# Methodology for measuring the economic development of biomass value chains, in West Region, Romania

## Strategic Case Study

## -Final report-

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# 1. Introduction

Clean, renewable energy resources for heat and electricity are an important part of the solution to the climate, economic, environmental, and security challenges posed by our fossil fuel use. Bioenergy—the use of biomass—can provide a sustainable, low-carbon alternative to fossil fuels while enabling communities to benefit from local resources.

According to the National Sustainable Development Strategy Romania 2013-2020-2030 (developed by the Ministry of Environment and Sustainable Development, in collaboration with National Centre for Sustainable Development, in Bucharest 2008) on rural development, the main national objectives are:

- Developing a competitive environment in agriculture, forestry and fisheries based on knowledge and private initiative;
- Maintaining quality and diversity of rural space and forest estates in ways that maintain a proper balance between human activities and the conservation of natural resources.

Bio-economy development with the use of biomass is one of the answers in achieving the objectives of rural development that Romania wants to achieve, by creating a new industry that connects the interested actors of the supply chain, as well as improving competitive strengths in agriculture and forestry by improving the competitive performance of commercial and semi-subsistence farms, to encourage cooperation and association among them in line with sustainable development principles, to support the pooling of producers into integrated production chains.

The development of a biomass- based industry will help achieve the main national objectives by encouraging the diversification of rural economy, to improve the quality of life in rural areas, by diversifying non-agricultural activities and by developing a significant contribution to the objectives of Europe 2020 Strategy. In the European Bio-economy Strategy, at the end of November 2012, The Committee of the Regions has underlined the important role of bio-based products and a bio-based society in Europe.

Bio-based industries are a cornerstone of the EU bio-economy in generating growth and jobs. Although bio-based products and biofuels currently only represent about 1% of the 22 million jobs generated by the European bio-economy today, bio-based industries are expected to grow more rapidly and substantially than more traditional bio-economy sectors (Festel, G.,2011, “Presentation at the 4$^{th}$ Annual European Forum for Industrial Biotechnology & the Biobased Economy”, Amsterdam, 20 October 2011).

To reach the potential and ensure competitiveness of Europe’s bio-based industries and their value chains in global market, a number of hurdles need to be overcome:

- Biomass feedstock will need to be sourced in Europe in a sustainable way and without unintended negative consequences, such as loss of biodiversity, indirect land use change or negative effects for food security.
- Different players, including agriculture and forestry, industries and waste managers need to set-up cooperation along full value chains, with the aim of increasing resource-use efficiency by reducing the current fragmentation and isolation of these sectors.
- New processes need to be developed to separate, pre-treat and convert this feedstock into bio-based products, biofuels, and generating energy.
- Significant investment in up-scaling of technology and infrastructure is needed to assess to relative merits of radically different technology options and to identify winning options. This will mean upgrading existing Bio-based industries (e.g. pulp and paper mills, biofuels, starch, chemical, etc) and developing new and scalable biorefinery models.

The bio-based industry value chains (ranging from primary production to industrial users or to consumer brands) are complex and so are the technological and innovation challenges that need to overcome to unlock its socio-economic and environmental potential. Only a strong strategic vision, a well-structured and defined research and a long-term stable financial commitment can help to achieve the necessary breakthroughs and provide sufficient certainty.

## 2. Natural background of the area

The Western Development Region, named shortly Western Region, is one of the eight regions of development from Romania. It was constituted in this shape on the 28th of October 1998, by the association of the counties Arad, Timis, Caras-Severin and Hunedoara. Historically speaking, the region includes a part of Banat province (3 of the 4 counties), as well as the land of the old Dacia, with the capital city in Sarmizegetusa, nowadays Hunedoara county.

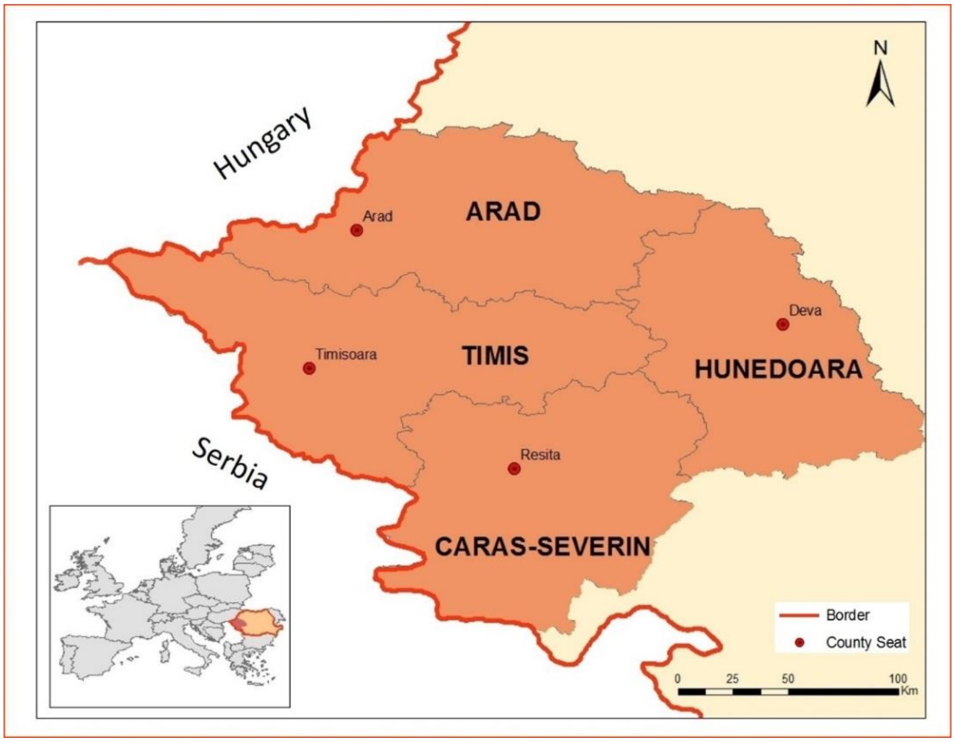
The Western Region is part of the Euro region Danube- Kris- Mures- Tisa, the Euro region formed of the four counties of the Western Region, three counties of Hungary (Bacs- Kiskun, Bekes and Csongrad) and the autonomous region of Serbia, Vojvodina. The Euro region was founded in 1997, based on a collaboration protocol.

Geographically speaking, the Western Development Region is situated in Western side of Romania, at the border with Hungary and Serbia (map 1). It occupies an area of 32.034 km$^2$, about 13 % of the total area of Romania. The size of the region is comparable to countries like Belgium or the Republic of Moldavia.

Administratively, the 4 counties that form the Region have the following characteristics:

| County | Occupied area of the counties | Administrative capital | No. of inhabitants | Occupied area of the cities |
|---|---|---|---|---|
| Timis | 8,697 km$^2$ | Timisoara | 336,089 | 129.2 km$^2$ |
| Arad | 7,754 km$^2$ | Arad | 162,984 | 116.5 km$^2$ |
| Caras-Severin | 8,514 km$^2$ | Resita | 73,282 | 198.34 km$^2$ |
| Hunedoara | 7,063 km$^2$ | Deva | 56.647 | 34 km$^2$ |

*Table 1: Administrative features of the region's counties*




*Map 1: Administrative map of West Region*

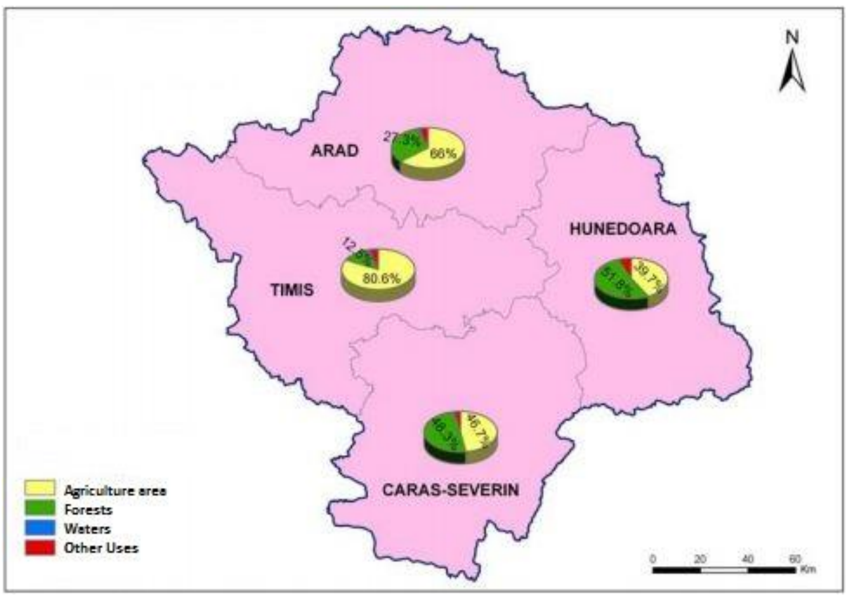
The position of Arad, Timis and Caras- Sverin counties next to the border offer the region a higher degree of openness, the presence of the Danube as a partial frontier with Serbia offer a plus of contact and openness between the two countries.

