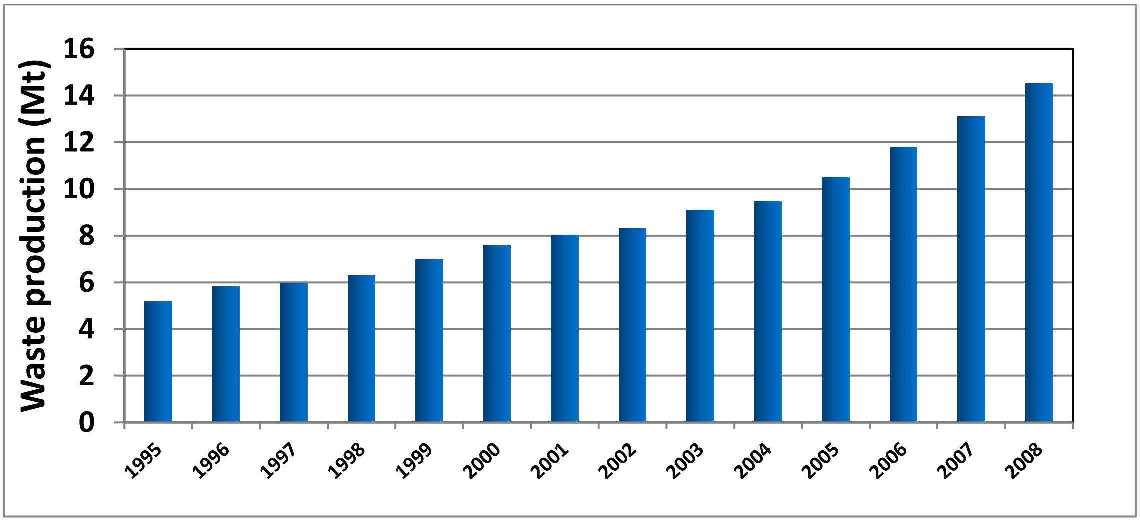


Figure II.7: Evolution of waste in Algeria between 1995 and 2008.[26]

The production of waste in the average cities in Algeria was 0.5 kg / person / day in 1980 and reached 0.6 kg / person / day in 2002 to reach 0.8 kg / person / day in 2005, while for large cities, production was 0.76 kg / person / day in 1980 and reached 1.2 kg / person / day in 2005 (METAP, 2004). The amount of household and similar waste (DMA) experienced a substantial increase in recent decades due to growth galloping demography combined with uncontrolled urbanization. It is estimated at around 10.3 Mt in 2013. This production will exceed 12 Mt in 2020 and will approach 17 Mt in 2030 (AND, 2010).

2.3.6. Biogas production

The urban solid waste deposits in Algeria have been estimated at more than 11,000,000 tons for the year 2010, while the total mass of fresh organic waste of urban origin was estimated at nearly 8,300,000 tons spread across 48 wilayas for the same year. However, from some treatment methods ecologically more sustainable, technologically and economically accessible to contexts of Algeria, these deposits can be quantified preferentially in terms of resources. In fact, the methanation in particular allows not only to treat and to stabilize the organic waste, but also the opportunity to valorise this waste as a source of energy (cooking, lighting, electricity) and / or as sources of materials fertilizers for agriculture. The methanisation has the merit of being simultaneously a renewable energy production sector and an alternative waste treatment sector organic.

The availability of residual biomass (Agricola waste) has a strong relation to seasons and limited in some months during the year .It is rare that one of agriculture products can be produced all year , and it is hard to ensure the storage of it because of the risk of development of proliferation of certain pest fungi So those products can’t stored and must be eliminated very Quickly This situation push us to ignore the storage because of the high amount of storage and use it in others field like biomass.

2.4. Conclusion

As we can see after this chapter that the revolution of energies and the road to biomass has a wide future from production to the needs of uses, after that we will see how it is relevant to Algeria and which methods, types and forms can be developed in our country.

Chapter III

Multi-criteria analysis based on geographic information system

3.1 Introduction

After seeing in the last chapter the possibility and the availability of biomass potential in Algeria we will see in this chapter the favorable zones of biomass in Algeria by coupling the GIS with MCDA in our dissertation

3.2 Geographic Information Systems

As we know the Matlab and Fortran one of the most well-known programs in IT we find the GIS as a key to generate and study the potential , geography , sciences and a lot of domains for this we used it in our study in order to help us in citing the favorable sites

3.2.1 Definition of the GIS

A Geographic Information System is a tool for making and using spatial information. Bolstad(2002) defines GIS as: “a computer-based system to aid in the collection, maintenance, storage, analysis, output, and distribution of spatial data and information.” With the development of information technology and the price of sufficiently powerful computers falling below a critical threshold, GIS has become widely used in the fields of government and public services, business and service planning, logistics and transportation, and environmental studies. Longley et al. (2005) state that a GIS is composed of six components: the network, which is the most fundamental part, hardware, software, spatial database, management and the participation of people.

3.2.2 GIS uses

- **Mapping where things are.**
- **Mapping quantities**
- **Mapping densities.**
- **Finding what is inside.**
- **Finding what is nearby.**
- **Mapping change.**

3.3 Multi-criteria decisionan alysis

It is generally assumed that multi-criteria decision analysis (MCDA) originated at the beginning of 1960s. Most of practitioners of MCDA consider that their field stems largely from the early work on goal programming and research of Simon[22].

- **Decision** is a choice between alternatives.
- **Criterion** is some basis for a decision that can be measured and evaluated. It is the evidence upon which a decision is based. Criteriacanbe of two kinds: factors and constraints.
- **A factor** is a criterion that enhances or detracts from the suitability of a specific alternative for the activity under consideration. It isthereforemeasured on a continuous scale.
- **A constraint** serves to limit the alternatives under consideration. In many cases constraints will be expressed in the form of a Boolean (logical) map: areas excluded from consideration being coded with a 0 and those open for consideration being coded with a 1 [24].
- **Multi-attribute** decision making methods are data-oriented. An attribute is a concrete descriptive value, a measurable characteristic of an entity, including inter-entity relationships. Multi-attribute techniques are referred to as discrete methods because they assume that the number of alternatives is explicit. Multi-attribute decision problems require that choices be made among alternatives described by their attributes. This implies that attribute objective relationships are specified in such a form that attributes can be regarded as both objectives and decision variables. Attributes are used as both decision variables and decision criteria [25].

Table III.1: Summary of MCDM Methods.

Method	Advantages	Disadvantages	Areas of Application
Multi-Attribute Utility Theory (MAUT)	Takes uncertainty into account; can incorporate preferences.	Needs a lot of input; preferences need to be precise.	Economics, finance, actuarial, water management, energy management, Agriculture
Analytic Hierarchy Process (AHP)	Easy to use; scalable; hierarchy structure can easily adjust to fit many sized problems; not data intensive.	Problems due to interdependence between criteria and alternatives; can lead to inconsistencies between judgment and ranking criteria; rank reversal.	Performance-type problems, resource management, corporate policy and strategy, public policy, political strategy, and planning.
Case-Based Reasoning (CBR)	Not data intensive; requires little maintenance; can improve over time; can adapt to changes in environment.	Sensitive to inconsistent data; requires many cases.	Businesses, vehicle insurance, medicine, and engineering design.
Data Envelopment Analysis (DEA)	Capable of handling multiple inputs and outputs; efficiency can be analyzed and quantified.	Does not deal with imprecise data; assumes that all input and output are exactly known.	Economics, medicine, utilities, road safety, agriculture, retail, and business problems.
Fuzzy Set Theory	Allows for imprecise input; takes into account insufficient information.	Difficult to develop; can require numerous simulations before use.	Engineering, economics, environmental, social, medical, and management.
Simple Multi-Attribute Rating Technique (SMART)	Simple; allows for any type of weight assignment technique; less effort by decision makers.	Procedure may not be convenient considering the framework.	Environmental, construction, transportation and logistics, military, manufacturing and assembly problems.
Goal Programming (GP)	Capable of handling large-scale problems; can produce infinite alternatives.	It’s ability to weight coefficients; typically needs to be used in combination with other MCDM methods to weight coefficients.	Production planning, scheduling, health care, portfolio selection, distribution systems, energy planning, water reservoir management, scheduling, wildlife management.

ELECTRE	Takes uncertainty and vagueness into account.	Its process and outcome can be difficult to explain in layman's terms; outranking causes the strengths and weaknesses of the alternatives to not be directly identified.	Energy, economics, environmental, water management, and transportation problems.
PROMETHEE	Easy to use; does not require assumption that criteria are proportionate.	Does not provide a clear method by which to assign weights.	Environmental, hydrology, water management, business and finance, chemistry, logistics and transportation, manufacturing and assembly, energy, agriculture.
Simple Additive Weighting (SAW)	Ability to compensate among criteria; intuitive to decision makers; calculation is simple does not require complex computer programs.	Estimates revealed do not always reflect the real situation; result obtained may not be logical.	Water management, business, and financial management.
Technique for Order Preferences by Similarity to Ideal Solutions (TOPSIS)	Has a simple process; easy to use and program; the number of steps remains the same regardless of the number of attributes.	Its use of Euclidean Distance does not consider the correlation of attributes; difficult to weight and keep consistency of judgment.	Supply chain management and logistics, engineering, manufacturing systems, business and marketing, environmental, human resources, and water resources management.

3.4 Methodology and results

In our study we used the GIS in order to get the cards of potential by having a study between the evolution of population and the waste (organic one) then we treated it by MCDA in order to set alternatives and having the favorable sites by the end.