Considering the landscape of the Region, according to some opinions, it is characterized under morphological report, by the big diversity of the landscape, descending in steps from East to West (R.Munteanu &all, 1970). This morphologic model is disposed in the shape of a semicircle, with mountains on the outside, as we move towards the inside of the semicircle being arranged hills, foothills and high plains and in the center there can be found the low plain of Timis.

The Western Region presents individualized climatic features, due to geographic position, also due to the variety of the landscape. These characteristics determine major features and local nuances of the climate. The biggest part of the region is found under the influence of temperate continental climate, with sub- mediterranean influences.

As a result of geomorphological and climate features, the Western Region differentiate trough a distinct biogeography, following the natural setting of vegetation and fauna, depending on altitude. At the same time, considering the latitude zonality of vegetation, the largest part of the region overlaps forested steppe zone, prevailing the herbaceous vegetation, small shrubs, with forested subareas.

An important resource that Western Region disposes is the forest resources (forest and other lands with forest vegetation). 34,3% of the total area of the Region is forested; Hunedoara and Caras-Severin counties present big interest in this sense, the forested area occupying about 50% of the area of the counties. The use of lands in the region is highlighted in the following map (map 2).



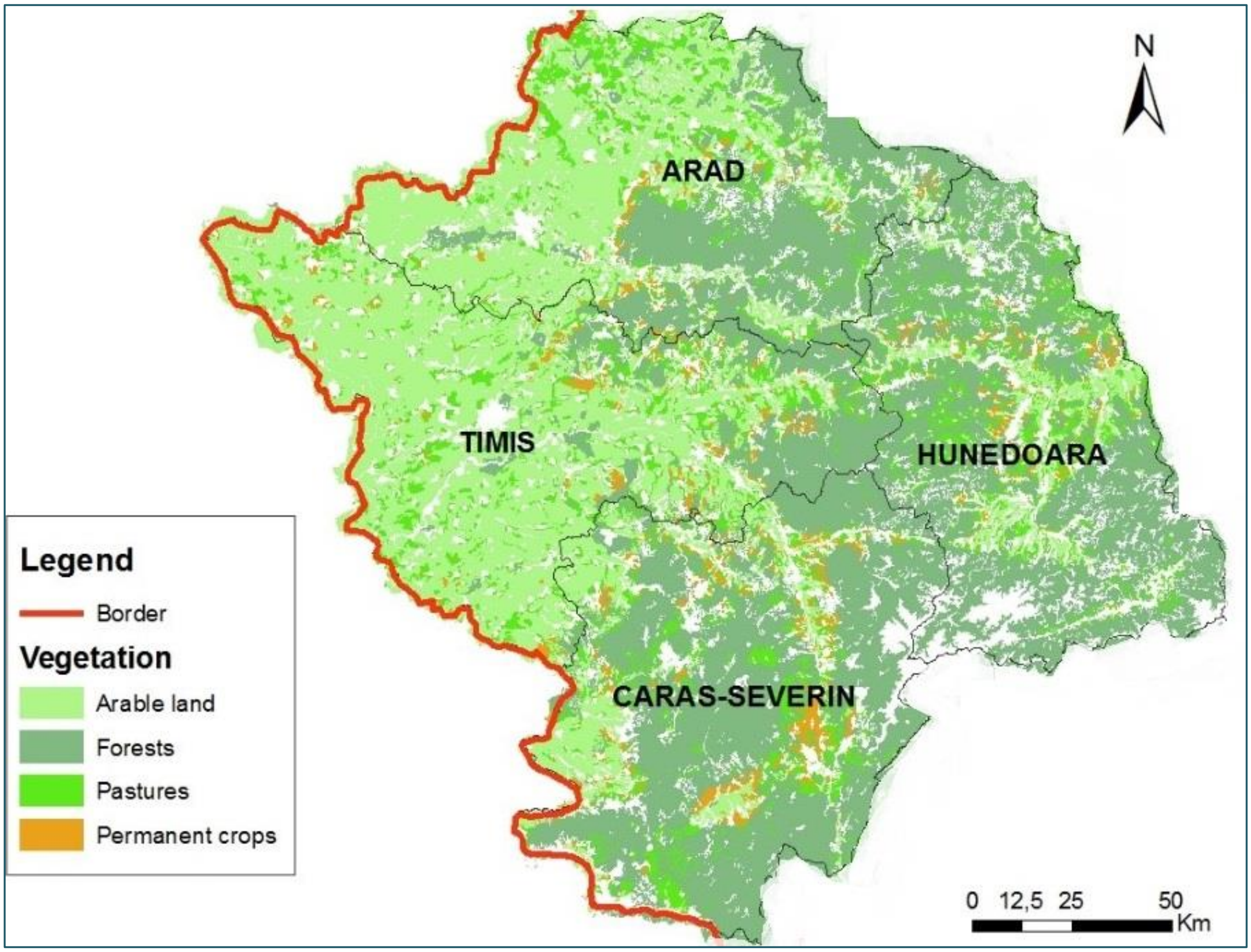

*Map 2: Use of lands in Western Region of Romania (source: Regional Development Agency)*

According to the map, the land fund of the Region is structured as presented in the following table:

| | Agriculture | Forests or forested vegetation |
|---|---|---|
| Timis | 80.6% | 12.5% |
| Arad | 66% | 27.3% |
| Caras- Severin | 46.7% | 48.3% |
| Hunedoara | 39.7% | 51.8% |
| West Region | 59% | 34% |

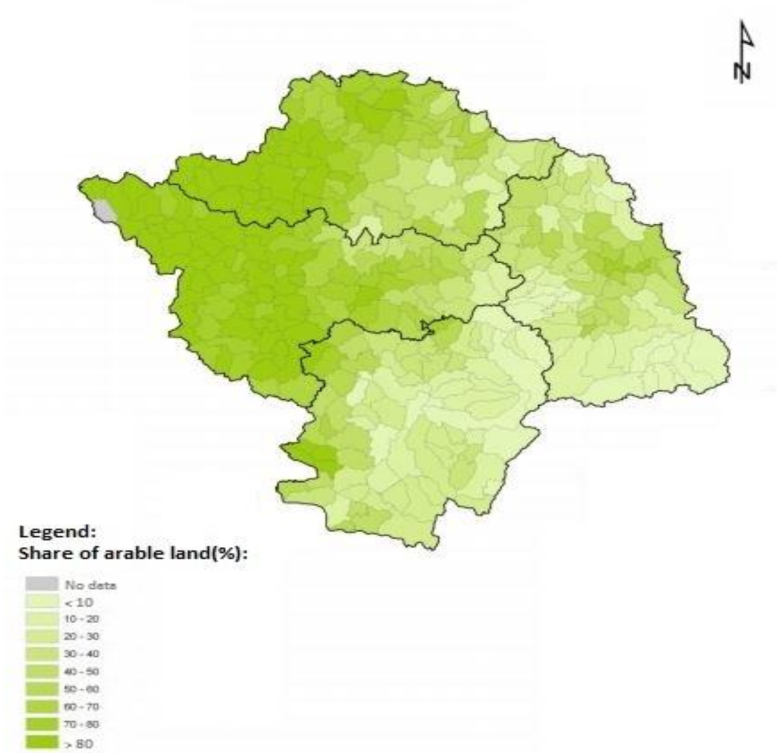
*Table 2: The use of land in Western Region in 2007*

The following map (map 3) presents the type of used vegetation in the Western Region, by categories: arable land, forests, pastures and permanent crops.