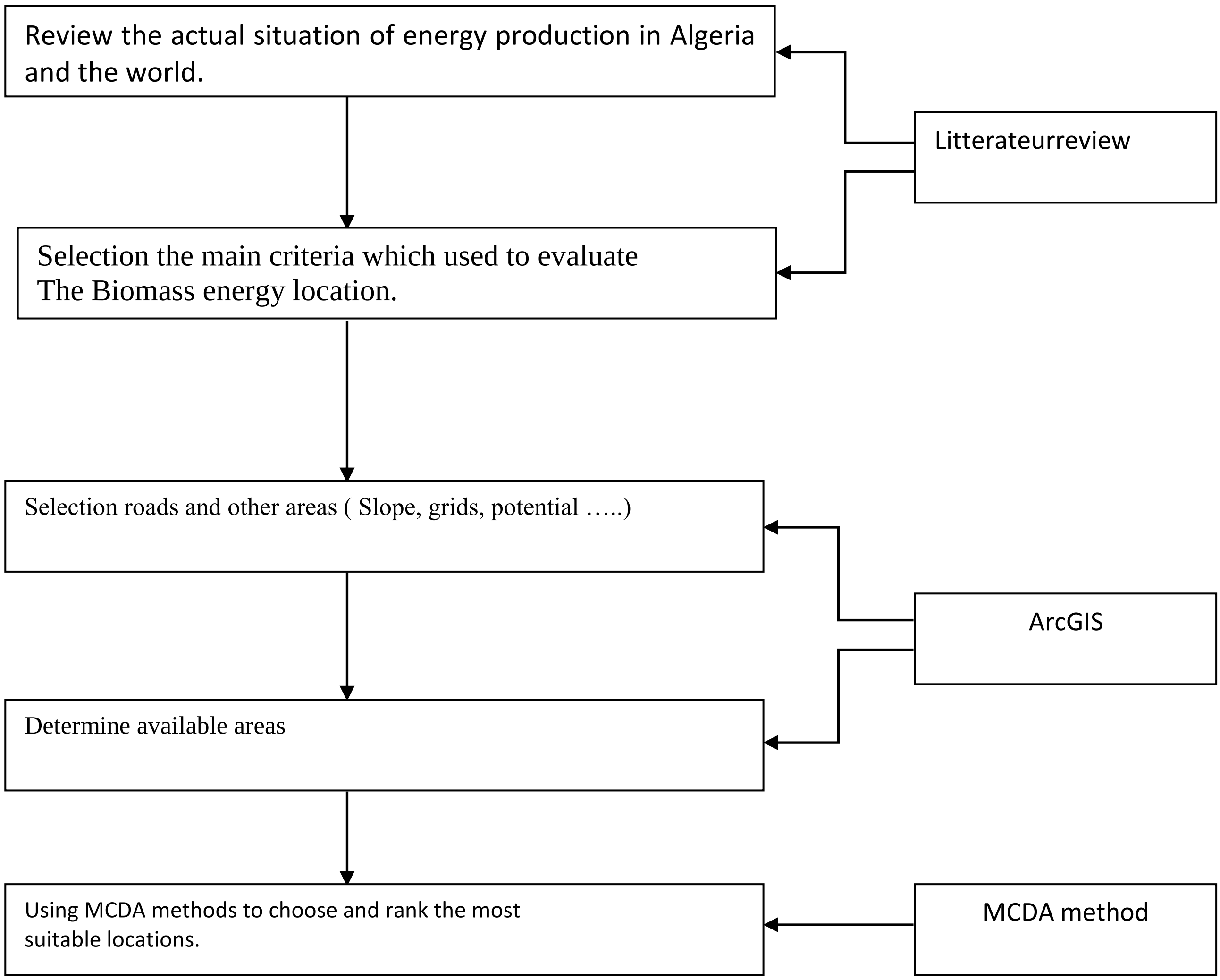


Figure III.1: Summary of research steps and methodology

3.4.1 Problem definition

Algeria is one of the biggest countries around the world and it has a wide reserve of biomass recourses however this biomass potential is not well studies moreover we have to know where is the best areas located in order to reach more percentage of the gain from this renewable energies, for that our study will be about having a clear data of biomass potential in Algeria and using the GIS –MCDA in order to get the favourites sites.

3.4.2 Constrains and factors

In this study around 14 criteria (attributes are involved in the methodological process ,either as constrains (exclusionary criteria) or a factors (no exclusionary criteria) [17], so after reviewing the Algerian realities plus other studies in similar sector we saw that there’s a common factors are shared in all studies like the distance to national roads table 1 all these factors are splits to three main categories : social and safety ,economic and environmental.

Table III.2: Constraints Table

Constraints	Description
Roads and railways	To exclude areas which contain or are less than 1000 away from motorways ,roads and rail network
Built up areas	To exclude buildings 200 m
Minimum Areas	Potential sites must have an area of at least 1 ha for implementation of a biogas plan
Electricitygrid	To exclude areas who contains elec grid or voltage line less 200 m than
Protected Areas	To exclude protected areas by less 70 m away
Slopes	No more 15% or less 2.5%
Commercial and industrial buildings	To exclude commercial and man work buildings (factories , airport ..ect) 200m
Sand Dunes	To exclude sand dunes areas (1000m)
Mountains	To exclude mountains areas (1000m)

Based on constraints shown in Table III.2 the GIS obtains independent eligible geographic areas of polygonal shape (referred as polygons from now on) considered as non excluded or potentially suitable sites, through basic GIS operations of ESRI® ArcGIS® 10 (buffering, boolean logic, etc.) The final constraint relates to the physical shape of polygons.

Table III.3: Table of factors.

Type	Name	Factors	Objective
Environmental	F1	Potential of Biomass	Maximize
Economic	F2	Slope	Maximize
	F3	Distance to roads	Maximize
	F4	Distance to railways	Maximize
	F5	Distance to grids	Maximize
Social & Safety	F6	Population	Maximize
	F7	Distance to municipalities	Maximize

In this study, the criteria factors are defined by the returning to international experiences like the Portuguese one ,which identified three dimensions: an environmental dimension, an economic dimension, and a social and safety dimension.

a) Potential of biomass

The rise in biomass potential values and the reduction in other sub regions is a key criterion in determining the suitable area for the establishment of Biomass energy project because it is the only source of energy in such projects[18-19].

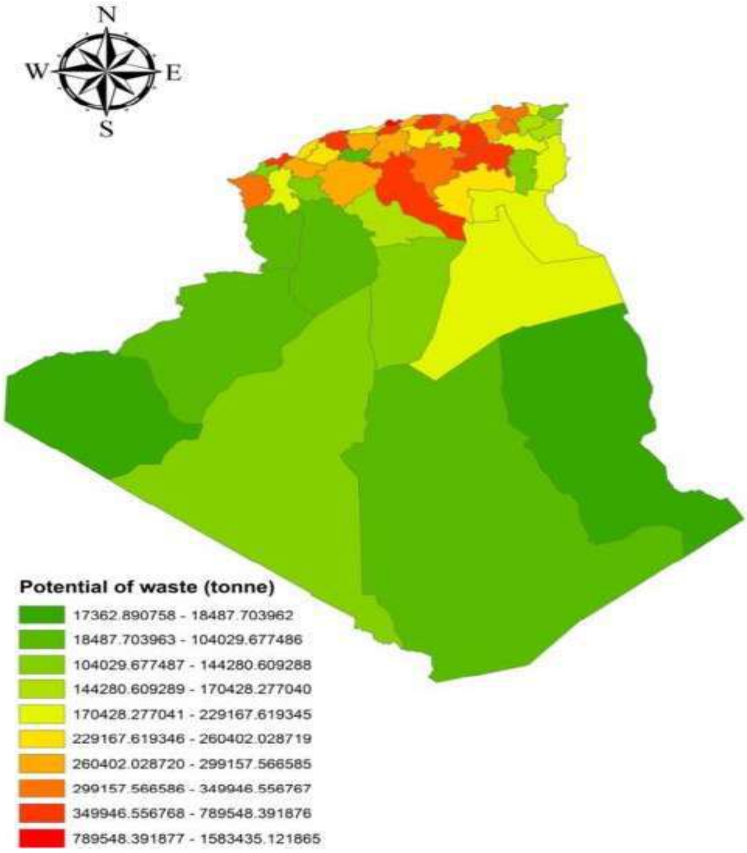


Figure III.2 Potential of waste (tonne).

b) Slope

Slope is a required substance most biomass energy projects, for cooling, steam generation or / and daily use. In terms of slope, the slope between 2.5%-15% are suitable areas for factory building while the slopes with others percentage are not suitable[20].