*Map 3: Vegetation, by types, in the Western Region*

The share of arable land for the year 2011 is presented in the map bellow (map 4), the share of forested land for the same year is presented in the following graphic.




*Map 4: Share of arable land*

For the forested share, at national level, the Western Region is the second richest in terms of natural forested resources (Graph 1).


*Graph 1: Share of forested area in the development regions of Romania*

Considering the geographic features of the region, the use of biomass for bio-economy development, comes naturally. In order to create a business model for the use and integration of biomass supply- chain, this study will focus on providing an overview on the current state of biomass availability and usage in West Region of Romania, as well as providing brief presentation of roadblocks for further development of biomass supply chains. Also, the focus will be on developing transnational interactions that could be a solution to biomass development in the region. In that sense, the target of the next chapters is to assess the energetic potential of existing biomass in Western Region, and the necessary features of the supply chain, needed in order to develop a sustainable business in biomass field.

# 3. Assessment of the existing biomass potential (Western Region)

## 3.1 Primary and secondary agriculture residues

In order to highlight the energy potential of primary agriculture residues, the study will focus on presenting the production of the primary cultures. The tables bellow present the surfaces, type of use, and production/ha.

| | Arad | Caras-Severin | Hunedoara | Timis |
|---|---|---|---|---|
| Occupied area of the counties | 775409 | 851976 | 706267 | 869665 |
| Agriculture surface | 510624 | 397276 | 280377 | 698638 |

| | West Region | Arad | Caras-Severin | Hunedoara | Timis |
|---|---|---|---|---|---|
| Arable | **1090197** | 349856 | 127226 | 79615 | 533500 |
| Pastures | **550236** | 126109 | 184036 | 117566 | 122525 |
| Grassland | **210541** | 25495 | 73557 | 82274 | 29215 |
| Vineyards and nurseries | **8573** | 3577 | 768 | - | 4228 |
| Orchards and nurseries | **27368** | 5587 | 11689 | 922 | 9170 |

*Table 3: Agricultural surface by use categories (ha) (source: Vintila, T., Biofuels and renewable resources, 2013)*

Considering the cultivated area, in the following table will be presented the medium production/ hectare for each kind of culture.

**Main crops and crops residues in West Region**

| Culture | | West Region | Arad | Caras-Severin | Hunedoara | Timis |
|---|---|---|---|---|---|---|
| Wheat | ha | 242244 | 75440 | 13896 | 6349 | 146559 |
| | Production t/ha | 4.004 | 4.221 | 3.308 | 3.707 | 3.971 |
| Maize | ha | 288660 | 101201 | 33927 | 20578 | 132954 |
| | Production t/ha | 3.498 | 3.699 | 3.461 | 3.872 | 3.295 |
| Barley | ha | 43510 | 9126 | 1545 | 2182 | 30657 |
| | Production t/ha | 2.661 | 3.184 | 2.887 | 1.341 | 2.587 |
| Sunflower | ha | 44842 | 12582 | 3561 | 54 | 28645 |
| | Production t/ha | 1.866 | 1.726 | 1.426 | 0.722 | 1.985 |
| Sugar beet | ha | 641 | 627 | - | 14 | - |
| | Production t/ha | 36.476 | 36.778 | - | 22.929 | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| Vines | ha | 5,391 | 1,491 | 532 | - | 3368 |
| | Production t/ha | 0.005576 | 0.005617 | 0.002748 | - | 0.006005 |

*Table 4: T/ha of the main cultures (source: Vintila, T., Biofuels and renewable resources, 2013)*

According to the Ministry of Environment and Water Management, in the paper "Code of good agricultural practices- For water protection against pollution caused by nitrates from agricultural sources", the rate of productivity in terms of biomass production for each type of culture is given by the following rate:

| | Wheat | Barley | Oat | Corn grain | Sun Flower | Sugar Beet | Potatoes | Vegetable |
|---|---|---|---|---|---|---|---|---|
| Grain : straw | 1:1.3 | 1:1 | 1:1.5 | 1:1.6 | 1:3 | 1:1 | 1:0.5 | 1:1.5 |

*Table 5: Tons of primary agriculture production and the corresponding quantity of secondary harvest*

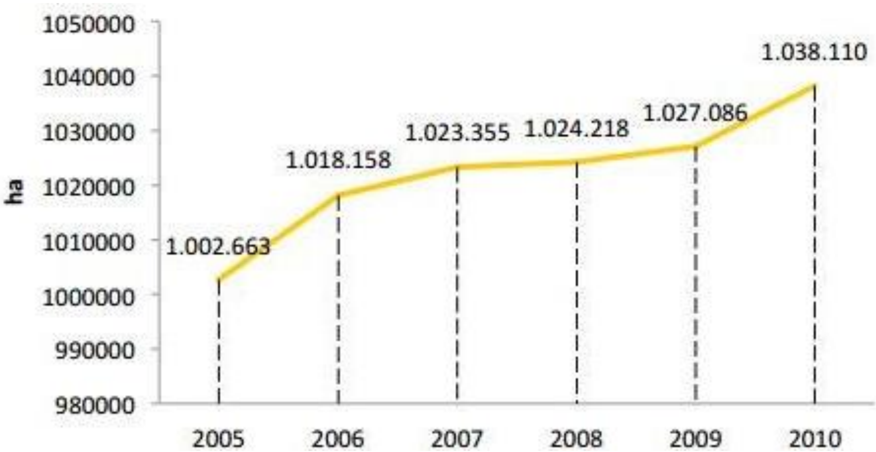
Due to technology development, the machineries used in agriculture nowadays are separating directly the primary agriculture production of the secondary harvesting. Considering the use of agriculture land- mostly for food production- the interesting solution for biomass use and development are the secondary agriculture residues. In this terms, biomass use will develop a new industry, new jobs and assessment of a full potential of economic opportunity, that hasn't been reached in Romania.

## 3.2 Wood biomass

The Western Region of Romania is a diverse land, with a lot of forested areas. Mostly, we can find this areas in the Caras-Severin and Hunedoara counties, but there can be found in smaller regions in Arad and Timis counties.

In this sense, the study will focus its attention on the forestry areas of the region, firstly in terms of used land, and then on the volume of wood that can be reached for biomass use. Most of the forests are used for furniture production and some of them are used for heating, mostly in the rural areas.

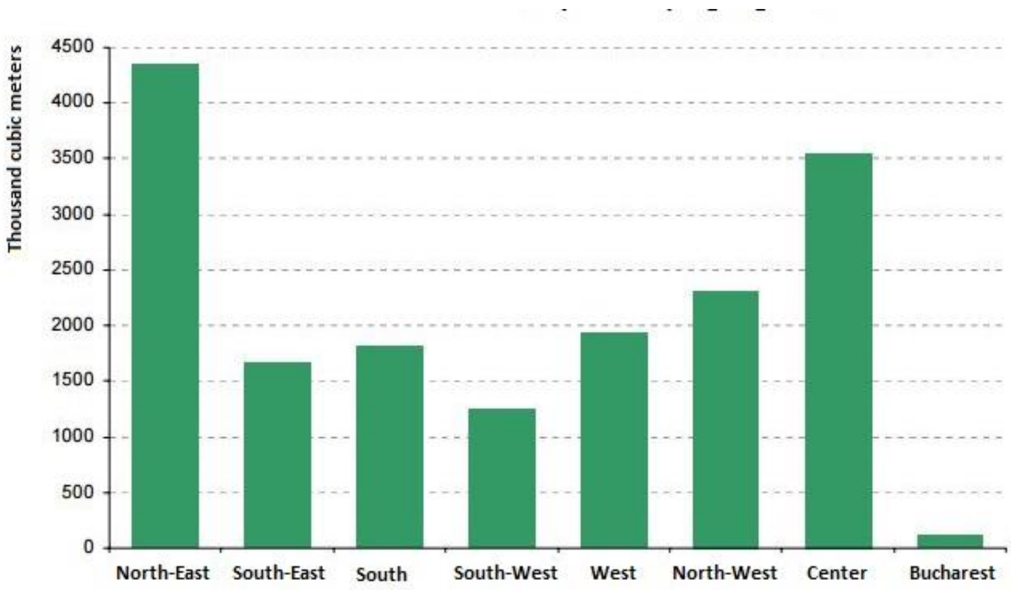
As it is shown in the Graph 1 above, the Western Region is one of the richest forested region of Romania. There are about 1030.5 thousand hectares (at the end of 2009, according to the National Statistical Institute) forested area and is growing in this sense, since 2005 (see the graphic below).