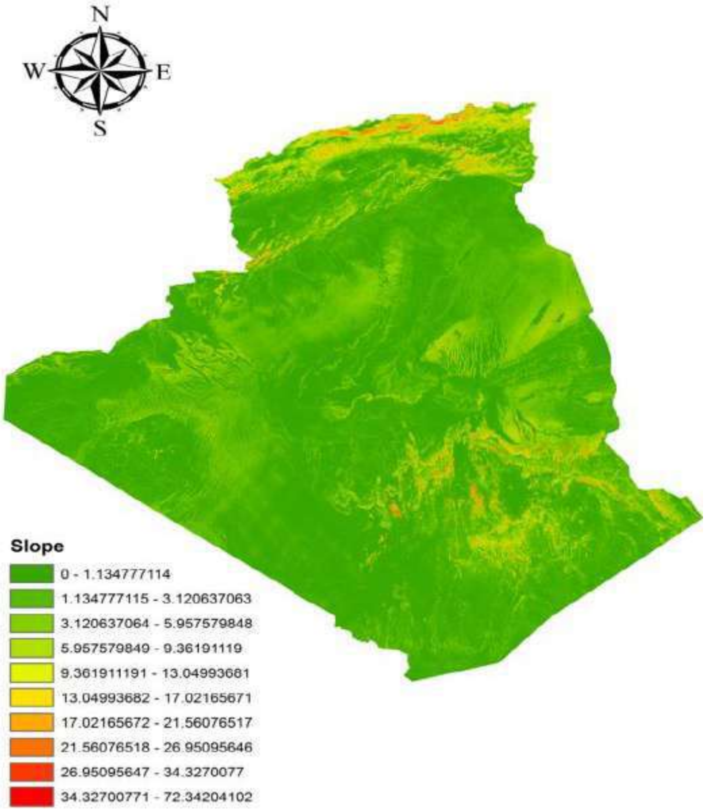
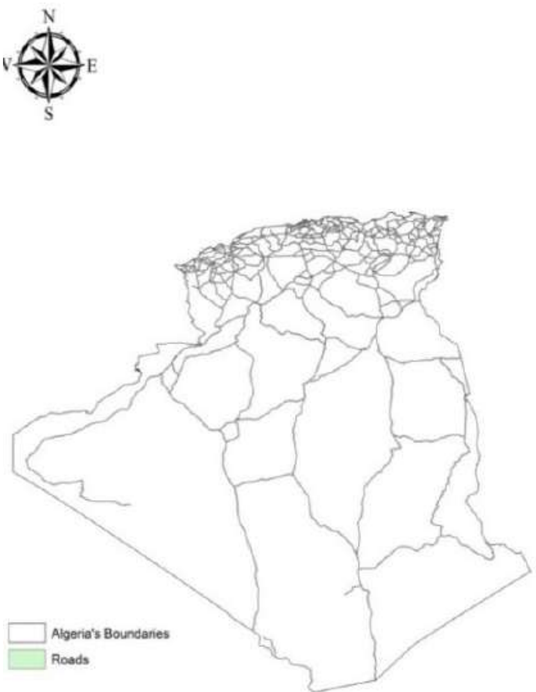
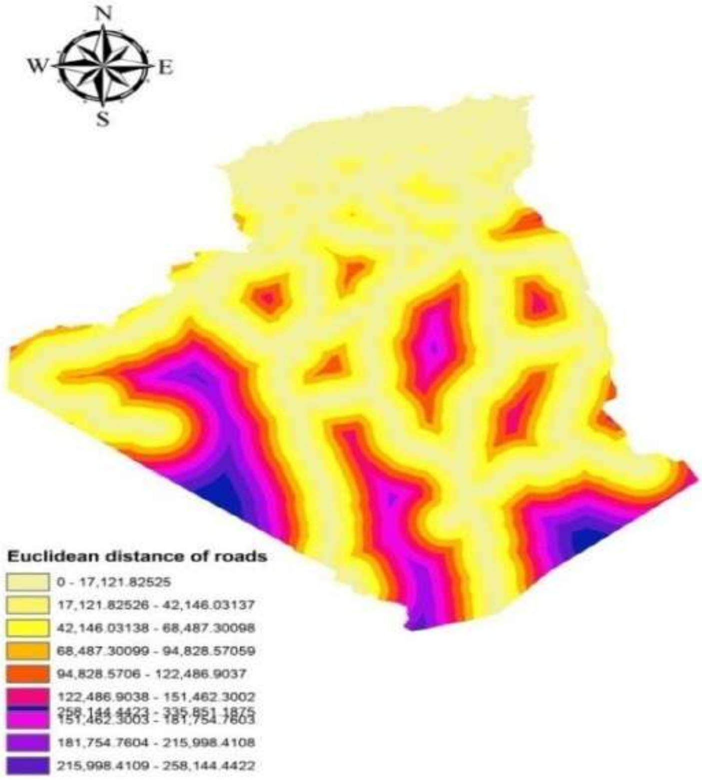


Figure III.3 Slope.

c) Roads

The proximity or distance of the road is an important criterion in the process of reporting or determining the appropriate place to set up the Biomass energy project, which facilitates the transport factor that allows the easiest access to the plant during installation and operating phases[15-17], [20].



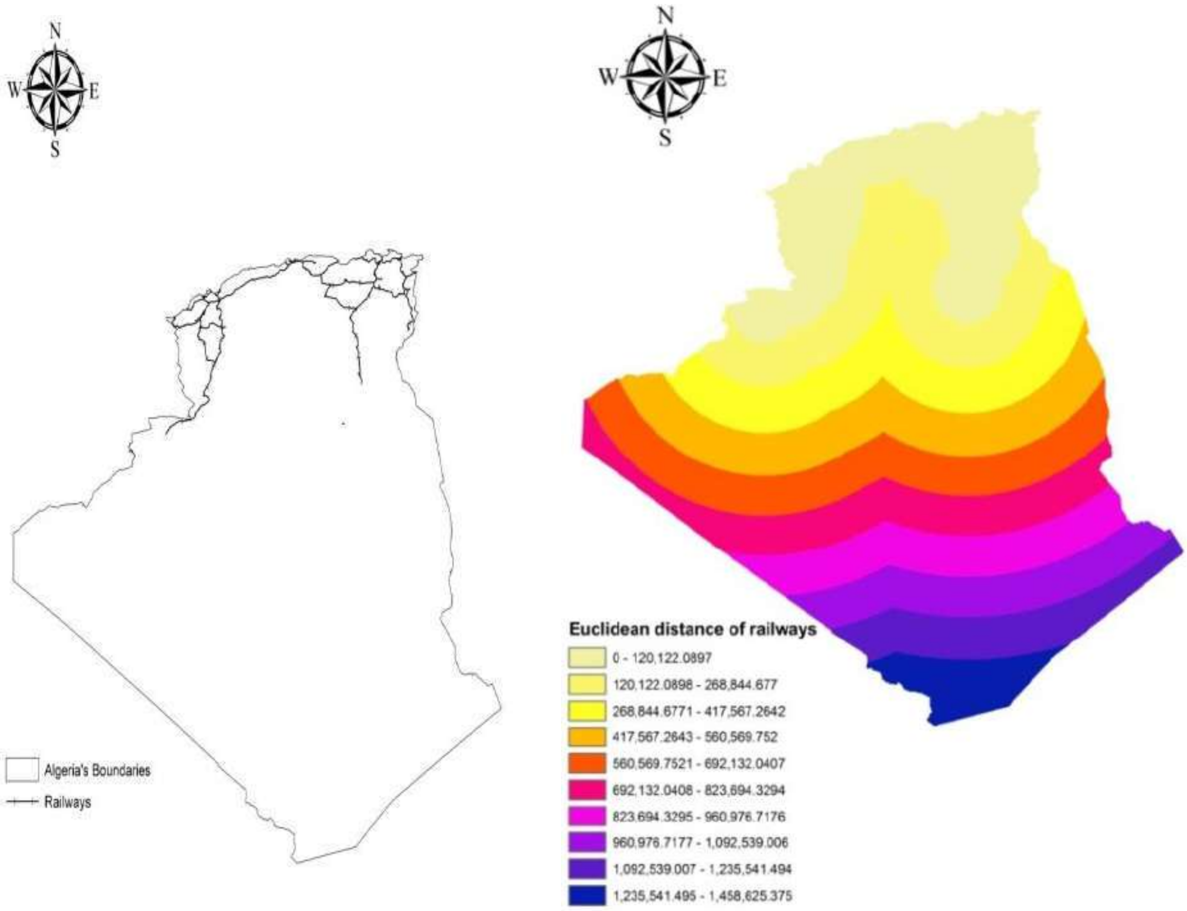


(a)

Figure III.4(a) Distance to roads in Algeria **(b)**Roads in Algeria.

d) Railways

The proximity or distance of the railways is an important too criterion in the process of reporting or determining the appropriate place to set up the Biomass energy project[15]16][17].