*Graph 2: Evolution of forested areas in the Western Region (2005-2010), source: Territorial Statistical Institute*

According to Brad M., in the thesis “RESEARCH ON HIGH RECOVERY OF SMALL DIMENSIONS WOOD”, 2005, the medium volume of forested area in the Region is about 230 $m^3$ /ha. This means that there are about 23701.5 thousand $m^3$ of wood in the Western Region Area.

Even though the Western Region is one of the richest wood areas of Romania, the following graphic will show that the region is one of the least harvested, which means that the forestry level is healthy and ready to be used for different alternatives, that won’t harm the natural environment.




*Graph 3: Volume of wood harvested in the Developing Regions of Romania, source: The National Statistical Institute*

According to the National Institute of Statistics, 780 ha are used for forest artificial regeneration, which means that 179400 $m^3$ of forest can be used for biomass.

The most interesting part of the forest for biomass use, with the least expensive operations, are the by-products resulted after harvesting, as well as the wood of small dimensions. 5% to 10% of a forest are residues, according to the forestry regional operators (National Institute of Forest Use). The small dimensions wood refers to trees that have dimensions: 25-35 cm diameter, 2-3 m height. These kind of wood is easy to access, as well as it is easy to process, making it cheaper.

Considering the total forested area, it results that 51525 to 103050 ha are surfaces of by-products that can be used in biomass exploitation. This exploitation can reach to 23701.5 thousand $m^3$ of wood to be used as biomass supply for pelleting and briquetting.

## 3.3 Energy crops

Energy plants are plants used for manufacturing biofuels such as biodiesel, bioethanol, or by combustion, for heat or electricity generation. These crops, as EU regulations state, are grown with minimal financial costs, as well as minimal costs for harvesting.

In Europe, including Romania, the growth of energy plants hos overcome the experimental stage, as there are large cultures of energy plants, with big density on hectare (area). Here, we can include woods culture, like poplar or willow, but also herbage from the temperate-continental climate, like Miscanthus.

In the Western Region the most commonly energy crops developed are of willow and Miscanthus. The fields of Timis and Arad counties are considered to have very fertile soil, used a lot in agriculture, and more recently, with energetic plants, like the willow or Miscanthus. In the two counties, there are about 500 ha planted with this energetic cultures. One hectare of willow produces 20 tons with 0% humidity or up to 35 tons with humidity of 35% - 40%; from this we can deduct that the region produces up to 17,500 t of willow (for further analysis we will consider a smaller amount of willow as directly accessible, due to lack of references sources).


*Example of Willow culture in Duestii Noi, Timis county*

*Miscanthus in Arad, after 3 years of production*

The full process of willow, from seeding, until is cropped:



Nevertheless, another energetic crop to be taken in consideration for the biomass industry is Paulownia. At the moment, the use of Paulownia implies only as a decorative plant, it can be found in several parks of different cities of the Western Region, but not used for its energetic component.

The growth of energy plants is still at its very early phases, in Western Region, and in all Romania. We consider that the plantation of energy crop will grow as soon as bio-economy is going to be developed in our country. This study case is showing the need of increasing bio development and the use of energy crops.

# 4. Energetic potential of biomass use

For the theoretical energetic potential for each type of biomass, have been taken in consideration the total production for each type of biomass (presented in the chapters above), adding the theoretical energetic capacity for each kind of biomass. The final results are presented in MWh/t.

It is also presented the assessment of the technical and achievable energetic potential.

| **Type of biomass** | **Tons of residues produced yearly (t)** | **Theoretical Energetic Potential (MWh/t)** | **Technical Energetic Potential (MWh/t)** | **Achievable Energetic Potential_2020 (MWh/t)** |
|---|---|---|---|---|
| Wheat straws | 1,262,817 | 5,139,669 | 2,569,835 | 2,569,835 |
| Maize residues | 1,616,496 | 8,858,398 | 4,429,199 | 4,429,199 |
| Barley straws | 113,126 | 452,504 | 226,252 | 226,252 |
| Sun flower | 242,146 | 1,063,024 | 531,512 | 531,512 |
| Sugar beet | 23,396 | 21,005 | | |
| Wood residues | 1,400,000 | 6,020,000 | 3,010,000 | 3,010,000 |
| Energetic willow | 10,000 | 57 | 57 | 57 |
| Miscanthus | 2,000 | 8.8 | 8.8 | 8.8 |
| **Total Energy Potential (MWh)** | | **21,661,874** | **10,830,937** | **10,830,937** |

*Table 6: Energy Potential, by source*

The results show as a total theoretical potential for the region is almost 22 TWh, while an achievable potential by 2020 is about **11 TWh/year**. This means, that by 2020, the West Region could benefit from the development of this new sector, reaching up to a yearly economic value of **1 billion 210 million Euros/year**, considering a price of 0,11Eur/kWh.

## 5. Assessment of the biomass potential with the use of non-utilized lands

For the assessment of the potential of biomass, the first focus stopped on the amount of land left for non-usage, or is used improperly. For this assessment, it was taken in consideration that we know that 7% of the total land is unused (*Image 2: Use of lands in Western Region of Romania*).

Next, the calculations were made by taken in consideration the specific use of lands (*Table 2*):

- Arad county, 66% of the total land is used for agriculture, 27.3% forests of forested vegetation
- Timis county, 80.6% of the total land is used for agriculture, 12.5% forests of forested vegetation
- Caras- Severin county, 46.7% of the total land is used for agriculture, 48.3% forests of forested vegetation
- Hunedoara, 39.7% of the total land is used for agriculture, 51.8% forests of forested vegetation

We considered not changing the direct purpose of the land, but using energetic crops for the reforestation. The results are presented in the table below:

| Possible use | Arad | Caras-Severin | Hunedoara | Timis | Western Region |
|---|---|---|---|---|---|
| Agriculture (MWh/year) | 496.07 | 385.66 | 271.78 | 679.44 | 1,832.97 |
| Energy crops (MWh/year) | 1,689.26 | 3,283.81 | 2,919.45 | 867.49 | 8,760.01 |
| **Total theoretical potential (MWh/year)** | 2,185.33 | 3,669.47 | 3,191.24 | 1,546.94 | 10,592.98 |

*Table 7: Energy Potential, by the use of non-utilized lands*

Considering the results presented in the previous chapter (*Energetic potential of biomass use*), and the results of the assessment of the lands without use, or improperly used, we can tell that the total energetic potential of the region doubles, reaching to **22 TWh/year** of energy, by using only the wastes of agriculture and forests, as well as using properly some lands that are currently underused.

The theoretic economic impact of the energetic potential will reach up to **2 billion 420 Million Euros/year**, for **22 TWh/year**. The numbers were calculated considering the current price of energy in Romania, and is referring only to the energy that can be produced.

Nevertheless, it has to be taken in consideration the costs of production, and also the costs of human resources. Also, this amount of energy would reach a need of creating new district heating systems plants, at the moment the only working plant that can use biomass is situated in Timisoara, the administrative capital of the Region.