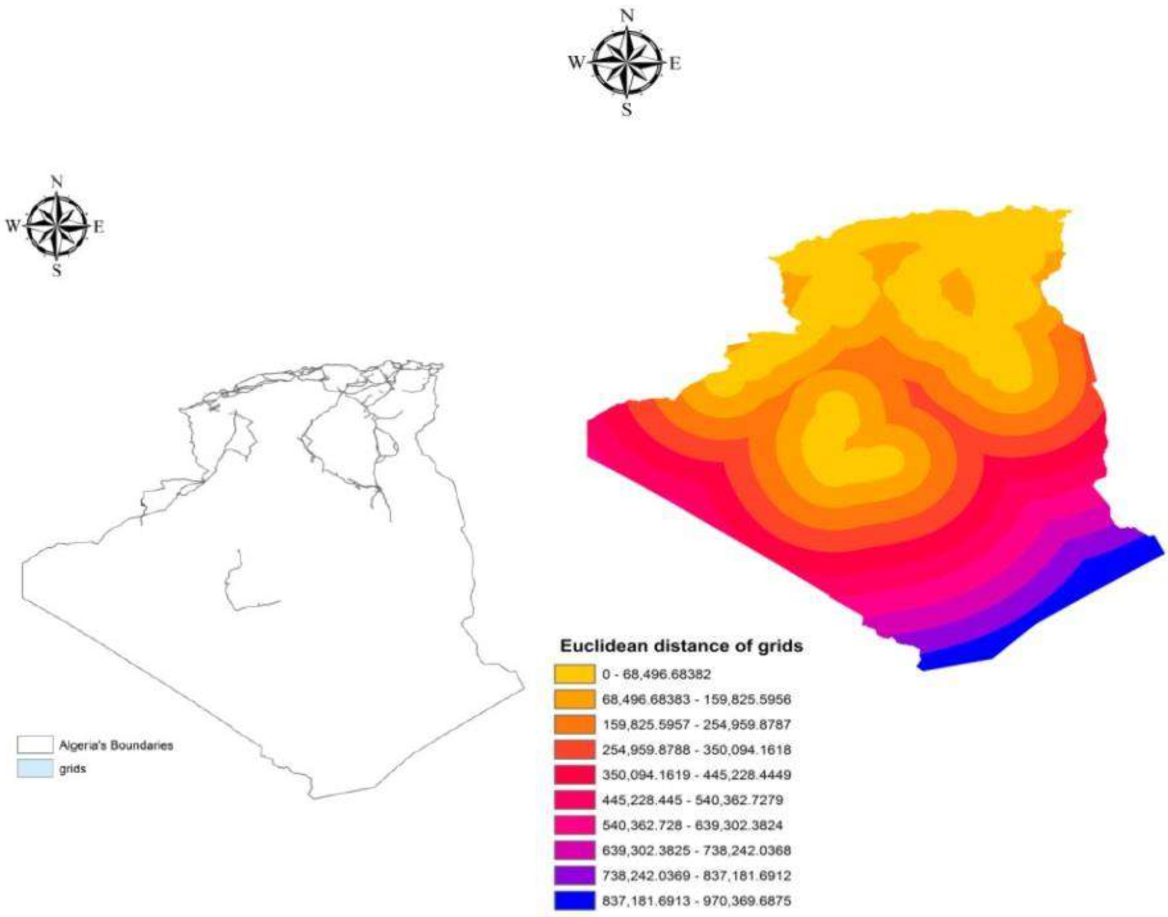


(a) **(b)**

Figure III.5(a) Railways **(b)** Euclidean distance of railways.

e) Grids

The construction of a Biomass project somewhere is better to be close to the electrical grid and therefore the proximity distance from the electrical grid is an important criterion for determining the appropriate place for the project[18].



(a) **(b)**

Figure III.6(a)grids**(b)** Euclidean distance of grids.

f) Population

The proximity or population in the area of the project should be near to people potential since we have to not be far from the population in order to gain the transportation fees and use it well [21].

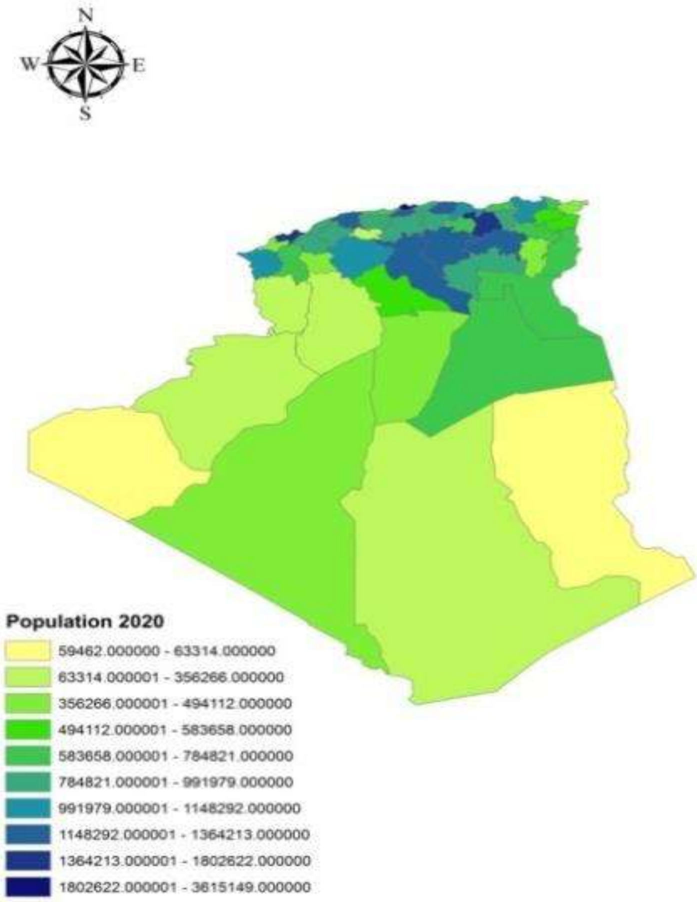
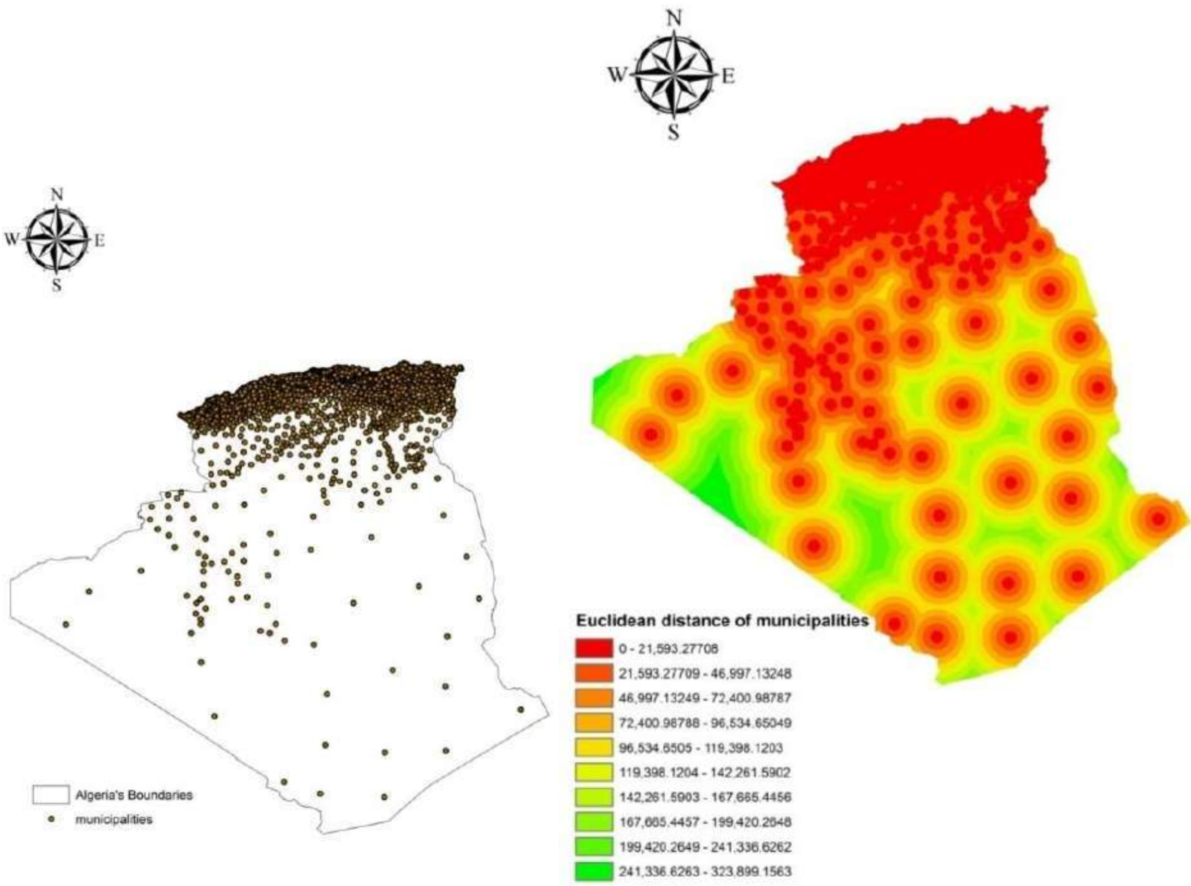


Figure III.7: Population in Algeria 2020.

g) Municipalities

The proximity or distance of the municipalities should be near to the project since we have to not be far from it in order to gain the transportation fees[20],[21].



(a) **(b)**

Figure III.8:(a) Municipalities**(b)**Euclidean distance of municipalities.

So After deleting the most uncomfortable areas such as, urban and agricultural areas, mountains, and sand dunes, we selected the available areas (alternatives), which are 24 regions in this study.

The most regions which can be an alternative for new biomass energy project are presented in **Figure III.9** these areas considered as candidates to select and rank by applying MCDA method in the next steps.

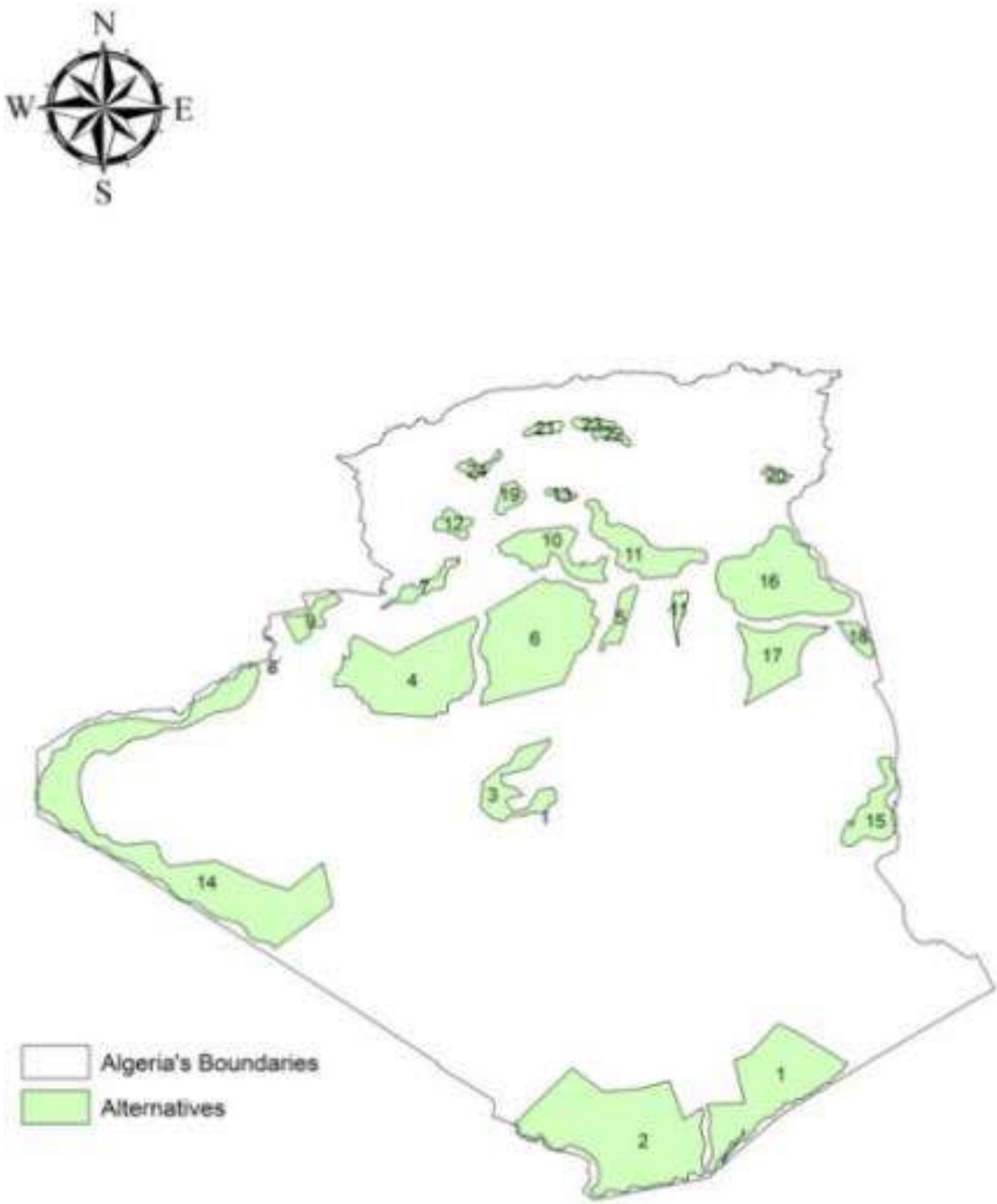
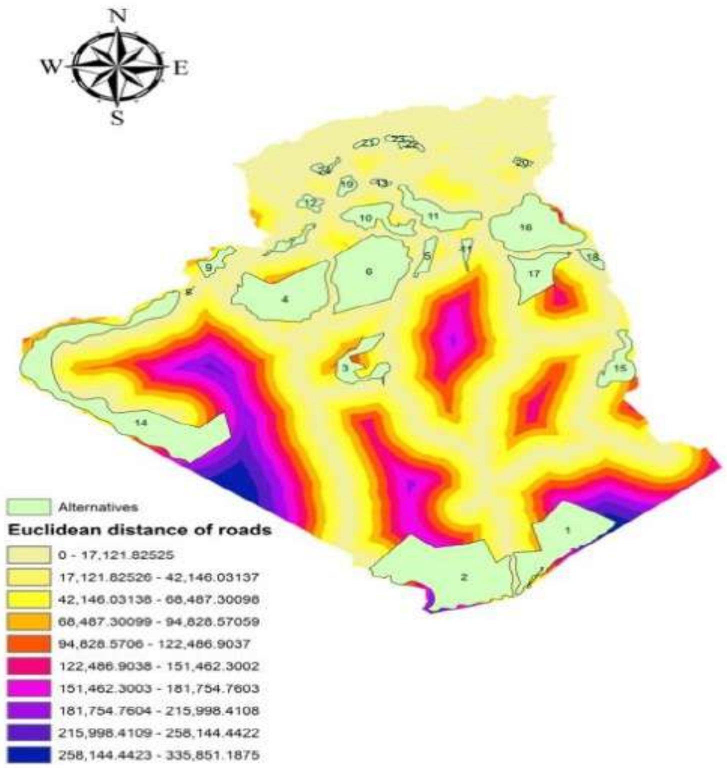
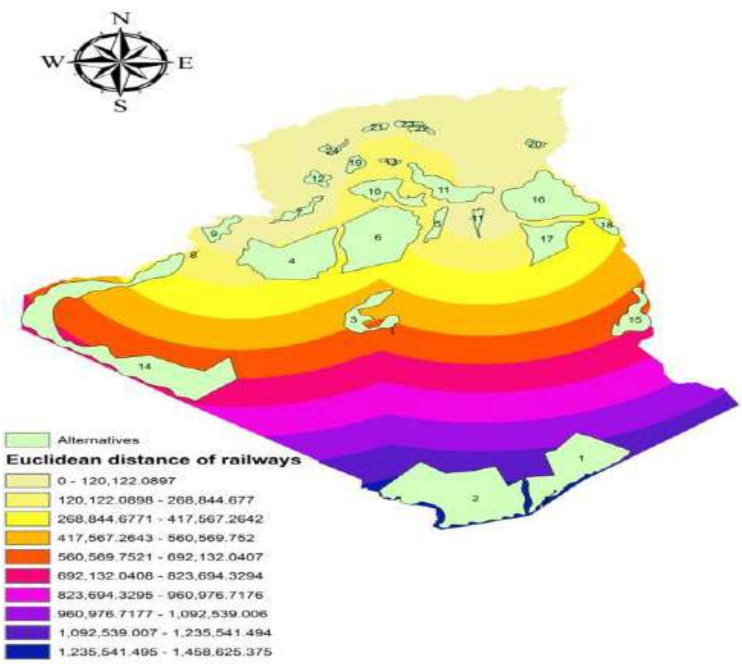


Figure III.9: Available areas

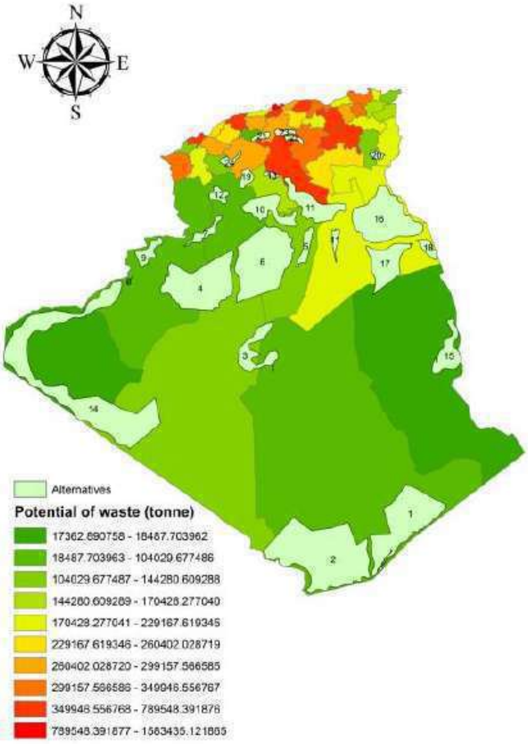
So the previously identified potential sites (polygons) are the location alternatives to be subject to a multi-criteria evaluation process. Each of polygons has a different shape and area and the occupied space is not ho- mogeneous for each factor.

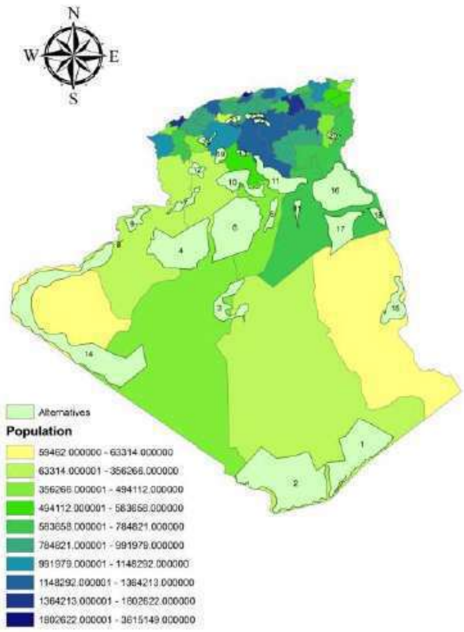
So we compare each alternative with a factors in order to obtain the performance table .



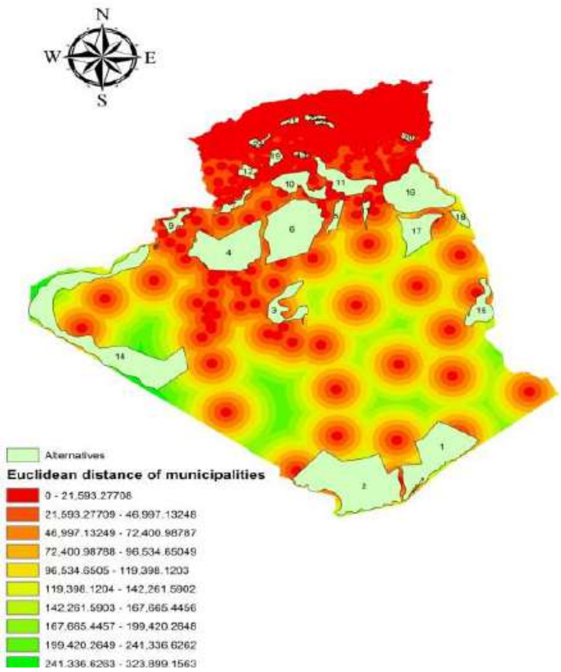


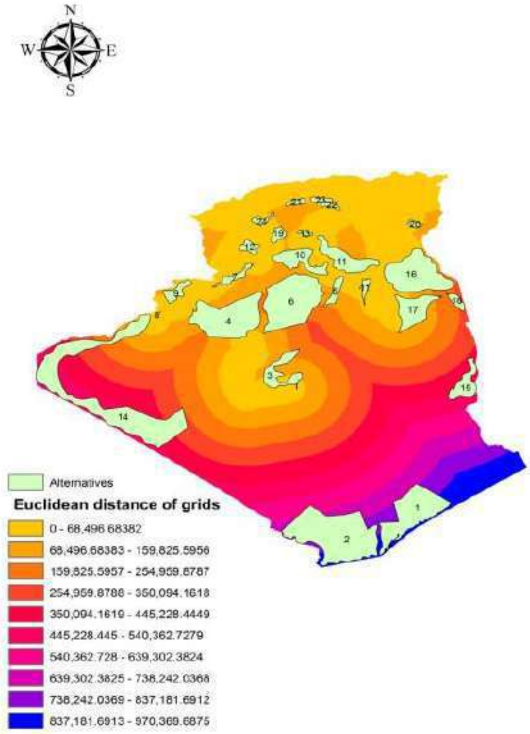
(a) **(b)**


N
W
E
S
Alternatives
Potential of waste (tonne)
17362.690758 - 18487.703962
18487.703963 - 104029.677486
104029.677487 - 144280.609288
144280.609289 - 170428.277040
170428.277041 - 229167.619345
229167.619346 - 260402.028719
260402.028720 - 299157.566585
299157.566586 - 349946.556767
349946.556768 - 789548.391876
789548.391877 - 1563435.121865