Another possibility would be to use the biomass for the traditional heaters in the country side of the region, which is currently using only chopped wood as an energy resource. Biomass use will have a great impact mostly in the rural areas, creating a sustainable new industry in these disadvantage areas.

# 6. Assignment of an economic value for each type of biomass

For the determination of the economic value for each type of available biomass, the methodology of working was market research. In this sense, the data presented bellow followed a 6 month period of research, on internet (different selling websites- see reference no 6 and 7), but also by consulting with experts in this field and with specialized companies. Also, another important part of the process of research is to find out the price of the raw material without transport included. To get a clearer image on the available market, there has been organized a call-center, through which we found out that most of market prices include transport costs. Regardless of this aspect, the costs presented in this study are to be taken in consideration without transport included.

**The costs of raw material are influenced by the season. In this case, the prices were analyzed over a specific timeline, but can be the subject of some features of availability (if most of the raw material was sold, then we will find variations of costs). For a database more anchored in reality it is recommended a deeper analysis.**

The costs for biomass differs, depending by the source of biomass - agricultural, forest, energy crops-, but also it depends of the amount of residues that is to be bought- for 1t of biomass, the price is different than for 200 kg, for example.

Considering all the above, the costs of raw materials is going to be separated into different categories, depending of their source:

5.1 Costs for agricultural wastes

a. Straws from wheat, hay
b. Maize wastes
c. Sun flower wastes

5.2 Costs for forestry wastes and sawdust

a. Forest waste
b. Sawdust

5.3 Costs for energetic crops

a. Energetic Willow
b. Mischantus

## 6.1 Costs for agricultural wastes

a. Straws from wheat, hay

**Wheat**, Hay /by the side of the road:

1 Kg: 0.05 €

**1 t: 50 €**

b. Maize wastes

**Maize**/ by the side of the road:

1 kg: 0.12 €

**1 t: 120 €**

c. Sun flower wastes

**Sun Flower**/ by the side of the road:

1 kg: 0.07 €

**1 t: 70 €**

Nevertheless, we have to consider that in almost all situations Romania- including the Western Region, these residues following the agricultural activity are left on the fields to dry and at the end of the season they are burnt.

**The costs for all the agricultural residues, taken directly from the fields is 0 €.**

## 6.2 Costs for forestry wastes and sawdust

a. Forest waste

**Forest residues**/ after the process:

**1 m$^3$: 15 €**

b. Sawdust

**Sawdust**/ after the process:

1 kg: 0.1 €

**1 t: 110 €**

The costs for wood change from a year to another, depending on the process of reforestation. The prices presented above are the result of market research. But all this prices can change if the distributor of the wood is the National Forestry Administration.

Wood residues are less expensive, if the wood is bought directly from the National Forestry Administration:

**1 m$^3$: 7.5 €**

## 6.3 Costs for energetic crops

For energetic crops, the market is not yet developed, so the indicative costs presented below where accessed by phone, from the known specialists and cultivators of the area.

a. Energetic Willow

**Energetic Willow**/ by the side of the road:

**1 t: 35 €**

b. Miscanthus

**Miscanthus**/ by the side of the road:

**1 t: 30€**

As stated above, the market of energetic crops is still not well defined and access to providers is quite limited, so the costs are promotional, but specialists estimate that in the following years the costs are going to stabilize at about 50 €/t, as the resource begins to be sought and to be an integrated part of the relatively stable value chains.

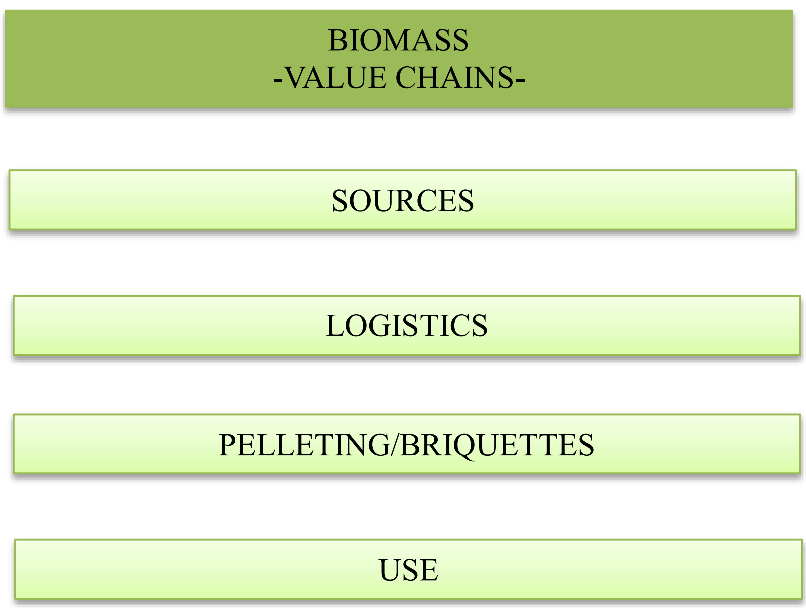
# 7. Determination of the mobility potential

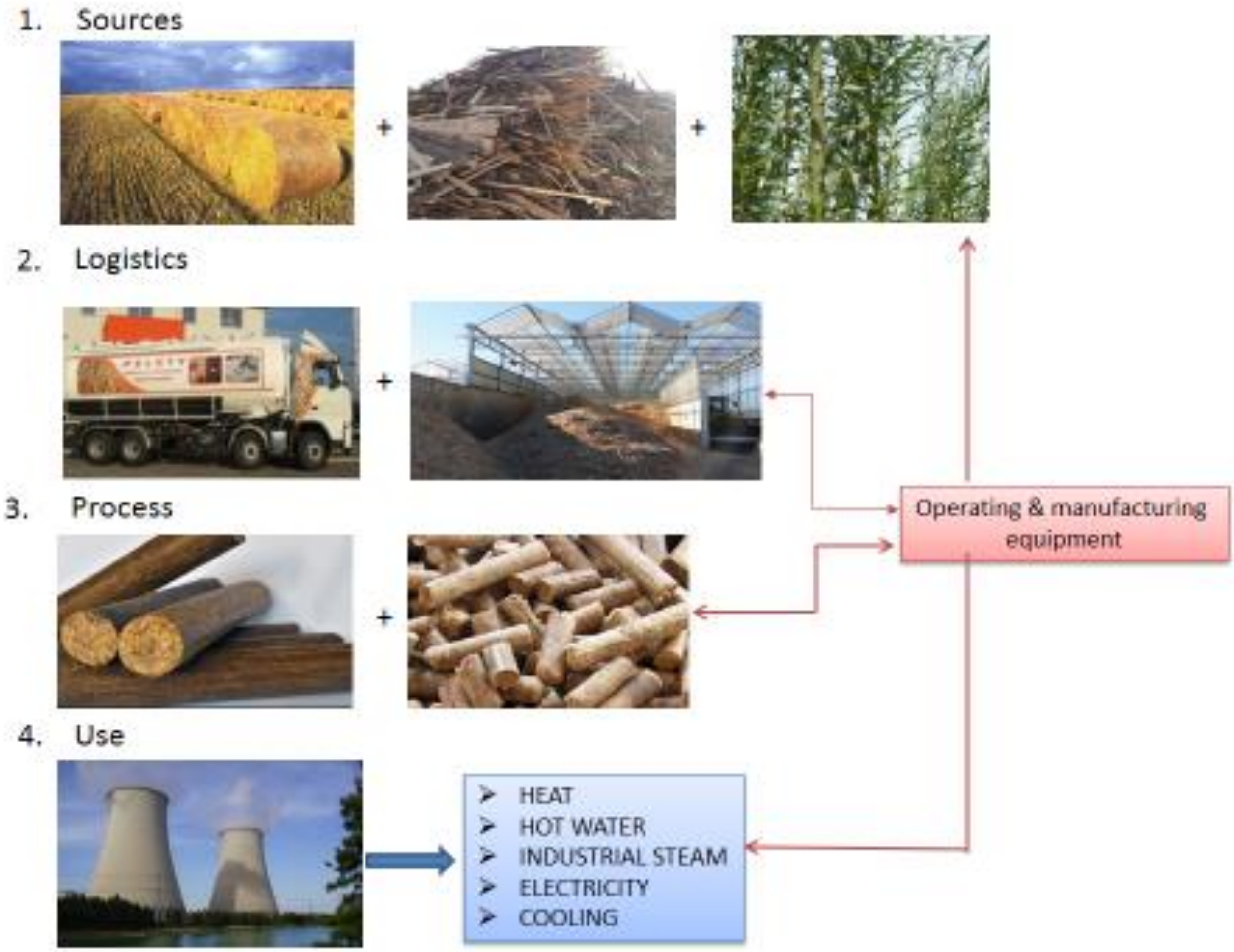
The study has focused so far on biomass- existing and potential, determine an economic value for each kind of biomass, and determine the possibility of creating an economic environment by integrating the biomass in the value chain.