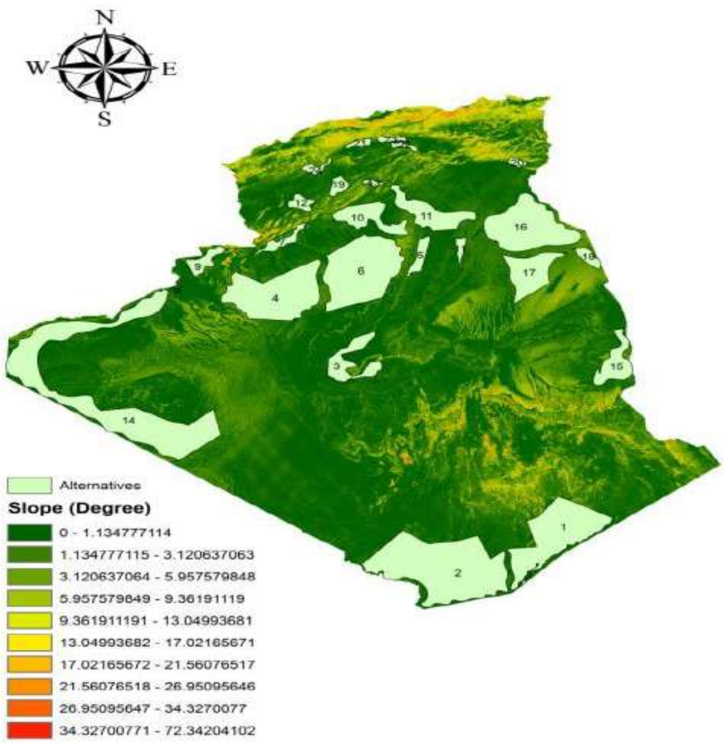

N
W
E
S
Alternatives
Population
59462.000000 - 63314.000000
63314.000001 - 356266.000000
356266.000001 - 494112.000000
494112.000001 - 583658.000000
583658.000001 - 784821.000000
784821.000001 - 991979.000000
991979.000001 - 1148292.000000
1148292.000001 - 1364213.000000
1364213.000001 - 1802622.000000
1802622.000001 - 3615149.000000

(c) **(d)**


N
W
E
S
Alternatives
Euclidean distance of municipalities
0 - 21,593.27708
21,593.27709 - 46,997.13248
46,997.13249 - 72,400.98787
72,400.98788 - 96,534.65049
96,534.6505 - 119,398.1203
119,398.1204 - 142,261.5902
142,261.5903 - 167,665.4456
167,665.4457 - 199,420.2648
199,420.2649 - 241,336.6262
241,336.6263 - 323,899.1563


N
W
E
S
Alternatives
Euclidean distance of grids
0 - 68,496.68382
68,496.68383 - 159,825.5956
159,825.5957 - 254,959.8787
254,959.8788 - 350,094.1618
350,094.1619 - 445,228.4449
445,228.445 - 540,362.7279
540,362.728 - 639,302.3824
639,302.3825 - 738,242.0368
738,242.0369 - 837,181.6912
837,181.6913 - 970,369.6875

(e) **(f)**



(g)

Figure III.10: Overly alternatives with criteria **(a)** Euclidean distance of roads **(b)** Euclidean distance of railways **(c)** Potential of waste (tonne) **(d)** Population**(e)** Euclidean distance of municipalities **(f)** Euclidean distance of grids **(g)**Slope.

The Figure III.10 shows the overlap of the alternative and each of the factors that we have in order to obtain the tables and the properties of each .

3.4.3 Assessment and analysis by MCDA Methods

We applied MCDA scores for the 24 chosen alternatives, using 7 sustainability criteria (Municipalities, Roads, railways, slope, population, potential and Grid), it all shown in **Table III.3.**

Table III.4: Performance table

Alternatives	Municipalities	Grid	Road	Railways	Slope	Population	Potential
1	0-199,420.2648	639,302.3825-970,369.6875	0-335,851.1875	960,976.7177-1,458,625.37	0-72.34204102	59462.000000 -276596000000	18487.703963-104029677486
2	0-199,420.2648	540,362.728-970,369.6875	0-335,851.1875	1,092,539.007-1,458,625.37	0-72.34204102	59462.000000-583658000000	18487.703963-144280.609288
3	0-142,261.5902	0-254,959.8788	0-122,486.9037	417,567.2643-692,132.0407	0-13.04993681	59462.000000-583658000000	18487.703963-144280.609288
4	0-96,534.65049	0-254,959.8788	0-122,486.9037	0-417,567.2642	0-13.04993681	59462.000000-583658000000	18487.703963-144280.609288
5	0-96,534.65049	0-254,959.8788	0-68,487.30098	0-268,844.677	0-13.04993681	276596000000-583658000000	104029677486-144280.609288
6	0-119,398.1203	0-254,959.8788	0-122,486.9037	120,122.0897-417,567.2643	0-13.04993681	59462.000000-583658000000	18487.703963-144280.609288
7	0-72,400.98787	0-159,825.5957	0-42,146.03137	0-120,122.0897	0-72.34204102	59462.000000-583658000000	18487.703963-104029677486
8	0-46,997.13248	0-68,496.68382	0-17,121.82525	120,122.0897-268,844.677	0-13.04993681	276596000000-583658000000	18487.703963-104029677486
9	0-46,997.13248	0-159,825.5957	0-94,828.57029	0-120,122.0897	0-72.34204102	276596000000-583658000000	18487.703963-104029677486
10	0-72,400.98787	0-159,825.5957	0-94,828.57029	120,122.0897-268,844.677	0-13.04993681	59462.000000-583658000000	18487.703963-144280.609288
11	0-72,400.98787	0-159,825.5957	0-68,487.30098	0-268,844.677	0-72.34204102	276596000000-1802622.000000	104029677486-1583435.121865
12	0-46,997.13248	0-68,496.68382	0-42,146.03137	0-120,122.0897	0-13.04993681	59462.000000-276596000000	18487.703963-104029677486
13	0-21,593.27708	0-68,496.68382	0-17,121.82525	120,122.0897-268,844.677	0-72.34204102	276596000000-1802622.000000	170428.277041-1583435.121865
14	0-323,899.1563	0-738,242.0368	0-215,998.4108	120,122.0897-823,594.3294	0-72.34204102	59462.000000-583658000000	17362.890758-144280.609288

15	0-167,665.4457	350,094.1619-540,362.728	0-122,486.9037	560,569.7521-823,594.3294	0-13.04993681	59462.000000-276596000000	17362.890758-18487.703962
16	0-142,261.5902	0-254,959.8788	0-151,462.3002	0-417,567.2643	0-13.04993681	583658000000-1024512.000000	170428.277041-229167.619345
17	0-167,665.4457	0-254,959.8788	0-151,462.3002	120,122.0897-417,567.2643	0-13.04993681	59462.000000-1024512.000000	17362.890758-229167.619345
18	72,400.98788-167,665.4457	68,496.68382-254,959.8788	0-42,146.03137	268,844.677-417,567.2643	0-13.04993681	583658000000-1024512.000000	170428.277041-229167.619345
19	0-46,997.13249	0-159,825.5957	0-42,146.03137	0-268,844.677	0-13.04993681	59462.000000-1024512.000000	104029677486-299157.566585
20	0-46,997.13249	0-159,825.5957	0-42,146.03137	0-120,122.0897	0-72.34204102	59462.000000-1024512.000000	18487.703963-229167.619345
21	0-21,593.27708	0-159,825.5957	0-42,146.03137	0-120,122.0897	0-72.34204102	59462.000000-1024512.000000	18487.703963-299157.566585
22	0-21,593.27708	0-68,496.68382	0-17,121.82525	0-120,122.0897	0-72.34204102	583658000000-1802622.000000	299157.566585-789548.391876
23	0-21,593.27708	0-68,496.68382	0-17,121.82525	0-120,122.0897	0-72.34204102	583658000000-1802622.000000	26042.028720-789548.391876
24	0-21,593.27708	0-159,825.5957	0-42,146.03137	0-120,122.0897	0-72.34204102	59462.000000-1024512.000000	104029677486-299157.566585

Table III.3 present all the alternatives by giving its values of factors by using the superposition.

To normalize the values of performance table, we use the following equations:

- Positive influence: $Ni = (Ai-A_{min})/(A_{max}-A_{min})$
- Negative influence: $Ni = (A_{max}-Ai)/(A_{max}-A_{min})$

Table III.5: Normalization

Alternatives	Municipalities	Grid	Road	Railways	Slope	Population	Potential
1	0.10828025	0	0	0.08235294	1	0.15344093	0.06569873
2	0.10828025	0	0	0.08235294	1	0.3237828	0.09111874
3	0.15178571	0.26865672	0.13978495	0.17355372	0	0.3237828	0.09111874
4	0.22368421	0.26865672	0.13978495	0.28767123	0	0.3237828	0.09111874
5	0.22368421	0.26865672	0.25	0.44680851	0	0.3237828	0.09111874
6	0.18085106	0.26865672	0.13978495	0.28767123	0	0.3237828	0.09111874
7	0.29824561	0.42857143	0.40625	1	1	0.3237828	0.06569873
8	0.45945946	1	1	0.44680851	0	0.3237828	0.06569873
9	0.45945946	0.42857143	0.18055556	1	1	0.3237828	0.06569873
10	0.29824561	0.42857143	0.18055556	0.44680851	0	0.3237828	0.09111874
11	0.29824561	0.42857143	0.25	0.44680851	1	1	1
12	0.45945946	1	0.40625	1	0	0	0.06569873
13	1	1	1	0.44680851	1	1	1
14	0.06666667	0.09278351	0.07926829	0.14585104	1	0.3237828	0.09111874
15	0.12878788	0.12676056	0.13978495	0.14585104	0	0.15344093	0
16	0.15178571	0.26865672	0.11304348	0.28767123	0	0.56834544	0.14472814
17	0.12878788	0.26865672	0.11304348	0.28767123	0	0.56834544	0.14472814
18	0.12878788	0.26865672	0.40625	0.28767123	0	0.56834544	0.14472814
19	0.45945946	0.42857143	0.40625	0.44680851	0	0.56834544	0.18892948
20	0.45945946	0.42857143	0.40625	1	1	0.56834544	0.14472814
21	1	0.42857143	0.40625	1	1	0.56834544	0.18892948
22	1	1	1	1	1	1	0.49863009
23	1	1	1	1	1	1	0.49863009
24	1	0.42857143	0.40625	1	1	0.56834544	0.14472814

Table III.4 present the normalization table of the performance one since we can't apply the MCDA with the current values with contain ranges we applied the equation(*) and (**) to have it as scale from 0 to 1 .

3.4.4 **ELECTREI** Method

The purpose underlying the description of this method is rather theoretical and pedagogical. The method does not have a significant practical interest, given the very nature of real- world applications, having usually a vast spectrum of quantitative and qualitative elementary consequences, leading to the construction of a contradictory and very heterogeneous set of criteria with both numerical and ordinal scales associated with them. In addition, a certain degree of imprecision, uncertainty or ill-determination is always attached to the knowledge collected from real-world problems.

The method is very simple and it should be applied only when all the criteria have been coded in numerical scales with identical ranges. In such a situation we can assert that an action "a outranks b" (that is, "a is at least as good as b") denoted by aSb, only when two conditions hold.

On the one hand, the strength of the concordant coalition must be powerful enough to support the above assertion. By strength of the concordant coalition, we mean the sum of the weights associated to the criteria forming that coalition. It can be defined by the following concordance index (assuming, for the sake of formulae simplicity ,that $\sum_{j\in J} w_j = 1$where J is the set of the indices of the criteria):

$$c(aSb) = \sum_{\{j:g_j(a)\geq g_j(b)\}} w_j$$

(Where$\{j: g_j(a) \geq g_j(b)\}$ is the set of indices for all the criteria belonging to the concordant coalition with the outranking relation aSb.)

In other words, the value of the concordance index must be greater than or equal to a given concordance level, s, whose value generally falls within the range [0.5,1−minj∈Jwj],i.e.(aSb)≥s.

On the other hand, no discordance against the assertion "a is at leastas good as b" may occur. The discordance is measured by a discordance level defined as follows:

d(aSb)=max{j:gj(a)<gj(b)},gj(b)−gj(a),

This level measures in some way the power of the discordant coalition, meaning that if its value surpasses given level, v, the assertion is no longer valid .Discordant coalition exerts no power whenever d(aSb)≤v.

Both concordance and discordance indices shave to be computed for every pair of actions (a, b) in the set A, where a *f*= b.

It is easy to see that such a computing procedure leads to a binary relation in comprehensive terms (taking into account the whole set of criteria) on the set A. Hence for each pair of actions (a, b), only one of the following situations may occur:

- aSb and not bSa, i.e., aPb(a is strictly preferred to b)
- bSa and not aSb, i.e., bPa(b is strictly preferred to a)
- aSb and bSa, i.e., aIb(a is indifferent to b)
- Not aSb and not bSa, i.e., aRb(a is incomparable to b)

This preference-in difference frame work with the possibility to resort to incomparability, says nothing about how to sel9ect the best compromise action, or a subset of actions the DM will focus his attention on. In the construction procedure of ELECTREI method only one outranking relation S is matter affect.

Table III.6: Values of weights criteria

Factors	Municipalities	Grid	Road	Railways	Slope	Population	Potential
Weight	6	7	5	4	3	6	9
Normalizedweight	0.667	0.778	0.556	0.444	0.333	0.667	1

After applying the Electer I we find the discordance matrix and discordance matrices, the results showed in the tables below

Table III.7 : Matrices' de concordance

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	/	0.625	0.075	0.075	0.075	0.075	0.3	0.3	0.3	0.075	0.075	0.45	0.075	0.225	0.45	0.075	0,075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
2	1	/	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.075	0.45	0.075	0.6	0.45	0.075	0,075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
3	0.925	0.925	/	0.75	0.625	0.75	0.375	0.45	0.375	0.45	0	0.45	0	0.925	1	0.525	0,525	0.4	0.075	0	0	0	0	0
4	0.925	0.925	1	/	0.775	1	0.375	0.45	0.375	0.45	0	0.45	0	0.925	1	0.625	0,625	0.5	0.075	0	0	0	0	0
5	0.925	0.925	1	1	/	1	0.375	0.55	0.5	0.675	0.225	0.45	0.1	0.925	1	0.625	0,625	0.5	0.175	0	0	0	0	0
6	0.925	0.925	1	0.85	0.625	/	0.375	0.45	0.375	0.45	0	0.45	0	0.925	1	0.625	0,625	0.5	0.075	0	0	0	0	0
7	1	0.775	0.775	0.775	0.775	0.775	/	0.55	0.85	0.775	0.625	0.675	0.175	0.7	1	0.625	0,625	0.625	0.475	0.475	0.475	0.175	0.175	0.475
8	0.925	0.7	0.775	0.775	0.775	0.775	0.825	/	0.825	0.775	0.55	0.9	0.4	0.7	1	0.625	0,625	0.625	0.625	0.45	0.3	0.3	0.3	0.3
9	1	0.825	0.775	0.775	0.65	0.775	0.875	0.7	/	0.775	0.5	0.7	0.175	0.775	1	0.625	0,625	0.5	0.5	0.5	0.35	0.175	0.175	0.35
10	0.925	0.925	1	1	0.875	1	0.7	0.55	0.675	/	0.425	0.45	0.1	0.925	1	0.625	0,625	0.5	0.35	0.175	0.175	0	0	0.175
11	1	1	1	1	1	1	0.775	0.55	0.75	1	/	0.45	0.55	1	1	1	1	0.875	0.725	0.625	0.625	0.45	0.45	0.625
12	0.775	0.55	0.625	0.625	0.625	0.625	0.775	0.725	0.775	0.625	0.55	/	0.275	0.55	0.85	0.625	0,625	0.625	0.625	0.55	0.4	0.275	0.275	0.4
13	1	1	1	1	1	1	0.9	1	0.9	1	1	0.9	/	1	1	1	1	1	1	0.9	0.9	0.9	0.9	0.9
14	0.85	0.85	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.075	0.45	0.075	/	1	0.55	0,075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
15	0.7	0.55	0.2	0.2	0.075	0.2	0	0.075	0	0.075	0	0.225	0	0.55	/	0.2	0,35	0.225	0.075	0	0	0	0	0
16	0.925	0.925	0.875	0.85	0.625	0.85	0.375	0.45	0.375	0.45	0	0.45	0	0.925	0.875	/	1	0.875	0.225	0.375	0.15	0	0	0.375
17	0.925	0.925	0.725	0.85	0.625	0.725	0.375	0.45	0.375	0.45	0	0.45	0	0.925	0.875	0.85	/	0.875	0.225	0.375	0.15	0	0	0.375
18	0.925	0.925	0.85	0.85	0.75	0.85	0.5	0.45	0.5	0.45	0.125	0.575	0	0.925	1	0.85	1	/	0.35	0.5	0.325	0	0	0.5
19	0.925	0.925	1	1	1	1	0.825	0.7	0.825	1	0.55	0.725	0.1	0.925	1	1	1	1	/	0.825	0.675	0	0	0.675
20	1	1	1	1	1	1	1	0.7	1	1	0.625	0.825	0.175	1	1	1	1	1	0.775	/	0.625	0.175	0.175	0.85
21	1	1	1	1	1	1	1	0.7	1	1	0.625	0.825	0.325	1	1	1	1	1	1	1	/	0.325	0.325	1
22	1	1	1	1	1	1	1	1	1	1	0.775	1	0.775	1	1	1	1	1	1	1	1	/	1	1
23	1	1	1	1	1	1	1	1	1	1	0.775	1	0.775	1	1	1	1	1	1	1	1	1	/	1
24	1	1	1	1	1	0.825	1	0.7	1	1	0.625	0.825	0.325	1	1	1	1	1	0.775	1	0.775	0.325	0.325	/

As result the alternatives who had 1 are the best in terms of the concordance factor .