Keeping this in mind, the study will focus on determining value chains, assignment of an economic value to each part of it, and determining the mobility potential, in order to determine an equation for logistic analysis.

## 7.1 Value Chains

The logical steps towards the use of biomass are depicted below:






In the image above, we have determined the sources, the logistics, the process and the usage.

As the value chain has been established, further we will focus on determining the economic value of each part of the chain (the economic value of the sources has been determined in the chapter above).

## 7.2 Economic value of the logistic component

The logistic component refers to:

1. Transport 1 (from the raw material source, to the processer) ,
2. Storage,
3. Transport 2 (from the processer, to the user).

The transportation costs can vary due to the distance from the source, to the processer, and the distance from the processer, to the user. But after researching the available market, the most common price is given by the distance of transportation, and by the quantity to be transported. So, for a better economic value for transportation, the distance to be transported has to be in a range of 300 km, and the average quantity to be transported is of 7.5 t.

So, an average price for **transportation** has been establish to be **0.1 €/ t*km.**

The storage component is part of the necessary logistic to create a sustainable chain of bio-economy. The storage is an important component, especially when thinking about wood biomass, or energetic crops. The agricultural residues are commonly stored on the fields, after the harvest. Commonly, the storage doesn't represent the main issue in the value chain, because the developers of raw material have already a storage unit.

*Example of field storage*

Considering the needed logistic, we will take in consideration for developing a sustainable value chain for bio-economy development the transportation.

The difference between **Transport 1** and **Transport 2** is given by the volume of the transported material. For straws, for instance, the price will be **6 time less** for the same amount transported from the processer to the user, due to volume consideration (same amount of raw material occupies 6 time more space in a trailer, then the same amount processed).

Even if the costs for transport is the same, **the difference between Transport 1** (from the raw material source, to the processer) and **Transport 2** (from the processer, to the final user**) is given by the volume** of the material.

## 7.3 Economic value of the process

Maybe the most important part of the economic chain is the processing of pellets and briquettes. The value of the pellets on the market is given by the whole logistics needed in order to be produced:

1. Pelleting machinery
2. Briquetting machinery
3. Workers
4. Energy usage of the pelleting/briquetting machineries

A pelleting machinery, can cost **between 2.400 Euros to more than 20.000 Euros**. The costs depend on the capacity that a machine can cover (from 100 kg/h, to more than 500 kg/h, even 1 t/h), but also on the type of raw material is used (straws, wood, energetic crops). But the process of pelleting includes also the drying of the material (for a bigger market value of the end product), as well as shredders for the raw material and grinders.

The price for a shredder and a grinder can vary from **2.000 Euros to 10.000 Euros**, depending on the machinery's capacity, the type of raw material it can shred/grind.

On the market there can be found the full line of pelleting, with the shredders, grinders, and dryers included. If we consider the easiest way to transform raw material into marketable pellets, a full line will be required. The complete line can be acquired from 30.000 Euros (for a capacity of 100 kg/h), up to 65.000 Euros (for a capacity of 1 t/h).

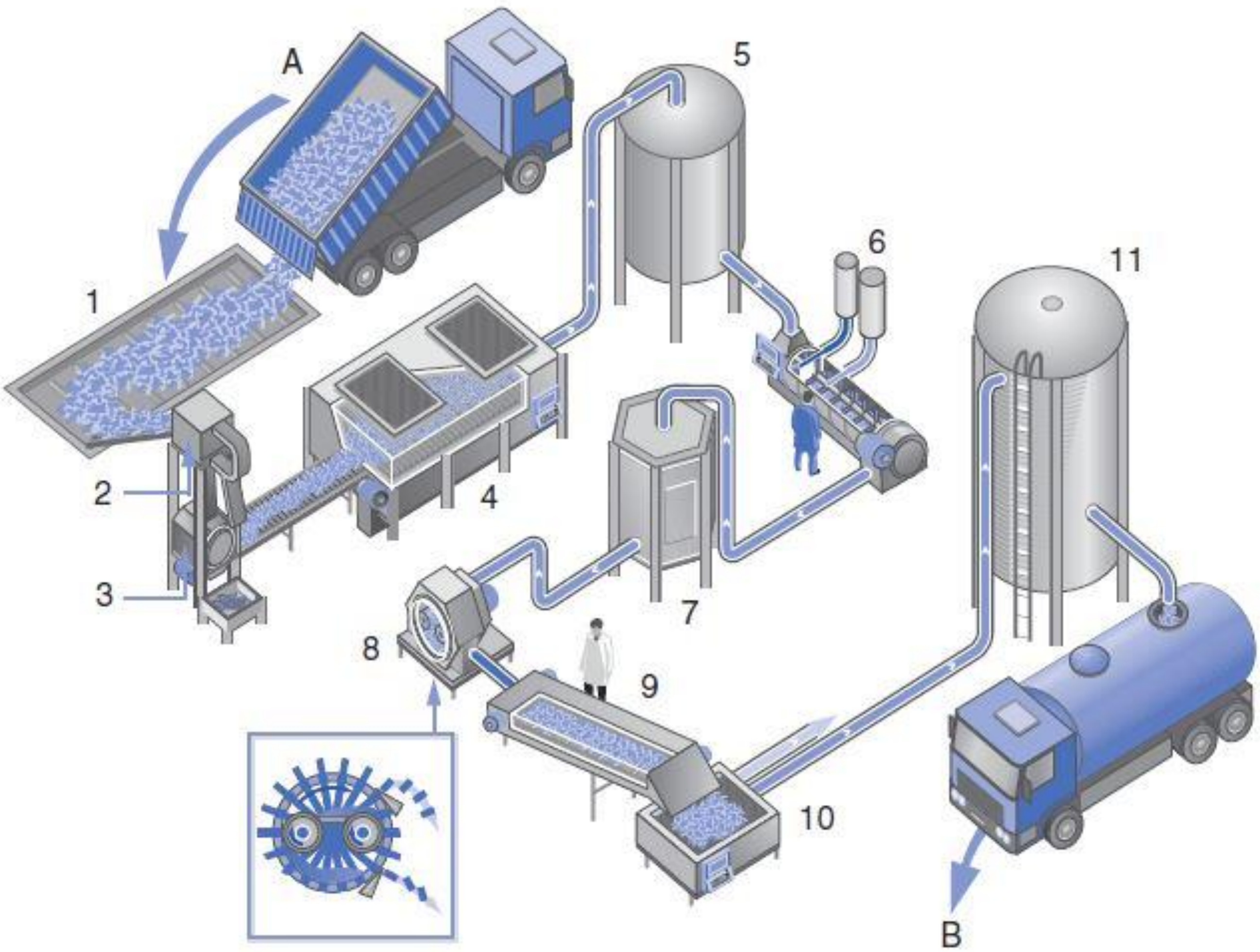



*Image 6: Pelleting line : A. Raw material  delivery; 1. Conveyor; 2. Sorter; 3. Hammer mill; 4. Drying installation; 5. Drying silo; 6. Conditioning device; 7. Ripening container; 8. Mold press; 9. Cooler; 10. Sieve; 11. Pellets silo; B. Transport to the final user*

The briquetting machineries function on the same principle as the pellets machineries, the difference is given by the final products, and the usage. A complete briquetting line can be acquired at about the same prices as a pelleting line (**30.000 Euros- 65.000 Euros**).