Table III.8 : Matrices' of discordance

	1	2	3	4	5	6	7	8	9	10	11	12
1	/	0.1703419	0.2686567	0.2686567	0.3644556	0.2686567	0.9176471	0.3644556	0.9176471	0.4285714	0.9343013	0.9176471
2	0	/	0.2686567	0.2686567	0.3644556	0.2686567	0.9176471	0.3644556	0.9176471	0.3644556	0.9088813	0.9176471
3	1	1	/	0.1141175	0.2732548	0.1141175	0.8264463	0.8602151	0.8264463	0.2732548	0.9088813	0.8264463
4	1	1	0	/	0.1591373	0	1	0.8602151	1	0.1599147	1	0.7313433
5	1	1	0	0	/	0	1	0.75	1	0.1599147	1	0.7313433
6	1	1	0	0.0428331	0.1591373	/	1	0.8602151	1	0.1591373	1	0.7313433
7	0.9176471	0.02542	0.02542	0.02542	0.02542	0.02542	/	0.5714286	0.1612138	0.02542	0.9343013	0.5714286
8	1	1	0.02542	0.02542	0.02542	0.02542	1	/	1	0.02542	1	0
9	0.02542	0.02542	0.02542	0.02542	0.02542	0.02542	0.02542	0.8194444	/	0.02542	0.9343013	0.5714286
10	1	1	0	0	0.0694444	0	0.5531915	0.8194444	0.55	/	1	0.5714286
11	0	0	0	0	0	0	0.5531915	0.5714286	0.5531915	0	/	0.5714286
12	1	1	0.300575	0.300575	0.300575	0.300575	0.300575	0.59375	1	0.300575	1	/
13	0	0	0	0	0	0	0	0	0.5531915	0	0.531915	0.5531915
14	0.0416136	0.0416136	0.1758732	0.1758732	0.3009575	0.1758732	0.854149	0.9207317	0.854149	0.3009575	0.9088813	0.9088813
15	1	1	0.1703419	0.1703419	0.3009575	0.1703419	0.854149	0.8732394	0.854149	0.3018109	0.8465591	0.8732394
16	1	1	0.0267415	0.0718985	0.1591373	0.0290653	1	0.8869565	0.7123288	0.1591373	0.8552719	0.7313433
17	1	1	0.0267415	0.0948963	0.1591373	0.0520632	1	0.8869565	1	0.1694577	0.8552719	0.7313433
18	1	1	0.0229978	0.0948963	0.0948963	0.0520632	1	0.7313433	1	0.1694577	1	0.7313433
19	1	1	0	0	0	0	1	0.59375	1	0	1	0.5714286
20	0	0	0	0	0	0	0	0.59375	0	0	0.8552719	0.5714286
21	0	0	0	0	0	0	0	0.5714286	0	0	0.8110705	0.5714286
22	0	0	0	0	0	0	0	0	0	0	0.5013699	0
23	0	0	0	0	0	0	0	0	0	0	0.5013699	0
24	1	0	0	0	0	0	0	0.59375	0	0	0.8552719	0.5714286

	13	14	15	16	17	18	19	20	21	22	23	24
1	0.8552719	0.0442013	0	0	0	0	0.0442013	0	0.0442013	0.5714286	0.5714286	/
2	0.9343013	0.1703419	0.1397849	0.4149045	0.4149045	0.4149045	0.4285714	0.9176471	0.9176471	0.9176471	0.9176471	0.9176471
3	0.9088813	0.0927835	0.1397849	0.2686567	0.2686567	0.2686567	0.4285714	0.9176471	0.9176471	0.9176471	0.9176471	0.9176471
4	0.9088813	1	0	0.2445626	0.2445626	0.2664651	0.3076737	0.8264463	1	1	1	1
5	1	1	0	0.2445626	0.2445626	0.2445626	0.2445626	1	1	1	1	1
6	1	1	0	0.2445626	0.2445626	0.2445626	0.2445626	1	1	1	1	1
7	1	1	0	0.2445626	0.2445626	0.2445626	0.2445626	1	1	1	1	1
8	0.9343013	0.02542	0	0.2445626	0.2445626	0.2445626	0.2445626	0.2445626	0.7017544	0.7017544	0.7017544	0.7017544
9	1	1	0.8869565	0.2445626	0.2445626	0.2445626	0.2445626	1	1	1	1	1
10	0.8194444	0.02542	0.02542	0.2445626	0.0790294	0.0790294	0.2445626	0.2445626	0.5405405	0.8194444	0.8194444	0.5405405
11	1	1	0	0.2445626	0.2445626	0.2445626	0.2445626	1	1	1	1	1
12	0.7017544	0	0	0	0	0.15625	0.1612138	0.5531915	0.7017544	0.7017544	0.7017544	0.7017544
13	1	1	0.1534409	0.5683454	0.5683454	0.5683454	0.5683454	1	1	1	1	1
14	/	0	0	0	0	0	0	0	0.5531915	0.5531915	0.5531915	0.5531915
15	0.9333333	/	0.0621212	0.2445626	0.2445626	0.3269817	0.3927928	0.854149	0.9333333	0.9333333	0.9333333	0.9333333
16	0.8732394	1	/	0.4149045	0.4149045	0.4149045	0.4149045	1	1	1	1	1
17	0.8869565	1	0.0267415	/	0	0.2932065	0.3076737	1	1	1	1	1
18	1	1	0.0267415	0.0229978	/	0.2932065	0.3306716	1	1	1	1	1
19	0.8712121	1	0	0.0229978	0	/	0.3306716	1	1	1	1	1
20	1	0	0	0	0	0	/	1	1	1	1	1
21	0.8552719	0	0	0	0	0	0.0442013	/	0.5405405	0.5714286	0.5714286	0.5405405
22	0.8110705	0	0	0	0	0	0	0	/	0.59375	0.59375	0
23	0.5013699	0	0	0	0	0	0	0	0	/	0	0
24	0.5013699	0	0	0	0	0	0	0	0	0	/	0

As result the alternatives who had 0 are the best in terms of the discordance factor .

And after combining both tables we found that alternatives 1,9,8,12,15,14,17 are not comparable , however the others who has 1 in concordance and 0 in the discordance will be the best suitable sites and shown in the table after **Table III.8 .**

Table III.9: Classifications of Alternatives in Algeria.

Classifications	Alternatives	Wilayas Concerned
01	23-22	Msila-Djelfa -Medea
02	21	Tiaret-Medea-Tesimsilet
03	13	Laghouet -Djelfa
04	20	Tebessa-Khenchela
05	24	Tiaret - Saiida
06	11	Gherdaia-Ouargla-Djelfa-Elbayadh-Laghouat
07	19	Laghouat –Elbayedh-Tiaret
08	5—10	Ghardaia-Elbayedh-Laghouat
09	4	Adrar-Bechar-elbayedh
10	6	Gherdaia-Elbayedh-Adrar
11	2-7-3-16-18	Tramnrasset-Adrar-Ouargla

As result we can find that the alternatives 23-22 are the best sites in Algeria followed by 21,13,20,24,11,19 as second choice , 5-10,4,6 third choice and finally 2-7-3-16-18 as last choice .

3.5 Conclusion

Algeria, technically and economically is a great potential for potential power exploration. In the industrial scale is so promising, and by keeping this frequency, it can help the domestic electricity demand in the future.

ArcGIS is one of the best softwares to manipulate and create maps, import and export data in different formats .Arcgis is used to define location districts or find potential and perform many other tasks. Maps present several types of information about an area at once; ArcGIS finds hidden information by adding layers to a map and treating the ensemble.

After gathering the desired ArcGIS data, we finished by selecting 24 appropriate areas that have the most needed factors. These areas considered as candidates to select and rank by applying ELECTER 1 method.

General Conclusion

This study investigated the optimal location of potential biomass facilities in Algeria . In addition, an integrated multi-criteria analysis and Geographical Information System (GIS-ELECTER I) model in conjunction with a supply chain cost analysis were developed to determine the best candidate locations. The estimated biomass availability indicated that Algeria has an abundant biomass feedstock to operate biomass and energy facilities with The wooded area covers about 250 million hectares of woody areas and about 4.2 million hectares forests area.

The study focus on the methodology of determining the most appropriate locations. First of all, the suitable sites for biomass are selected and integrated by GIS. Then, the filtration constraints are used. The selection methodology also includes some alternative filtering process in order to determine the suitable sites.

For a better classification of the 24 polygons not definitively classified, having areas

Outranking methods are a type of MCDA methods that are well suited to land suitability assessment and to deal with spatial decision problems since they: permit to consider qualitative evaluation criteria (in addition to quantitative ones) for which preference intervals ratios have no sense;

The MCDA method requires nu- merical values but it is not possible to associate with each polygon a unique value for each factor. To overcome this difficulty we resort to descriptive statistical values and spa- tialized scenarios. We apply this process again to new smaller sites inside these classified polygons, created through a vector grid, to obtain a more specified and complete suitability classification.

Algeria is a default approximation that allows concluding to deposits far larger than the estimated values obtained. The results of this study highlight the real interests of energy valorisation of biomass in Algeria, the potential of resources for the production of energy from biomass in 2015 is 14.55 TWh and it will reach 92.63 TWh by 2050, without taking into consideration the constraints of profitability of the installations.

Therefore, although land plots excluded by the hard constraints or poorly classified by the ELECTRE I model are clearly alternatives to be excluded, land plots with a good classification are not necessarily politically acceptable alternatives for siting a plant.

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