Next, in determining the economic value of the processing, it has to be considered the human resource component. Important in this matter is the quantity of pellets and briquettes is to produce, as well as the number of hours to be worked. So, for example, in a small factory of pelleting, where there can be produced 100 kg/h, in a working day- 8 h, there can be produced 800 kg. For this small quantity of pellets, there would only be necessary the work of only one person. In Romania, the average salary for a worker is about 600 € /month (taxes included).

So, the workers economic value is to be taken in consideration, only if the pelleting line has to cover more than 1 t/day, or even for bigger facilities that produce 1 t/h. For a small factory the workers economic value isn't a big part of the investment.

Finally, in the processing part, is the energy usage for the working machineries. This is an important economic part, due to the many machineries that are needed in the process. A **medium energy consumption** has been determined at **10 KWh**.

**Example:** In a month, 30 working day, with 20 h of working the energy consumption gets to about 60 MWh. The price for 1 KWh in Romania is of 0.11 €. The total price for 60 MWh energy consumption, in a full working month, is 6.600 €/ month.

The example above underlines the importance of energy consumption, and how much it can influence the whole costs of a factory. Nevertheless, there are alternative solutions that can help diminish the costs for energy (Solar panels, for examples).

All this variables are to be developed and taken in consideration in the following chapter of this study, to determine the equation for logistics analysis of the biomass value chain.

From the studies and market analysis, we can conclude that for a pelleting/ briquetting line that produces 1t/ h, the entry costs of pellets is of 50 €/t (using straws as raw material), sold to the final user with 130 €/t.

# 8. Developing the Equations for logistic analysis of the biomass value chains

As presented in the chapters above, for the final user the cost of biomass is directly influenced by the logistic components. From the harvested raw material, until the final product (briquettes, pellets) there are many steps that influence both the quality of biomass (calorific power), but also the cost of the final products. The developed equation for the logistic analysis is described below:

**Equation for logistic analysis:**

$$P\left[\frac{€}{t}\right] = r\left[\frac{€}{t}\right] + t1\left[\frac{€}{t*km}\right] + p\left[\frac{€}{t}\right] + t2\left[\frac{€}{t*km}\right]$$

*P= pellets/briquettes final costs*
*r= raw material costs*
*t1,2= transport costs*
*p= processing costs*

Considering the logistic analysis, transport 1 and transport 2 accounts for more than 30-40% of the total cost for end user biomass, means that placing links in the supply chain is very important. Such territorial component plays important role.

How every link of the value chains can be influenced by the territorial component is going to be analyzed in this chapter, with consideration on every connecting link of the bio-value chain.

## 8.1 Raw material costs

First to take in consideration, in the hypothesis described above (30-40% costs of the end user are on transportation), is that if the costs of transport would be free, the costs of final products (pellets and briquettes) would be almost the same.

Another issue to consider is the variation of prices of two suppliers of the same raw material. In this sense, we consider that the price variation is given in a fair amount by the geographic distance between the supplier and the final user (see the following example).

Example: 1 ton of straws delivered from 20 km away can be 130% more expensive than 1 ton of straws delivered from 10 km away

On a territorial level, we could observe big differences in costs, given by the geographic feature of a particular area, in this sense we consider that a map that will show both geographic and economic components, could facilitate the access of final users to best prices (best economic opportunity). As well, it would encourage entrepreneurs to start building businesses in the field of biomass, having a clear idea on the available market, on the available resources and where these businesses would be best fitted (considering the availability and quality of roads, for example).

## 8.2 Transport 1 costs

The costs of prices in terms of transport (concluded in the market analysis of chapter 7.2) varies depending on the presence and arrangement of main and secondary road infrastructure (forestry and agricultural roads).

Roads infrastructure influence the accessibility to raw biomass. In this sense, we can observe the lack of a radial diffusion of the accessibility from the source, but we can see the presence of forms that follow the road network.

The secondary roads (forestry and agricultural) need specialized transport equipment, that leads to different cost coefficient depending on roads type. For further research of this study, the transport cost would need to be differentiate by the types of roads (primary, secondary).

The road ends can be considered elements of appointed costs- loading and unloading. This means that the transport distance is not influencing directly proportional total cost of transport. Further considerations, in a deeper analysis, are referring to variation of costs per kilometer and variation of costs per transport.

In macro-territorial perspective, we can consider the areas included in between primary roads as areas of further analysis and we can attribute cost coefficient depending on the report between the surface area of analysis and perimeter of the same area.

## 8.3 Processing cost

The costs for processing could present cost elements, other than raw material and energy, plus a fixed percentage, depending on the distance from inhabited areas, considering the access to labor, accessibility to utilities and scale of the unit, but for this study we consider these elements are to be studied in depth in another project.

Nevertheless, for a further analysis of this study, the described elements should be taken in consideration.

## 8.4 Transport 2 costs

The cost for transport 2 is quite constant. The distances that we have referred to in this study are of maximum 350 km. Of course, the type of road influence the total costs, and in a deeper analysis it has to be taken in consideration. In the case of transport 2, most of the used routes imply the primary, main, roads.

In this sense, we don't see further barriers, as the transportation market (in which we can include also transport 2) is quite stable. The market of transportation (primary roads) is very well developed in Romania, as well as it is very competitive and standardised. Also, we don't foresee of different elements of special analysis in the expanse of a territory.

What could be an element of interest would be the presence of logistic hubs and their location. In this stage the international character can interfere, do extra costs could appear (toll, different fees, etc).

## 8.5 Selling of final products

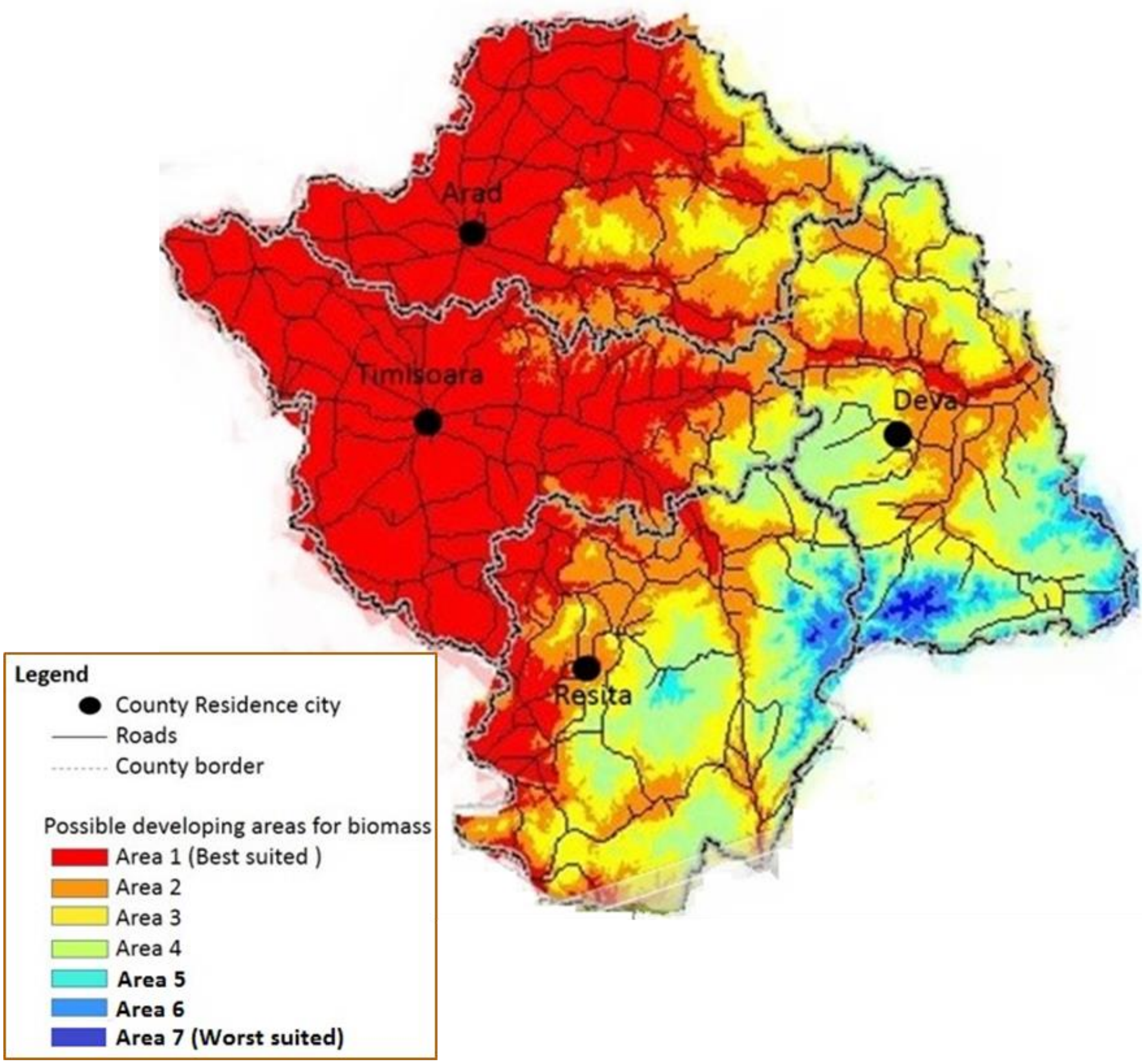
In the context of selling the final products, a subject of analysis should be the geographic concentration of demands: in a specific area the demand can be for an industrial consumer, but isolated, or domestic households in big numbers and density per area.

The two situations presented above are different cases that have to be analysed to fully understand the needs of a specific territory.

For further analysis, it would be an interesting study the further research of the market, depending on the variation of demand concentration inside a territory (see the following example).

**Example**: An industrial consumer (district heating) will create disadvantages for domestic households that will be encouraged to reconnect to the system.

For a deeper analysis of a territory, we consider that a GIS based tool could facilitate the access on different markets of biomass. An example of graphic of the accessibility of biomass in the Western Region, depending on the final user costs can be found in the following map. The tool could create a graphic form of any of the used layers: costs for raw material, Transport 1 costs, Transport 2 costs, before and processing costs, etc.




*Example of temperature map for straw biomass supply chain*

# 9. Conclusions

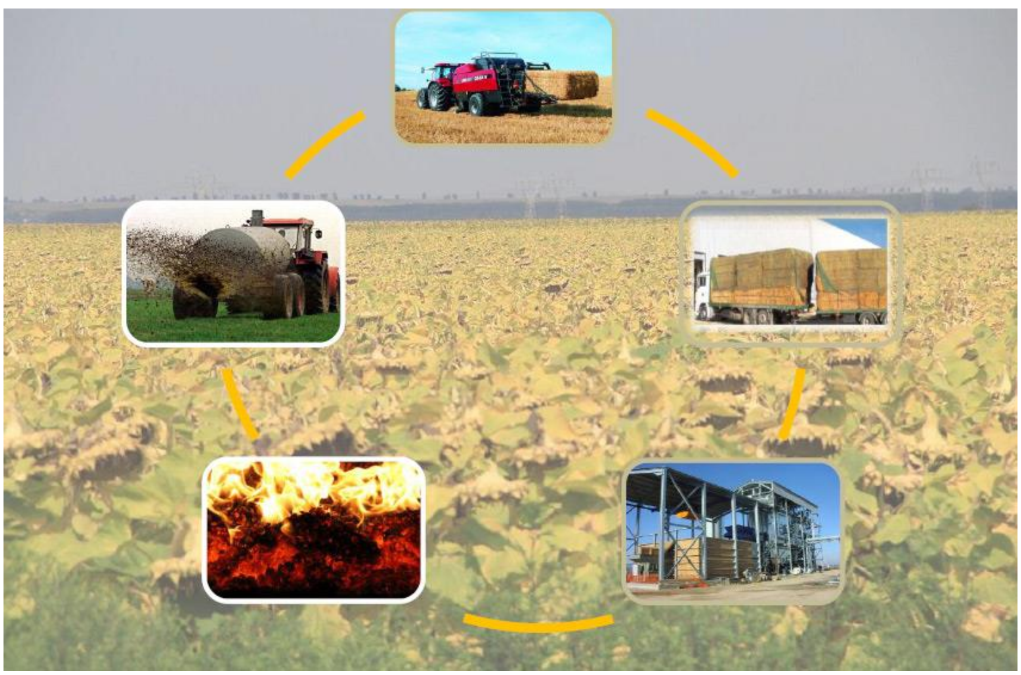
This study focused on assessing the potential of biomass development in the Western Region of Romania, by taking in consideration the costs components of every link of the value chains.

We could find out that Western Romania is a virgin area in terms of biomass use, as well as it is very rich in energetic potential. With a rich natural background, with many agricultural activities, rich forests, areas that are not used or not properly used, this study could focus on the missing links of the value chain.

In the case of West Romania, the missing links is the lack of cooperation and association among actors, which makes the drafting of a business plan in biomass very much harder, as a lot of guess work has to be done. This is not sustainable for a territorial development that could be uniform and transparent.

As we could find out in the process of research of this study case, there is supply of raw biomass, energy demand, but the connection in between them is very poorly. That leads to a potential of about 22 TWh/year to be wasted, and an economic value of 2 billion 420 Million Euros/year that isn't achieved.

In this context, the West Development Region of Romania could easily be self-sustained and use its natural background in the process of self-sustainability.



In this sense, we can foresee possible solutions, as well as interest among actors to reach to a solution.

One of the solutions that we consider appropriate is an accurate mapping of the actors. In this case, the use of biomass, and of the value chain would be transparent and would have traceability. An important factor is the nature of the raw biomass sources, for we know that some cultures exist for 20-25 years and have a high degree of predictability, but straw crops, for instance, present a high degree of unforeseeable for calculation purposes, as that varies depending on the decisions of the agricultural, on the epidemics, on the weather conditions, etc.

In this case the mapping tool should have and include a system with a high rate of updating. This tool could also help for the integration of supply chains and create a well-developed market.

The equitable distribution of added value within the supply chain could be analyzed and reach to the development of policies of encouragement of biomass sector, by preventing market distortions, while being aware of the sector (see example below).

**Example:** There could be subsidies for pellets and briquettes for the areas with a specific number of inhabitants, known that are under the critical mass, and that could vary from one year to another, depending on mapping.

All in all, the development of bio-economy with the use of biomass is one of the answers in achieving the objectives of rural development that Romania wants to achieve, by creating a new industry that connects the interested actors of the supply chain, as well as improving competitive strengths in agriculture and forestry by improving the competitive performance of commercial and semi-subsistence farms, to encourage cooperation and association among them in line with sustainable development principles, to support the pooling of producers into integrated production chains.

Another part that has to be taken in consideration in following studies is the environmental impact of biomass use, in a sustainable way. In this sense, one of the most important problem in this world is about the increase of $CO_2$ in the atmosphere, which contributes to global warming. This type of bioenergy offers an alternative to fossil fuels. Greenhouse gas emission can be removed through the process of carbon sequestration or removing carbon dioxide from the atmosphere into long-lived carbon pools. Therefore, the process of photosynthesis combines atmospheric CO2 with water, releasing oxygen into the atmosphere and holding the carbon atoms into the plant cells. This carbon neutral process can help displace CO2 emissions from burning fossil fuels. Using biomass for fuel and other bio-products can bring about other environmental benefits, including the recovery of degraded land, reduction of soil erosion, and protection of watersheds.

We would like to conclude this study by recalling the interest of development of bio-economy in the Western Region and the involvement of different actors. We can affirm that the industry is growing from one month to another, and the interest and involvement of both public and private actors is increasing.

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